Walter Leal Filho
Editor

CLIMATE CHANGE MANAGEMENT

The Economic, Social and Political Elements of Climate Change

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The Economic, Social and Political Elements of Climate Change

Springer

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Foreword

This book contains a set of papers presented during the world's second online climate change conference (Climate 2009) held on 2–6 Nov 2009. The idea of running on-line climate conferences was born in Hamburg in the summer of 2008. With the first on-line climate change conference (titled "Climate 2008") and the second one titled "Climate 2009" groundbreaking a methodology was established: the execution of climate change conferences which are not – paradoxically – harmful to the climate as conventional conferences are, but ones which are climate-neutral. For this purpose, the Hamburg-based company "Klimainvest" purchased climate certificates (WWF Gold Standard) which have neutralized the emissions caused by desktop computers and notebooks used during the time of the conference by all conference participants. In doing so, millions of people – as opposed to a few hundred – can take part in the event, wherever they are, whenever they want and regardless of their economic situation or social status.

A unique feature of this book is its strong practice-oriented nature: it contains a wide range of papers dealing with the social, economic and political aspects of climate change, exemplifying the diversity of approaches to climate change management taking place all over the world, in a way never seen before. In addition, the book describes a number of projects and other initiatives happening in Africa, Asia, Europe, Latin America and the Australasian region, providing a profile of the diversity of works taking place today.

Primarily, the book looks at matters related to the economic aspects of climate change and, quite often, also looks at its relationship with sustainable development. In this area, interdisciplinary groups of economists, philosophers, ecologists and climate experts have produced a rich set of papers characterized by a diversity of contexts. In addition, many contributors to the book have analysed the impacts of climate change in farming systems, on health, food production and the effects of economic globalization to attempts to address the causes of climate change. Moreover, the book presents various tendencies grounded in the social and political roots of climate change, with special attention being paid to developing countries. Furthermore, the results of various empirical investigations and projects are presented, which touch upon areas as varied as ontology, ecosophy, anthropocentrism, biocentrism, ethical concepts, deep ecology and others. All in all, the various chapters illustrate how deep and how wide the roots of climate change are and how complex the handling of climate change-related matters may be.

Prepared in the framework of the International Climate Change Information Programme (ICCIP), this book – the second one in the Springer Climate Change Management Series – meets a perceived need for practice-based publications, i.e. publications which do not limit themselves to discussing theoretical aspects of climate change, but which actively seek to foster a broader understanding of what climate change is and means to people and to countries.

Hamburg
Summer 2010

Prof. Walter Leal Filho

Contents

Part I
Social Aspects of Climate Change

Chapter 1
Adaptive Capacities of European City Regions in Climate Change: On the Importance of Governance Innovations for Regional Climate Policies

Sybille Bauriedl

Abstract The higher the adaptive capacity of a region, the lower its socio-economic vulnerability is. Regional adaptive capacity is dependent on conditions such as economic power, technology, knowledge, institutions, infrastructure, and social equity. Not only are the impacts of climate change regionally very diverse, but the regional conditions to adapt to climate change are too. The paper discusses the implication of knowledge, institutional and infrastructure conditions of adaptation and the interdependencies of these conditions. Empirical outcomes of the case study in Northern Hesse (Germany) give some examples for the challenges of establishing regional governance innovations to handle these interdependencies. Another dominant condition of adaptive capacity is the discursive frames of regional climate change. While in international agreements and policy advice, resource-intensive economies and lifestyles are criticized as the main polluters, climate change debates at the regional level stress the options of climate change to strengthen regional economic competition. The paper suggests a perspective on multi-level governance and a perspective on policy integration for climate change adaptation to create a wide analytical view on these complex factors.

Keywords Adaptation · Adaptive capacity · Climate change governance · Policy integration · Regional governance · Urbanization · Vulnerability

Introduction: Adaptation Policies for European Regions

In the terms of the IPCC, adaptation policies are policies that intend to enhance adaptation. It defines adaptation as, "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates

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harm or exploits beneficial opportunities" (IPCC 2007: 869). While global climate change is defined as a crisis of resource-intensive economies and lifestyles, the impacts at the regional level are defined as an environmental crisis and regional climate change policy stresses options for efficient management of resources, based on economic strategies, which are shaped by the search for adaptation strategies that allow the continuation of urban lifestyles and patterns of consumption.

The notion "adaptation" was introduced by the United Nations Framework Convention on Climate Change at the Rio conference in 1992, where two main categories of response to climate change were established: mitigation and adaptation. Adaptation was not defined as precisely as mitigation and was used in several interpretations and there is still no coherent theory of adaptation. In the beginning, the concept of adaptation was used in discussions on how to cope with floods. The terms "coping", "risk management" and "vulnerability reduction" were used in a similar way to "adaptation". Climate change is pushing people beyond the limits of existing coping strategies in many places, but not in all places, and it will happen in different time periods. Designing adaptation policies and implementing them at the local level therefore remains a challenge for policymakers who differ in terms of how urgently they need to provide adaptation measures. Social vulnerability arises both from the regional impacts of climate change and from the social, political and economic responses to these changes. Adapation capacity therefore depends on regional resources and climate change discourses.

Not only do the impacts of climate change vary by region, but the definitions of climate change, vulnerability and adaptation do, too. The debate on adaptation and which strategy needs to be adopted has grown in complexity and is closely associated with the concepts of vulnerability and resilience and "each of these concepts has its own unique community of practice and research" (Schipper and Burton 2009: 3). Socio-economic and political factors determine regional and individual vulnerability. Adaptation is facilitated by reducing vulnerability and, conversely, adaptation reduces vulnerability (Kelly and Adger 2000). Many studies on climate policy highlight a strong interrelation of adaptive capacity and governance as an innovative form of government: "Interventions in social–ecological systems immediately confront issues of governance" (Lebel et al. 2006: 19). Adaptation policy has to handle questions such as: Who decides what should be adapted? For whom is adaptation to be managed, and for what purpose? Decision-making in the field of climate change adaptation is connected with multiple potential conflicts of various stakeholders.

Governance is a mode of conflict solving and ascertaining the priority of political decisions. Its outcome of concrete actions takes place in terms of management of regulation. The essence of governance is its focus on governing mechanisms, which are not based on recourse to the authority and sanctions of government. It involves recognizing the limits of government (Stoker 1998: 18). The governance perspective draws attention to the increased involvement of the private and voluntary sectors in service delivery and strategic decision-making. The normative link of governance and adaptation is the concern with "active" citizenship. Adaptation to climate change is interpreted as the responsibility of every citizen. An effective

CONDITIONS OF ADAPTIVE CAPACITY

- **economic power and flexibility**: financial resources of cities and districts;
- **technologies**: existence and access to adaptation technologies;
- **knowledge**: information about short and long-term impacts of regional climate change, capability to prioritize adaptation measures;
- **infrastructure**: flexible supply, mobility, energy systems;
- **institutions**: cooperative management structures;
- **equity**: access to knowledge, infrastructure, economic resources.

Fig. 1.1 Conditions of adaptive capacity (according to Smit and Pilifosova 2001)

realization of adaptation measures requires a high acceptance of the chosen strategies and this acceptance can be reached through the participation of a wide range of non-state actors in decision-making processes. Governing from the governance perspective is always an interactive process because no single actor, public or private, has the knowledge and resource capacity to tackle problems unilaterally (Stoker 1998: 22). This is especially relevant for socio-ecological problems such as the regional impacts of climate change.

In this paper I will pursue the question: What are its potentials and constraints for a sustainable climate change policy? My considerations focus on the presumptions of the discursive connection adaptive capacity and (regional) governance. I argue that the hegemonic definitions of prospects and risks of regional climate change frame possible adaptation policies. To discuss this argument I refer to some preliminary results of a case study on the adaptation policy of the Northern Hesse region (Germany), which is part of a research project on the acceptance of adaptation strategies and regional governance at the University of Kassel. My conceptual reference is the argument of Smit and Pilifosova (2001), who outlined six conditions of the adaptive capacity of a region, which are strongly interconnected. They argue that by increasing the impact of these conditions, the scope of action for adaptation policy will increase, too.

To achieve the aim of increasing the conditions of adaptive capacity (see Fig. 1.1), it is necessary to coordinate the different priorities of these conditions. For example, not all vulnerabilities can be solved by technology, and the process of innovation can be very slow. I will outline only three of these conditions of adaptive capacity: knowledge, infrastructure, and institutions.

Knowledge: What Are the Dominating Narrative Frames of Regional Climate Policies?

The impacts of regional climate change within complex processes of global warming and local climate variability confront urban development and regional governance with various problems (Eliasson 2000). The implications of ecological and social interactions at the local level and how to regulate societal nature relationships in urban areas are not well known (Bauriedl and Wissen 2002). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change emphasizes the human impact on global climate change. Taking this into consideration, future research on climate change has to focus on the interconnections between global emissions of greenhouse gases and concrete human activities, and built-up spatial structures in regional contexts. Knowledge about these complex interactions is comparatively low. This means that climate researchers need to downscale their knowledge about climate change scenarios from a global to a regional scale, while social scientists have to upscale their knowledge about socio-economic transformations as a condition for increased resource consumption from a local to a regional and global scale.

There is huge uncertainty about the direct impacts of climate change, e.g. the scope of changes, the differences by region, or the speed of the forecasted processes. There is also uncertainty about the indirect impacts of climate change, e.g. the risk of epidemics. And there is also uncertainty about the secondary impacts of the mitigation and adaptation activities chosen and the interdependencies of their ecological and social impacts. Climate change policy has to argue with a very weak knowledge base. Policymakers prefer precise data from climate change scientists to legitimize (economically confirmed) coping strategies. But climate change scientists provide qualitative knowledge, which is structured by powerful notions such as “disaster risk”, “vulnerability”, “resilience”, and “adaptation”. And these notions are open to multiple interpretations as to how to act.

Knowledge production by scientists in cooperation with policymakers has recently been the most powerful contribution to climate change policy (see, for example, the awareness of the IPCC Reports). Climate change researchers are recognized for environmental governance if they are formulating policy advice for required mitigation and adaptation measures. A proven practice to generate policy-relevant scientific knowledge is to map the impacts of climate change and to identify the most vulnerable regions in order to clarify the importance of local activities and environmental governance. This practice of mapping vulnerable regions increases the pressure on decision-makers to adapt to climate change. But it creates a regionalized ranking of vulnerable regions, too, and motivates stakeholders of “low vulnerable” ranked regions to do nothing and not adapt. Northern Hesse is one of the German regions qualified as low vulnerable, with the consequence that regional climate change scenarios generate only little feedback in the media and the political debate.

While scientists and ecologists transform the uncertainty of climate change knowledge in a discourse on climate risk, regional managers and entrepreneurs transform this uncertainty in a discourse on the possible benefits of climate change. Climate change is being reframed as an opportunity for innovation, new markets and enterprises. Regional impacts of climate change are interpreted in the context of regional development policy as win-win opportunities that can benefit industry and the climate alike. Frequently this innovation-based climate policy approach is focused solely on technological innovations, largely ignoring social or governance innovations (PEER 2009: 11).

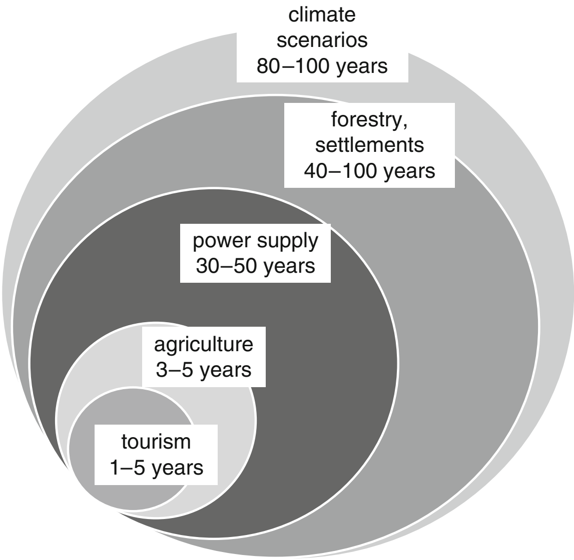

Fig. 1.2 Planning horizons in different sectors of regional development and climate scenario horizons

A sustainable regional adaptation to climate change needs an integrated perspective on development sectors and economic clusters. A vertical integration of policy fields draws the attention to possible contradictions of solely sectoral adaptation strategies. For example, in the adaptation policy process in Northern Hesse, it was immediately obvious that the long-term time horizons of the regional scenarios are not suitable for most of the sectors and clusters involved (see Fig. 1.2). Research is needed for both short-term effective adaptation strategies and long-term effective mitigation and adaptation strategies. The competence of spatial planners can be extremely relevant for regional climate policy, because they work with an integrative perspective on different development sectors and time horizons. The effects of uncertain scientific knowledge are not specific for climate policy. Decision-makers have to handle the uncertainty of future developments in the context of demographic, economic and technological development, too. But decision-makers in particular formulate a high necessity of certain scenarios for small-scale, short-term horizons, especially in the policy field of climate change adaptation.

Infrastructure: Is the "European City" an Adapted Urban Development Strategy?

Multiple overlapping and interwoven trends of spatial transformation in Europe's city regions have been recognized over the past few decades. Current climate change research frequently deals with questions of vulnerability of settlements caused by the results of climate change, e.g. windstorms, flooding or sea level rise within a global-to-regional perspective. A regional-to-global perspective has to analyse the links between historically grown spatial structures, living and economy in city regions and CO_2 emission intensity as an important part of climate change. A singular regional view examines today's settlement structures as emerging from the simultaneous processes of urban sprawl, re-urbanization, demographic change and economical restructuring with regard to globalization. The focus on ecological impacts has predominantly concentrated on direct land consumption, the induction of traffic and issues of the urban ecology approach, e.g. surface sealing, heat islands and urban aeration affecting both the urban micro- and mesoclimate. To evaluate the ideal of the European city it is necessary to interrelate these perspectives to a widened conception and spatial perspective. This perspective is vital for various reasons: a relevant share of CO_2 emissions can be tracked back to city regions as centres of emission, as city regions are gaining importance as the trend of urbanization continues. At least on the European level, the consequences of global warming will become especially apparent in city regions. Furthermore they possess a well-linked competence for innovation and intervention. Finally, city regions are areas for spreading new lifestyles that could offer opportunities for CO_2 mitigation in the future. "Cities have special responsibilities both to their own citizens and to everyone else to mitigate future climate change" (Hunt et al. 2007: 2615).

Because the success of climate policy is subject to huge delay, research is needed for both short-term effective adaptation strategies as well as long-term effective mitigation strategies. It is therefore necessary to broaden the recent focus on adaptation strategies (Ruth 2006). Exposition, size and interspaces of buildings, configuration of construction materials and surface of buildings and streets have more influence on local increases in temperature than global warming. Even though these microclimate phenomena are well known (Bulkeley and Betsill 2003), the results are hardly considered in urban planning. Instead, strategies of sustainable urban development such as redensification and re-urbanization are still the principles of urban models for European cities (Siebel 2004). Positive climate effects of a compact city have not yet been verified systematically, even though the social constraints of the principle "urbanity by density" has been sufficiently demonstrated (Sieverts 1997). Nevertheless the principle of compact urban development is acknowledged as ecologically sustainable because of its efforts to reduce surface sealing and traffic prevention.

The ecological and social impacts of different models of urban settlement structures (e.g. "patchwork city", "polycentric city", "in-between city", "netcity") and spatial processes (e.g. "urban sprawl", "re-urbanization") regarding their effects for CO_2 emissions is still to be clarified. One main question will be to analyse to what extent the guiding principle of the European city, with its characteristic attributes of centrality, compactness, urbanity, and mixed urban functions that are usually supposed to be sustainable, can be considered CO_2-efficient as well (Bauriedl et al. 2008). Several arguments are constantly referred to in spatial planning, as in adaptation politics, such as:

(a) City regions with settlement axes and interspersed with green are promoting carbon dioxide sinks
(b) City regions with a compact structure and re-urbanization trends are promoting low energy consumption for housing
(c) City regions with a settlement structure of mixed functions and a concentration of high-level functions in the inner city are promoting low-emission mobility patterns

Standardized strategies of mitigation and adaptation are not suitable solutions for urban development. Most adaptation measures on regional climate agendas are taken from the best practice checklists of sustainable urban development (Bauriedl 2007). To cope with the negative impacts of global and regional climate change and to avoid unintended interactions of mitigation and adaptation strategies, scientific knowledge about urban structures and urban living has to be reflected on different assumptions. In addition to searching for spatial structures of city regions that enable climate-friendly urban lifestyles and consumption, the conditions and constraints that influence these structures and the social and global impacts of changing urban lifestyles have to be examined.

Institutions: Multi-Level Governance for Successful Climate Policy Integration

Climate change plays a more prominent role in national governmental programmes than ever before. But at the local level, many large cities, as well as several smaller municipalities, have made climate commitments that are often more ambitious than commitments made at the national level. The decision-making power of many adaptation measures is located with the authorities of regional planning, regional management, regional alliances, enterprises, local affairs and administration, municipalities and the local citizens. Local experience of extreme weather events has made it obvious that climate change mitigation and adaptation are matters of multi-level governance. Yet frequently the efforts of mitigation and adaptation are seen in the context of just one level of governance (PEER 2009: 11). Adaptation at the local level is crucial; for example, water management, agriculture and energy supply are policy areas, which need to be supported by appropriate national and European frameworks, such as funding strategies and adequate legal instruments. Bache and Flinders defined multi-level governance as a concept that “contained both vertical and horizontal dimensions. ‘Multi-level’ referred to the increasing interdependence of governments operating at different levels, while ‘governance’ signalled the growing interdependence between governments and non-governmental actors at various territorial levels” (Bach and Flinders 2004: 3).

The multi-level governance of climate change policy is framed by different climate discourses and understandings of adaptation for the global and the local scale. Policy advice from IPCC Reports from 2001 and 2007 are important origins for this argument. Adger and his colleagues focus on the need to strengthen adaptive capacity to cope with climate change at the local scale of natural resource management and at the international scale of climate change policy (Adger et al. 2003). The adaptation concept became the main argument for coping with the impacts of climate change at the regional level. Local policies – especially in European regions – are shaped by the search for adaptation strategies, which allows continuing common styles of production and consumption. We can see that different definitions of vulnerability and adaptation in global and regional climate change policies exist simultaneously, and these definitions can be relevant at one level and non-relevant at another level of climate change governance.

In the early 1990s, two obstacles were attributed to adaptation: reducing the apparent need for mitigation, and playing down the urgency for action (Schipper and Burton 2009: 7). Approaches in radical geography emphasize the production of scales and their interconnection with the concept of "politics of scale". For a policy analysis on climate change governance it would be useful to transfer this concept to the concept of knowledge production. Radical geography analyses the complex and contested reconfiguration of interscalar regimes. It focuses on the process of allocating politics of scales as a practice of legitimizing policies (Smith 1984). With the notions of "upscaling", "downscaling", and "rescaling", the concept identifies the possibility of shifting policies from one scale to another. In climate change governance we can identify the discursive practice of upscaling responsibilities for mitigation strategies on the one hand, and the discursive practice of downscaling disaster risks (e.g. floods and heat islands) and positive options of climate change (e.g. regional competition for a renewable energy cluster) on the other. Local governments and regional planning authorities in Northern Hesse prefer adaptation strategies that fit into an economic rationality of adaptation with a risk management of costs and benefits. Adaptation strategies that require a reordering of regional governance and a new awareness of environmental accountability have to date been marginalized. This climate change policy is contextualized by the national policy of the German government that supports technological innovations to solve environmental problems. It is based on the dual strategy of increasing efficiency and increased use of renewable energies and regenerative raw materials (PEER 2009: 38).

Governance Innovations: Lessons from Innovative Institutions for Regional Adaptation in Northern Hesse

Policy interdependencies often lead to unclear competencies or responsibilities for government agencies at different levels, often in respect of the problem of budgeting. Reforming such policy interdependencies and improving policy integration is by no means a trivial matter. Multi-level governance offers the opportunity to mandate policy response to the most appropriate level, as expressed by the subsidiarity principle (PEER 2009: 25). Regions invariably yield a complex mixture of ecosystem goods and services, each with its own set of stakeholders. And they yield a specific formation of adaptation actors and institutions. Figure 1.3 summarizes the horizontal and vertical cooperation and coordination of adaptation governance in Northern Hesse so far. The debate on climate change governance and adaptive capacity in the Northern Hesse region was initiated at the national level by the Federal Ministry of Education and Research with the research programme "Climate Change in Regions" (KLIMZUG). Without this top-down initiative there would not yet be any activities for climate change adaptation governance in the region. The main promoters at the regional level are environmental researchers from Kassel University and the regional management agency of Northern Hesse. The research network has a normative approach to creating an innovative governance formation as a contribution to an increasing adaptive capacity.

The Federal Hessian Ministry of Environment has created an expert centre on climate change in Hesse with the aim to transfer information about regional climate change and to evaluate adaptation strategies at the scale of the state as a whole. One of the most important economic clusters in Northern Hesse is the renewable energy sector, which means that the regional management agency concentrates its promotional activities in this cluster, looking for benefits of regional adaptation strategies. This renewable energy sector has already created transnational networks, and the authority of non-state actors from green energy business within the regional governance formation is very strong. The national government encourages stakeholders within this sector, and several local governments cooperate in creating a regional consumer market for green energy and for re-communalizing the energy supply.

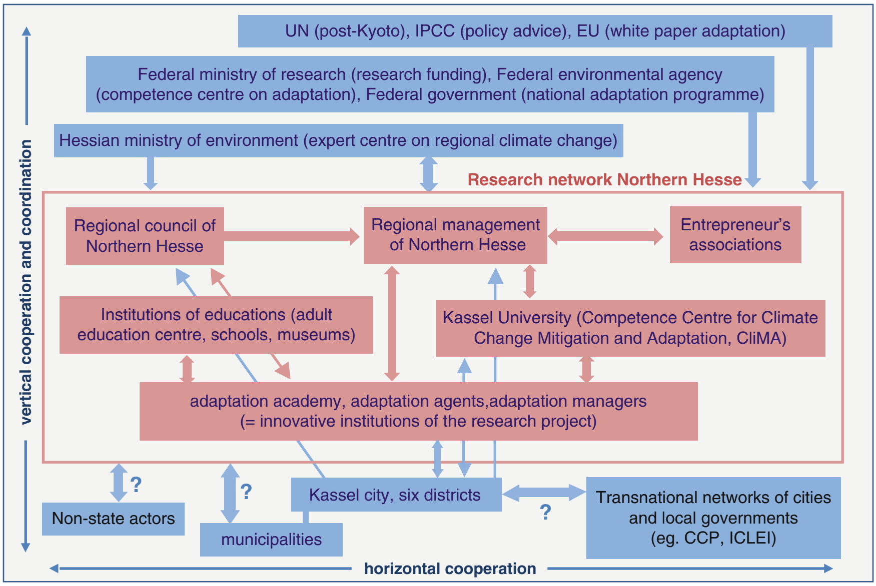

Fig. 1.3 Multi-level governance of adaptation policy in Northern Hesse (Germany)

The research network has initiated three governance innovations. Five colleagues are employed as adaptation agents in the districts' administration with the aim of guaranteeing knowledge transfer between the administration and the scientists. Three colleagues are employed at the regional management agency for the transfer of climate change and adaptation of knowledge to the stakeholders of the different economic sectors. Finally, two colleagues, in cooperation with the adult education centre, are creating an adaptation academy to transfer climate change knowledge to the citizens of Northern Hesse. All three institutional innovations support the development actor networks, they initiate participation processes, and their activities on the path to stabilizing good governance for regional adaptation will be evaluated. The science–policy transfer is one of the main issues of the recent governance debate in the research network. Even the innovative institutions' "adaptation agents" could not avoid conflicts between scientific perspectives and administrative perspectives on climate change governance. One problem is the acceptance of innovative ideas to reorder authorities and to affect traditional power structures. The regional council and the local administrations seek for policy advice from scientists to consolidate their regional authority. The interest in innovative horizontal coordination or processes of policy participation is very low. The vertical cooperation within transnational networks is rather low, too. Until now, Kassel has been neither a member of the network Cities for Climate Protection (CCP), nor are the local government members of the International Association of Local Governments (ICLEI). The objective of our research project at the department of political sciences is to elaborate these conflicts in reforming decision-making processes and to support the development of suitable regional governance.

Conclusions: Integration of Climate Change Policy into Regional Governance Needed

This paper discussed the features and conditions for integrated and more coherent climate policies and governance processes. There is a growing awareness that successful adaptation to climate change will depend on policy integration in other sectoral policies such as policies on water, waste management, energy supply, spatial planning, transport, and infrastructure. For a sustainable (regional) climate policy, an integrative approach to governance is essential. The aims of climate change adaptation and mitigation have to be incorporated into all stages of policy-making in each policy sector, complemented by an attempt to aggregate expected consequences for mitigation and adaptation into an overall evaluation of policy, and a political commitment to minimize contradictions between climate policies and other policies (PEER 2009: 19).

Regional impacts of climate change affect various policy fields and require an integrated risk management. The complex task of adaptation cannot be coped with using solely hierarchical and state-centred tools. Governance seems to be an appropriate type of government to establish adaptation strategies for sustainable regional development. Which specific actor and institutions have to participate, how should coordination processes be organized and who is responsible for establishing which adaptation strategies? These are questions that have to be answered in a broad regional debate on climate change, like the one that has begun in Northern Hesse. Interdisciplinary research networks on regional climate change have a central position in initiating the necessary communication and networking process.

Innovative governance formations pose a challenge for regional institutions. Even if cooperation between regional management and enterprises exist, as in Northern Hesse, policy processes with the participation of civil society, like “Agenda 21” processes, are very difficult to carry out successfully. To establish adaptation strategies and make them obligatory and sustainable, wide acceptance and legitimacy is essential. Participation processes can generate this acceptance of chosen strategies and legitimacy of the existing institutions.

Furthermore, developing variable steering mechanisms which adapt to altering ecological conditions and socio-economic impacts of regional climate change is a complicated challenge. Regional governance for an increasing adaptive capacity has to follow a permanent recurring process cycle with four main stations:

1. Define the regional situation, identify key stakeholders and develop effective links between the relevant parties in a multi-level setting
2. (Re-)formulate a mission statement on the road to a climate change-adapted region
3. Influence and steer relationships in order to achieve desired outcomes for a climate change-adapted regional development
4. Think and act beyond individual sub-systems, avoid unwanted side effects and establish mechanisms for effective coordination (system management)

Of course, identifying a set of appropriate principles by regional authorities is only the starting point. Institutions can shape policy outcomes but cannot determine them. As Stoker states: “governance means living with uncertainty and designing our institutions in a way that recognizes both the potential and the limitations of human knowledge and understanding” (Stoker 1998: 26). In this sense the regional adaptation to climate change is a permanent learning process for each actor and institution.

References

Adger WN, Huq S, Brown K, Conway D, Hulme M (2003) Adaptation to climate change in the developing world. Prog Dev 3:179–195

Bach I, Flinders M (2004) Themes and issues in multi-level governance. In: Flinders M, Bach I (eds) Multi-level governance. Oxford University Press, Oxford, pp 1–11

Bauriedl S (2007) Spielräume nachhaltiger Entwicklung: Die Macht stadtentwicklungspolitischer Diskurse. München

Bauriedl S, Wissen M (2002) Post-Fordist transformation, the sustainability concept and social relations with nature. A case study of the Hamburg region. J Environ Policy Plann 4:107–121

Bauriedl S, Baasch S, Winkler M (2008) Die klimagerechte europäische Stadt? Siedlungsstrukturen, städtischer Lebensstandard und Klimaveränderungen. RaumPlanung 137:67–71

Bulkeley H, Betsill H (2003) Cities and climate change. Routledge, New York, London

Eliasson I (2000) The use of climate knowledge in urban planning. Landsc Urban Plan 48:31–44

Hunt JDR, Maslin M, Killeen T, Backlund P, Schellnhuber HJ (2007) Introduction. Climate Change and urban areas: research dialogue in a policy framework. Philos Trans Roy Soc 365:2615–2629

IHDP (2005) Science plan. Urbanization and global environmental change. IHDP, Bonn

IPCC (2007) Climate Change 2007. Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report, IPCC, Cambridge

Kelly PM, Adger WN (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Clim Change 47(4):325–352

Lebel L et al (2006) Governance and the capacity to manage resilience in regional social-ecological systems. Ecol Soc 11(1):19

PEER – Partnership for European environmental research (2009) Climate policy integration, coherence and governance. PEER, Sastamala

Ruth M (2006) Smart growth and climate change. Regional development, infrastructure and adaptation. Edward Elgar, Cheltenham

Schipper ELF, Burton I (2009) Understanding adaptation: origins, concepts, practices and policy. In: Schipper ELF, Burton I (eds) The Earthscan reader on adaptation to climate change. Earthscan, London, pp 1–11

Siebel W (2004) Einleitung. Die europäische Stadt. In Siebel W (ed) Die europäische Stadt. Frankfurt a. M., Germany, pp 11–48

Sieverts T (1997) Zwischenstadt: zwischen Ort und Welt. Raum und Zeit, Stadt und Land, Braunschweig

Smit B, Pilifosova O (2001) Adaptation to climate change in the context of sustainable development. In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White K (eds) Climate change 2001: impacts, adaptation and vulnerability. Cambridge University Press, Cambrdige, pp 807–812

Smith N (1984) Uneven development. Nature, capital and the production of space. Idea, Oxford, New York

Stoker G (1998) Governance as theory: five propositions. Int Soc Sci J 155:17–28

Chapter 2
An Assessment of Climate-Induced Conflict Risks Over Shared Water Resources in Africa

Samir A. Algamal

Abstract This paper was designed to inform policymakers and stakeholders about the implications of climate change and the scarcity of water due to climatic and non-climatic factors. This scarcity in shared water resources could lead to a dispute over its distribution and use. Consequently, the study is specifically aimed at shedding light on negotiation as a mitigation tool for conflict resolution in water-stressed areas. Both historic and scientific data that shows the frequent occurrences of water dispute among African countries are used. A conflict resolution technique to disputing parties is proposed.

The results of the analysis suggested that threats to water security are already the primary cause of some of the most intractable conflict in Africa. Salinization of coastal aquifers due to heavy withdrawals of freshwater, pollution of rivers, lakes, and reduction in hydropower energy as direct consequences to climatic changes, as well as other abuses of water resources, could lead to extremely serious disputes. The study has also shown that even though technical solutions are now available for solving most of the existing problems related to water resources and other environmental issues, the social and political mechanisms for realistically implementing these solutions within the sustainable development paradigm are still unknown. Furthermore, conflict over the utilization of water resources within a sustainable development paradigm is especially pronounced in the context of transboundary river basins, as well as transboundary aquifers that cross international boundaries. Negotiation on water in areas of conflict could be used as a valuable tool to help negotiate policies, treaties and laws that promote sustainable development throughout the basin, and especially with respect to the equitable utilization of water from both quality and quantity viewpoints.

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Keywords Conflict · Mitigation · Shared water resources · Transboundary · Water-stressed basin

Introduction

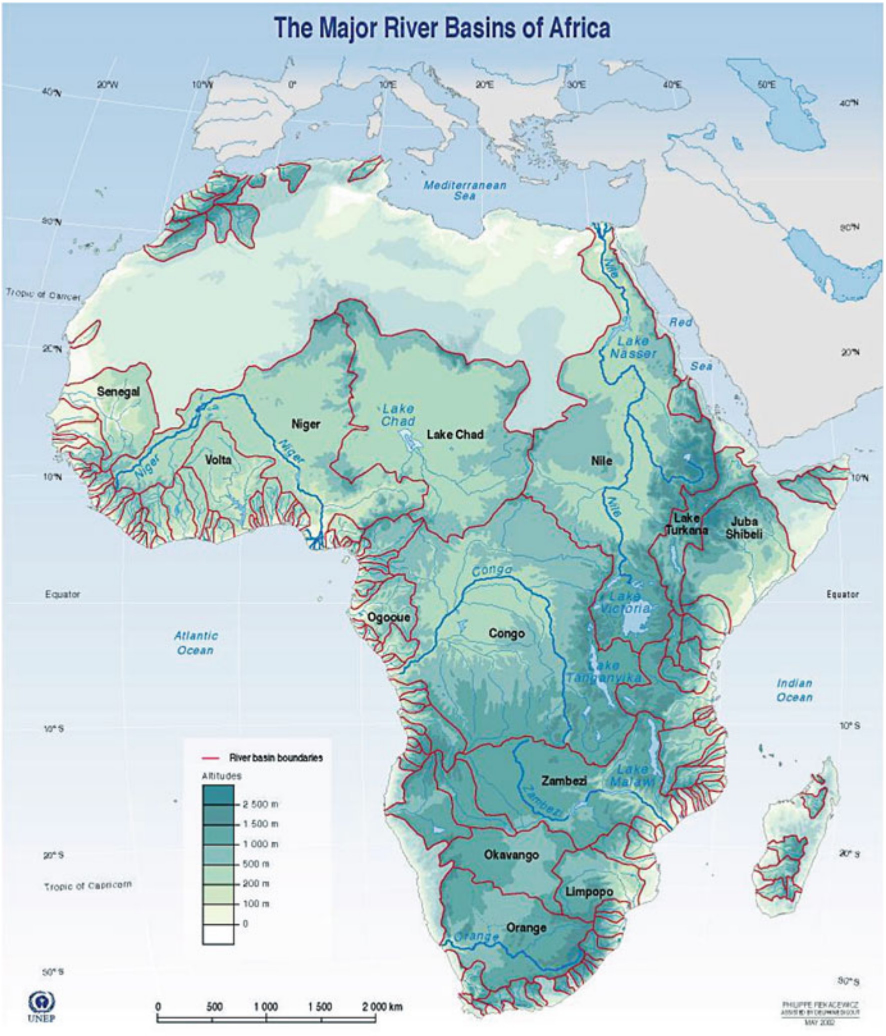
Water is one of several current and future critical issues facing Africa. About 25% of the contemporary African population experiences water stress, while 69% live under conditions of relative water abundance (Vörösmarty et al. 2000). However, this relative abundance does not take into account other factors such as the extent to which that water is potable and accessible, and the availability of sanitation. Despite considerable improvements in access in the 1990s, only about 62% of Africans had access to improved water supplies in the year 2000 (WHO/UNICEF 2000). One-third of the people in Africa live in drought-prone areas and are vulnerable to the impacts of droughts (World Water Forum 2000), which have contributed to migration, cultural separation, population dislocation and the collapse of ancient cultures. Droughts have mainly affected the Sahel, the Horn of Africa and southern Africa, particularly since the end of the 1960s, with severe impacts on food security and, ultimately, the occurrence of famine.

Climate Change and Freshwater Demands in Africa

Water access and water resource management are highly variable across the continent (Ashton 2002; van Jaarsveld et al. 2005; UNESCO-WWAP 2006). In order to shed light on water resources in Africa on a "vis-à-vis" basis, it should be noted that out of the 261 transboundary river basins in the world that represent surface water resources, 61 are recognized in Africa covering 62% of Africa's surface area (Fig. 2.1). In West Africa 25 transboundary rivers basins are shared among 17 African countries (Fig. 2.2) of which 11 for Niger-Benue, 4 for Senegal, 6 for Volta and 4 for Comoe. Transboundary rivers are increasingly disputed as a result of increased freshwater demand and decreased availability (due to worsening climate conditions).

The 17 countries in West Africa that share 25 transboundary rivers (Fig. 2.2) have notably high water interdependency (Niasse 2007). Eastern and southern African countries are also characterized by water stress brought about by climate variability and wider governance issues (Ashton 2002; UNESCO-WWAP 2006). Significant progress has, however, been recorded in some parts of Africa to improve this situation, with urban populations in the southern African region achieving improved water access over recent years (van Jaarsveld et al. 2005).

As far as the shared groundwater resources are concerned, 38 transboundary aquifers are recognized in Africa (UNESCO 2004) (Fig. 2.3). Within the scope of the present paper, only notable case examples from West Africa will be considered.



Source: Aaron T. Wolf et al., 1999; Revenga et al., *Watersheds of the World*, World Resources Institute (WRI), Washington DC, 1998; Philippe Rekacewicz, *Atlas de poche*, Livre de poche, Librairie générale française, Paris, 1996 (revised in 2001).

Fig. 2.1 Major river basins representing surface water resources in Africa

Observational records and climate projections provide abundant evidence that freshwater resources all over the world and in Africa in particular are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems. In global-scale assessments, basins are defined as being water-stressed if they have either a per capita water availability below 1,000 m^3 per year (based on long-term average runoff) or a ratio of withdrawals to long-term average annual runoff above 0.4. A water volume of 1,000 m^3 per capita per year is typically more than is required for domestic, industrial

Fig. 2.2 Major river basin in West Africa
Source: Transboundary Freshwater Dispute Database (2000)

and agricultural water uses. Such water-stressed basins are located in northern Africa. In water-stressed areas, people and ecosystems are particularly vulnerable to decreasing and more variable precipitation due to climate change. As a direct consequence, habitats and ecosystems in Africa are currently under threat from a variety of impacts and climate change is likely to be an additional stress. Higher temperatures and increased variability of precipitation would, in general, lead to increased irrigation water demand, even if the total precipitation during the growing season remains the same. The impact of climate change on optimal growing periods, and on yield-maximizing irrigation water use, has been modelled assuming no change in either irrigated area and/or climate variability (Döll 2002; Döll et al. 2003).

Difficulties, Constraints and Limitations Related to Climatic Changes in Africa

Low adaptive capacity of African countries, as well as consecutive dry years with widespread disruption, are reducing the ability of the society to cope with droughts by providing less recovery and preparation time between events. Furthermore, future rainfall patterns are not clear cut but it is likely that over the next 50 years

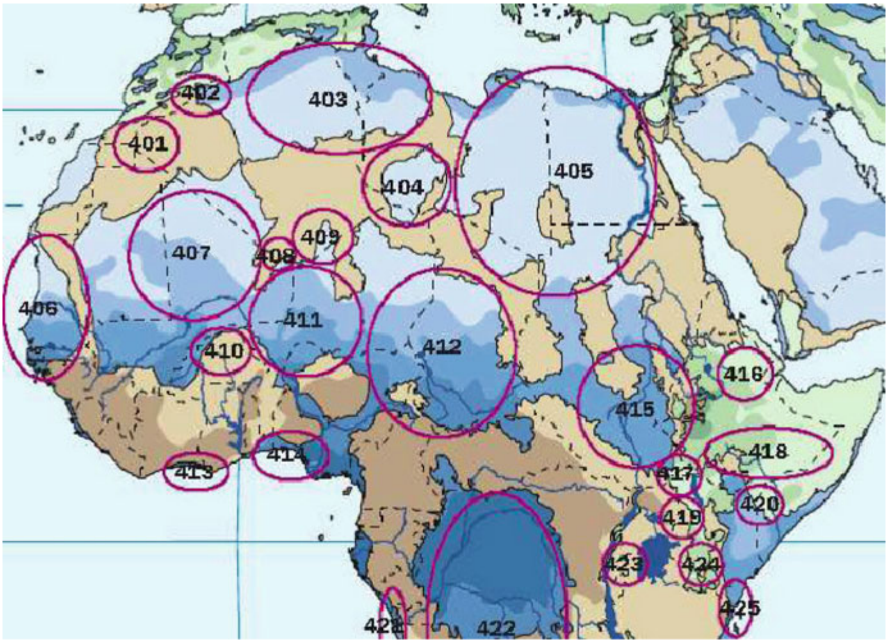


Fig. 2.3 Major transboundary aquifers representing groundwater resources in Africa
Source: UNESCO 2004

there will be a decrease in rainfall of 10–25% over northern parts of Africa in the months of June, July and August and a 10–60% decline in March, April and May. In contrast, western Africa may see an increase in rainfall of 10–35% in the December, January and February period, which is normally a dry time, with an increase also during September, October and November of between 7% and 28%.

Another difficulty arises from the low distribution density of weather stations which is one per 26,000 km^2 – eight times lower than the World Meteorological Organization's minimum recommended level. In addition to the lack of good monitoring of the El Niño Southern Oscillation as it relates to Africa; the onset of the Sahel precipitation and the interaction of Saharan dust with climate.

Case Studies on African Water Conflicts

Cameroon Versus Nigeria on Lake Chad

Problem Definition

The flooded area of Lake Chad (Fig. 2.4) has declined drastically as a direct consequence of climatic change from 37,000 km in 1963 to 25,000 in 1973 and then to 2,000 km^2 at present. So the total area of the lake was split; with only the southern part

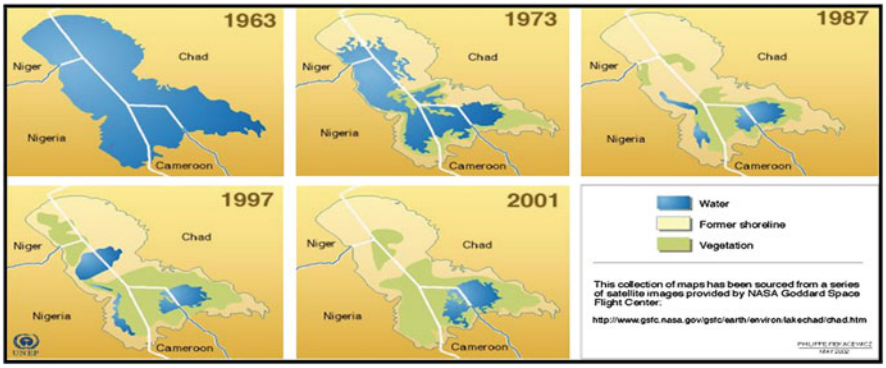


Fig. 2.4 Changes in the spatial distribution of Lake Chad and its associated resources

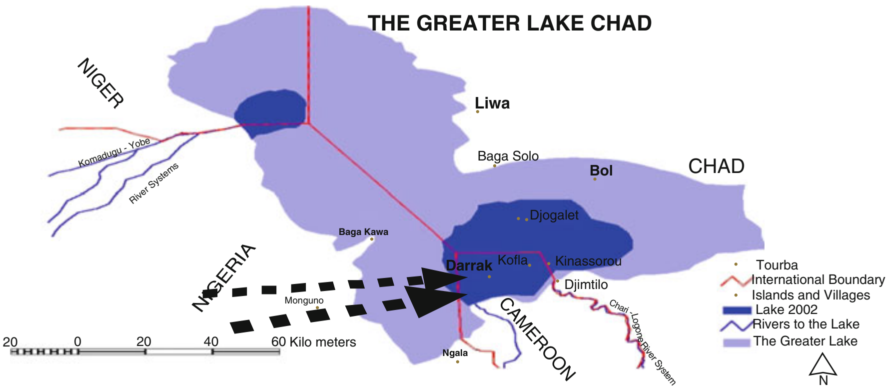


Fig. 2.5 Migrations of Nigerian fishermen to Cameroon
Source: Transboundary Freshwater Dispute Database (2000)

now as perennial surface water bodies. Accordingly, fishermen from the Nigerian shore had to follow the receding lake (Fig. 2.5) – a situation which has ended with them settling in Cameroon territory. Eventually, the government of Nigeria followed its citizens: administration, school, health facilities, police, military, i.e. border dispute Cameroon-Nigeria (Transboundary Freshwater Dispute Database 2000).

Senegal Versus Mauritania

Problem Definition

The Senegal river has its main source in the Fouta-Djalon Mountains in Guinea and provides water to the semi-arid parts of Mali, Senegal, and Mauritania. The basin

Fig. 2.6 Senegal river basin
Source: Transboundary Freshwater Dispute Database (2000)

has a total area of ~483,000 km^2 and the river course is 1,800 km long (Fig. 2.6). Mauritania has the largest area of the basin with 50%, followed by Mali with 35%, Senegal with 8%, and Guinea with 7%. Box 3.5 summarizes the main basin characteristics (Gibb et al. 1987).

Eight severe drought events have occurred during the period from 1970 to 1980. The whole area has suffered from chronic rainfall deficits particularly from 1986 to 1988 where, in September 1988, the traditional transboundary land use practices constituted a dispute and it was the beginning of a real crisis and the consequent loss of lives in both countries. Eventually 75,000 Senegalese and 150,000 Mauritanians were repatriated. In June 2000, fresh tension for the same reasons has occurred (Transboundary Freshwater Dispute Database 2000).

Ghana Versus Burkina Faso (1998)

Problem Definition

The White Volta and Black Volta contribute 56% of inflows into the Akosombo Reservoir of the Akosombo and Kpong Dams which produce more than 90% of Ghana's electricity. Consequently, any decline in rainfall will be expressed directly on the decline in water level in the Akosombo Reservoir (Fig. 2.7), and this situation will impact directly on energy production in Ghana, provided that total storage capacity of the entire Burkina Faso reservoir is about 1.49 billion m^3 which

Fig. 2.7 Ghana versus Burkina Faso location map

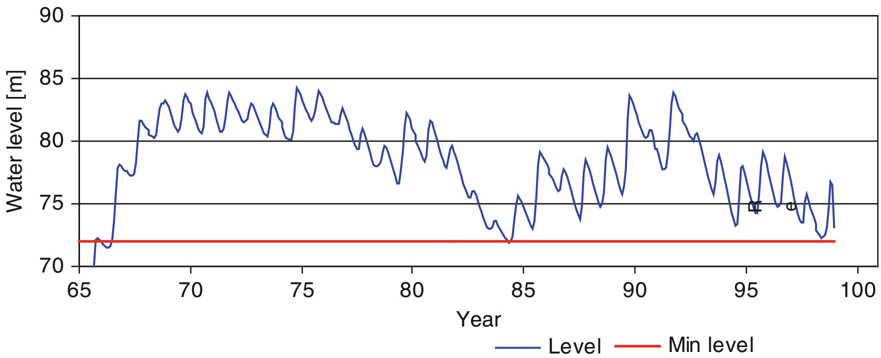


Fig. 2.8 Water level in Akosombo Lake (Niasse 2007)

constitutes less than 5% of the volume of the Akosombo Reservoir (Fig. 2.8). Burkina Faso cannot therefore be blamed for any decline in the reservoir producing hydroelectricity for Ghana (Niasse 2007).

Niger Versus Nigeria on the Niger River Basin

Problem Definition

The Niger river basin, located in western Africa, covers 7.5% of the continent and spreads over ten countries (Fig. 2.9). The area of the Niger river basin in Guinea is only 4% of the total area of the basin, but the sources of the Niger river are located

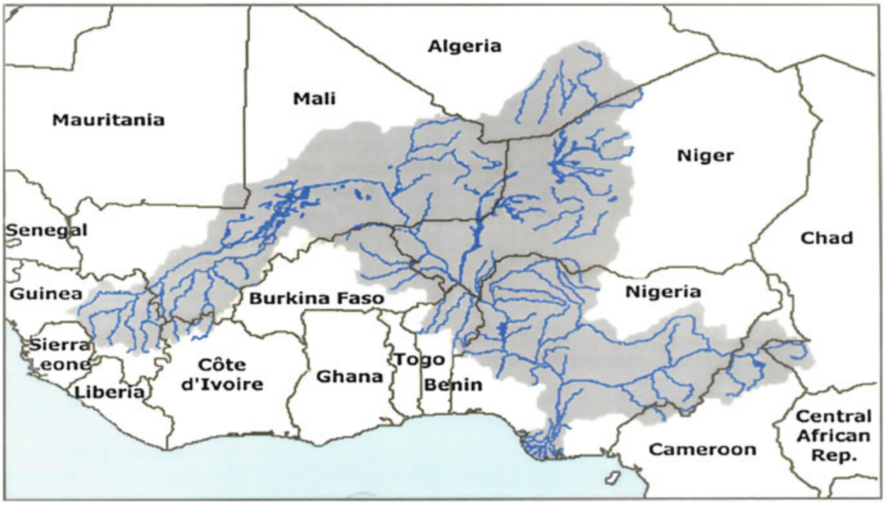


Fig. 2.9 Niger river basin

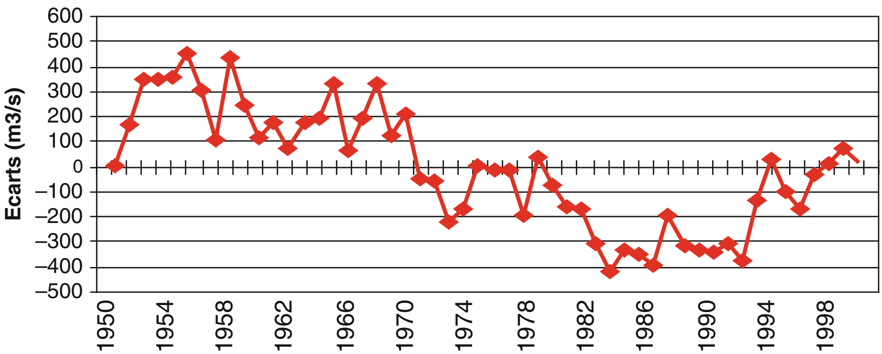


Fig. 2.10 Annual discharge of Niger river at Niamey (Le Barbe and Tapsoba 2002)

in this country. The quantity of water entering Mali from Guinea (40 km^3 per year) is greater than the quantity of water entering Nigeria from Niger (36 km^3 per year), about 1,800 ha further downstream (IUCN-IWMI-Ramsar-WRI 2003).

This is due among other reasons to the enormous reduction in runoff in the inner delta in Mali through seepage and evaporation combined with almost no runoff from the whole of the left bank in Mali and Niger (Fig. 2.10). According to the Nigerian point of view, more than 10% increased withdrawal compared to the current situation is considered unacceptable. Eventually, there is the risk that water conflict could caused by blaming upstream countries for what is really the fault of climatic change (Niasse 2007).

Eastern Africa (IGAD Region)

Problem Definition

More than 70% of the population of eastern Africa is rural and practises subsistence agriculture (WHO/UNICEF 2000). Rapid population growth and an increasing demand for food, combined with the high variability in rainfall and frequent droughts, are putting growing pressure on natural resources. Analyses of current economic and environmental trends reveal increasing competition over access and use of freshwater resources, at the same time that population growth, industrialization and climate change are adding stress to these resources. There is also competition for access to water resources between countries, some of which depend on fresh water not only for domestic, agricultural and industrial consumption but also for hydropower generation. Freshwater availability and access are thus priority issues for the entire region. The major river basins in eastern Africa that are internationally shared include: Rufiji, Juba, Victoria/Upper Nile, Turkana and Shaballe (Fig. 2.11).

Eastern Africa has experienced at least one major drought each decade over the past 30 years. There were serious droughts in 1973/1974, 1984/1985, 1987, 1992/1994, and in 1999/2000. There is evidence of increasing climatic instability in the region in terms of increasing frequency and intensity of drought (FAOSTAT 2000).

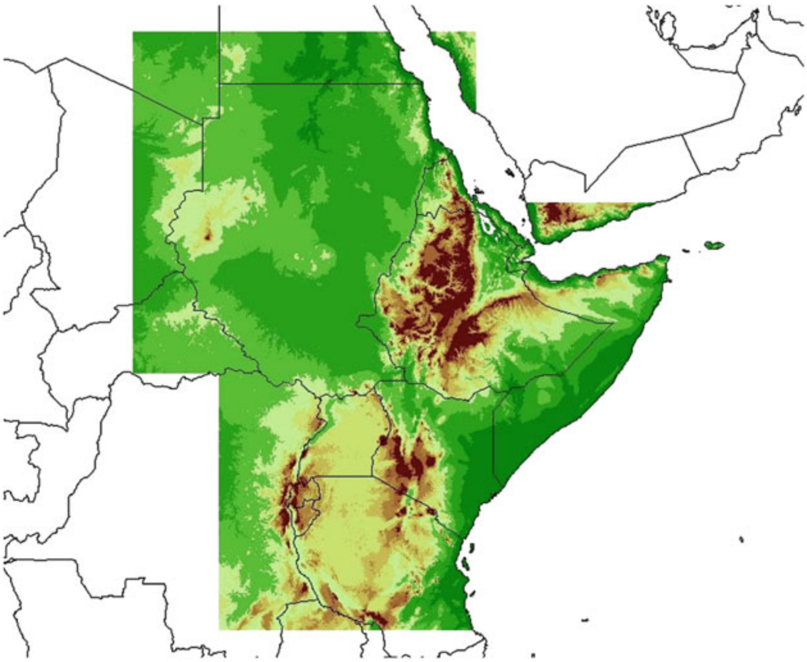


Fig. 2.11 Major river basins and lake drainage areas of eastern Africa
Source: Transboundary Freshwater Dispute Database (2000)

Eastern Africa is fairly well endowed with freshwater, with a total average renewable amount of 187 km^3 per year (UNDP and World Bank 2000). Uganda has the largest share of this, with 39 km^3 per year (1,791 m^3/capita per year) while Eritrea has the smallest, with 2.8 km^3 per year (data on per capita resources is not available; UNDP and World Bank 2000).

Conflict Resolution Techniques

Theoretically, collaboration for addressing a wide range of environmental disputes involves three phases (Vlachos 1996):

- Problem definition or problem architecture
- Direction setting (predominantly negotiations over substantive problems)
- Implementation (systematic management of inter-organizational relations and monitoring of agreements)

Some countries adopted environmental standards from the EU while others modified their existing guidelines for assessment and impact studies. Subsequently, we assume a hypothetical case study derived from a real world problem (Nachtnebel 1990) by modifying a purely Austrian conflict about hydropower utilization into an international dispute. This case study is a good and typical example for the upper section of the Danube. However its replication to cases in Africa could be of paramount nature. It is assumed that:

- The country acts rationally
- There is complete information about the system
- There is an agreed set of alternatives
- There is full communication among the partners involved
- The countries may have different objectives and criteria
- They have different preferences
- The project's impacts are different in each country

Conclusions and Recommendations

Case examples from Africa show that risks of water conflicts are real. Lessons learned from the foregoing water conflicts have shown that, although high water interdependency can be opportunities for promoting international cooperation, they can also be causes for aggravated conflict risks, especially where the following factors are combined in a lumped parameters approach:

1. Decreased water demand to respond to growing development needs
2. Decreased water availability as a direct consequence of climatic change and climatic variability

3. Large water infrastructure projects planned in isolation by individual riparian countries
4. Weak coordination that results in conflict prevention accompanied by the absence of resolution mechanisms

Eventually, it is recommended that the impact of climate on water resources be recognized on an ad hoc basis in order to reduce risks of climate-inducing water conflict.

References

Ashton PJ (2002) Avoiding conflicts over Africa's water resources. Ambio 31(3):236–242
Ashton PJ, Ramasar V (2002) Water and HIV/AIDS: some strategic considerations in Southern Africa. In: Turton AR, Henwood R (eds) Hydropolitics in the developing world: a Southern African perspective. African Water Issues Research Unit (AWIRU), Pretoria
Döll P (2002) Impact of climate change and variability on irrigation requirements: a global perspective. Clim Change 54(3):269–293
Döll P, Hauschild M (2002) Model-based regional assessment of water use: an example for Northeastern Brazil. Water Int 27(3):310–320
FAOSTAT (2000) AQUASTAT Database. FAO, Rome
Gibb A et al (1987) Etude de la gestion des ouvrages communs de l'OMVS. Rapports phase 1, Vol 1B, Optimisation de la crue artificielle. Electricité de France Euroconsult, France
IUCN, IWMI, Ramsar, and WRI (2003) Water resources eAtlas: watersheds of the world. World Resource Institute, Washington DC (CD available)
Le Barbe LT, Tapsoba D (2002) Rainfall variability in West Africa during the years 1950-90. J Clim 15:187–202
Nachtnebel HP (1990) Comparison of Hydropower utilization and environmental impacts along the Danube downstream of Vienna. Ingenieurs et architectes Suisse 18:412–415
Niasse M (2007) Climate-induced conflict risks over shared waters in West Africa. In: The third international conference on climate and water, Helsinki, Finland, 3–6 Sept 2007
Ramsar sites: List of Wetlands of International Importance, http://www.ramsar.org/
Transboundary Freshwater Dispute Database (2000) Facing the facts: assessing the vulnerability of Africa's water resources to environmental change. UNESCO/UNEP Publications, Geneva
UNDP, UNEP, World Bank, and WRI (2000) World resources 2000–2001: People and ecosystems: The fraying web of life. World Resources Institute, Washington DC
Van Jaarsveld AS, Biggs R, Scholes RJ, Bohensky E, Reyers B, Lynam T, Musvoto C, Fabricius C (2005) Measuring conditions and trends in ecosystem services at multiple scales: the Southern African Millennium Ecosystem Assessment (SAfMA) experience. Philos Trans Roy Soc B Biol Sci 360:425–441
Vlachos E (1996) Hydro diplomacy and dispute resolution in private water resources conflicts. In: Transboundary water resources, vol 7, Nato Asi Series 2. Springer, Berlin
Vörösmarty CJ, Green PJ, Salisbury J, Lammers RB (2000) Global water resources: vulnerability from climate change and population growth. Science 289:284–288
WHO/UNICEF (2000) Global water supply and sanitation assessment 2000 report. World Health Organization, Geneva
World Water Forum (2000) The Africa water vision for 2025: equitable and sustainable use of water for socio-economic development. World Water Forum, The Hague, p 30

Chapter 3
Indigenous Communities and Climate Change Policy: An Inclusive Approach

Vinita Krishna

Abstract Climate change is one of the greatest social and economic challenges today. It is a global problem which needs a global solution and for this each country has to play its part in reaching that global solution through local actions.

Adverse weather conditions are impacting the society on all fronts, be it food, habitat, livelihood, or income. There is an urgent need to take into consideration input from all segments of society. This paper deals with one such segment: the indigenous communities who have the vast potential to adapt in response to climate change. The paper deals with a general review of the efforts of indigenous communities across Asia with a specialized focus on the capacity of indigenous communities in India in combating climate change. The recognition that many environmental problems are local in nature is a rationale behind including the indigenous communities in addressing this global issue. These communities constitute an insignificant percentage of the global population and their contribution to the greenhouse gas emissions is minimal. A collaboration between these communities and the climate scientists could evolve solutions which go beyond the need to mitigate emissions and development of clean development mechanisms.

Presenting a holistic approach of the indigenous communities in coping with climate change, the paper provides an input to the policy makers on including the views of stakeholders from this sector to deal with the local needs and adopt a balanced approach between adaptation and mitigation strategies. It also gives an insight to the general public into more alternatives to climate change solutions.

Keywords Adaptation · Climate change · Inclusive policy approach · Indigenous communities · Mitigation · Traditional knowledge participatory decision-making

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Introduction

This paper seeks to explore the threats and challenges of climate change faced by the indigenous communities of Asia in general, with a special focus on India.

Based mostly on a literature review due to the absence of adequate research or data on indigenous communities in most of the developing countries, referenced materials include project reports, negotiation texts, relevant journals, books, and the climate assessment reports. The aim of the paper is to discuss the current situation of this vulnerable group and bring to light possible areas for further research. The indigenous communities and their traditional knowledge systems in mitigation and adaptation have for a long time been neglected in climate change policy formulation and implementation and have only recently been taken up in climate change discourse. The paper also explores networking actions by indigenous communities to make their voice heard.

The term "indigenous" has prevailed as a general term in some countries; there may be a preference for other terms: "indigenous peoples" or "indigenous communities". There are some local terms (such as tribes, first peoples, aboriginals, ethnic groups, adivasi, janajati), or occupational and geographical terms (hunter-gatherers, nomads, peasants, hill people, rural populations, etc.) that, for all practical purposes, can be used interchangeably with "indigenous peoples".

The UN Permanent Forum on Indigenous Issues has identified inadequate data collection and disaggregation concerning indigenous peoples as a major methodological challenge in policymaking. Compared to the other population groups in most countries, there is no available disaggregated data on the situation of indigenous communities which can be used to qualify policies and monitor the impact of programmes. To gain an accurate understanding of indigenous peoples' situation, relevant data collection must be undertaken with the full participation of indigenous peoples.

Out of the six billion people in the world, indigenous peoples constitute at least 370 million. They practise relatively neutral or even carbon-negative lifestyles, having a substantial impact in lowering GHG emissions. Nevertheless, as pointed out in the report of the seventh session of the UN Forum on Indigenous People, some of the serious impacts of climate change, such as worsening drought conditions and desertification, leading to increased numbers of forest fires that affect land use, are causing serious loss of biodiversity. This seems to threaten the sustainable existence of indigenous communities. Furthermore, mitigation measures, such as renewable energy projects (hydropower dams, geothermal plants) and implementation of REDD, taken without the free, prior and informed consent of indigenous communities, deprives them from their participatory role and excludes them from the decision-making processes of their nation.

Social Impact of Climate Change on Indigenous Communities Across the Globe

The impact of climate change on indigenous communities is most apparent in the case of the Inuit peoples who are experiencing climate change threats from the rising level of greenhouse gases (GHGs). The findings of The Arctic Climate Impact Assessment, an extensive scientific study on climate change in 2005, reported the rise in warming by 4–7°C by the end of the century, with summer sea ice disappearing within 60 years. Local peoples' habitats and livelihoods being at stake, they have filed a legal petition against the US government on the grounds of a human rights violation. Such impacts are not restricted to the Arctic but are being observed in many places across the globe as climate change intensifies. From the British Columbian coast to the Kalahari desert in Africa to the English countryside and to the Himalayan mountains, local people are noticing changes in climatic conditions. The Andean region of South America has suffered an increase in respiratory illness, a decrease in alpaca farming (small farm livestock) and a shortened growing season. In Kenya, the Samburu people are losing their livestock to severe, extended droughts. The Dayaks in Borneo have documented climate variations including rising water levels and the loss of traditional medicinal plants. In spite of such widespread impact of climate change, indigenous communities are showing signs of coping with factors like changing trends in precipitation, droughts, and floods by practising their traditional methods. For example, in the Kalahari in Africa, recent changes in precipitation have encouraged a shift from rain-fed agriculture to manually watered homestead gardening and a shift from cattle to goats. On the other hand, British Columbian Gitga'at communities, having being unable to sun-dry their food because of unseasonable wet spells, have switched over to novel techniques, such as freezing their food until the weather gets sunny or drying it indoors. These communities are also adapting to the changing patterns of livelihood and habitat, as in the case of the Makushi of Guyana who move from their savannah homes to forest areas during droughts and plant cassava, their main staple crop, on moist floodplains normally too wet for the crop.

The adoption of the "stewardship role of indigenous peoples and new challenges" as the main theme of the sixth UN Forum on Indigenous Issues speaks of the growing vulnerability of climate change. In this forum, indigenous peoples expressed concern for both the problem of climate change and the proposed solutions. Raising the issue of their exclusion from the UN Framework Convention on Climate Change (UNFCCC) and the closed-door approach in climate change policy, indigenous peoples claimed that with their traditional knowledge, they could contribute significantly to identifying proper and sustainable solutions, as opposed to the present market-based solutions such as carbon trading and agro-fuels production which are questionable both ethically and environmentally. Indigenous peoples also expressed concern at the Clean Development Mechanism (CDM) projects, some of which have caused the deaths of indigenous peoples who refused to hand over their territories for the purpose specified in the projects. The decision on Reduced Emissions from Deforestation and Degradation (REDD) was also questioned, as it makes no reference to indigenous peoples' rights.

However, the authors of the International Union on the Conservation of Natural Resources (IUCN) report highlight the fact that indigenous peoples' vast experience in adapting to climate variability will not be sufficient – they also need better access to other information and tools.

Based on the current situation, indigenous communities are asserting themselves through summits such as the Asia Summit on Climate Change and Indigenous Peoples, Bali, 2009, and the Indigenous Peoples' Global Summit on Climate Change, held in Anchorage, Alaska, 2009, to highlight their vulnerability and the impact of climate research.

The Social Impact of Climate Change on Indigenous Communities in Asia

As a physiologically diverse and ecologically rich continent, Asia is more vulnerable to the impact of climate change than other regions. This problem is compounded for the indigenous communities who are the actual caretakers of the natural abode and resources. The UN Forum on Indigenous Issues points out in the Asian review that with a rise in temperatures by 2–8°C and further climatic variation, in Asia, there will be a decrease in rainfall, crop failures and forest fires, all of which will threaten the existence of tropical forests, a rich haven of biodiversity and their conservator-indigenous communities.

The findings of the report of the Asia Summit on Climate Change and Indigenous Peoples held in Bali highlighted that indigenous communities in the Asia region inhabit the most fragile ecosystems ranging from tropical rainforests, high mountain areas, low-lying coastal areas and floodplains, as well as temperate forests and that they are at the forefront of climate change impacts and threats. One such anticipation of the scientists in this context is that people in low-lying areas of Bangladesh could be displaced by a one-metre rise in sea levels. Such a rise could also threaten the coastal zones of Japan and China. The impact will mean that saltwater could intrude on inland rivers, threatening some freshwater supplies. In the high altitude regions of the Himalayas, glacial melts affect hundreds of millions of rural dwellers who depend on the seasonal flow of water. There might be more water in the short term, but less in the long term as glaciers and snow cover shrink.

In the coastal zones of Asia, the main impact is seen as sea-level rise and more frequent and severe storms. In countries such as Bangladesh and India, which are particularly vulnerable to tropical cyclones and storm surges, approximately 76% of the total loss of human lives has occurred due to cyclones. In terms of sea-level rise, the consequences will be quite serious in countries such as Bangladesh and Vietnam, where 15 million and 17 million people, respectively, could be exposed, given a relative change in sea level of 1 m.

Tropical forest ecosystems around the globe, particularly the ones in Asia which support the livelihoods of people from several regions of the world, belong to the most vulnerable ecosystems to climate change variability and long-term changes in temperature and rainfall (CIFOR 2007). In many cases, climate change may result in longer dry seasons and will make these regions more prone to major forest fires. Evidence of this can already be seen in the Indonesian region Borneo. This will require major adjustments in the lives of indigenous forest-dwelling peoples.

Despite such vulnerabilities of indigenous communities, climate change in Asia faces numerous barriers in being treated as a mainstream policy issue. With priority given to technological development in most of the developing countries, this issue gets sidelined. Dealing with the issue in a tiered manner, i.e. at the local, regional and the national level, could generate a better response to the impacts of climate change.

Lombok Island in Indonesia is a case in point for managing climate change at the regional level. This island is under a serious threat of climate change, but being a part of Nusa Tenggara Barat Province, it has already prepared a Provincial Action Plan for Mitigation and Adaptation to Climate Change. Hence, Lombok Island shows serious commitment to its provincial government in preparing its society to face the impacts of climate change.

Moving away from water, drought and storms as the major impacts of climate change, the International Union on Conservation of Natural Resources (IUCN) notes that changes to land cover and biodiversity caused by climate change could force indigenous communities to "alter their traditional ecosystem management systems" and, in the extreme, eventually lead to a loss of their traditional habitats (Maachi 2008).

Asia is a rich reservoir of indigenous knowledge (referred to as traditional local knowledge), which is unique to local communities and is acquired through local peoples' experience and observations of their surrounding natural systems (Srinivasan 2004). One example of the impact of climate change on indigenous knowledge is the changes in the agricultural cycle as a result of intensified changes in the climate.

Many indigenous communities in Asia rely on the observation of particular indicators, which make the community able to determine cropping patterns, i.e. when it is appropriate to plant, cultivate and harvest (see Box 3.1).

Many more such indigenous coping strategies are known to enhance adaptive capacity but very few of them have been integrated into national or local adaptation planning in Asia, perhaps due to insufficient recognition of their value and bias against local knowledge. Indeed, many local ways to cope with climate extremes, which were once considered primitive and misguided, are now seen as appropriate and sophisticated. However, adaptation is often a complex process that requires detailed site-specific considerations; any adaptation measure must effectively utilize or be built on indigenous coping strategies. For effective integration of local coping strategies into adaptation plans, a thorough assessment of the strengths and weaknesses of each strategy is necessary, as some are no longer adequate to cope with the impacts of climate change.

Realizing the importance of local knowledge and the involvement of indigenous communities in successful adaptation, there is a growing interest in international

Box 3.1 The Kiling Connection

In the Sagada region of the Philippines, the calendar is not counted in terms of days, weeks or months; rather, it is indicative of the particular agricultural activity of that period. Each month is divided according to specific indicators. These indicators are either activities in the field or the blooming of certain plants. For example, their year begins with Kiling, which is the name of a small bird whose chirping indicates that the typhoon season has ended. Based on the chirping activity of the Kiling bird, this period coincides with October in the Roman calendar, and this is the time for sowing rice grain on the seedbeds. Farmers in the Philippines take it as a cue for sowing rice but, unfortunately, this custom of relying on particular indicators to determine farming patterns is in disarray due to changes in climatic conditions.

institutions to support community-led initiatives on adaptation or proactive micro-adaptation. For example, in 2003, the UNFCCC initiated a database of local coping strategies for adaptation to disseminate information to a wider audience.

The Global Environmental Facility (GEF) is one such international effort. Through its small grants programme, it supports community-oriented adaptation projects in which local knowledge is duly considered. If other bilateral and multilateral donor agencies can also take initiatives to support, collect and integrate local knowledge in adaptation planning, the prospects for improved adaptive capacity will be enhanced. Long before the advent of complex numerical climate models, many indigenous communities have used changes in their environments to predict fluctuations in the weather and climate. Social and communal activities such as feasting, fishing and hunting patterns were planned in response to changes in weather and climate and revolved around the different seasons. While weather and climate patterns have been documented for many years using Western scientific techniques, little attention has been paid to documenting the traditional environmental observations made by indigenous peoples (Penehuro Lefale 2003).

Role of Indigenous Communities in Dealing with Climate Change

The Intergovernmental Panel on Climate Change has acknowledged that indigenous knowledge about climate change events in the past could be an “untapped resource” in developing additional adaptation strategies (Henessey and Fitzharris 2007). Most of the indigenous communities still practise their sustainable traditional livelihoods, such as swidden agriculture, hunting and gathering, pastoralism, extraction of non-timber forest products, small-scale mining and agroforestry. Such practices result in small ecological footprints. So why not use their knowledge in the areas under imminent threat of climate change due to deforestation, flood and desertification?

Climate change has affected their food security, their innovative practices of agricultural rituals and their traditional knowledge, but with the help of customary laws and practices on natural resource management, they have managed to conserve their forests and biodiversity. For example, in terms of mitigating and adapting to climate change, the Iklahan community of the Philippines have successfully fought for their rights over native lands through Certificate of Ancestral Domain Claims (CADC) and Certificate of Ancestral Domain Titles (CADT) (see Table 3.1). While with the Philippines Association For Intercultural Development (PAFID) they could protect their ancestral land and culture, with the Kalahan Educational Foundation (KEF) they could raise awareness about reforestation.

Traditional weather forecasting by the Tagbanuas, another community of the Philippines, had decreased due to the severity of climate change, and their subsistence activities were affected. Nevertheless, with their traditional knowledge, they have managed to find new adaptive strategies by practising swidden farming (adjustment in planting and clearing period), diversifying their fishing area, suspending seaweed farming for two years, being dependent on root crops (kurut/burut) and discovering a new water source.

Indigenous communities can also play an important role in strengthening social and economic ties between different groups of peoples in times of crisis. Groups affected by adverse climate conditions can acquire resources from other groups not experiencing the same problems (due to a reliance on different agricultural techniques, the use of different resources and ecosystems, or local variation in climatic conditions, for example). This sharing of resources is seen among the Penan Benalui foragers and Kenyah Badeng farmers in Borneo.

However, with impending climate change, some of these reciprocal systems may break down, as certain groups may become more permanently disadvantaged. The breakdown of such systems is evidenced in the archaeological record of Mimbres

Table 3.1 Community-based approach of the Ikalahan to adapt to and mitigate climate change

Year	Community struggle	Community action and results
1973	Land grabbing	Fought in courts and won the case; established KE & KA
	Land tenure and security	Pressured government for land lease and signed the MOA 1 and were granted CADC and CADT
	Mapping of the domain	Trained local people for survey and sought assistance from PAFID
1974 onwards	Forest fires and illegal logging	Established community rules and regulations Created firelines (*gaik*) and green breaks with maguey and *ipil-ipil*
	Land use and land management	Came up with land use plan (wildlife sanctuary, production forest and *dappat*)
	Reforestation	KEF staff, barangay officials and individual efforts Identification of endangered species
	Livelihood	Food processing; continuous planting of indigenous species

Source: Indigenous peoples' local mitigation and adaptation measures to climate change: case of the Ikalahans and Tagbanuas of the Philippines (presentation at Asia Summit on Climate Change)

Box 3.2 Collaborative Approach in Mitigating GHGs

Bushfires are a major source of GHG emissions. Mitigating these emissions is currently the main concern of climate change policy.

In the Northern Territory of Australia, bushfires account for around half of all greenhouse gas emissions. Involving the indigenous communities, the West Arnhem Fire Abatement Project (WALFA) has been started to reduce wildfires in the Arnhem Land Plateau by creating fire breaks and patchy mosaics of burnt country.

The strategies are reliant on both indigenous knowledge and western technology (Altman et al., 2007). Strategic burning is carried out in the early dry season when fires are lower in intensity and limit the damage to the upper canopy. This prevents the spread of more intense and highly polluting fires in the late dry season and reduces the total amount of land burnt and greenhouse gases emitted.

WALFA has an abatement target of 100,000 tonnes per year and in its first 2 years it has abated an estimated 256,000 tonnes of carbon. It also provides an opportunity for economic development for indigenous communities. It has provided employment for 30 indigenous Australians from the five Aboriginal communities involved in the partnership (Altman et al. 2007; ATSISJC 2007).

Valley in New Mexico. The Mimbres culture predominantly inhabited moist valley bottoms, which buffered them against droughts. In a period of above-average rainfall, satellite settlements were established in higher and drier areas, which probably receive support from the more humid main settlement areas in dry years. However, when conditions became permanently dry, there was not only the dissolution of upland settlements, but of the whole Mimbres culture. In this context, it becomes imperative to encourage the social networking of indigenous communities and save the rich reservoir of their traditional knowledge from extinction.

Yet another important role played by the indigenous communities has been their resistance to the extraction of oil, gas and minerals from their lands, which act as carbon sinks. They have contributed significantly to the mitigation of GHGs by resisting the deforestation and destruction of their forests and by managing forest fires (see Box 3.2). Unfortunately, indigenous communities' positive contributions to the abatement of greenhouse gas emissions are not generally recognized nor compensated by the UNFCCC and other multilateral and bilateral bodies.

Potential Response of Indigenous Communities

Climatic variation in current times is more extreme than in the past and indigenous people are finding it difficult to adjust to it, although there is archaeological evidence of their successful adaptations in the past. Unnoticed, unheard for most of the time in the national agenda of most of the developing countries, they continue to adapt with signs of resilience in different pockets of the world.

Adaptive Strategies in the Past

Indigenous communities have played the role of observers and adaptors since the evolution of the species. Much of this evidence is based on archaeological analyses in the absence of a complete and obvious timeline. From archaeology we know that food shortage is common and central to survival during disasters and climate change. The invention of agriculture was almost certainly a major adaptation to climate change.

However, much of what people have developed in response to disasters like climate change has also been lost. For example, in the case of domesticated crops, their wild relatives have been lost. At present, the existence of many such species is being threatented or they are on the verge of extinction. Such archaeological evidence could prove a positive step to building resilience in fighting climate change by reconstructing these processes as prehistoric farming techniques and environmental management.

Among plant use, it is being observed that what were prehistorically common seasonal foods have now become famine foods. Although usually justified by observed use in famine, this term is rarely explicitly defined. Based on the common practice to cite use of famine foods as an indicator of famine (Corbett 1988), experts on this issue deduce an underlying premise that these resources, which are generally harder to acquire or are lower in calories or quality, are resorted to only in times of crop failure (Huss-Ashmore and Johnston 1994) and such food is termed famine food. Most traditional vegetables – wild and managed – used during food shortages were first cited as a vibrant part of the staple diet, indicating a dynamic strategy of nutritional resilience. Because of their dietary prominence during times of food shortage, traditional vegetables, especially in Africa, are often referred to as famine food.

There is a danger now that knowledge of famine food and its management will be lost forever with the current trend in climate change. A research study of this trend could come up with interesting outcomes of the impact of climate change on food security.

Indigenous communities have used biodiversity over space and time as a buffer against climate change and natural calamities. In prehistoric times, biodiversity of the earth was devastated during periods of drastic climate change. Even during current global warming and its impact on biodiversity, indigenous people are instrumental in maintaining the balance on the basis of their carbon neutral living. The major climatic changes affecting biodiversity are temperature fluctuations at different times and precipitation unpredictability. The protection of biodiverse habitats such as forests and mangroves can provide multiple benefits for adaptation, mitigation and biodiversity conservation – by storing carbon, protecting coastlines, limiting erosion and regulating water flow, which reduce the risks of flooding.

Proxy analysis, a tool for data analysis, is not based on primary factors, such as people and/or climate change; rather it is indicative of other factors. Pollen analyses, for example, indicate climate change and human activities, i.e. what diversity of crops were used by people in a particular climatic period and under what environmental conditions. These are powerful lessons to contemplate as we can consider what indigenous people can teach us about climate change.

Adaptive Strategies in the Present

Indigenous people in times of climatic variation are known to have used phenological markers to predict the favourable and unfavourable times for biodiversity maintenance. These markers can be the appearance of certain birds, the mating of certain animals, or the flowering of certain plants (see Box 3.3). With climate change, many of these phenological events are occurring earlier or may not be as useful indicators of changing weather patterns as they used to be.

Changes may also take place in agricultural techniques, such as irrigation replacing rain-fed agriculture or changes in location during acute climatic crises. Indigenous people shift to settlements which are less susceptible to adverse climatic conditions. Changing lifestyle and food habits is also practised as an adaptive strategy by some, such as the Kenyah communities in Borneo, who plant new crops such as maize in the drying river beds during droughts cause by El Niño events, or switch to extracting starch from wild sago palms during El Niño droughts and floods.

There is numerous documentation of Asian countries which are most vulnerable to the impacts of climate change. They are employing traditional and innovative adaptation practices, which include improved agricultural techniques and building technologies, prevention of soil erosion, rainwater harvesting, crop and livelihood diversification, shoreline management, use of new materials, seasonal climate forecasting, community-based disaster risk reduction, and so on (see Table 3.2).

Indigenous communities are also sharing their resources as is evident from their presentation made at their summit in Alaska. A new farming method developed by the Quezungal people in Honduras, who plant their crops under trees so that the roots anchor the soil and reduce crop damage during natural disasters, was presented as a new adaptation effort.

Box 3.3 Indigenous Communities' Phenological Markers in Predicting Climate Change

Dayaks of Borneo observed bird species that they had never seen before and they became aware that the level of water in the rivers was higher/lower than usual for the season and that the traditional plants used as medicinal remedies could not be found any more. However, with extreme climatic variations, the behaviour and migration patterns of birds, which were traditionally used to guide these natural phenomena, no longer provide reliable guidance. Nor do

(continued)

these climatic disturbances provide accurate guidance to their hunting and cultivation activities.

The Punan communities in East Kalimantan, Indonesia base their observations on the phases of the moon to decide upon activities such as planting agricultural and tree crops, clearing cultivation areas, hunting, etc. But with the changes in climate, these lunar signals may no longer coincide with the favourable times for these activities and the Punan may be misled in taking their decisions (Boedhihartono 2004).

Table 3.2 Innovative responses of the indigenous communities from Asia

Countries	Vulnerability and impact	Adaptive strategies
Vietnam	This country is impacted by typhoons, unpredictable weather, and the threat of saltwater intrusion from sea-level rise	Planting dense mangroves along the coast to diffuse tropical-storm waves
Bangladesh	Coastal peoples of Bangladesh dependent on livelihoods from fisheries and mangroves are expected to be one of the most heavily impacted by sea-level rise caused by climate change	The communities are creating floating vegetable gardens to protect their livelihoods from flooding Catkins are grown in sandy soil in Manikganj to prevent erosion and raised platforms – manchans – are constructed inside the houses as coping strategies against flood
Philippines	The indigenous communities of Ifugao in the Luzon province of Philippines have been fighting hard to preserve their rice – their staple and stable source of food – from the impacts of climate change	Based on the indigenous knowledge and skills of the Ifugaos, such as employing wooden spades, digging sticks and bare hands, rice terraces have been planned. Water management made their terrace construction work easier. Rice produced from the terraces was augmented by sweet potatoes and other vegetables In Matalom province, Kahun, a soil developing technique is practised for checking soil erosion caused by heavy rainfall
Nepal	Landslides and floods make the topsoil vulnerable to the impacts of climate change	In its mountainous regions, ploughing sloping land in a sword-like fashion to prevent soil erosion
Indonesia	Indonesia has the highest loss of forest area due to regular processes of deforestation and overgrazing. This creates an additional need for new land to compensate for loss of soil fertility, fires and drought caused by climate change	Indigenous people of Borneo in Indonesia will need to readapt their way of life to all these changes in their environment, and possibly also to the impacts of carbon sequestration projects

The Impact of Climate Change on Indigenous Communities in India

The United Nations Development Programme (UNDP) has warned that "Changes in average temperatures, rainfall patterns and monsoon timings will affect India's entire environment, especially the nation's water resources, sea-levels and biodiversity, impacting a wide range of sectors, particularly agriculture". It is the poorest of the poor who will be severely affected. According to economist Nicholas Stern, "…in India people understand the rising water stress, and how vulnerable they are to melting glaciers and snows from the Himalayas, but this thinking has to go beyond to assess the other impacts as well, i.e. loss of traditional knowledge and the forced relocation of the indigenous communities".

Tackling Water Stress with Traditional Practices in India

Climate change will impact India first and foremost through its water resources, as the Indian monsoon, the country's lifeline, will be significantly affected by climate change, says a report released by the NGO Greenpeace.

There have been experiments to adapt crops in Andhra Pradesh, India, to grow under minimum water availability, as in traditional practices. Despite the adequate availability of soil moisture in command areas at an earlier time, crops are usually not grown in irrigation tank areas before the tanks are half full of water. Experimentation with early deep seedling and weeding in June demonstrated that under specific conditions, a crop can be grown with considerably less water. This is important during dry years when tanks and reservoirs are deficient in water. Experiments carried out during drought conditions showed that although yields per hectare decreased, the total yield in the command areas would increase by as much as 50% (Bergkamp et al. 2002). Crops are being adapted to the changing hydrological cycles.

The Zabo and Cheo-ozihi system in Nagaland is another indigenous technique for managing runoff water. The *zabo* (the word means "impounding runoff") system is practised in Nagaland in northeastern India. Also known as the *ruza* system, it combines water conservation with forestry and agriculture.

Villages such as Kikruma, where zabos are found even today, are located on a high ridge. Although drinking water is a major problem, the area receives high rainfall. The rain falls on a patch of protected forest on the hilltop; as the water runs off along the slope, it passes through various terraces. The water is collected in pond-like structures in the middle terraces; below are cattle yards, and towards the foot of the hill are paddy fields, where the run-off is ultimately collected.

The river Mezii flows along the Angami village of Kwigema in Nagaland. The riverwater is brought down by a long channel. Bamboo pipes are used to divert the water through secondary branches of the main channel. One of the channels is named *Cheo-oziihi*. *Oziihi* means water and *Cheo* was the person responsible for the laying of this 8–10 km long channel with its numerous branches. This channel irrigates a large number of terraces in Kwigwema, and some terraces in the neighbouring village. There are three *khels* and the village water budget is divided among them.

Carbon Offsetting Techniques

Community-based forestry projects initiated by the World Bank in Andhra Pradesh and Orissa in India propose to mobilize and encourage small and marginal farmers to raise plantations of tree species with high rates of carbon sequestration in their farmlands. Besides capacity-building measures, this project will:

- Provide short-term financing to farmers from an upfront payment by the global BioCarbon Fund. Such mobilization of funds from the international bodies, such as the SBI wing of the UNFCCC, would be a welcome move towards GHG reductions.
- Involve local communities in the protection of plantations and generate additional income from carbon credits to farmers. Such a step promotes the participatory approach of the local people and should be considered while implementing REDD in developing countries.
- Develop forest sector strategies with a livelihood and conservation focus. The conservation of forests maintains them as the natural sinks of carbon and retains the rights of the natural custodians – the indigenous communities.

The Madhya Pradesh Lok Vaniki Initiative is another example of involving stakeholders in forest conservation. The M. P. Lok Vaniki Act 2001 (M. P. Act No. 10 of 2001) provides an opportunity for willing landholders to manage their own forests. The law encourages owners of private forests and other tree-clad areas to manage their natural resources on scientific lines, in order to maximize both economic and environmental returns. Chartered foresters help prepare management plans and silvicultural operation in these forests by training the landholders.

Community-managed forests exist in the Himalayan region, as well, which become an important carbon pool, as previously deforested areas in these forests are showing signs of regeneration. The mean carbon sequestration rate for community forests in India and Nepal is close to 2.79 t C ha^{-1} per year, or 10.23 t CO_2 ha^{-1} per year, under normal management conditions and after local people have extracted forest products to meet their sustenance needs.

Besides this, a study of "climate change vis-à-vis tribals" has been planned by the Indian government to find out the traditional mechanisms and methodologies applied by the tribals to cope with climate change and consolidate existing knowledge of tribals to adapt to climate change. This study will seek to identify bio-indicators which could help tribals recognize and anticipate climate change and prepare them to cope better with the rapidly changing climate.

The historical role of indigenous and local communities in protecting biodiversity and ecological landscapes and processes through sustainable livelihood and sustenance activities and traditional knowledge systems has also been acknowledged by the civil societies of India in their environmental manifesto.

The ongoing efforts have a long way to go, however, as India will need to better manage these resources and reduce the burden that environmental degradation is imposing on the population, particularly on the most vulnerable groups – the indigenous communities. Right from compiling the data and information on these groups, efforts have to be made to integrate their needs in the mainstream development. India has initiated several coordinated climate research programmes to assess and understand the implications of climate change despite the fact that there are no binding commitments to reduce greenhouse gases. But it is more important to study the situation of the vulnerable groups – indigenous communities – and work on their adaptive strategies. There is an imminent need to strengthen the legal provisions (similar to the customary laws and land tenure rights for the indigenous communities facing the impact of climate change in the Philippines), work towards the development of appropriate responses, and implement the global mitigation measures only after monitoring their impact on the vulnerable indigenous communities.

Why There Is a Need To Have an Inclusive Approach in Climate Change Policy

The inclusion of indigenous peoples' voices in issues affecting them is important and relevant, as their right to participate in decision-making is confirmed in Agenda 21 of the Declaration on the Rights of Indigenous Peoples. Article 18 of the Declaration on the Rights of Indigenous Peoples states that "Indigenous peoples have the right to participate in decision-making in matters which would affect their rights, through representatives chosen by themselves in accordance with their own procedures, as well as to maintain and develop their own indigenous decision-making institutions". It is therefore time for them to get fully involved in all the ongoing debating issues on climate change.

The Economic Social Council report points out that indigenous peoples were not consulted in the creation of the United Nations Framework Convention on Climate Change or the negotiations on the Kyoto Protocol. In spite of this, the indigenous peoples of the Arctic carried out their own consultations with their hunters and with Western scientists, which shows their growing awareness about the impact of climate change on their lives.

One of the biggest challenges of climate change is how best to combine traditional and scientific knowledge for incorporation into decision-making processes. That most of their knowledge is not documented and peer-reviewed has been recognized in the Indigenous Peoples' Global Summit on Climate Change, held in Anchorage, Alaska in 2009. With their willingness to start to document and express their findings in a way that is easier for scientists to use, these traditional offerings of indigenous communities can be taken up as serious research. It is being realized that “If mainstream scientists want to incorporate local knowledge and local impacts as they said they did, they have to move away from a strictly guided and formulated approach to what information is valid and what isn’t . . . they have to meet some of these [indigenous] stakeholders halfway”.

To further justify an inclusive approach in policy making, it can be argued that indigenous peoples interpret climate change in a far more subtle way than believed at present. Innovations will be crucial to adaptation and biodiversity conservation in the wake of climate change. Many communities are already practising innovative techniques using agricultural biodiversity and traditional practices, such as seed exchange and field experimentation, to adapt to climate change. Traditional knowledge is an inseparable part of indigenous culture, and their livelihoods and their local environment. With unprecedented climate changes, livelihood strategies come under increased stress as knowledge based on known indicators reveals the limitations of local coping strategies in the face of broader global processes.

In fact, local interpretations of climate change help people to make better sense of observed climate changes, but do not necessarily empower them to act. Local peoples’ experiences and interpretations, as well as scientific research, indicate that climate change seldom acts in isolation, but interacts with other environmental and social factors. Interactions tremendously affect peoples’ perceptions and adaptations to climate change.

Although scientific explanations for climatic changes have mainly concentrated on anthropogenic greenhouse gas emissions, the traditional farming practice of indigenous communities in fact brings about mitigation benefits. Their carbon-neutral techniques produce far fewer greenhouse gas emissions than modern intensive approaches that rely on mechanization, and inputs such as fertilizers and pesticides derived from fossil fuels.

Seldom do the media report on climate changes that impact the timing and outcome of agricultural activities, such as hunting, fishing and resource gathering. Scientific causal explanations of climate changes may be seen as removed and abstract for the local people. As a consequence, people may feel powerless and/or not responsible for combating climate change, despite their own vivid experiences of climate change impacts. This was seen to be the case with farmers in western Austria, who had many detailed observations of climate change, ranging from increased wind-felled trees, increased drought, and decreased snow cover, but whose information on climate change causes were largely based on the media and who did not see themselves as connected to the causes or their solutions. In contrast, where media play a limited role, interpretations are more closely dependent on people’s own observations and local interpretations.

It needs to be determined whether development policies, while making full use of modern science, are also truly sustainable. This is in consonance with the Asia’s Indigenous Peoples Summit on Climate Change in Bali, Indonesia, where one of the major recommendations was that “Scientific reports should include human and social factors". In the context of indigenous communities, a presentation report on Malaysia highlighted the link between traditional knowledge and climate resilience, stating the fact that "Vulnerability is increased by loss of traditional knowledge and the space in which traditional knowledge lives". Citing the example of Padi knowledge, which deals with a particular strain of rice and its cultivation in Malaysia, recommendations were made for restoring and documenting the traditional knowledge of indigenous communities so as to form an intersection between this knowledge and the modern-day knowledge base.

The report of the International Council for Science (ICSU) working group details some of the many ways in which traditional knowledge and modern science can, and frequently do, work closely together. It points out that traditional knowledge has often played a role in the development of modern science, citing, for example, Linneaus's use of folk taxonomies in his development of biological classification systems. It also describes how, more recently, scientists have begun to work closely with indigenous communities to promote a synergistic effect in sustainable agriculture and ecological practice. Such work is likely to increase in importance during this century, because of the recognition that many environmental problems are local in nature and the fact that there is a growing need for the cooperation of traditional peoples in addressing global issues. This is supported by the findings of an IUCN report that in the Arctic, scientists and indigenous people work together and this opens doors to knowledge not accessible through western scientific methods.

Adaptation and Mitigation

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report published in early 2007 confirmed that global climate change is already happening. Since then, there has been a debate on adaptation versus mitigation in combating climate change.

The UNFCCC refers to adaptation in Article 2 and Article 4 (4.1(b,e,f), 4.8 and 4.9) and explicitly mentions the traditional coping strategies as one of the appropriate adaptive strategies.

> "There are many options and opportunities for countries to adapt, with adjustments and changes required at every level: community, national and international. Appropriate adaptation strategies involve a synergy of the correct assessment of current vulnerabilities to climate change impacts; use of appropriate technologies; and information on traditional coping practices, diversified livelihoods and current government and local interventions. Adaptation to climate change is a necessary strategy to complement climate change mitigation effects. Adaptation often produces benefits as well as forming a basis for coping with future climate change. However, experience demonstrates that there are constraints to achieving the full measure of potential adaptation".

Long-term adaptation to climate change requires anticipatory actions, which would require considerable investment of capital, labour, and time, which are the major challenges in the Asian region.

The IPCC's First Assessment Report warned that the greatest effect of climate change on society could be human migration, i.e. involuntary forms of displacement and relocation (OSCE 2005). This seems to point to population mobility as a less desirable form of adapting to climate change – a last-resort coping strategy when other adaptation possibilities are unavailable or have failed. In such situations, working towards the in situ adaptation would be a risk-proof and low-cost measure for the indigenous communities in the developing world.

Adaptation is the process whereby ecological, social or economic systems adjust in response to actual or expected climatic stimuli and their effects or impacts while mitigation is the process whereby GHGs emissions are reduced and the sinks of GHGs are enhanced. Strategies for mitigation and adaptation must take into account not only the ecological dimensions of climate change, but also the dimensions of human rights, equity, and environmental justice.

In this debate of adaptation versus mitigation, a "one size fits all" approach would not be a workable solution. Rather, making both the processes situation and nation-specific would better take care of the impact of climate change. For example in India, over a quarter of India's poorest people, many of whom are indigenous people, depend on forests for part of their livelihoods. However, almost half the country's forests have been degraded, and their average productivity is a third of their potential. A new World Bank report, "Unlocking Opportunities for Forest-Dependent People in India" by Grant Milne, suggests that if national and state-level reforms are introduced and forest productivity improved, the condition of indigenous communities can improve. Globally, many governments are increasing the rights of forest communities to use and manage forest resources. However, without adequate monitoring of the impact of REDD, its implementation might pose a constraint to the in situ adaptation of indigenous communities due to issues of tenure rights, access to resources and benefit sharing.

Indigenous practices, such as rotational farming, pastoralism, hunting and gathering, often use environmentally friendly, renewable and/or recyclable resources which contribute significantly to the mitigation of GHGs. There is ample evidence for the same. The Igorot of the Philippines, the Karen of China, Myanmar and Thailand, and the Achiks of India continue to practise traditional, rotational agriculture. This practice increases the overall health of forest and jungle ecosystems, which are critical to the mitigation of global warming. However, R. K. Pachauri, head of the IPCC has warned that very soon climate change impacts will exceed the adaptive capacities of local communities and that we need to have a strategy by which the adaptation has to be local, while mitigation has to be global.

The Stern Review, a report on the economics of adaptation has analysed possible measures to combat climate change and concluded that extensive adaptation strategies are of the highest priority and that the costs of preventing climate change are significantly lower than the projected costs of damage from climate change. However, the cost issue of adaptation has been challenged on various accounts. It is argued that for successful implementation of adaptive strategies, generation of funds is a major concern. To quote an example, it is estimated that the cost of relocating just one of the many Alaskan native villages threatened by flooding and erosion worsened by climate change is as much as $400 million. Adaptation based on the traditional knowledge of communities at risk would be a better alternative in order to reduce their vulnerability to climate change. More specifically, the in situ adaptation, which entails strengthening the existing conditions for the indigenous communities in their habitat, would make them resilient to climate change impact.

A paper published early in 2009 by the International Institute for Environment and Development (IIED) warns that to be effective, policies must have greater input from local communities who are particularly vulnerable to climate change and have valuable local knowledge. Pro-poor, biodiversity-friendly ways to adapt to and mitigate climate change are clearly the way forward. "But for them to work, local communities must be involved in decisions about how biodiversity is used. Good governance and fair access to land and resources must be at the heart of these efforts but biodiversity is also key to adaptation to climate change, particularly as it enhances the resilience of farming systems and other ecosystems". For centuries, traditional farmers have used the diversity within both domesticated and wild species to adapt to changing conditions.

Carbon trading and carbon sequestration plantations are likely to create demand for land in the humid tropics of Asian countries. Employing multi-stakeholder processes in the implementation of policies such as REDD brings up challenges for the indigenous people, as well as allowing for the exploration of their potential in adaptation and mitigation measures.

Indigenous communities who are less integrated into the market economy and whose land rights are less clear or less easily defended in courts will rarely benefit from the payments flowing out from the forest management projects. In addition, avoided deforestation payments will probably flow to central or regional governments and not to forest-dwelling peoples. These payments may be linked to restrictions on forest use that deny development options to indigenous peoples. In this situation, it is anticipated that mitigation measures might run contrary to the adaptative measures or vice versa.

Recently, the UNDP estimated that the additional costs of adaptation in developing countries would be as high as $86 billion per year by 2015 (UNDP 2008). Likewise, the World Bank estimated that $10–40 billion per year would be necessary to adequately address adaptation needs, while the funds under the current climate regime are less than $200 million. Given the wide gap between requirements and supply, existing publicly available funds have to be utilized to finance adaptation projects. In addition to public funds, the role of the private sector (e.g. insurance) will be increasingly important. But there is divided opinion even on the funding mechanisms for addressing adaptation in developing countries. In addition, the mitigation and adaptation efforts to address the disproportionate impact on tribes are going to require considerable funding to put into effect. The cost of relocating just one of the many Alaska native villages threatened by flooding and erosion exacerbated by climate change is estimated to be as much as $400 million. Therefore, the effects of climate change on tribes will also have major legal and practical ramifications, of which policy makers must be aware.

Policy Issues and Gaps

Ever since the Intergovernmental Panel on Climate Change said that action must begin immediately to avoid irreversible damage, climate change has risen to the top of the global policy agenda. To stabilize the situation, the Panel has asked for drastic reductions in GHG emissions within the next 10–15 years. Article 3.1 of the United Nations Framework Convention on Climate Change, adopted in Rio in 1992, states "The Parties should protect the climate system for the benefit of present and future generations of humankind on the basis of equity and in accordance with their common but differentiated responsibilities and respective capacities. Accordingly, the Parties of developed countries should take the lead in combating climate change and the adverse effects thereof". However, there is a lack of accountability in the practising climate system and reducing emissions on the basis of equity as envisaged in Article 3.1 of the UNFCCC.

The reluctance of the developed countries to comply with the "polluter pays" principle from Kyoto to Bali to Poznan has so far created a status quo in climate change policy. This is a major concern for developing countries and especially their most vulnerable group – indigenous communities who have the smallest ecological footprints, and still carry the heavier burden of adjusting to climate change.

The adaptation versus mitigation debate has been another issue ever since the confirmation of global climate change by the Intergovernmental Report in 2007. There are still heated debates on the costs of adaptation, which will be very unevenly distributed around the world, with poor nations predicted to bear the brunt of climate change-related damages and costs. Indigenous communities and their plight are seldom mentioned in these discussions and climate change has yet to move up in the priority list of most of the developing countries. In Asia, it is considered purely an environmental rather than a developmental issue. Besides this, the importance of technology in Asia often outweighs the other factors, such as social and economic ones, and this approach often overlooks the needs of indigenous communities who are not to gain directly much with the CDM and low energy drive for mitigating the impact of GHGs emissions.

While these are issues at the policy formulation level, there are other major gaps at the policy implementation level as well. Policy at the national level often fails to attend to the particular local situation and the national goals do not reflect the reality of the local needs. This comes in the way of effective implementation of policy. Lack of information and adequate data on indigenous communities may pose a great challenge in monitoring the impact of REDD in forest areas. At the same time, implementing the Clean Development Mechanisms for reducing GHGs raises issues such as who will pay for technology development and technology transfer.

As outlined by the UNFCCC governments are supposed to:

- Gather and share information on greenhouse gas emissions, national policies and best practices

- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries
- Cooperate in preparing for adaptation to the impacts of climate change

However, there is a wide gap between what is on paper and what is practised in reality. The north and south divide over the emission reduction percentage blocks the way forward to adapting strategies especially required for developing countries, which are poor in resources. This goes against the spirit of cooperation and financial support as mentioned in the UNFCCC.

Recommendations and the Way Forward to Copenhagen

Based on all the case studies of indigenous communities in this paper, the following recommendations are suggested as a way forward to Copenhagen in December 2009. Overall, recommendations are general in nature with pick-and-choose mechanisms for the different developing nations. A good policy needs to be in tune with the reality at the local level. National policies are sometimes challenged by the conflict of interests in whole and in part, where "whole" represents the national success and "part" represents a particular sector or local entity. This clash of interests can be taken care of by upscaling good practice and downscaling good policy intentions for effective sustainable policy implementation. For example, the carbon-neutral techniques of the indigenous communities can be upscaled as a GHG-mitigating measure, while at the same time formulating pro communities REDD policy can be taken up as a top-down approach.

There is a need to shift the focus to the most vulnerable group – indigenous peoples – who are actually the primary actors within global climate change monitoring, adaptation, and innovation. Indigenous peoples must have a voice in policy formation and action in the same way they do in other relevant UN processes, such as the UN Permanent Forum on Indigenous Issues, the Convention on Biological Diversity, the World Intellectual Property Organization, the Human Rights Council and, to some extent, the United Nations Framework Convention on Climate Change, among others.

Technology-traditional knowledge platforms need to be created to facilitate the knowledge process in both ways. For instance, remote sensing data from NASA, for better understanding of land vegetation, can be combined with the traditional knowledge of indigenous communities through the use of a geographical information system (GIS).

All these discussions can be broadly covered under the following three headings:

1. Empowerment of indigenous communities
   - Promote land tenure and access rights to natural resources of indigenous communities

- Facilitate access to scientific information and technology for in situ adaptation
- Conservation of biodiversity in order to increase resilience and adaptive capacity of indigenous communities
- Sharing of expertise and resources between different groups of indigenous communities and capacity building and empowerment of indigenous peoples to deal with climate change
- Active involvement of indigenous communities in decision-making

2. Designing an inclusive policy approach

- To meet the challenge of "uncertainty" linked with climate change, inputs from all sectors under the impact of climate change
- Participatory agenda and responses to climate change at regional, national and local levels in terms of mitigation and adaptation
- Recognize indigenous and traditional peoples' own coping strategies to adapt and incorporate their perceptions into the climate change policy
- Encourage countries to adopt National Adaptation Programmes of Action (NAPAs) and ensure the integration of indigenous and traditional knowledge
- Include NGOs and civil societies in climate change projects

3. Monitoring the strategies

- Explore carbon offset strategies that indigenous peoples practise and for which they should be rewarded through payments and other means
- Maintain or enhance livelihood diversification for indigenous communities
- Address specific risk management strategies in areas where traditional and indigenous peoples live and where projected hazards will have the most serious impacts
- Create awareness of traditional adaptation and mitigation strategies such as sustainable carbon neutral and carbon negative livelihoods and expand knowledge of these practices
- Develop a virtual climate change centre and knowledge bank on traditional knowledge

Areas for Further Research

- Identify indigenous peoples living in the most vulnerable areas to climate change.
- Design situation-specific projects and community-oriented projects.
- Monitor the implications of mitigation efforts under international mechanisms, such as the REDD and CDM on ecosystems on which indigenous and traditional peoples' livelihoods depend.
- Collect and analyse information on past and current practical adaptation actions.

- Joint network of climate change researchers, ethnoecologists, and indigenous peoples.
- How to incorporate their knowledge in the development process of adaptation and mitigation strategies to climate change?
- Analyse the economic and social costs and benefits of adaptation measures.
- Explore options for funding for adaptation funds.
- Monitor the traditional and non-traditional adaptation measures and assess their impact.

Conclusion

From the documentation of a wide range of case studies it is evident that over the past, the indigenous communities around the world have adapted their livelihoods to a wide variety of climatic variations. They have immense potential to alleviate the adverse impacts. There is an urgent need to integrate their knowledge into mainstream policy. However, the climate experts feel that these adaptive strategies will be insufficient to cope with the future hazard level. In fact, the situation in Asia specifically is complicated by numerous interrelated social economic and political factors. Hence, it is essential to explore appropriate situations and nation-specific ways to enhance the resilience of indigenous communities and to reduce factors such as cost which come in the way of adapting strategies. In the Copenhagen negotiations in December 2009, summit participants are planning to formulate a declaration calling for world governments to include indigenous peoples as well.

References

Altman J, Whitehead P (2003) Caring for country and sustainable indigenous development: Opportunities, constraints and innovation. CAEPR Working Paper No. 20/2003, CAEPR, Canberra

Banskota K, Karky B, Skutsch M (2007) Reducing carbon emissions through community-managed forests in the Himalaya. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu

Bullock H, Mountford J, Stanley R (2001) Better Policy-making. Centre for Management and Policy Studies, London

Degawan M (2008) Mitigating the impacts of climate change, Solutions or additional threats? Indigenous Affairs. http://www.iwgia.org/graphics/Synkron-Library/Documents/publications/Downloadpublications/IndigenousAffairs/IA%201-2_08%20articles/IA%201-2_08%20Asia%20-%20Mitigating....pdf. Accessed 28 July 2010

Garcia-Alix L (2008) The United Nations permanent forum on indigenous issues discusses climate change. Indigenous Affairs 1–2:16–23

Henderson R (2008) Tax regime can prompt behaviour change. Special report on climate change, The Weekend Australian, 29–30 March, p 3

Henessey K, Fitzharris B (2007) Climate change impacts, adaptation and vulnerability

http://arcticportal.org/en/icr/ealat
http://www.savanna.org.au/all/walfa.html
http://www.downtoearth.org.in/
http://www.theGEF.org
http://www.ipcc.ch/SPM13apr07.pdf
http://www.ipcc.ch/SPM040507.pdf
http://www.ipcc.ch/WG1_SPM_17Apr07.pdf
http://www.lswn.it/en/conferences/2008/indigenous_peoples_hardest_hit_by_climate_change_describe_impacts
http://www.lswn.it/en/press_releases/2008/climate_fight_must_enlist_biodiversity_and_communities
http://www.rainwaterharvesting.org/Rural/Traditional3.htm
http://www.sciencedaily.com
http://www.tkbulletin.wordpress.com
http://www.thaindian.com/newsportal/south-asia/very-soon-we-wont-be-able-to-adapt-to-climate change-pachauri_100129500.html
http://www.un.org/esa/socdev/unpfii/documents/E_C19_2008_CRP_9.doc
http://www.wesnetindia.org
Huberman D, REDD and Poverty Environment Partnership (2008) The social implications of reducing emissions from deforestation in developing countries. Draft background paper by IUCN on behalf of the Poverty Environment Partnership (PEP). IUCN, Gland, Switzerland
Intergovernmental Panel on Climate Change, Working Group I (2007) 4th Assessment Report: the physical science basis – summary for policy makers. www.ipcc.org
Lynge A, Tauli-Corpuz V (2008) Impact of climate change mitigation measures on indigenous peoples and on their territories and lands. UN Economic and Social Council, New York
Maachi M (2008) Indigenous and traditional peoples and climate change issues paper Shadananan Nair, 2009: climate change: societal impacts and current policies and adaptation strategies in India. IOP, Delhi
Muller J, Almedom AM (2008) What is 'famine food'? Distinguishing between traditional vegetables and special foods for times of hunger/scarcity (Boumba, Niger). J Hum Ecol 36(4): 599–607
Nalliw-Licnachan E (2009) Indigenous peoples of Ifugao: Responding to climate change, national commission on indigenous peoples & NGO: Save the Ifugao terraces movement, Lagawe, The Philippines. IOP, Manila
Nilsson C (2008) Climate change from indigenous perspectives: key issues and challenges, IWGIA climate change policies in the Asia-Pacific: Re-uniting climate change and sustainable development. IGES, Hamaya, Japan
Oxfam Briefing Paper (May 2007) Adapting to climate change. Oxfam, London
Peskett L, Harkin Z (2007) Risk and responsibility in reduced emissions from deforestation and degradation. ODI Forestry Briefing 15, ODI, London.
Rubis J, Bakir D (2009) Interactions between global climate change and traditional lifestyle initiatives of the indigenous peoples of Malaysia: A Bidayuh-Jagoi case study. United Nations University, Institute of Advanced Studies Traditional Knowledge, Darwin, Australia
Secretariat of the United Nations Permanent Forum on Indigenous Issues (UNPFIS) (2007) Climate change: an overview. UNPFIS, New York
UNDP, UNEP, WB, WRI Publications (2008) Roots of resilience: growing the wealth of the poor. WRI, Washington DC

Chapter 4
Mitigating Climate Change Via Clean Energy Financing: An Assessment of the Asian Development Bank's Mitigation Efforts in Southeast Asia

Laurence L. Delina

Abstract As Southeast Asia has registered an impressive economic growth in recent years, considerable stress to the environment in the form of an increasing level of emissions has also been paramount. Development failed to trickle down and energy poverty remains a significant issue in Asia. While it is important to amend the current emission trajectory and, at the same time, address issues about energy access, a colossal need to mobilize funding is necessary – a gap which multilateral development banks are expected to fill. This article explores and assesses the important role the Asian Development Bank (ADB) has in addressing these issues. Drawing on the assessment of ADB Country Strategies and the energy sector portfolio in Thailand, Indonesia, the Philippines and Vietnam, the enquiry reveals, among other things, that only 42% of ADB energy financed projects contain renewable components, and that data on how ADB projects addressed on the issue of energy poverty remains unavailable. On top of the quantitative data presented, this article also presents a critical engagement of ADB's policy environmental assumptions.

Keywords Asian Development Bank · Clean energy investments · Climate change mitigation · Renewable energy · Southeast Asia

Introduction

Energy security and sustainable development have both moved up the global agenda because of concerns regarding climate change, particularly over increasing emissions from conventional energy sources and economic reasons brought about

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by volatile energy prices. Both issues are important, critical even, especially for a growing region such as Southeast Asia. A viable strategy significantly focused on adequate and clean energy infrastructure is thus needed to meet the dual requirement of sustainable growth and energy security. Inadequate amount of investment, however, is hampering not only the current energy production and distribution situation but also efforts to make it clean as possible. Traditional sources of funding therefore need to be shored up by innovative financing solutions.

Multilateral Development Banks (MDBs) are considered to be at the forefront in channelling finance to the development of a low carbon economy. MDBs possess a significant role in facilitating and fostering sustainable development strategies aimed at poverty elimination in the countries they are serving. With issues on environmental sustainability and access to clean energy, development banks can advance this particular agenda by being catalysts to this much needed financial infrastructure in order to reshape the current emission trajectories of their member/client countries and address issues of energy poverty side by side.

A better understanding of these significant roles seen through the lens of Asian Development Bank's (ADB) clean energy policy is this paper's overall objective. This paper looks at the engagement of ADB in four Southeast Asian countries, namely Thailand, Indonesia, the Philippines, and Vietnam. We review the economic situation of these study countries, show the parallel increase in carbon emissions in "Economic, Energy and Emission Trends in the Study Countries", and suggest that these current growth trajectories need serious amendments. We conclude from this section that the case countries are facing a twofold challenge, that is, to meet their necessary energy requirements to sustain their economic growth and to address the development issues especially relating to energy access for the poor. The section "Nexus Between Climate Change Mitigation, the Clean Energy Paradigm, and Energy for the Poor" further discusses the relationship between these challenges by understanding the confluence among climate change mitigation, the clean energy paradigm and energy poverty issues. A discussion in "Financing Issues and the Funding Role of MDBs" regarding problems on financing clean technology and the role of MDBs in filling the gap follows. An analysis of ADB's country strategies and energy sector portfolio was finally undertaken to understand the Bank's climate engagement vis-à-vis the challenges presented earlier. Some conclusions and recommendations wrap up the paper.

Economic, Energy and Emission Trends in the Study Countries

Prior to the global financial crisis that shocked the world in late 2008, panglobal financial organizations particularly the World Bank (2007) and ADB (2008b), named Asia as among the world's most economically dynamic regions. In 2007 for instance, developing Asia's GDP posted an impressive growth of 8.7%. This is the fastest recorded rate of growth since 1988 in the region (ADB 2008b: iii).

In Southeast Asia, where this paper is centred, this record rate of growth has been visible especially when compared with the mid-1990's Asian financial crisis. The World Bank's 2005 Global Monitoring Report showed that Southeast Asia's real per capita GDP rose by more than 6% annually in the 1980s and 1990s, while other developing regions in the world continue to struggle. In 2007, ADB (2008b) reported that Southeast Asia's economic growth fundamentals inched up by 6.5% against 1997 figures. On a per country basis, the Philippines has expanded at a 30-year high of 7.3% in 2007 while Vietnam has continued to grow at a quick rate of 8.5%. Indonesia accelerated to 6.3% in the same year while Thailand moderated at 4.8% due to fading consumer and business confidence in the context of heightened political uncertainty in 2007 (ADB 2008b). Coupling this economic growth is the increase in demand and consumption of electrical energy which fuels the region's economy (see Fig. 4.1).

Figure 4.1 shows that electric power consumption in the four study countries has been an increasing trend, such that within a quarter of the past century, these countries had almost doubled their energy usage. This only highlights the critical role that energy has on economic development. By 2030, ADB projected that energy use in Asia will increase by 112%. This also means that by that year, the region will become a member of the world's league of large energy consumers. In addition, this will also translate into Asia being a contributor to around 42% of the total global emissions, which will place the region on the level of the world's top energy-related greenhouse gas emitters (ADB 2007: 10; Kuroda 2008: 4). This analogy between energy consumption and emissions is further demonstrated in Fig. 4.2.

While emissions are contributed by a variety of sources, the proportion of energy sector emissions has been significantly higher compared to other contributors.

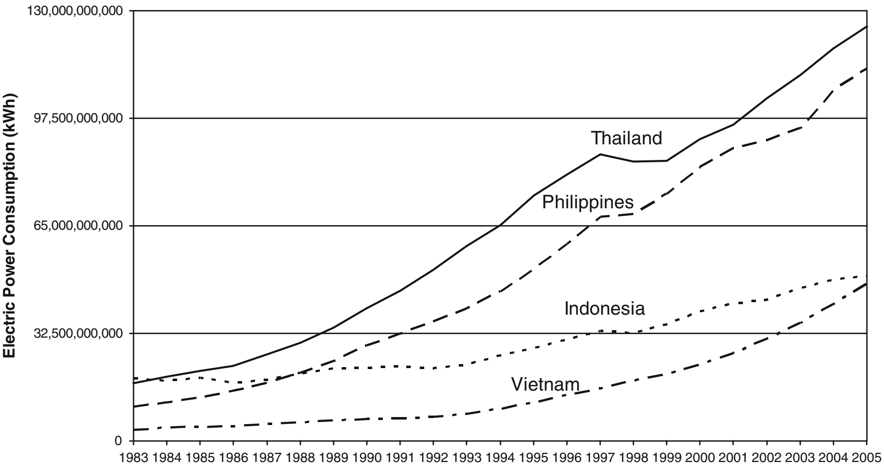

Fig. 4.1 Electric power consumption in Thailand, the Philippines, Indonesia, and Vietnam (1983–2005) in kWh
Source: World Bank (2008)

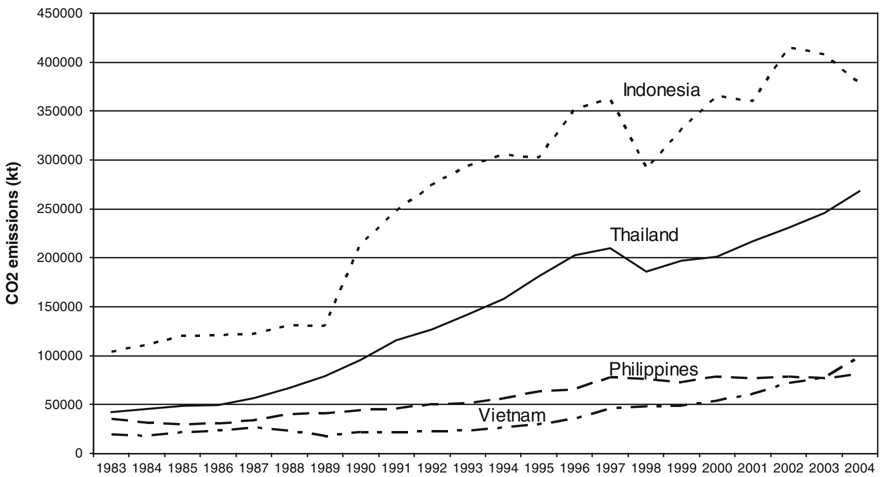

Fig. 4.2 Carbon dioxide emissions in Thailand, Indonesia, Philippines, and Vietnam (1983–2004) *Source*: World Bank (2008)

The World Resources Institute (2009) through its Climate Analysis Indicators Tool shows that the energy sector contributes almost 93% of total CO_2 emissions in the study countries; 36% of which is from electricity sources (see Table 4.1).

Despite the evidence that the study countries had boosted their economic fundamentals and that energy consumption is on the rise, development was not as encompassing as it should be. The continuing massive inequalities in terms of energy access and consumption describe this failure to make development felt across spectrums of society especially by the bottom poor. While affluent communities enjoy easy access to energy, living without electricity continues to affect other dimensions of human development (UNDP 2007). The World Energy Council verifies these disparities: around 20% of the world population living in industrialized countries consume nearly 60% of the world's energy supply, while 27% of the world population continue to live deprived of electricity access. In the study countries, World Energy Outlook (2006) estimates that around 131 million or 29% of the entire population are living without access to modern electricity. These are people who live without one light bulb in their homes and continue to rely on firewood for cooking. Figure 4.3 tells more about this disparity.

International development organizations such as the World Bank (2007) have acknowledged the relationship between poverty eradication and access to energy. The achievement of the United Nations' Millennium Development Goals (MDGs), has been continually hindered by a situation where a large proportion of the world's population are confronted by energy poverty. While changing this picture is vital for development, it should not be forgotten that the challenge extends beyond providing electricity. It moves further to include providing the necessary solutions which seek to decrease the depth of per capita carbon footprint in the developing world. What matters from the perspective of GHG emissions is how these energy

Table 4.1 Carbon dioxide emissions by sector (excludes land use change)

Sector	Thailand		Philippines		Indonesia		Vietnam		Total	
	$MtCO_2$	%	$MtCO_2$	%	$MtCO_2$	%	$MtCO_2$	%	$MtCO_2$	%
Electricity and heat	91.60	39.30	31.90	38.30	135.10	36.77	21.70	22.72	280.30	35.97
Manufacturing and construction	51.90	22.27	11.00	13.21	93.30	25.39	27.50	28.80	183.70	23.57
Transportation	55.90	23.98	28.00	33.61	73.90	20.11	20.30	21.26	178.10	22.85
Other fuel combustion	14.80	6.35	5.60	6.72	38.70	10.53	10.90	11.41	70.00	8.98
Fugitive emissions			0.30	0.36	8.00	2.18	0.60	0.63	8.90	1.14
Total for energy	214.20	91.89	76.80	92.20	349.00	94.99	81.00	84.82	721.00	92.52
Industrial processes	18.90	8.11	6.50	7.80	18.40	5.01	14.50	15.18	58.30	7.48
Total	233.10		83.30		367.40		95.50		779.30	

Source: World Resources Institute (2009)

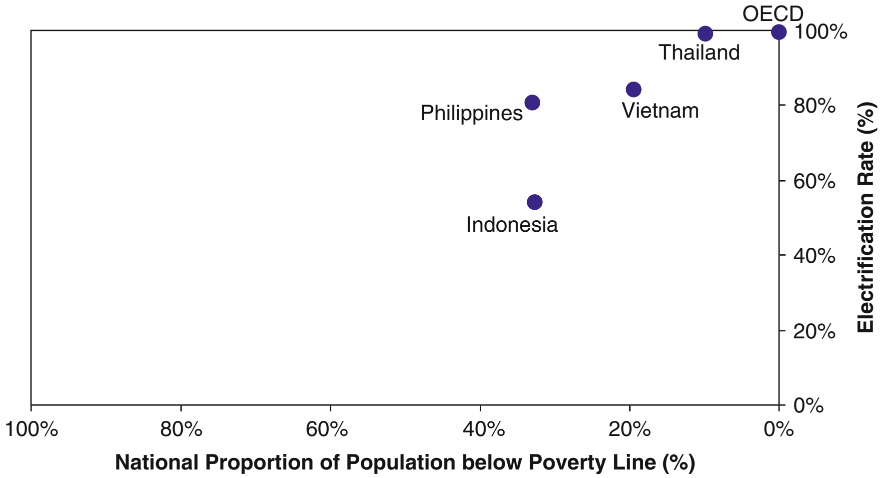

Fig. 4.3 Link between poverty and access to electricity (2004)
Sources: ADB (2008a, b, c, d, e); IEA (2008)

services are being provided for the poor, not just the presence of the provision. Socolow (2006 in Miller 2008) calculated that if the basic human needs for the estimated 1.6 billion people without electricity access and the 2.6 billion people without clean cooking fuel were to be met overnight, the increased energy use required would produce less than a 3% increase in global carbon emissions. However, emissions could be much greater if the poor are provided with electricity supplied by inefficient coal plants using poorly managed transmission systems with high loss rates. The need to provide electricity to the world's poor, therefore, has extended to include ways on how to ensure that energy production and distribution is done in a clean and efficient manner.

Providing the necessary resources, constructing pro-poor financial mechanisms, and developing and implementing clean policies to address this issue are not only functions of individual states and governments but also of development agencies and multilateral and bilateral donors. These agencies are expected to commit sufficient funds to support the needs of developing countries and address the clean energy challenge.

Nexus Between Climate Change Mitigation, the Clean Energy Paradigm, and Energy for the Poor

Recognizing the gargantuan challenge posited in the preceding section and in light of the current climate regime which established that excessive emissions have brought about tremendous changes in the climate system, some world governments-particularly advanced economies- have agreed to reduce their emissions to

1990 levels. Given the magnitude of the challenge, it is imperative that mitigation and adaptation actions are not focused only in developed countries but should also be jointly shared in developing countries.

The orthodox paradigm to combat climate change has stressed on the exclusive utilization of market mechanisms, common to which are carbon trading, carbon taxation, and implicit pricing via regulations and standards. This policy is clearly embedded in the international convention on climate change (the UNFCCC) and its subsequent Kyoto Protocol. This market-based climate policy, however, has been regularly criticized. For instance, Stern (2008) acknowledges that carbon markets cannot simply correct the burgeoning climate problems, in the same vein that Bluhdorn (2007) lucidly discounted this exclusive reliance in the market paradigm. Market-based policy, Bluhdorn (2007: 85) posits, has reduced "the ecological problematic to concerns about resource consumption and waste emissions which completely eclipses all other dimensions of the ecologist critique". Nevertheless, we do not fully discount the role of the market in our environmental conversations. The role of the market is essential, however: Irwin (2008: 49) argues that it is not "the only explanatory and theoretical principle capable of advancing arguments and solutions to the vast, interrelated cosmos of environmental problems". We need to put up additional infrastructure to encourage significant change in energy consumption and GHG emissions (Irwin 2008). It is also important to stress that taking climate action is essentially more about limiting the extraction and usage of fossil fuel at levels below the current trend. We can only advance this policy by shifting extensively towards the utilization of readily available clean and renewable sources.

In the international arena, the Johannesburg Plan of Implementation not only called for action at all levels to substantially increase the global share of renewable energy sources, but also to improve rural access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources as a major requirement to meeting the MDGs (World Summit on Sustainable Development 2003). In their 2008 theme study on energy security in the Asia Pacific region, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) suggests that renewable energy technologies can help optimize energy consumption and widen access to energy services for poor rural populations. Moreover, renewable energy technologies also address environmental issues as they are built on an ecologically benign system.

Despite claims that small energy projects offer unstable and frail rates of return on investment, there is a growing body of evidence to suggest that such investments are in fact far less risky than they are often perceived to be. Miller (2008), for instance, has provided several examples about how smaller scale renewable energy technologies are advantageous. These examples are followed up by a list of several donors which have actually financed small enterprises and nurtured small clean energy companies which provide energy services to electricity-deprived rural households. Practical Action (2006) has also reported the noteworthy progress of some smaller scale decentralized renewable energy projects such as solar photovoltaic (PV) systems, small-scale wind electricity generators, small-scale hydro schemes and biomass systems. These energy systems are considered appropriate in a small community setting because they "use local resources, can be sized according to need, operated and managed locally, and because local people can participate in the process of planning and installation" (Practical Action 2006). To illustrate that these systems work, Practical Action (2006) statistics reported the following figures: 150,000 decentralized renewable energies in Kenya, 100,000 in China, 85,000 in Zimbabwe; around 150,000 PV and wind systems for health clinics, schools and other communal buildings worldwide; over 45,000 small-scale hydro schemes in China; and more than 50,000 small-scale wind turbines in remote rural areas in the world.

In the case of Southeast Asia, the region has yet to demonstrate practice and exploit the bulk of power that may be generated from its renewable energy resources despite the already established commercial competitiveness of renewable energy systems (UNESCAP 2008). Issues related to financing remain one of the immediate causes for this deficiency.

Financing Issues and the Funding Role of MDBs

Recognizing the role of an enabling environment for technology demonstration and transfer in order to realize the shift towards clean energy sources in developing countries, Stern (2008) argues the need for adequate financing flows to cover for the extra costs needed. Unless financing issues are addressed, Stern (2008) warns that developing countries are extremely unlikely to join the effort to mitigate climate change on the scale and pace required. For a long time, developing countries have acutely felt the inequities of the situation and since they are just beginning to overcome poverty, they argue that they should not be asked to slow down, especially on the way they use conventional energy sources to fuel their economic growth. Stern (2008), however, is convinced that with adequate financing infrastructure, these countries will be easily converted to moving towards a low-carbon growth path.

Energy projects are often capital-intensive in nature, thus, the availability of financing is critical (Miller 2008). The World Bank (2007) foresees this problem when it predicts a huge funding gap for energy infrastructure for the period 2005–2030 in developing countries. The same concern is echoed in the UNESCAP (2008) study in the Asia-Pacific region. While the private sector traditionally provides sources of funds, it is essential to remember that these conventional private investors are always focused on maximizing returns. Thus, they would hardly be attracted by the idea of providing energy access for the poor unless subsidies or other financial incentives are in place and unless clear policies on tariffs and risks are set in advance (Miller 2008). It must also be understood that providing subsidies, especially large ones, can also harm the already weak economies of developing countries. In this case, development institutions are expected "to take the lead in finding ways to address funding issues" (Whaley 2008: 13).

In the 2005 meeting of the world's leading industrialized nations in Gleneagles, MDBs were called upon to broaden and accelerate their activities on providing access to energy via clean energy programmes (G8 2005; ADB et al 2008; Miller 2008). In 2007, the Bali Action Plan adopted through the United Nations Framework Convention on Climate Change's (UNFCCC) Conference of Parties in Bali, Indonesia reiterated the emphasis to support developing countries in identifying suitable actions to address climate change via clean energy financing (Miller 2008; Nakhooda 2008). This emphasis is specifically expressed in Paragraph 1(b) of the Bali Plan of Action which conditions "nationally appropriate mitigation actions by developing country Parties" on the provision of "technology, financing and capacity-building". The importance of commitments to financial assistance, investment and technology transfer to developing countries is emphasized in Paragraph 1(e), which states that "resources should be additional, adequate, predictable and sustainable; 'positive incentives' should be created for developing country implementation of mitigation strategies; innovative means of funding for meeting the costs of adaptation by particularly vulnerable countries; public- and private-sector funding and investment should be mobilized (UNFCCC 2007).

MDBs are created to realize an ambitious agenda of eliminating poverty and fostering sustainable development. Support to energy work by providing financing and policy advice for economic development is among their core works. In light of the climate change regime, the challenge for these development banks also means helping their client countries identify opportunities to reduce emissions associated with economic development. One opportunity involves investment in clean energy.

ADB's Engagement in Clean Energy Finance: A Case Study

The Asian Development Bank (ADB) is the only MDB based in Asia. ADB puts forward its energy vision through its Clean Energy and Environment Programme, which concentrates on clean energy and efficiency measures to improve energy security and to reduce emissions. It accomplishes this task by helping countries promote clean energy technologies and services, and by building their capacities.

In 2006, ADB claimed that 20% of its lending portfolio was spent on projects with environmental components. In 2007, the Bank provided $1.4 billion (or 14% of total 2007 lending of $10.11 billion) for investment in the energy sector (ADB 2008e). In 2008, ADB had strengthened its operations, begun refocusing on the environment, and put a premium on climate change consideration. This new strategic orientation is embedded in the Bank's landmark document called Strategy 2020, which directs the Bank's operations into five core specializations which include environment and climate change.

Parallel to the release of Strategy 2020, ADB also came up with its climate change strategy to help the Bank's developing member countries (DMCs) move their economies on to low-carbon growth paths through activities such as expanding the use of clean energy sources, improving energy efficiency, reducing fugitive

GHG emissions, such as methane released from landfills, modernizing public transport systems, and arresting deforestation (ADB 2008a: 14). To achieve this goal, ADB sets up its clean energy and environment programmes, which include the Energy Efficiency Initiative, Carbon Market Initiative, and Sustainable Transport Initiative (ADB 2007: 16).

Assessment of ADB's Clean Energy Strategies in Southeast Asia

In this paper, ADB's climate strategies and exposure on clean energy investment are assessed to specifically determine the degree to which climate change concerns are reflected in the Bank's activities. This article follows the following framework. The assessment was accomplished at two levels: conceptual and operational. The conceptual level of analysis dissects the Bank's country strategies and its climate considerations, whereas the operational level assesses the Bank's energy lending portfolio.

Two questions guided the assessment. At the conceptual level, we ask how ADB acknowledges climate change considerations and the need to mainstream climate change into its operations in the four study countries, while at the operational level, how ADB incorporates opportunities to mitigate emissions and reduce climate risk in its strategies and project development.

Conceptual Assessment of ADB's Country Strategies

Answering question 1 entails the evaluation of the degree to which climate change concerns are reflected in the Bank's Country Partnership Strategies (CPSs) and the succeeding Country Operations Business Plans (COBPs). These documents show ADB's plans of actions with regard to a specific DMC and are publicly available (ADB 2008c). The strategies and/or plans were evaluated based on four indicators as to whether the Bank has (1) identified its priority sectors that will be affected by climate change and are central to climate change mitigation, (2) set any goals to mitigate GHG emissions in these identified sectors, (3) consider the additional costs of adaptation, and (4) consider options that will meet costs of low carbon development. The result of this assessment is presented in Table 4.2.

The assessment suggests that recent ADB country strategies in the four study countries have increasingly made note of opportunities to reduce emissions. Of the strategies reviewed, all have recognized interventions in the energy sector and have included the need to improve efficiency and reduce emissions. The strategies for Indonesia have noted the need to enhance energy efficiency and reduce dependence on oil, and have then set goals to reduce air emissions. They further note the need to find opportunities to finance some of the country's lower emission options particularly related to Kyoto Protocol's Clean Development Mechanism (CDM). On the other hand, the strategies for Vietnam have explicitly mentioned vulnerability concerns while identifying specific outputs and targets to increase resilience to the

Table 4.2 Assessment of ADB country strategies in four Southeast Asian study countries

Country	Document assessed (type/date)	Priority sectors with significant implications for climate change	Climate change mitigation – specific indicators or goals and targets	Includes climate adaptation – specific indicators or goals and targets	Explores options to finance costs of low carbon development
Thailand	CPS/April 2007	Infrastructure, energy	Yes – energy efficiency and renewables in energy sector	No	Yes – trading of carbon credits under CDM
Indonesia	CSP/October 2006, and COBP/October 2008	Agriculture, energy, transport	Yes – energy efficiency and renewables in energy sector	Yes – flood management	Yes – trading of carbon credits under CDM
Philippines	CSP/June 2005 and COBP/October 2008	Infrastructure, energy, agriculture, water supply	Yes – energy efficiency and renewables in energy sector	No	No
Vietnam	CSP/September 2007 and COBP/October 2007	Agriculture, water supply, energy, transport, forestry	Yes – energy efficiency, notes GHG emissions in energy and agriculture sectors, renewable energy in energy sector	Yes – increased capacity for disaster management and mitigation	Yes – considering opportunities for ADB's carbon market initiative

Acronyms: *CPS* Country partnership strategies, *CSP* Country strategy and program, *COBP* Country operations business plan
Source: ADB (2008c)

likely impacts of climate change in the country. Although ADB mentioned expected impacts of climate change in the study countries, the strategies and plans have inconsistently noted vulnerabilities, as illustrated in the strategy for the Philippines. The strategies also lack succinct ideas as to how the Bank and the DMC can cooperate with respect to harnessing and expanding renewable technologies.

Operational Assessment of ADB Energy Sector Lending

Since energy is central to the challenge of climate change mitigation, this paper took the assumption that ADB's energy sector portfolio should reflect the extent to which climate change issues have been mainstreamed into the Bank's overall operations. This involves an assessment of the Bank's energy sector loans and was accomplished by reviewing documents for energy-supported projects during the period 2000–2008. Like country strategies, the Bank has also made the database all of its supported projects publicly available (ADB 2008d).

Three-question criteria guided the evaluation of each energy sector loan. These are (1) Were GHG emissions associated with the project accounted for? (2) Were alternative climate-friendly approaches considered? And, (3) were other options to access additional resources to meet the costs of less GHG-intensive technology considered? The conclusion would be, if a project answered "yes" to two or three of the criteria, then climate change should have been "incorporated"; if one, then climate change should have been "cited"; and if none, then climate change is considered to be "disregarded". The result of the assessment is presented in Fig. 4.4 and presented in more detail in the Appendix.

Until 2002, the online database lacks data with regard to ADB-supported energy projects, which explains the absence of data for years 2000 and 2001 in Fig. 4.6.

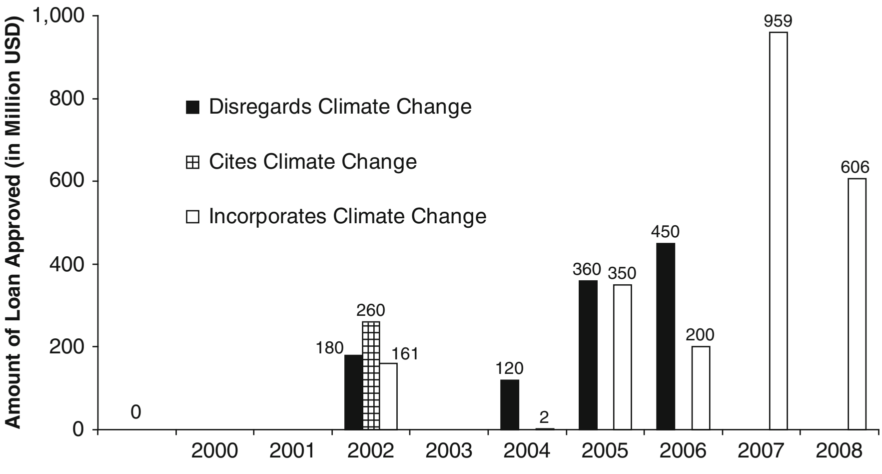

Fig. 4.4 ADB support for energy projects in Thailand, the Philippines, Indonesia, and Vietnam (2000–2008)
Source: ADB (2008d)

Climate change tended to be a marginal consideration among ADB-sponsored energy projects until 2006. However, shortly after the launch of the Bank's new programmes on clean energy and climate change in 2007, there was a 100% improvement in the extent to which climate change considerations are reflected in project documentation. This improvement seems to stem in part from implementation of the Bank's Energy Efficiency Initiative, which involves screening all projects for efficiency opportunities, and monitoring efficiency components in its energy portfolio.

Figure 4.6 also shows that attention to climate change as measured in the Bank's energy portfolio has varied significantly from year to year. This is in part because support towards the energy sector tends to be "lumpy", which often involves several large-scale discrete conventional projects. Twelve of the seventeen projects assessed in this paper, which amount to US$ 100 million and more, show this overwhelming support towards conventional projects. Only 42% (7 of the 17) of the energy projects assessed had renewable components while 52% (or the other ten) remain conventional, mainly involving coal power.

Some Conclusions and Policy Recommendations

The conceptual and operational assessment of ADB's strategies and energy investment has yielded valuable and timely data. The figures presented in this paper tell us that the Bank has remained engaged in energy-intensive and fossil-fuelled sectors and is expected to follow the same trajectory in the years to come.

At the conceptual level, ADB country strategies show that until 2008, climate change was not a major agenda in the study countries and the Bank. The inconsistency of attention granted to climate change in these strategies and plans may reflect, in part, the priorities of national development agendas of the study countries, which may not always place due emphasis on climate change. This tells us that the countries have to incorporate low carbon growth paradigms in their development aspirations. Although the energy sector was identified in all strategy documents as among the Bank's priorities, these documents need realignment, particularly in terms of focus, that is, a shift from conventional and carbon-intensive infrastructure towards more environmentally benign renewable systems, which are missing in the current documents. These strategies also need rewriting to reflect the paramount concerns to address climate change and specifically incorporate clean energy actions, among other climate mitigating efforts.

At the operational level, the trend with respect to ADB's investments in climate-friendly technologies has shown promise. This is shown especially in 2008 when all project documentation began considering climate change across the board. This is indeed a notable improvement and needs to be sustained and increased. The challenge for climate policy remains unchanged and that is to move quickly and encompassingly in order to promote changes on a much larger scale than before. ADB is therefore expected not only to expand its energy investments but also to radically shift towards clean energy projects regardless of size.

ADB has indeed begun raising its support for low carbon technologies especially regarding energy efficiency. However, this needs to be increased to significant levels and incorporated in the Bank's country strategies. While it is notable that the Bank has adopted specific targets to increase support for renewable energy and energy efficiency, a colossal scope to scale up these efforts remains vital. The Bank still needs to realign its investments in the most climate-sensitive and energy-efficient ways possible. While its conventional energy projects such as coal are often lucrative commercial investments, it does not deliver real sustainable development outcomes. ADB therefore needs transformative (and radical) changes in the energy sector to immediately steer investment from business-as-usual towards low carbon and environmentally sustainable choices. This will be difficult to achieve currently and in the years to come if the Bank opts to remain invested in many huge and often conventional coal energy projects as it does at the moment.

Investments need to be scaled up and targeted specifically at decentralized renewable energy systems to address the challenge of limiting the expansion of energy poverty in rural communities. Studying China's energy sector, Karplus (2007) found that innovation performance is strongest in industries that have experienced institutional decentralization. It therefore follows that ADB needs to assess its existing financing mechanisms against their real impact in ensuring energy access for the poor and consider community-based, off-grid, decentralized renewable energy systems. This proportion of pro-poor clean energy investments should also increase speedily and consistently considering the magnitude of the current climate and energy challenge. These projects, although small in size, possess greater "added value" on a longer term basis, as compensated by environmental, social and developmental impacts. These efforts are also essential seed capital for future development and can provide the necessary framework and reference for other investors to tolerate small-scale investments.

The challenges in accessing clean energy services are huge. While this paper discussed the financial constraints and how development banks such as ADB can fill funding gaps, lack of money is not the only constraint: there are other important barriers, including social, technical, managerial, and institutional issues that need to be addressed. In terms of financial barriers, however, the Bank is best positioned to take the lead in ensuring that growth is sustainable without compromising the environment. That change includes the radical reduction of the amount of fossil fuels Southeast Asia is burning, an immediate shift towards clean and environmentally benign energy sources, and allowing the poor to share the fruits of development by providing their much needed energy. The clock is ticking. Unless significant changes in terms of how Southeast Asia fuels its growth are put into action, the struggle to mitigate the ill effects of the changing climate remains.

Appendix: Assessment of ADB Energy Sector Portfolio

(Loans and grants to both public and private sectors in Thailand, Indonesia, Philippines, and Vietnam, 2000–2008). Source: ADB 2008d

Country/Project name	Project Identification No./ Approval Date	Documents Reviewed	Amount (US$ Million)	(1) GHG emissions accounted?	(2) Alternative climate-friendly approaches identified?	(3) Options to access additional resources to meet the costs of less GHG intensive technology considered?	Overall consideration of climate change	Energy poverty statistic available?
Thailand/BLCP Power Project (Private Sector Loan)	37904/November 2003	Summary Environmental Impact Assessment	110	Yes	No	No	Cites	No
Indonesia/South Sumatra to West Java Phase II Gas Pipeline Project (Private Sector Loan)	39928/August 2006	Environmental Assessment Report	200	Yes	Yes	Yes	Incorporates	No
Indonesia/Tangguh LNG Project (Private Sector Loan)	38919/December 2005	Summary Environmental Impact Assessment	350	Yes	Yes	Yes	Incorporates	No
Indonesia/Power Transmission Improvement Sector (Loan)	35139/December 2002	Report and Recommendation of the President to the Board of Directors	140	No	No	No	Disregards	No
Indonesia/Renewable Energy Development (Loan)	34100/December 2002	Report and Recommendation of the President to the Board of Directors	161	No	Yes	Yes	Incorporates	No
Philippines/Privatisation and Refurbishment of the Calaca Coal-Fired Thermal Power Plant Project (Private Sector)	41958/June 2008	Environmental Assessment Report	210	Yes	Yes	Yes	Incorporates	No
Philippines/Acquisition and Rehabilitation of Masinloc Coal-Fired Thermal Power Plant (Private Sector)	41936/January 2008	Environmental Assessment Report	200	Yes	Yes	Yes	Incorporates	No
Philippines/Power Sector Development Program Loan (Loan)	37752/December 2006	Report and Recommendation of the President to the Board of Directors	450	No	No	No	Disregards	No

(*continued*)

(continued)

Country/Project name	Project Identification No./ Approval Date	Documents Reviewed	Amount (US$ Million)	(1) GHG emissions accounted?	(2) Alternative climate-friendly approaches identified?	(3) Options to access additional resources to meet the costs of less GHG intensive technology considered?	Overall consideration of climate change	Energy poverty statistic available?
Philippines/Renewable Energy and Livelihood Development project for the poor in Negros Occidental (Grant)	37267/January 2004	Proposed Grant Assistance	1.5	No	No	Yes	Incorporates	No
Philippines/Electricity Market and Transmission Development (Loan)	36018/December 2002	Report and Recommendation of the President to the Board of Directors	40	No	No	No	Disregards	No
Vietnam/Song Bung 4 Hydropower Project (Loan)	36532/June 2008	Environmental Assessment Report: Technical Assistance Report	196	Yes	Yes	Yes	Incorporates	No
Vietnam/Mong Duong 1 Thermal Power Project – Project 1 (Loan)	39595/October 2007	Environmental Assessment Report	27.86	Yes	Yes	Yes	Incorporates	No
Vietnam/Multitranche Financing Facility Mong Duong 1 Thermal Power Project (Loan)	39595/September 2007	Environmental Assessment Report	930.71	Yes	Yes	Yes	Incorporates	No
Vietnam/Northern Power Transmission Expansion (Sector) Project (Loan)	38196/December 2005	Summary Initial Environmental Examination Report	360	No	No	No	Disregards	No
Vietnam/Northern Power Transmission (Sector) Project (Loan)	32273/December 2004	Summary Initial Environmental Examination Report	120	No	No	No	Disregards	No
Vietnam/Phu My 3 Power (Private Sector)	36901/October 2002	Extended Annual Review Report; Summary Environmental Impact Assessment	75	Some	No	Yes	Cites	No
Vietnam/Mekong Energy Company Ltd (Phu My 2.2 Power) (Private Sector)	35914/July 2002	Summary Environmental Impact Assessment	75	No	Yes	No	Cites	No

References

ADB (2007) Climate change ADB programs: strengthening mitigation and adaptation in Asia and the Pacific. Asian Development Bank, Manila, Philippines

ADB (2008a) Strategy 2020: the long term strategic framework of the Asian Development Bank 2008–2020. www.adb.org/documents/policies/strategy2020/Strategy2020.pdf. Available Oct 2008

ADB (2008b) Asian development outlook 2008. http://www.adb.org/Documents/TARs/REG/39263-REG-TAR.pdf. Available Oct 2008

ADB (2008c) ADB country partnership strategies. http://www.adb.org/Documents/CSPs/default.asp. Available Nov 2008

ADB (2008d) ADB supported projects. http://www.adb.org/Projects/. Available Oct–Nov 2008

ADB (2008e) ADB annual report 2007. http://www.adb.org/Documents/Reports/annual_report/2007/Annual-Report-2007-Vol01.pdf. Available Nov 2008

ADB, African Development Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank, and World Bank Group (2008) Joint MDB Report to the G8 on the implementation of the clean energy investment framework and their climate change agenda going forward. http://www.mofa.go.jp/policy/economy/summit/2008/doc/pdf/0708_07_en.pdf. Available Oct 2008

Bluhdorn I (2007) Democracy, efficiency, futurity: contested objectives of societal reform. In: Bluhdorn I, Jun U (eds) Economic efficiency-democratic empowerment: contested modernization in Britain and Germany. Lexington Books, USA, p 85

G8 (2005) The Gleneagles Communique. http://www.unglobalcompact.org/docs/about_the_gc/government_support/PostG8_Gleneagles_Communique.pdf. Available Oct 2008

International Energy Agency (IEA) (2008) World Energy Outlook 2006. Annex B: Electricity access. http://www.worldenergyoutlook.org/docs/weo2006/electricity.pdf. Available Nov 2008

Irwin R (2008) Heidegger, politics and climate change: risking it all. Continuum International Publishing Group, New York and London

Karplus V (2007) Innovation in China's energy sector. http://iis-db.stanford.edu/pubs/21519/WP61__Karplus_China__Innovations.pdf. Available Aug 2009

Kuroda H (2008) Investing in clean technologies. In: Development Asia 1.4

Miller A (2008) Financing the integration of climate change mitigation into development. Clim Policy 8:152–169

Nakhooda S (2008) Correcting the world's greatest market failure: climate change and the multilateral development banks. In: World Resources Institute (WRI) Issue Brief. World Resources Institute (WRI), Washington DC, USA

Practical Action (2006) Decentralised energy schemes. http://practicalaction.org/?id=decentralised_energy. Available Aug 2009

Stern N (2008) Rich countries must lead the way. Dev Asia 1:22–23

United Nations Development Programme (UNDP) (2007) The human development report 2007/2008: fighting climate change: human solidarity in a divided world. http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf. Available Aug 2008

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (2008) Energy security and sustainable development in Asia and the Pacific. UNESCAP, Bangkok, Thailand

United Nations Framework Convention on Climate Change (UNFCCC) (2007) Bali action plan. http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf#page=3. Available Oct 2008

Whaley F (2008) Rising seas, melting glaciers. Dev Asia 1:16–21

World Bank (2007) Adapting to climate change. In: East Asia Environment Monitor 2007. World Bank, Washington DC, USA

World Bank (2008) Online world development indicators. http://ddp-ext.worldbank.org.ezproxy.auckland.ac.nz/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=6. Available Oct–Nov 2008

World Resources Institute (2009) Climate analysis indicators tool (CAIT) Version 6.0. WRI, Washington, DC

World Summit on Sustainable Development (2003) Johannesburg plan of implementation. http://www.wsscc.org/fileadmin/files/pdf/For_country_pages/Thematic_networking/Johannesburg.pdf. Available Nov 2008

Chapter 5
Nikan oti (the future): Adaptation and Adaptive Capacity in Two First Nations Communities

Willie Ermine and Jeremy Pittman

Abstract In the clamour to understand climate change and its inevitable impacts on environments and societal structures, the central notion of human capacity to effectively respond to altered human conditions has received little attention. Yet climate change has the potential to bring about undesirable shifts in the human experience on the social, economic, political and environmental fronts with the potential of negatively impacting the human social order on a substantial scale. Understanding past responses to shifts in the human living condition can help mitigate social upheaval in the wake of climate change disruption.

First Nations Peoples in Canada have valuable cultural resources and experiences that may be informative in confronting the social challenges presented by climate change. A research project was undertaken to document exposure sensitivities, adaptive strategies and adaptive capacities in two First Nation communities in Saskatchewan. The research was informed by past experiences the communities had with turbulent changes in their sociocultural environments and the nature of responses that cushioned them amidst the changes. The community people identified strengths, such as philosophy, indigenous knowledge, and practical approaches to visioning the future for the benefit of their youth, as important elements of survival and overcoming negative effects of change.

Keywords Adaptation · Capacity · Change · Climate change · Community · Elders · First Nations · Indigenous · Philosophical · Sociocultural

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Introduction

It is widely anticipated that global warming and climate change in general will have considerable and adverse impact on ecosystems and human communities. Indeed, climate change has the potential to bring about catastrophic changes to environments that trigger massive shifts in the human experience on the social, economic, political and environmental fronts. Conceivably, climate change would not only affect the landscape but in doing so, cause huge stresses and upheavals in the human experience brought about by lifestyle changes, displacement, shifts in population, and a myriad of other possibilities. Anticipated changes to the ecosystems and the inevitable impacts of these conditions on human populations will most assuredly have deep psychological and life-transforming effects on individuals and whole communities. What happens to the human heart and soul, the epicentre of impact experience, when turbulent change occurs in the things that people care about has received little attention in climate change discourse. Yet, without the appropriate exploration into these issues, gaps would exist in terms of understanding and determining individual and collective vulnerability and what the pertinent responses would be valuable to irrepressible change the projected climatic dimension of the future would spawn. Duerden (2004) has written that:

> What we need to know, and what lies fairly in the preview of social scientists, is how human activity will respond to change. From the standpoint of affected populations, the important questions are "What will the impact be on way of life?" and "How shall we adapt?" (p. 210)

Understanding past experiences and the responses by various human communities to massive shifts in their sociocultural circumstance can help in anticipating and alleviating broader social crisis and upheaval in the wake of climate change disruptions. The central intention of this paper is to advance the thesis that understanding adaptation and adaptive capacity in the context of climate change can be enhanced by exploring the interface humans have with their natural environment. Two community case studies were undertaken with Elder focus groups as part of a research project entitled "Nikan Oti: Future – Understanding Adaptation and Adaptive Capacity in Two First Nations" with the intention of understanding adaptation and adaptive capacity and specifically how communities make adjustments to their natural or human systems amidst unprecedented change that impacts them. The research project was undertaken to document exposure sensitivities, adaptive capacities and adaptive strategies to change in two First Nations communities in north central Saskatchewan. This paper will examine some the results of that study and will specifically look at the Elder memory and the value of Elder thought in trying to draw out how human collectives perceive and work with change. Memory work with Elders reveals how First Nation communities underwent changes not only in terms of their experience with the climate and the environment, but also in their sociocultural dimensions, where change was a central and engrossing issue. The Elder memory of the changes that happened to their people and disrupted the life of the community, the philosophies that inherently guided the people to confront unknowns, and the human capacities that help initiate a conciliation of the future will be examined.

Elder Contributions

First Nations Peoples in Canada have a wealth of cultural philosophies, knowledge, and experiences closely tied to the land that may be examined more closely in an effort to create awareness about response attributes to the challenges presented by climate change. Indeed, indigenous people, and Elders in particular, have begun to add their voices and observations to the increasing body of knowledge on climate change. This has particularly been the case in northern regions where livelihood activities often remain tied to the land. For example, in 2003, the Department of Resources, Wildlife and Economic Development of the Northwest Territories attended the Dene Nation Elders Gathering in Rae-Edzo to initiate discussions on climate change and develop a series of regional workshops with Elders around this issue. Initiatives such as these and others point to the growing collaboration between western scientists and Indigenous communities, and particularly Elders, to explore and address climate change issues. It is also inevitable that Elders, because of their worldview and knowledge of cultural philosophies associated with close experiences with the land, can also contribute insights about how the broader society can achieve and maintain a more holistic understanding of the natural world order. Specifically, this can be done by exploring how Elders perceive the nature of changes they have experienced out on the land, the past responses and practices of community, past successes and failures, as insights about human self-determination and what is important as humans face up to the natural world of the future and the looming changes we must negotiate if climate change is indeed running rampant.

One of the undercurrents in the focus group sessions with the Elders from James Smith and Shoal Lake relates to the way the issue of climate change is framed. In the western scientific perspective, climate change is largely a physical phenomenon that is observable and can be documented and presented in highly organized ways even if its causes and impacts are not clearly understood yet. Karl and Trenberth (2003), for example, have stated that scientific instrumentation like global climate models, are:

> fully coupled, mathematical computer-based models of the physics, chemistry, and biology of the atmosphere, land surfaces, oceans and cryosphere and their interaction with each other and with the sun and other influences (p. 1721).

There can be no doubt that scientific data collection and instrumentation is valuable in charting an understanding of the various phenomena that would induce climate change. The Elders from James Smith and Shoal Lake Cree Nations provided a broader interpretation to the concept of climate change in contrast to the largely quantitative context provided by contemporary biological and physical sciences. For the Elders, the issues of "climate" and "change" are complex and interrelated, with each reciprocally affecting each other in some manner. The Elders talked about the notion of change and social–cultural dimensions of the human/natural environment relationship as much as they discussed climate itself. Perhaps another category that can be interpreted from the Elder discourse is the "mental climate" that contributes to the manner in which humans think about and behave towards nature. For the Elders, the issue of climate change is as much about a declining humanity marked by the loss of ecological values as it is about natural forces.

Elders' perceptions of the natural environment are important in understanding the complex array of challenging questions presented by global climate change. The Elders believe that by understanding the spiritual world, society can more readily understand the functioning of the natural world. With this understanding, knowing becomes possible. Beck et al. (1992), in their book *The Sacred* state:

> [A] knowledgeable human being was one who was sensitive to his/her surroundings. This sensitivity opened him/her to the Grand mysteries and to the possibility of mystical experiences, which was considered the only way to grasp certain intangible laws of the universe (p. 164).

This fundamental principle of First Nations thought is often discounted in western scientific circles. However, understanding its value can lead to insights about the various profiles of climate change just it would on many other important issues. As Jeremy Hayward has stated, "it is just that the modern description leaves out so much – it leaves out the sacredness, the livingness, the soul of the world". In many instances the Elders can provide the heart and soul, the narrative of the human experience with nature, to western scientific constructs of data and figures with the result that the state of art in climate change understanding may be achievable.

Historical Changes

Timeframe seems an important element in determining the nature of change and assessing the success or failure of the human response to the disruption of lifestyle. The Elders in the study established historical perspectives as they committed to a discourse on change and adaptation experienced by their people. The Elders talked about their history as a field of memory that included the lives of their ancestors along with their own first-hand experiences into a narrative form that illustrated a wide-ranging sequence of events otherwise known as community history. Providing this wider latitude to community consciousness was a way of identifying inconsequential aberrations from the long term and sustained change affecting community life. From this Elder history emerges a picture of the many faces of change that challenged the people over time and the identification of resources that gave a sense of existential continuity and hope for the future of the people. The climate change record which is based almost exclusively on technological and scientific documentation of climatic factors has left serious gaps in understanding these community perspectives of change. As Smithers and Smit (1997) state, "the standard approach is rarely connected to current experience of communities and usually does not relate to the actual adaptive decision-making process in communities" (p. 392).

Change would seem to be the keyword and central issue in trying to understand adaptation and the adaptive capacity of a community. Any change in environment, whether it is climate change affecting eco-regions or sociocultural change that takes place in collectives, creates tensions and tests the capacity of the people to adapt to the shifting circumstances. Many First Nations communities have gone through significant social, economic and political transformations over the course of history that had serious implications for social wellbeing. While some changes are certainly unprecedented, First Nations people are not unfamiliar with change. Serious economic, political and social transitions of the past have tested not only First Nations' resolve to persist as a people but also measured their capacity for adapting to new realities. For instance, the First Nation communities involved in this study had gone through significant changes as the people shifted from largely traditional subsistence economies to contemporary mainstream lifestyles over the course of the Elder memory. This in itself is a record of adaptation. The communities' lifestyles were tightly connected to the natural environment through trapping, hunting, fishing, and other means of northern livelihood. The traditional way of life in the northern forests was marked by self-sufficiency. However, the passage to urbanized lifestyles and adoption of mainstream conveniences also shifted the consciousness of the people away from the land that had sustained them in the past. The Elders in the study were very clear that the lifestyle change and an alternate mode of knowledge practice had severe impact on community vitality that is still being felt.

Both communities of James Smith and Shoal Lake had encountered different waves of life changing forces over the course of their histories. The changes to their environments and their collective existence speak of shifts and tensions happening at deeper levels of human experience where the peoples' perseverance and capacity to effectively respond to life altering forces are rigorously tested. The community experiences and the peoples' wherewithal to prevail amidst challenge may be the portals to the examination of how humans react and adapt to fundamental changes to their living conditions.

The focus group Elders from both James Smith and Shoal Lake spoke of the passage in eras and lifestyle conversions that altered community dynamics and displaced the philosophies and knowledge that had sustained them in the past. In some instances, the changes that the Elders talked about had a negative impact on the people's confidence and self-determination. For example, James Smith First Nation Elders identified a catastrophic cattle die-off in their past that had a severe impact on the people's self-sufficiency. Without the cattle, the people's sensibilities for independence were disoriented and a domino effect of events was triggered. According to one of the Elders, the loss of livelihood resulting from the cattle die-off created the conditions that led to the introduction of social assistance in the community. The old people of the community at the time had wisely opposed the introduction of social assistance in their community because they saw it as the precursor to the destruction of a people's independence through a system of welfare. Indeed, the Elders spoke of how the events of that history injured the spirit of the James Smith Cree Nation – the same spirit that the community had relied on to pull the people through the many adversities of the past.

The Shoal Lake Cree Elders said that great changes had similarly taken place in their community since the time of their ancestors. Perhaps the biggest change and the most incendiary was the displacement of traditional knowledge that formerly guided the people through fluctuating circumstances. The insidious effect of this repression of cultural knowledge is felt most acutely in the disposition of the youth. Mainstream influences such as different forms of education and the uptake of a sedentary lifestyle resulted in altered youth behaviours that were considered outside of the norm for the community. One Elder states that "they are not skilled to run their lives in good ways". Another Elder remarked that:

> Presently, the youth say they are men but they only know the book knowledge. They do not actually know how to work. Presently, the youth have a different nature to them.

One of the lady Elders also laments the neglect of traditional environmental education and skills development to young people and how mainstream education has not properly addressed that form of learning. She states:

> Our young people will face difficulty if all they are shown are the white ways of life. They are also behaving like the white people in the ways of foolishness.

There is a general recognition that the youth are bearing the impacts of a delicate transition period between the traditional lifestyles of the past and the emergence of contemporary urbanized influences in the community. One of the great challenges for the people of the community is a need to repatriate youth from their communities to traditional environmental and cultural knowledge. Connections to the land traditionally meant that the natural environment provided for an array of health needs including clean air and water, natural foods, medicinal plants, and spiritual grounding.

The Elders from the two communities of James Smith and Shoal Lake Cree Nations had seen their old people, the ancestors, and they remembered the virtues that kept the community people grounded and actively engaged with their environments. Changes brought on by the passage of eras, economic catastrophes, loss of cultural foundations and the impacts of alternate modes of knowledge practice have negatively impacted the communities and have tested the resolve and capacity of a people to persevere and adapt to new realities. For both First Nation communities, the re-engagement with time honoured knowledge and the mobilization of innate human capacities would be the touchstone by which change and adaptation would be negotiated.

Adaptive Capacity

The background to this discussion on climate change is the ever-present worldview as informed by the Elders in the focus group. This worldview is formed and guided by a distinct knowledge tradition with its insights, values, interests, as well as social, economic and political realities of the community people over the course of their history. This worldview is reflected in the philosophies that the Elders discussed in relation to the environment and physical climate. These perspectives provided insights into how people confront significant cultural and social changes taking place in their lives and about inner resources of people that cushion and mediate severe change to circumstances such as those that may be presented by climate change.

Smit and Pilifosova (2003) have suggested that vulnerability is a function of a community's exposure to climate change effects and its adaptive capacity to deal with that exposure. Further, adaptive capacity is understood as the ability of a community to effectively plan for and cope with climate change impacts. Adaptive capacity is shaped by a number of interrelated factors, including the social, political, economic and cultural systems in place. In addition, the degree to which these systems demonstrate qualities of resilience, stability and flexibility will reflect their adaptive capacity (Smithers and Smit 1997). For both of the communities involved in the study, adaptive capacity was inherently linked to cultural traditions, but it is those same traditions that have been impacted by lifestyle and philosophical changes. Impending changes envisioned for the natural order of the future will assuredly further complicate people's lives. As noted by Ford and Smith (2004), "while indigenous communities have historically demonstrated adaptability to a variety of stresses, their coping abilities have been put under considerable strain by recent climatic and environmental changes" (p. 394). Indeed, the Elders from the two communities had seen many sociocultural changes take place in their communities over the course of their Elder memory. However, it is the coping mechanisms such as philosophy and the psychological capacity that guided the people through tumultuous changes that seem most insightful and substantial to discussions of how to make adjustments to global climate change. For the people of James Smith and Shoal Lake, the alteration of the physical construct will not offer the final solution. The James Smith and Shoal Lake Cree Nations looked inward to find the resources they needed to thrive in traditional lifestyles and find continuing promise that these attributes are their primary claim to adaptive capacity.

The Elders from the two First Nation communities had faith in the inherent strengths of their own people and believed that time-honoured philosophies of their ancestors would enhance their adaptive capacity. The James Smith Elders saw two adaptation strategies for their community. First was to instil the "drive" of their ancestors to the next generations and secondly to focus on their own capacity to model the virtues that they wanted the young people to adopt. The Shoal Lake Elders believed that adaptation hinged on their people's deep seated spirituality and philosophy. They saw value in having a land philosophy and the people's capacity to "intent" the future for the benefit of future generations.

James Smith Capacity To Adapt

The Elders in the James Smith focus group remembered that their ancestors possessed a certain kind of determination that was crucial to a living effectively in traditional lifestyle. This "drive", as one Elder called it, is the determined effort to do the things necessary for family survival even if the conditions in which to work with were difficult. The Elder explains it in the following way:

> It was hard. Sometimes there was no food. They had to travel long distances but they always had faith. My grandpa or my dad, to bring the food whatever it was. No matter if it was storming, a blinding storm, they'd go and get something and bring it home.

The world of the Elders' ancestors was challenging because there were no modern conveniences and family survival depended on having not only determination but also the skills congruent to the natural environment. Individuals had to find their own spark of resolve to carry out responsibilities even if they were ensconced in challenge. The Elders in the study said that the determination, or the drive, possessed by the ancestors was a valuable virtue befitting the time but also had relevancy for subsequent generations. One Elder recalls that lessons he received were about tenacity and perseverance in the face of challenges that dot the human journey of experience. He states:

> I do not own any part of life but a partner of mine once told me not to give up. Do not give up. Therefore I cannot give up simply because I do not own anything.

The Elders also said that a crucial component of determination is having foresight and the ability to plan ahead. One of the James Smith Elders tells us that his grandfather taught him the value and critical skill of planning ahead particularly when interacting with nature. He tells us the following:

> They always planned ahead. My grandpa used to say. When you wake up in the morning try and figure out the route you're going to take. Where ever you're going to walk to, you will hunt along the way or to find food on the way for your life that day. You have to put all that in order.

Survival in the traditional lifestyle of the indigenous past meant having foresight and always being prepared for the worse, particularly in the natural milieu where people have no control over prevailing conditions. The Elders remembered the determination of the ancestors and also thought of their own past experiences where the access to this inner drive was warranted and proved valuable in surmounting challenges. Hearing the Elders speak of survival virtues such as perseverance and the compulsion to triumph over challenges holds notable promise for human capacity and as a potential paradigm for human adaptation to the stringency of climate change.

Shoal Lake Capacity To Adapt

The Elders from the Shoal Lake Cree Nation felt that they were blessed to have had wise and philosophical ancestors. They have come to know the mindset about land, philosophy and life that pervaded their old people. One Elder said "I am getting old and I am beginning to think like an elder. It is these elders that model the ways and I follow their example". One Elder felt like she has had the burden of responsibility that goes with Eldership in the community for the longest time. She states:

> Presently, as I continue to follow my path in this community of Shoal Lake, I am the oldest amongst us who sit here. I am the oldest and I do not pretend to be young at 80 years on September 2. It seems I have been old for the longest time.

A part of the philosophical mindset or the wisdom that comes with age is the uncanny ability to think and speak in metaphor. One of the images that the Elders constructed as a metaphor for their people and as a way of relating the change in community life is the idea of “land”. That is, when the Elders talk about the land, they are talking about their own people. As an example, when life in the community was under respectable order and people were content, the Elders talked about his time as a beautiful period. One Elder provides this example in his own words. He states “I too have considerable experience in the way that I saw the land. I was shown how the land was and in the many ways of its beauty”. As times and lifestyles changed and people altered their ways, the Elders used the metaphor of the land as a description of what they saw. The oldest in the group of Elders states, “I have seen the changes that have happened in our land”. Presently, the Elders see the extent that people have changed in the community and remark, “It is so that everything is looking different on our land”. During this time of unprecedented change in the community, the people have neglected the wisdom of the Elders for the guidance needed. One Elder sees this negligence in people and states “we do not know how the old people think and what they want. That is the way I see our land”. Another Elder wanting better ways for the people remarked, “It may sound like I am complaining but I am not. I simply want better ways for our land”. Even as the Elders sound off their frustrations and words of counsel for the betterment of the community, the metaphor resurfaces as a wake-up call to the community. Indeed, the Elders recognize and acknowledge their responsibility duty to care for the land (i.e. community people). One Elder tells us “we need to be the caretakers of this land where we had been placed to walk the earth”. Finally, a part of that responsibility to take care of the land (people) is to ensure that the youth are equipped with the life skills necessary to create an optimum community once again. One of the Elders states “the path that we have followed is not recognizable to them. It is true however that the young people we talk about will be guided into the future to see that land in the way that we saw it”. For the Shoal Lake Elders, the teachings and the mind set they received from the old people have instilled in them a way of looking at life and ways to intent the future for the youth. The metaphorical mind speaks volumes of how people need to be tuned to the living pulse of the mothering earth. What befalls the land will befall the people.

First Nation Spiritual Philosophies

The spiritual practices, or the resources of the community people to respond to the unknown, are deeply embedded in the cultures of both communities involved in the study. The people’s spirituality and belief in a Supreme Being are continuous practices that have been observed in the community for many generations and the Elders tell us that the continuity of beliefs was a treasured gift from the ancestors. One Elder stated:

> I think that was the greatest gift. The drives they had so much in our old people long ago were so strong in their belief, in their Creator. The Creator gave them strength to survive those storms and those starvation times.

Presently, the Elders acknowledge that the belief in the Supreme Being is what has sustained the community people through many generations and through many changes. One lady Elder tells us so much. She states, "To me our belief and value system has a lot to do with where we are today, our survival and determination to our Creator". Another Elder also said that "[It] has always been our experience that we were always taken care of".

Many of the Elders displayed deep inwardness and by its expression revealed their innermost thoughts about the nature of their community existence. They have an inherent belief in the power of their spirituality to move the life-sustaining energies in ways that give them comfort. The spiritual life of the Elders meant that there was always recognition that life had meaning beyond the physical and that people had to transcend the earth bound gratifications. One of the Elders saw the need for higher levels of existence similar to the way the ancestors had lived their lives. He states:

> It is considerable how we are tied to earthly pleasures but it is dangerous because it will eventually destroy us. We see that already. We have to try and rise up and try to understand how we can assist the youth to live in good way, the way we have been treated by our parents in the past.

The spirituality of the James Smith and Shoal Lake people was manifested in various ways. For example, one Elder remembers that the old people of the past were a gifted people with human capabilities to forecast the weather and even to look into the future. She tells us:

> They were given gifts of foreseeing the future. They were told of the future path by somebody. I have no way of telling who told them these things, but they were powerful. They were never surprised at what was going to happen. They even had capabilities to forecast the weather, they knew those things.

The Elders suggest that the degree the people retain knowledge of the land would determine their coping capabilities in crisis situations. They also saw value in their culture because of their deep belief that it would be the primary factor that can guide them as they negotiate the future. One Elder stated that "that is the only thing that can assist us into the future as I think of it. That is what I have to stand up for as long as I am on this earth". Without a doubt, the spiritual culture in its various forms sustained the people through many years and the Elders recognize that it was important for the community people to return to those teachings. One of the Elders tells us that the ancestors "technology was good at that time too. Our medicine was good. Our medicine kept us going. We have to go back to some of those things".

Thought for the Future

The James Smith Elders saw changes happen in their territory, their community and in their people. They recognized that dependency and a general deterioration of values were hurting the people. As counter measures, the Elders identified education, skills development and values teachings as the necessary adjustments that the community would have to make to prepare the next generations for the future. In the community of Shoal Lake, the Elders had deep concerns about the challenges that their youth faced in times of shifting lifestyles and circumstances. The Elders in both communities looked deeply at their own roles to repatriate the youth to a knowledge system conducive to survival.

In the past, community life revolved around the rhythms and patterns of the natural environment. Values, language and the other components of culture were taught within this natural setting. Traditional ways, songs, ceremonies, and insights of First Nations knowledge are tied to the use of the land and the description and deeper understanding of those processes are embedded within indigenous languages. The Elders remembered that this knowledge held the community together as an integrated whole. The knowledge moulded the norms and collective cultural codes that explained how people should live and act within their natural and social environments. The Elders from James Smith and Shoal Lake spoke of these relationships and what it means to be a good human being. Therefore, the Elders clearly see the importance of sustaining connections to the land and environment as a foundation for maintaining cultural continuity and as the basis for healthy individuals.

Berkes and Jolly (2001) have suggested that it is important to consider issues of resilience and adaptation to a changing environment. Such lessons can be learned from First Nations communities that have adapted and responded to severe changes in the past. As global warming is a proven and progressing phenomenon, it will be necessary for human populations to adapt to, as well as attempt to lessen the impacts of, changing environments. Berkes and Jolly provide other examples of adaptive strategies used by the Inuvialuit community of Sachs Harbour to cope with a changing Arctic environment. They highlight the importance of traditional knowledge, both in terms of understanding what is happening on the land and in developing adaptive responses rooted in specific cultural contexts.

The Elders also looked deeply at their own roles and responsibilities to repatriate the youth to a knowledge system that they believe would enhance their adaptive capacity for the future. A part of this strategy for community adjustment was to focus on the youth and find ways that will transform their knowledge and teach skills to the youth for use in a future fraught with uncertainty.

Conclusion

Understanding past experiences and the responses by First Nations to multifaceted changes in their sociocultural dimensions could help broader society understand and determine individual and collective vulnerability and what the pertinent responses would be to irrepressible change the projected climatic dimension of the future would spawn. The two First Nation communities of James Smith and Shoal Cree Nations provided discourse about what happens to the human heart and soul, the epicentre of impact experience, when turbulent change occurs in the things that people care about. The central intent of this paper was to advance the thesis that understanding adaptation and adaptive capacity in the context of climate change can be enhanced by exploring the connections humans have with their natural environment. This paper examined the results of a study involving First Nation Elders and specifically looked at Elder memory and the value of Elder thought in the determination of how human collectives perceive and work with change. Memory work with Elders reveals how First Nation communities underwent changes not only in terms of their experience with the climate and the environment, but also in their socio-cultural dimensions where change was a central and engrossing issue. The Elder memory of the changes that happened to their people and disrupted the life of the community, the philosophies that inherently guided the people to confront unknowns, and the human capacities that help initiate a conciliation of the future were examined. Understanding our past responses to shifts in the human living condition can help mitigate social upheaval in the wake of climate change disruption and the prevention of human misery on a substantial and protracted scale.

References

Beck P, Walters A, Francisco N (1992) The sacred: ways of knowledge, sources of life. Navajo Community College, Arizona

Berkes F, Jolly D (2001) Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. Conserv Ecol 5(2):18. www.consecol.org/vol5/iss2/art18

Duerden F (2004) Translating climate change impacts at the community level. Arctic 57 (2):204–212

Ermine et al (2005) Report Isi Askiwan – The state of the land: Prince Albert Grand Council elders gathering on climate change. Climate Change Impacts and Adaptation Program, Ottawa, Ontario

Ermine W et al (2007) Report Isi Wipan – Climate: identifying the impacts of climate change and capacity for adaptation in two Saskatchewan first nation communities. Climate Change Impacts and Adaptation Program, Ottawa, Ontario

Ermine W, Pittman J, Sauchyn D (2008) Report Nikan Oti – Future: understanding adaptation and capacity in two first nations. Climate Change Impacts and Adaptation Program, Ottawa, Ontario

Fenge T (2001) The inuit and climate change. Isuma 2(4):79–85

Huntington HP (1998) Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51:237–242

Karl R, Trenberth KE (2003) Modern global climate change. Science 302:1721

Parkins J (2001) Locally defined indicators of community sustainability in the Prince Albert Model Forest. In: Information Report NQR-X-379. Canadian Forestry Service, Northern Forestry Center, Canada

Smit B, Pilifosova O (2003) From adaptation to adaptive capacity and vulnerability reduction. In: Smith JB, Klein RJT, Huq S (eds) Climate change, adaptive capacity and development. Imperial College Press, London, pp 9–28

Smithers J, Smit B (1997) Human adaptation to climate variability and change. Global Environ Change 7(2):129–146

Chapter 6
Mitigation of the Earth's Economy: A Viable Strategy for Insurance Systems

Liam Phelan, Ann Henderson-Sellers, and Ros Taplin

Abstract This paper proposes reflexive mitigation as an ecologically effective insurance system response to dangerous anthropogenic climate change. Reflexive mitigation is an adaptive approach to mitigating climate change recognizing (1) atmospheric CO_2e concentrations consistent with Earth system stability will vary over time in response to changes in the Earth system and the global economy, and in the relationship between them; and (2) relationships between the Earth system, the economy and the insurance system are evolving, and therefore understanding of them is necessarily incomplete. The paper presents a complex adaptive systems approach to anthropogenic climate change and demonstrates that the Earth system, the global economy and the insurance system are connected social–ecological systems. Current insurance system responses to anthropogenic climate change are generally adaptive and weakly mitigative rather than strongly mitigative. The paper argues successful insurance system adaptation to anthropogenic climate change depends on returning the climate to a stable, familiar and relatively predictable state: effective mitigation is therefore a necessary precondition for successful longer-term insurance system adaptation.

Keywords Adaptation with grace · Adaptive cycle · Climate change · Complex adaptive systems · Insurance · Reflexive mitigation · Social–ecological systems

Insurance Systems and Climate Change

This paper is about effective mitigation of climate change, and about the role the insurance system might play in this. We argue that whilst adaptation is essential for human welfare, mitigation is a strategic response to climate change for human

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social systems generally, and for the insurance system specifically. Climate change mitigation measures are those aimed at avoiding dangerous anthropogenic climate change by (1) significantly and rapidly reducing greenhouse gas emissions; and (2) protecting surviving carbon sinks (United Nations 1992).

Insurance has been described as "society's primary financial risk manager" (Hecht 2008, p. 1959). Given the magnitude of the risks climate change presents human societies, the nature of insurance system responses are important. Beginning in the early 1990s, insurance was repeatedly characterized as the industry with most to lose in a climate changed world, and therefore the business sector most likely to take a lead on mitigation (Gelbspan 1998; Leggett 1993; Sachs et al. 1998). The characterization of the industry as particularly vulnerable to climate change impacts persists, for example (Pinkse and Kolk 2009, p. 93). Yet insurance industry responses to climate change have emphasized adaptive and some weakly, rather than strongly, mitigative measures (Phelan et al. 2008, 2010).

Adaptation to climate change is necessary because some climate change impacts are already manifest, others are imminent, and there is a warming commitment in the Earth system which implies further impacts (Hansen et al. 2005, 2008). We describe adaptive responses as tactical as opposed to strategic insofar as they do not directly address the causes of the threat. Tactical measures can also support strategic action: for example adaptation can "buy time," while strategic mitigation measures take effect. However there is very little time available: mitigating climate change requires fundamental change urgently (Richardson et al. 2009).

The paper adopts a complexity theory approach (Bradbury 2003; Waltner-Toews et al. 2008). The complexity approach highlights dynamism internal to systems as well as cross-scale interaction between systems. This theoretical perspective is useful for engaging with disequilibrium systems such as the Earth system, characterized by non-linear change and capacity for surprise (Schneider 2004). We characterize the global economy and insurance system also as complex adaptive systems. We conceptualize the insurance system broadly as comprising all the participants and their relationships that together allow ongoing provision and use of financially viable insurance. This includes for-profit and mutual insurers, government providers of insurance, reinsurers, specialized service suppliers such as loss modellers and brokers, regulatory authorities and industry representative bodies. This system also includes the legal and institutional frameworks created and used to facilitate access to insurance. Investors in insurance companies as well as insurers' substantial investments are also included (Phelan et al. 2010).

Relationships between the three systems are key to this analysis and are described in Sect. 6.2. Section 6.3 proposes a strong mitigation scenario for the insurance system and introduces two new concepts: reflexive mitigation and adaptation with grace. In contrast, Sect. 6.4 critiques the insurance system's current adaptive and weakly mitigative approaches to climate change. Section 6.5 concludes the paper.

Linked Social–Ecological Systems

Open social–ecological systems are complex adaptive systems comprising co-evolving human–social and ecological elements, and which interact with other social–ecological systems (Berkes and Folke 1998). A standard analytical approach to linked social–ecological systems describes smaller social–ecological systems as *nested* in larger social–ecological systems (Gunderson and Holling 2002). Our analysis focuses on the insurance system embedded in the global economy, in turn nested in the foundational Earth system, the largest social–ecological system. The emphasis on system dynamism and cross-scale, inter-system interaction (1) highlights phenomena which result from cross-scale interaction (i.e. carbon emissions from the global economy impacting the state of the Earth system, as well as opportunities to effect change in the relationship between the insurance system and the economy); and (2) is conducive to exploring opportunities for making changes in one system in order to drive changes in another system.

Complexity theory is still in its infancy and

> "tends to employ an eclectic collection of theories and methodologies designed to deepen our limited understanding of the properties of complex adaptive systems" (Finnigan 2003, p. xi).

Complex adaptive systems (CASs) approaches have been applied in a range of disciplines (Anderson et al. 2005; Hartvigsen et al. 1998; Milne 1998). CAS approaches to social–ecological systems are still very much in flux, and continuing to be advanced (Gallopín 2006; Janssen and Ostrom 2006; Walker et al. 2006).

CASs theory explains systems' capacity to adapt and evolve as well the inherent unpredictability characteristic of complex adaptive systems. A complexity approach is useful and appropriate for our study of the insurance system because it (1) conceptualises integrated ecological and human social systems as social–ecological systems; (2) uses clear and economical language to describe system dynamics and cross-scale interactions between systems; and (3) supports multidisciplinary approaches to complex issues such as climate change. The theory accommodates the ambivalent role of the insurance system in dangerous anthropogenic climate change. Even as society looks to the insurance system for risk management, including management of climate risks, the insurance system simultaneously contributes to the creation of climate risks through the interconnectedness of the insurance system and the global economy.

Three Systems . . .

Both Lovelock's "Gaia" (Lovelock 2007) and Crutzen and Stoermer's "anthropocene" (Crutzen 2002; Crutzen and Stoermer 2000) convey the sense of a co-evolutionary process engaging ecological and human–social systems at global scale. Increasing anthropogenic CO_2e emissions causing changes in the Earth's climate, which in turn drive changes in human societies, is emblematic of the linked and co-evolutionary processes of ecological and human social systems at global scale. *Earth system science* and *global environmental governance*, originating in the natural and social sciences respectively, are research areas grounded in an understanding of the Earth system comprising intertwined ecological and human–social elements (Biermann 2007; Schellnhuber 1999; Steffen et al. 2003; Young et al. 2006).

The global economy has also been analysed as a complex adaptive system (Arthur et al. 1997; Beinhocker 2006). Beinhocker (2006) makes a detailed case for the superiority of complexity theory's explanation of economies as disequilibrium systems over orthodox equilibrium accounts. However whilst Beinhocker grounds his economic theory in physical reality, his thesis fails to connect with ecological reality, for example the notion of limits (e.g. Meadows et al. 2004; Meadows and Club of Rome 1972). In contrast Daly's earlier "steady state economy" approach (Daly 1982) clearly recognizes the social–ecological character of the economy, and in so doing makes the strong argument for a theoretical understanding of economy that recognizes Earth system limits.

We use the term insurance "system" and not "industry" purposely to bring focus to all of the participants and their relationships that together allow ongoing provision and use of financially viable insurance. This explicitly includes welfare state-style social insurances such as universal health care, unemployment benefits and age and disability pensions. Also included are participants in what is more commonly understood to be the insurance industry such as for-profit and mutual insurers, government insurers, reinsurers, specialized service suppliers such as loss modellers and brokers, government regulatory authorities and industry representative bodies. Investors in insurance companies as well as insurers' substantial investments are also included. The term also includes the legal and institutional frameworks created and used to facilitate access to insurance (Phelan et al. 2010).

. . .in Relationship

The conceptual approach to linked social–ecological systems is articulated graphically below. Figure 6.1 includes the Earth system, the global economy, and the insurance system, together with key cross-scale interactions relevant for this analysis. Indicative financial values are provided for the global economy and the insurance system to convey a comparative sense of scale. Values where indicated are generally for 2007, the most recent year for which disparate data is available, providing a systems "snapshot" from that year.

The global economy is valued (in 2007) at ~US$54 trillion (Swiss Re 2008, p. 8). A definite figure for the value of the insurance system overall remains elusive: data is available for some elements of the insurance system including both the insurance industry and state-funded social insurance, suggesting that the value for the

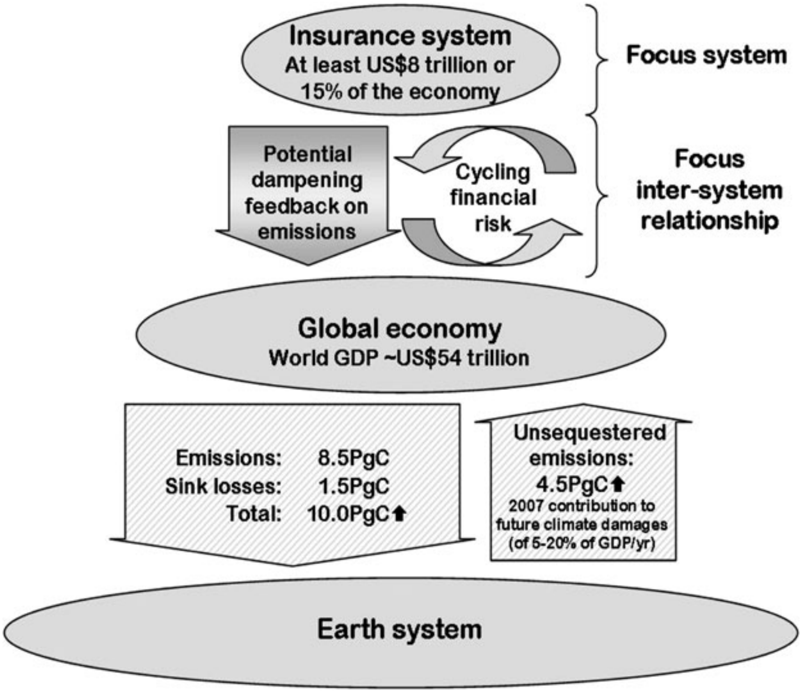

Fig. 6.1 The insurance system, the global economy and the Earth system, and key interactions among them: a "snapshot" from 2007

insurance system overall is large. For example, premiums – the major source of revenue for the insurance industry totalled US$4 trillion in 2007, and investment income generated an additional US$1 trillion for insurers (Mills 2009; Swiss Re 2008). Data for social insurance is even less comprehensive but what data is available underscores the magnitude of the insurance system. Health expenditure alone financed through social insurance totalled US$1.2 trillion globally (in 2006) (WHO 2009). Other key areas of state-financed social insurance expenditure are unemployment benefits and age and disability pensions (see OECD 2007, pp. 76–77). The modern welfare state, which includes forms of social insurance, is most developed in Europe, and some data and projections are available for European Union (EU) countries: unemployment benefit expenditure (for 2007) is projected at 0.85% of EU GDP (Economic Policy Committee and DG 2006, p. 190), i.e. circa US $142 billion.[1] Gross public pension expenditure (for 2010) is projected at 10.3% of EU GDP (Economic Policy Committee and DG 2006, p. 71),[2] i.e. US$1.8 trillion.

[1]Unemployment benefit spending projection for the EU25 group of countries. Combined GDP for the EU27 countries in 2007 totalled €12.3 trillion (European Union 2009) Currency figures converted using mid-2007 rates.

[2]Figure for the EU25 group of countries (excluding Greece).

On the basis of the above information, limited sectorally and jurisdictionally, we conservatively suggest the value of the insurance system globally is at least US$8 trillion (in 2007), at least 15% of the global economy and as such a significant subsystem. In Fig. 6.1 the Earth system remains unvalued in financial terms: for the purposes of our analysis it is sufficient to note the Earth system is without substitute and the existence of the other systems represented is wholly dependent on the Earth system (Daily 1997). The overall triangle shape of the figure with the Earth system placed at the base reflects this perspective.

Arrows between systems indicate cross-scale, inter-system relationships of interest for this analysis. Emissions from the global economy into the Earth system, and in return, future climate damages from the Earth system to the global economy are presented and valued in units of carbon emissions in 2007. Anthropogenic emissions are valued at 10 PgC,[3] comprising 8.5 PgC of emissions and 1.5 PgC of losses in surviving carbon sink capacity (Global Carbon Project 2008). Whilst the figure presents a static "snapshot" from 2007, global emissions continue to increase and this is indicated by the upward-pointing arrow immediately following the emissions figure. In 2007 the Earth system sequestered 55% of anthropogenic emissions, leaving 4.5 PgC of emissions remaining in the atmosphere (Global Carbon Project 2008). In Fig. 6.1 this is represented as 2007s contribution to future climate damages returning to the global economy as changes to familiar and reliable weather and climatic conditions. Future climate damages will result from shocks such as extreme weather events, and stresses such as longer-term impacts such as changes in the location and viability of agricultural zones.

As total anthropogenic emissions continue to accumulate the Earth system's efficiency in sequestering emissions is reducing (Global Carbon Project 2008). In combination with increasing emissions, this suggests an increasing rate over time of global emissions that remain unsequestered, indicated by upward-pointing arrow immediately following the emissions figure.

In Fig. 6.1 the inter-system relationship between the global economy and the insurance system is dominated by a cycling of financial risk. The socio-economic function of the insurance system is to assume financial risk. The insurance system pools and transfers risks across the economy. Ultimately, the insurance system is wholly nested within the economy, and therefore financial risks, even when shifted via the insurance system, remain internal to the economy. Traditional examples include insurers' substantial investments (in the case of the insurance industry) and governments' treasuries (in the case of social insurance). More recently insurers have also begun to spread risk outside of the insurance system and onto capital markets through catastrophe bonds and other financial instruments collectively known as insurance-linked securities (Phelan et al. 2010). This allows access to the greater financial capacity of capital markets, and also demonstrates the cycling of financial risk between and across the insurance subsystem and the broader economy.

[3] 1 Pg (petagram) = 1 billion (or 1,000 million) tonnes.

The focus of this paper is the theoretical potential for gearing the insurance system to drive or at least support cuts in anthropogenic emissions from the economy sufficiently rapidly and deeply to avoid dangerous climate change. In Fig. 6.1 this system interaction is also located in the relationship between the insurance system and the economy and represented by the downward arrow.

The insurance system is depicted as nested within the global economy, and in turn within the Earth system. Financial risk cycling (semi-circular arrows) by the insurance system pools and spreads climate (and other financial) risks across the global economy. Reflexive mitigation action by the insurance system may create beneficial dampening (or negative) feedback effects between the insurance system and the global economy (downward arrow from the insurance system to the global economy), and so encourage or even drive reduction in anthropogenic emissions from the global economy. The value of insurance system activity in 2007 is at least US$8 trillion[4] or 15% of the global economy, valued that year at ~US$54 trillion.

The Earth system incorporates the physical and chemical environment, the biosphere and also all human activities. The Earth system is without substitute and for the purposes of our analysis the Earth system remains unvalued in financial terms. Current anthropogenic CO_2e emissions and future climate damages are the key interactions between the global economy and the Earth system (this figure represents CO_2 only, the major greenhouse gas). In 2007 the atmospheric "insult" from the global economy comprises CO_2 emissions totalling ~8.5 PgC[5] and destruction of CO_2 sinks of ~1.5 PgC totalling an additional 10 PgC. "⬆." In 2007 around 45% of CO_2 emissions remained in the atmosphere, destined to return to the global economy as increased climate-related damages. The proportion of CO_2 emissions that remain unsequestered by the Earth system is also increasing over time, also indicated by an "⬆". Stern (2006) estimates future climate damages in the order of 5–20% of global GDP each year in the absence of strong mitigation.

Why Mitigation Is a Necessity for Insurance Systems

"Insurance is a means of constructing the promise of economic security in a precarious and uncertain world." (Knights and Vurdubakis 1993, p. 734). Yet the insurance system is a human–social system and not immune to the impact of anthropogenic climate change on Earth system stability. Fundamentally, financial risk in the global economy is manageable in the Earth system because of familiar system stability. Where the system remains in a familiar and stable state, past experience provides a reasonable guide for future experience. However a changing climate renders the Earth system unstable and characterized by unpredictable change (Schneider 2004).

[4] 1 trillion = 1,000 billion.

[5] 1 Pg (petagram) = 1 billion (or 1,000 million) tonnes.

On a timescale of interest to humans and our societies, the sum of climate change-related feedbacks in the Earth system is positive, i.e. climate change leads to feedbacks that reinforce rather than dampen changes in the climate (Allen and Frame 2007; Roe and Baker 2007). With warming, net positive feedback leads to further increases in warming so that climate pushes the Earth system further away from a familiar stable state to an alternate state which, whether stable or unstable, is unfamiliar. The non-linear quality of the change means the rate of the shift is continually increasing. Some aspects of non-linearity are reflected in recent predictions of the magnitude and timing of climate change impacts: in practice observed rates of climate change are repeatedly underestimated (Phelan et al. 2010). Additionally, Earth system thresholds means rates of change are uneven and unpredictable. Over time, increasing unpredictability tends to undermine the viability of the insurance system (Phelan et al. 2010).

Insurance responses to climate change to date are generally adaptive and weakly mitigative (Phelan et al. 2010). On the basis of a strictly linear understanding of insurance, adaptation measures appear as reasonable insurer responses to the threat of catastrophic losses. Adapting the insurance system to climate change allows greater capacity to take on risk short term. However, given the Earth system is a non-linear system, the long-term viability of adaptation strategies is limited. What appears to be an adaptation may in fact prove to be a maladaptation. In Sect. 6.3 we make a normative argument for the insurance system to pursue a strongly mitigative path. In contrast, Sect. 6.4 describes the current adaptive and weakly mitigative trajectory of the insurance system with reference to climate change.

Reflexive Mitigation: A Viable Insurance System Approach

Reflexive mitigation offers the insurance system's an alternative to adaptive and weakly mitigative responses to climate change. In this section we apply a four-phase *adaptive cycle* (Holling and Gunderson 2002) used to represent the evolving state of social–ecological systems, to demonstrate change in the insurance system as it travels a reflexive mitigation path. The adaptive cycle has been developed as an heuristic to explain change processes in social–ecological systems.

In this section we make a normative argument: reflexive mitigation ought to be pursued by the insurance system because in contrast to adaptive and weakly mitigative approaches, it offers the potential for ongoing viability of the insurance system. Given broader human societal reliance upon the insurance system, the approach supports the insurance system to make a significant contribution to the sustainability of human–social systems more generally, consistent with insurance's role as society's primary risk manager. The section concludes with a brief note on the relationship between climate change mitigation and adaptation measures.

Our argument is that reflexive mitigation is an ecologically effective – and therefore strategic – response to climate change. We use the term *reflexive* in two ways. First, in the Beckian (Beck 1992, 1995) sense: climate change is a creation of our own making, rather than a risk originating in the natural world. Further, climate change risk is large-scale and challenging spatially (i.e. global) and temporally (i.e. multi-generational in the making, requiring at a minimum many decades to mitigate, with varying aspects of the phenomenon manifesting at varied timescales, and with some committed impacts effectively permanent (Solomon et al. 2009). Climate change is a characterizing feature of Beck's late-modern civilization. The obvious corollary to this analysis is that halting and reversing anthropogenic climate change centres on changes in human–social systems.

Second, using the term *reflexive* emphasizes that we advocate adaptive policy-making (TERI and IISD 2006) in relation to mitigation. Such an approach recognizes that the Earth system, the global economy and the insurance system are connected social–ecological systems at varying scales. Accordingly (1) maximum atmospheric CO_2e concentrations consistent with achieving and maintaining Earth system stability will vary over time in response to changes in the Earth system, the global economy, and the relationship between them; and (2) relationships between the Earth system and smaller component systems including the global economy and the insurance system are evolving and therefore understanding of them is necessarily, and permanently, incomplete.

Ecologically effective mitigation refers to mitigation that delivers cuts in anthropogenic emissions sufficiently rapidly and deeply to avoid dangerous climate change. Industrialization has produced a rise in atmospheric CO_2e concentrations from pre-industrial levels of 280 ppm to current levels of 385 ppm – and concentration levels continue to rise. In contrast, a drop in concentrations to at least 350 ppm – and perhaps lower – is required (Hansen et al. 2008). A reflexive approach to mitigation aims for specific atmospheric concentration levels whilst acknowledging that scientific understanding of what levels are necessary will likely continue to change.

Figure 6.2 presents a reflexive mitigation scenario for the insurance system. The initial *conservation* phase describes the current state of the insurance system: the system has accumulated substantial financial and intellectual capital, is founded on a linear understanding of the Earth system, and is viable on the basis of the Earth remaining in a familiar and relatively stable state, where past experience provides a reasonable guide to future experience. The insurance system is therefore vulnerable to anthropogenic greenhouse gas emissions pushing the Earth system out of its current familiar and stable state.

Potential *release* phase events are combinations of sudden shocks and accumulated stresses, originating in climate changes in the larger Earth system, that increase the insurance system vulnerabilities indirectly through impacts to the global economy as well as directly. Shock events include weather catastrophes such as floods and heatwaves (Allen et al. 2007). Stress events include climate impacts such as multi-year droughts, effectively permanent shifts in rainfall patterns, and sea-level rise (Solomon et al. 2009). Climate change impacts can cascade though the global economy, impacting the insurance system in multiple ways. Over time uncertainty increases and predictability and insurability decrease. Insurance system stability decreases, as does societal faith in the insurance system.

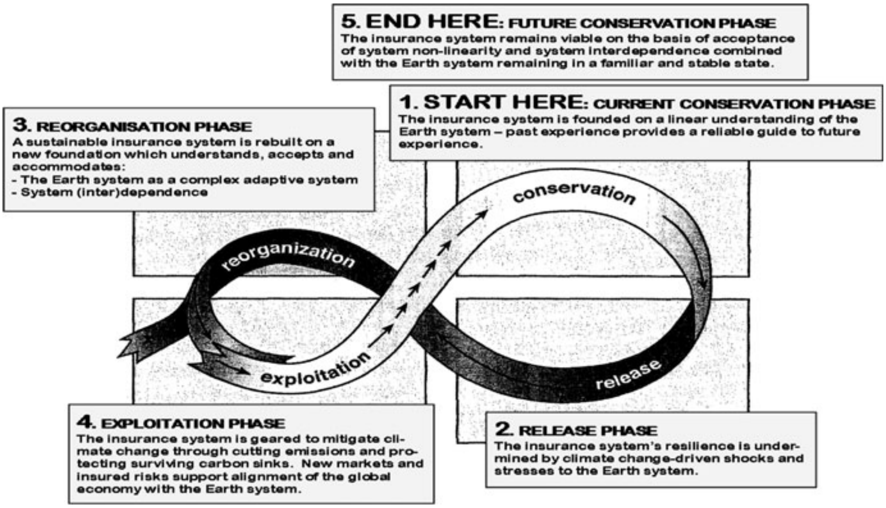

Fig. 6.2 An alternative path for the insurance system: reflexive mitigation and insurance system sustainability. Source: Adapted from Holling and Gunderson 2002, p. 34

The four-phase adaptive cycle is an heuristic developed to explain change processes in social–ecological systems. It is applied here to demonstrate the insurance system's potential transition from a linear to a non-linear operational basis. The cycle begins (at "1") with a description of the insurance system in it current form, characterized by a linear understanding of the Earth system. In the current *conservation* phase, past experience remains a reliable guide to future experience, giving meaning to terms such as "1 in a 100 year flood." The *release* phase (at "2") sees the insurance system's resilience undermined by unanticipated climate change-driven shocks and stresses, reflective of climate change having pushed the Earth system from a state of relative predictability to relative unpredictability. The implications of climate change on the insurance system are acknowledged and the *reorganization* phase (at "3") sees the insurance system rebuilt on an new foundation which recognizes (1) the Earth system is a complex adaptive system, and (2) interdependence of systems, and in particular, the dependence of the insurance system and the global economy on the Earth system remaining in a stable and familiar state. The *exploitation* phase (at "4") sees the insurance system geared to climate change mitigation through rapid and deep cuts in greenhouse gas emissions and protecting surviving carbon sinks. New governance arrangements see the insurance system used to encourage the alignment of the global economy with Earth system limits. Climate change is effectively mitigated and the insurance system enters a new *conservation* phase (at "5"), remaining viable on the basis of the Earth system remaining in a stable and familiar state.

At the *reorganization* phase, a new sustainable foundation for the insurance system is created, grounded in acceptance of system non-linearity, system interdependence, and in particular, the dependence of the insurance system and the global economy on the Earth system. This implies substantial change to insurance system structure and practice. The insurance system disengages from climate change risk-creating activity (e.g. insuring and investing in the fossil fuel sector). This action alone supports reflexive mitigation policy and action in other social–ecological subsystems that are components of the overall economy. Instead, the insurance system is reoriented around strongly mitigative and adaptive approaches to climate change.

At the *exploitation* phase, characterized by rapid growth, the insurance system is fully geared to mitigate climate change through supporting cuts in emissions and protecting surviving carbon sinks. The global economy is rapidly decarbonized. Such a shift is not wholly due to changes in the insurance system, however the larger change process in the global economy creates new risk management and opportunities for the insurance system. This is a significant shift for the insurance system and for the economy overall, and is achieved through many failures and some successes. Managing financial risk remains an important function in the economy.

This path leads to a genuinely new *conservation* phase, characterized by accumulation of financial and intellectual capital, where the insurance system is reconstituted on the basis of a non-linear understanding of the Earth system and recognition of system interdependence, and remains viable on the basis of the Earth system remaining in a familiar and stable state. A decarbonized global economy implies significant socio-economic change, include the nature of risks covered and the manner in which they are covered by the insurance system.

Did a Reflexive Mitigation Path for Insurance Appear Post-Katrina?

Unprecedented events in the production and certification of catastrophe modelling in Florida in the aftermath of Hurricane Katrina can perhaps be described as an abortive transition by the insurance system to a reflexive approach to insurance in a climate-changed world. The Florida Commission on Hurricane Loss Projection Methodology (FCHLPM) was created in 1995 to evaluate computer models and other recently developed or improved actuarial methodologies for projecting hurricane losses, to ensure reliable projections of hurricane losses so that rates for residential property insurance are neither excessive nor inadequate (FCHLPM 2009). Catastrophe loss modellers submit their loss models to the FCHLPM annually for accreditation. Once accredited, loss modellers can provide their models to insurers as a basis for pricing hurricane risk.

In April 2007 the FCHLPM refused to accept Risk Management Solutions (RMS) RMS's US Hurricane Model (version six) because it gave more weight to higher levels of hurricane activity in recent years rather than simply averaging hurricane activity over the longer term (RMS 2007). The standard approach since the first generation of hurricane catastrophe loss models has been to base hurricane activity rates on the "average of history" (Muir-Wood and Grossi 2008, p. 310). In the US this generally means the period since 1900. However, in the period since 1995, and in comparison to the period 1970–1994, hurricane activity in the Atlantic basin has increased by 60%, with an increase in intense category 3–5 storms of 120%. In 2004 and 2005, storms including Katrina also made landfall in the US. "Acknowledging that the long-term historical baseline is no longer the best measure of current hurricane activity means it is necessary to be explicit about the intended time horizon of the catastrophe model" (Muir-Wood and Grossi 2008, p. 311). From a CAS perspective, the more important point is it also means acknowledging non-linearity in the Earth system.

After refusal, a modified model incorporating the standard long-term historical baseline was submitted, which the FCHLPM subsequently accepted. The impasse was resolved simply by RMS complying with the provisions of the law. Nevertheless RMS continues to assert that the medium-term basis for projecting hurricane activity is better than the traditional long-term basis (RMS 2007). This highlights questions of sustainability of the insurance system in the longer-term. Muir-Wood et al. (2006) suggest that after accounting for changes in population and wealth, changes in extreme weather events may be responsible for a growth in insured losses by about two percent a year since the 1970s, and that this corresponds with rising global temperatures (Muir-Wood et al. 2006; Ward et al. 2008).

A Stable Basis for Adaptation with Grace

We argue that mitigation and adaptation approaches are linked: effective mitigation is a precondition for effective adaptation. We consider *adaptation with grace* as effective adaptation undertaken in an orderly and planned manner, embodying important principles of justice and equity, and with some hope of longevity. Adaptation with grace is wholly dependent on relative system stability provided by reflexive mitigation.

Adaptation to anthropogenic climate change in support of human welfare is necessary, given manifest climate change impacts and existing warming commitment in the Earth system (Hansen et al. 2008). Limits to climate change impacts – and therefore a basis for effective adaptation over the longer-term – relies on urgent mitigation action so that the Earth system remains in its current familiar and stable state. In the absence of familiar Earth system stability, potential adaptation efforts will be limited to *ad hoc* and reactive measures with reduced prospects for reflecting widely-shared ideas of fairness and equity, and with the term of benefits constrained by further changes in the Earth system.

Adaptation to Climate Change: Business-as-Usual

Attempting to survive changed circumstances under varied, even extreme conditions is standard practice for human beings, human institutions, and for living organisms generally. For this reason we suggest the insurance system's generally adaptive and weakly mitigative responses to climate change (Phelan et al. 2010) may be reasonably described business-as-usual (BAU). Adaptation measures may be characterized as proactive or reactive and may be successful or unsuccessful in result. Whatever the character or outcome of an adaptive response, adaptation is always a reaction to context as opposed to a conscious shaping of context. In this section we reprise the four-phase *adaptive cycle* used in the previous section to contrast the insurance system's current response to climate change. The key limitation of adaptive and weakly mitigative approaches to climate change is their basis in a linear rather than non-linear understanding of the Earth system: this is the source of risk in the approach.

In conceptualizing the insurance system pursuing an adaptive, BAU path, the initial *conservation* and *release* phases representing the current state of the insurance system and the impact on the system of climate risks are common to both the adaptation scenario and the mitigation scenario explored previously.

Paths diverge at the *reorganization* phase: in the BAU scenario, the extent of reorganization is minimal and the linear understanding of insurance remains. The insurance system adapts by making internal changes to compensate for climate change impacts to the global economy and to the insurance system itself. The system overall and elements within it are rebuilt and consolidated around reset linear understandings of the Earth system and cross-scale interactions. Examples include recalculation of maximum probable losses, increases to deductibles and limits to cover, industry withdrawal of cover from high-risk areas in extreme cases, and governments establishing state-backed insurance schemes to compensate for industry withdrawal. The insurance availability crisis is understood and responded to as a market failure and is not recognized as a system failure and instead: from this perspective, industry consolidation and government bailouts appear to be sound solutions. The insurance system have travelled this path previously, in relation to climate change and other risks. Examples include: insurers withdrawing cover for hurricane damage in Florida; and governments instituting state-backed insurance coverage in the face of industry withdrawal (Mills et al. 2005).

At the *exploitation* phase adaptive responses include efforts to increase capacity for accommodating risk internally to the insurance system and efforts to shift risk up scales beyond the insurance system. Examples include recalculating estimates of maximum probable losses on a linear basis, risk swaps to spread uncorrelated risks such as hurricanes in the Caribbean and earthquakes in Japan (Cummins 2007), and insurers creating insurance-linked securities is one example noted above. Shifting financial risk up a scale from the insurance system to the global economy without effectively dealing with the source of climate risk comes at a price: larger-scale risk and therefore higher stakes. The 2008 Global Financial Crisis is an example of larger-scale risk impacting the global economy as a whole and with specific implications for insurers by virtue of inter-system linkages. Whilst successful adaptive measures can increase system capacity to manage financial risk in the short term, they mask the cost of larger-scale failure later.

At the second iteration of the *conservation* phase, the "new" state of the insurance system resembles the previous state. The risks to insurance system viability are greater. Over time the cycle of system collapse and rebuilding is repeated, perhaps at accelerating frequency, and certainly at greater magnitude. Overall the potential for viable the insurance system is much more constrained: repeated shocks and accumulated stresses take their toll on the overall system. Ultimately, insurance system resilience is undermined to the extent the system flips into an alternate state. Even as the current state of the system no longer remains, it may be that insurance in some form remains viable. For example, insurance for risks could remain viable at significantly reduced geographic and temporal scales. Insurance for total losses may be replaced by partial loss insurance. Thus BAU insurance system responses constitute a high-risk approach to climate change, one in which the longer-term viability of the insurance system overall is unclear.

Conclusion

We suggest the future viability of the insurance system in its current state is dependent on decarbonizing the global economy. A CAS analysis demonstrates this by highlighting the non-linearity of the Earth system as a complex adaptive system, and linkages between the Earth system, the global economy, and the insurance system. In contrast, the insurance system currently operates on the basis of an incompatible linear understanding of the Earth system. In this context apparent adaptive responses of the insurance system to climate change may prove to be maladaptive responses. Adaptation is not an ecologically effective response to climate change for social–ecological systems nested within the economy, including the insurance system.

The implications of this conclusion are profound. Insurance formalizes risk pooling and shifting. Given contemporary societal reliance on insurance, large sections of the global economy would be radically reshaped were the insurance system substantially transformed, or were access to insurance to become more difficult. Depending on the extent and pace of the transformation of the insurance system, this might imply rapid socio-economic change on an unprecedented scale.

Despite insurance's long history (Pfeffer and Klock 1974; Trennery 1926), large populations globally continue to survive with minimal engagement with formal the insurance system such as the welfare state and insurance markets. As we've argued, attempted adaptation is possible under all sorts of conditions. Risk sharing is also arranged informally, for example within families and communities. Societies can exist without insurance systems: even the end of insurance as we know it does not mean the end of human societies.

The insurance system may still function if pushed into an alternate state, though perhaps in a way that is currently unrecognizable. For example, insurance coverage may be available but in a substantially reduced form. This includes reductions in the spatial and temporal scales at which insurance operates, the type and magnitude of risks that are insurable, and the degree of compensation available for losses.

Decarbonizing the global economy is an extraordinary challenge but one that the insurance system can address proactively. Commitments to carbon use in human–social systems are infrastructural, financial, political economic and socio-cultural. The insurance system is as ensnared by such commitments as other sectors in the global economy. In contrast, the existing warming commitment in the Earth system implies processes and impacts that cannot be wound back: commitments to warming already present in the Earth system are non-negotiable. Forcing the ecologically necessary shift in the global economy is an enormous challenge, but an attractive one to the extent that it offers an upper limit to climate impacts.

The challenge of decarbonizing the global economy calls for thinking at large scale, spatially and temporally. The insurance system alone cannot achieve this; equally, decarbonizing the global economy will not be achieved without a full contribution from the insurance system. Reflexive mitigation is proposed here as an insurance system response to climate change. It may be that reflexive mitigation strategies are appropriate for other social–ecological subsystems of the global economy also. Successful reflexive mitigation of climate change holds out real prospects for effective adaptation to climate change, adaptation with grace.

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References

Allen M, Pall P, Stone D, Stott P, Frame D, Min SK, Nozawa T, Yukimoto S (2007) Scientific challenges in the attribution of harm to human influence on climate. Univ PA Law Rev 155:1353–1400

Allen MR, Frame DJ (2007) Call off the quest. Science 318:582–583

Anderson RA, Crabtree BF, Steele DJ, McDaniel RR Jr (2005) Case study research: the view from complexity science. Qual Health Res 15:669–685

Arthur WB, Durlauf SN, Lane DA (1997) Introduction. In: Arthur WB, Durlauf SN, Lane DA (eds) The economy as an evolving complex system II. Santa Fe Institute, Addison-Wesley, Santa Fe, NM, USA

Beck U (1992) Risk society: towards a new modernity. Sage, London, 260 p

Beck U (1995) Ecological enlightenment: essays on the politics of the risk society. Humanities Press, Atlantic Highlands, NJ, V, 159 p

Beinhocker ED (2006) The origin of wealth: evolution, complexity, and the radical remaking of economics. Harvard Business School Press, Boston, MA, USA

Berkes F, Folke C (eds) (1998) Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge, UK

Biermann F (2007) 'Earth system governance' as a crosscutting theme of global change research. Glob Environ Change 17:326–337

Bradbury R (2003) Towards a new ontology of complexity science. In: Perez P, Batten D (eds) Complex science for a complex world: Exploring human ecosystems with agents. ANU E Press, Canberra, Australia

Crutzen PJ (2002) Geology of mankind. Nature 415:23

Crutzen PJ, Stoermer EF (2000) The "Anthropocene". Int Geosph Biosph Prog Newsl 41:16–18

Cummins JD (2007) CAT bonds and other risk-linked securities: state of the market and recent developments. Risk Manage Insurance Rev 11(1):23–47

Daily GC (ed) (1997) Nature's services: societal dependence on natural ecosystems. Island, Washington DC, USA

Daly H (1982) The steady state economy: What, why and how? In: Birrell R, Hill D, Stanley J (eds) Quarry Australia? Social and environmental perspectives on managing the nation's resources. Oxford University Press, Melbourne, Australia

Economic Policy Committee & DG ECFIN (2006) The impact of ageing on public expenditure: projections for the EU25 Member States on pensions, health care, long-term care, education and unemployment transfers (2004–2050). Special Report No.1/2006. European Commission (Directorate-General for Economic and Financial Affairs), Strasbourg, France

European Union (2009) Key facts and figures about Europe and the Europeans. European Union, Europe

FCHLPM (2009) Florida Commission on Hurricane Loss Projection Methodology. FCHLPM, FL, USA

Finnigan JJ (2003) Foreword. In: Perez P, Batten D (eds) Complex science for a complex world: exploring human ecosystems with agents. ANU E Press, Canberra, Australia

Gallopín GC (2006) Linkages between vulnerability, resilience, and adaptive capacity. Glob Environ Change 16:293–303

Gelbspan R (1998) The heat is on: the climate crisis, the cover-up, the prescription. Perseus Books, Reading, MA, USA

Global Carbon Project (2008) Carbon budget and trends 2007

Gunderson LH, Holling CS (eds) (2002) Panarchy: understanding transformations in human and natural systems. Island, Washington DC, USA

Hansen J, Nazarenko L, Ruedy R, Sato M, Willis J, Del Genio A, Koch D, Lacis A, Lo K, Menon S, Novakov T, Perlwitz J, Russell G, Schmidt GA, Tausnev N (2005) Earth's energy imbalance: confirmation and implications. Science 308:1431–1435

Hansen J, Sato M, Kharecha P, Beerling D, Berner R, Masson-Delmotte V, Pagani M, Raymo M, Royer DL, Zachos JC (2008) Target atmospheric CO_2: where should humanity aim? Open Atmos Sci J 2:217–231

Hartvigsen G, Kinzig A, Peterson G (1998) Use and analysis of complex adaptive systems in ecosystem science: overview of special section. Ecosystems 1:427–430

Hecht SB (2008) Climate change and the transformation of risk: insurance matters. UCLA Law Rev 55:1559–1620

Holling CS, Gunderson LH (2002) Resilience and adaptive cycles. In: Gunderson LH, Holling CS (eds) Panarchy: understanding transformations in human and natural systems. Island, Washington DC, USA

Janssen MA, Ostrom E (2006) Resilience, vulnerability, and adaptation: a cross-cutting theme of the international human dimensions programme on global environmental change. Glob Environ Change 16:237–239

Knights D, Vurdubakis T (1993) Calculations of risk: towards an understanding of insurance as a moral and political technology. Acc Org Soc 18:729–764

Leggett J (1993) Climate change and the insurance industry: solidarity among the risk community? Greenpeace, Amsterdam

Lovelock J (2007) The revenge of Gaia: why the Earth is fighting back – and how we can still save humanity. Penguin, London, UK

Meadows DH, Club of Rome (1972) The limits to growth: a report for the Club of Rome's Project on the Predicament of Mankind. Earth Island, London, UK

Meadows DH, Randers J, Meadows D (2004) Limits to growth: the 30-year update. Chelsea Green, White River Junction, VT, USA

Mills E (2009) From risk to opportunity 2008: Insurer responses to climate change. Ceres, Boston, MA, USA

Mills E, Roth RJ Jr, Lecomte E (2005) Availability and affordability of insurance under climate change: A growing challenge for the United States. Ceres, Boston, MA
Milne BT (1998) Motivation and benefits of complex systems approaches in ecology. Ecosystems 1:449–456
Muir-Wood R, Grossi P (2008) The catastrophe modeling response to Hurricane Katrina. In: Diaz HF, Murnane RJ (eds) Climate extremes and society. Cambridge University Press, Cambridge, UK
Muir-Wood R, Miller S, Boissonade A (2006) The search for trends in a global catalogue of normalized weather-related catastrophe losses. In: Workshop on climate change and disaster losses: Understanding and attributing trends and projections. Final Workshop Report. Hohenkammer, Germany
OECD (2007) Society at a glance: OECD social indicators, 2006 edn. Organisation for Economic Cooperation and Development, Paris, France
Pfeffer I, Klock DR (1974) Perspectives on insurance. Prentice-Hall, Englewood Cliffs, NJ, xiii, 513 p
Phelan L, Taplin R, Albrecht G (2008) A powerful agent of long-term socio-ecological governance? The global insurance industry as a driver for greenhouse mitigation and adaptation. In: 2008 Berlin Conference on the Human Dimensions of Global Environmental Change. Environmental Policy Research Centre, Freie Universität, Berlin
Phelan L, Taplin R, Henderson-Sellers A, Albrecht G (2010) Ecological viability or liability?: Insurance system responses to climate risk. submitted for publication
Pinkse J, Kolk A (2009) International business and global climate change. Routledge, London and New York
Re S (2008) Sigma No3/2008: World insurance in 2007. Swiss Re, Zurich, Switzerland
Richardson K, Steffen W, Schellnhuber HJ, Alcamo J, Barker T, Kammen DM, Leemans R, Liverman D, Munasinghe M, Osman-Elasha B, Stern N, Wæver O (2009) Synthesis report. Climate change: global risks, challenges and decisions. University of Copenhagen, Copenhagen
RMS (2007) RMS announces estimated hurricane activity rates for 2008 to 2012 [media release 20 Nov 2007]. Risk Management Solutions
Roe GH, Baker MB (2007) Why is climate sensitivity so unpredictable? Science 318:629–632
Sachs W, Linz M, Loske R, Wuppertal Institute for Climate Environment and Energy (1998) Greening the North: a post-industrial blueprint for ecology and equity. Zed, London, xii, 247 p
Schellnhuber HJ (1999) 'Earth system' analysis and the second Copernican revolution. Nature 402 (Suppl):C19–C23
Schneider SH (2004) Abrupt non-linear climate change, irreversibility and surprise. Glob Environ Change 14:245–258
Solomon S, Plattner G-K, Knutti R, Friedlingstein P (2009) Irreversible climate change due to carbon dioxide emissions. Proc Natl Acad Sci USA 106:1704–1709
Steffen W, Sanderson A, Tyson P, Jäger J, Matson P, Moore B III, Oldfield F, Richardson K, Schellnhuber HJ, Turner BL II, Wasson RJ (2003) Global change and the Earth system: a planet under pressure. Springer, Berlin
TERI and IISD (2006) Designing policies in a world of uncertainty, change, and surprise: Adaptive policy-making for agriculture and water resources in the face of climate change. Canada and New Delhi, India, International Institute for Sustainable Development (IISD) and The Energy and Resources Institute (TERI), Winnipeg
Trennery CF (1926) Origin and early history of insurance. P.S. King, London
United Nations (1992) United Nations framework convention on climate change. United Nations, New York
Walker B, Gunderson L, Kinzig A, Folke C, Carpenter S, Schultz L (2006) A handful of heuristics and some propositions for understanding resilience in social-ecological systems. Ecol Soc 11:13
Waltner-Toews D, Kay JJ, Lister N-ME (eds) (2008) The ecosystem approach: complexity, uncertainty, and managing for sustainability. Columbia University Press, New York, NY, USA

Ward RET, Herweijer C, Patmore N, Muir-Wood R (2008) The role of insurers in promoting adaptation to the impacts of climate change. Geneva Pap Risk Insurance Issues Pract 33:133–139

WHO (2009) Composition of world health expenditures. World Health Organisation, Geneva

Young OR, Berkhout F, Gallopín GC, Janssen MA, Ostrom E, van der Leeuw S (2006) The globalization of socio-ecological systems: an agenda for scientific research. Glob Environ Change 16:304–316

Chapter 7
Contribution of Urban Agriculture to Food Security, Biodiversity Conservation and Reducing Agricultural Carbon Footprint

Neeraja Havaligi

Abstract Urban agriculture has a definite role in food security in cities. This paper will explore the extent to which urban agriculture contributes to food security in cities with examples from different parts of the world. The paper will explore the potential of urban agriculture in biodiversity conservation in urban and peri-urban areas, its role in reducing the carbon footprint of agriculture, urban food needs and generation of organic waste. The potential for urban agriculture in securing carbon credits for cities will also be explored here.

Keywords Biodiversity · Carbon credits · Carbon footprint · Compost · Energy · Food security · Market · Policy · Urban agriculture

Introduction

Urban agriculture refers to the production of vegetables, meat and dairy products including their processing and marketing in and around urban areas (McCuaig 2006) or peri-urban areas (Bailkey and Nasr 1999). Achieving food security through a sustainable cycle of local resources including local waste produce is documented from the times of Machu Picchu (Vijoen et al. 2005).

Urban agriculture's importance received a mixed response in surveys conducted for this paper. Responses varied from positive, green thumbs up to remarks such as "Urban agriculture is an absurd illusion" and that "growing critical amounts of food on urban spaces is absurd". More than 90% of respondents in the United States thought that urban agriculture is something that is "done elsewhere", as in Cuba, or opined that urban agriculture does not contribute significantly to food security.

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About 50% of total respondents were receptive to ideas of edible landscaping and establishing good linkages with peri-urban farms for reasons ranging from recession, increased awareness of the eco-footprint of produce, and the desire to be connected to the process of food production.

Researched evidence and reading literature covering climate change, agriculture, and biodiversity conservation suggests that there is not a strong focus on linking urban agriculture to critical topics of food security, biodiversity conservation and carbon footprint of agriculture.

Urban Agriculture and Food Security

Worldwide about 800 million urban and peri-urban farmers are involved in urban agriculture and contribute to feeding urban residents (FAO, Brook and Davila 2000 and CGIAR 2006). An estimated 14% of the world's food is produced in urban areas through urban agriculture (Armar-Klemesu 2000; Smit 2000). Urban agriculture's contribution to food security is significant in many parts of the world. For example, in Kathmandu, Nepal, 37% of vegetable needs and 11% of animal produce needs are met through urban agriculture (Rees 1997). Intensive cultivation of just 6% of the land area in Hong Kong provides for 45% of its local food needs (Garnett 1996). In Kampala, Uganda, urban agriculture has contributed new job openings for migrant population into the cities in addition to providing vegetables, fruits and over 70% of poultry products for urban consumers (McCuaig 2006).

During WWI and II, more than 20 million home gardens in the United States, known as Victory Gardens, provided food security during the times of war by supplying 44% of the produce consumed in the country (http://sidewalksprouts.wordpress.com/history/vg/). Using less than 3% of land for agriculture, peri-urban agriculture in Australia's five mainland states produces as much as 25% of the total agricultural production in dollar terms (Houston 2005).

According to cityfarmer.org, the most extensive online source on urban agriculture, Cuba has what is believed to be the most extensive urban agriculture programme in Latin America (and probably the world), with more than 2,730 government-operated gardens. The experience of Cuba in urban agriculture was also the most quoted in literature and the interviews conducted for this paper as the best example where urban agriculture contributed to food security in the city.

Urban agriculture in Cuba is a good example of successful urban agriculture. Cuba's comprehensive, highly successful urban food production strategy includes extensive land reform, research and development and technical assistance demonstrating strong government support. In 1998, 541,000 tonnes of food was estimated to be produced in the city of Havana alone for local consumption. Some neighbourhoods in Havana produce as much as 30% of their needs. In 2002, 35,000 acres (140 km^2) of urban gardens in that city produced 3.4 million tonnes of food. In Havana, 90% of the city's fresh produce comes from local urban farms and gardens (Murphy 1999).

Across the world, communities that have taken up urban agriculture with a passion or as a way to address food security issues of migrants, squatters and food deserts have shown that urban agriculture can significantly address food needs and environmental issues.

Interviews conducted with urban and peri-urban farmers in the California Bay Area, Wisconsin, Chicago and parts of Canada, illustrated the significant role of urban and peri-urban farms in providing food security to the cities. For example, Community Sponsored Agriculture or CSA such as Family Farm Fresh, a network of growers within a 50-mile radius of Ivanhoe, California, provides weekly deliveries of seasonal fruits and vegetables plus eggs, honey, olive oil, juice, herbs, and edible flowers to its 300 members.

Full Belly Farm a certified organic farm spanning 200 acres in the Capay Valley of Northern California, supplies produce all year round to three farmers' markets, restaurants and wholesalers on a weekly basis, serving most of Sacramento and Bay Area in California. Its CSA supply of 1,500 boxes of produce per week, 49 weeks of the year, accounts for one third of Full Belly's business. Ninety-nine percent of produce from Full Belly Farm is consumed locally in California.

Interviews with several grassroots community organizations such as People's Grocery, City Slicker Farms, oaklandsol.org in the Bay Area, urban and peri-urban farmers including bee keepers, and government agencies such as parks and recreation department, public health department, etc. reveal that successfully managed urban agriculture including backyard and community gardening could potentially meet up to 30–40% of the produce needs of a city (Havaligi 2009).

City Slicker Farms, for example, produced about 8,000 pounds of food on its farms and 15,500 pounds from the 75 backyard gardens (in an interview with CEO, City Slicker Farms). This, coupled with farms in urban and semi-urban areas in a 100–150 mile radius, could potentially provide for all produce and dietary needs of the city. Jay Salinas, co-director of Growing Power's Milwaukee facility, which works with a network of urban and peri-urban farms in a 150 mile area remarked that Growing Power can meet up to 50% of the food needs of a family of four with its produce box. Growing Power is addressing the food desert issue through this network, community involvement and education.

In Vancouver, Canada, the Strathcona Community Garden, a diverse garden with 290 plots, 200 fruit trees and beehives, produces up to 5,000 pounds of honey in a year (McCuaig 2006). The rooftop farms such as the Millennium Gateway Farms in Vancouver, BC could produce 400–800 tonnes of vegetables (Hohenschau 2005). This garden has teamed up with Home Depot to manage and sell the compost from its vertical composting unit (VCU) that manages 100% of the community's commercial and residential organic wastes. Rooftop farms in Vancouver, BC could provide up to 20% of the vegetables consumed in the community. If sourced regionally, this would have required as much as 200 ha of farmland (Hohenschau 2005).

Urban agriculture's potential to contribute to the food security of cities depends on the city policies on land ownership and use, distribution and management of water and other resources, linkages between urban and peri-urban farms and their communities, direct marketing opportunities through farmers markets, CSAs etc., education and linkages to local schools and hospitals for education and lunch programmes, and universities for outreach, research and development.

Urban Agriculture and Biodiversity Conservation

The Global Biodiversity Assessment states that "overwhelming evidence leads to the conclusion that modern commercial agriculture has had a direct negative impact on biodiversity at all levels: ecosystem, species and genetic; and on natural and domestic diversity" (Heywood and Watson 1995). In both developing and developed countries, international and national institutions and legal structures play a role in agrobiodiversity loss (Wolff 2004). Biodiversity is also threatened by increasing ecological degradation by climate change (Millennium Ecosystem Assessment 2005; Revkin 2008). Crops may skip stages of their life cycle, have delayed or early flowering, seed set, maturity and may and may not be able to complete their life cycle. For example, experiments have shown that corn and soybean plants are likely to grow and mature faster, but will be more subject to crop failures from spikes in summer temperatures that can prevent pollination (Revkin 2008).

"Diversity is the fountainhead of agriculture and food security" (Cummings 2009 via tele-conference). Humans have used about 15,000 plants as food (Facciola 1998) domesticating 7,000 species of plants over the 10,000-year history of agriculture (UNEP 2008). Of these "only 30 account for the vast majority of the food we eat every day" as mentioned by United Nations secretary general, Mr. Ban Ki-moon (UNEP 2008). The world is fed by approximately 20 crops (Facciola 1998). Successful conservation of biodiversity depends on increasing efforts to do things "that have traditionally been outside the scope of the discipline" (Ehrlich and Pringle 2008).

Urban agriculture has great potential to help agrobiodiversity by taking on the cultivation of local varieties under its fold (www.freefarm.org). Urban agriculture provides an opportunity to experiment and grow different varieties suited to different microclimates, thus providing an important avenue for the plants to adapt and perform in the microclimates. Urban agriculture provides a great opportunity for in situ conservation of seed base, but provides an incredible opportunity for the crops to evolve in response to local microclimatic conditions. This kind of evolution is critical for adaptation to climate change. This is the most fundamental response to climate change we can have, to engage with life in the seed (Cummings 2009 via telecon).

When urban communities are linked up through their gardens and seed-sharing networks such as *hyperlocovore.com*, *seedsavers.com* etc., it creates a valuable source to produce and propagate locally adapted varieties that perform well in terms of yield and nutritional qualities. Urban agriculture enhances biodiversity by continued production of rare varieties of fruits and vegetables, which are adapted to local soils and climate (Havaligi 2009). Larger variety of fruits and vegetables are more often seen in small scale farmers (than large-scale growers) thus helping conserve cultivars of unique characteristics and importance to yield and adaptation which may otherwise die out (Garnett 1996).

Urban gardeners contribute to biodiversity conservation when they adopt planting of heirloom varieties and get together into a seed-sharing network. For example, Baia Nicchia (http://baianicchia.blogspot.com/), a small farm in Sunol, California, grows more than 50 heirloom varieties of tomatoes. Baia Nicchia's owner Fred, who breeds and cultivates tomatoes, remarked that small breeders like him and home gardeners are significant contributors to conserving the diversity of genes. He not only grows different heirloom varieties himself but also selects varieties from other home gardens in the area. As John Bela of *sfvictorygardens.org* emphasized: "seed saving and community based genetic diversity is an absolute core of the urban agriculture" (Havaligi 2009).

In India, urban agriculture is playing an important role in the conservation of medicinal herbs in the 14 different kinds of agro-climatic zones. A unique initiative called Home Herbal Gardens launched by Tata Energy Research Institute (TERI) encourages home owners to grow herbal home gardens within their apartment complexes. By distributing a wide variety of medicinal and aromatic herbs, TERI aims to create awareness about the medicinal values of these plants and the need for their conservation.

Urban agriculture has proved to be an efficient mechanism to slow down the loss of biodiversity (Smit 2000) and provide important ecosystem services (Davies et al. 2009) through the urban plant communities, supporting pollinators including birds and other organisms. For example, bee keeping in urban areas is becoming a critical part of maintaining ecosystem services, not just for urban agriculture, but also for surrounding farms where bees have practically disappeared (Havaligi 2009). In addition to pollinating 80% of insect pollinated crops, each hive can produce 100 pounds a year if it is properly tended (Cityfarmer 2009). Declines in some species of birds can be arrested or reversed with proper prioritization and resource allocation to conservation activities in urban areas (Fuller et al. 2009).

Urban Agriculture, Carbon Footprint and Carbon Credit

Currently over 50% of the world population lives in cities, and it is estimated that by 2025 over two thirds of the population will live in cities (UNFPA 2007). Rapid urbanization due to human migration and displacement (CARE 2009) caused by climate change increases the political, humanitarian and financial stakes involved (Zeller 2009a). The urban population in developing countries is growing three times faster (3% annually) than the rural population (less than 1% annually). To feed cities of this size, in some cases over 6,000 tonnes of food is expected be imported each day (Nugent and Drescher 2000).

The current industrial agriculture system is accountable for high energy costs for the transportation of foodstuffs. The average conventional produce item travels 1,500 miles (IDRC 2003) using, if shipped by tractor–trailer, one gallon of fossil fuel per 100 pounds (Pirog and Benjamin 2003). The agricultural sector is estimated to contribute about 28–33% of global greenhouse gas (GHG) emissions (Shattuck 2008). This, with 13.5% emissions generated during the transportation of produce (average bite travels 1,200 miles from field to fork), makes agriculture the single largest contributor to GHG emissions (FAO 2006; IPCC 2007a, b, c).

Large-scale agricultural operations, particularly those dependent on fossil fuels, contribute significantly to GHG emissions in the form of soil carbon, methane from large animal feedlot operations (23 times more powerful than CO_2 as a GHG and are responsible for 18% of global greenhouse gas emissions), and nitrous oxide released from synthetic fertilizers with 300 times the warming power of CO_2 (FAO 2006). We cannot continue to have food prices being driven primarily by the price of fossil fuels (Schill 2008).

Energy consumption and energy loss in agriculture occurs in different ways – use of fertilizers, operation of field machinery, and in irrigation, transportation, processing, and distribution of food and agricultural products. This consumption and loss can be significantly reduced by decreasing the distance that the food travels from point of production to point of consumption, decreasing the time the produce is put away under refrigeration before it is consumed or processed, reducing reliance on fossil fuel-based fertilizer use, and adopting solar farm equipment suitable for small farms.

Urban agriculture has a great potential to use solar-based farm equipment such as the solar tillers and solar charged tractor (Fig. 7.1). Figures from pioneer solar equipment builder Steve Heckeroth illustrate this well: 10 units of fossil fuel energy are required to produce one unit of food energy. Similarly, 8 units of fossil energy are required to produce 1 unit of food energy through global organic agriculture, 6 units of fossil energy for 1 unit of food energy through regional organic agriculture, 5 units of fossil energy for 1 unit of food energy through local organic agriculture, and lastly 0.01 units of fossil energy to produce 1 unit of food energy through solar-charged farm equipment on a small farm (Heckeroth 2007).

The climate bill that was passed recently in the US House of Representatives has the potential to cap greenhouse gas emissions across the United States by cap-and-trade provisions which would effectively raise the price of generating electricity using fossil fuels, and therefore help clean energy technologies – which are expensive relative to coal and natural gas – to become more competitive, thus creating a national market and target for renewable energy production (Galbraith 2009).

Advocates of renewable energy such as Steve Heckeroth think longer term even when facing a history of uncertain funding and markets. A strong feed-in tariff for solar energy, such as the one introduced by the Sacramento Municipal Utility District (SMUD 2009), may help the industry succeed in the long term. Successful uptake of renewable energy requires strong early support from the government to help them compete with cheap existing non-renewable energy resources.

Fig. 7.1 Solar charged electric agricultural tractor designed and built by Stephen Heckeroth, www.renewables.com

Establishing government-backed clean energy loans and subsidies are important in helping the small renewable energy industry to scale up. This, along with supporting clean energy policies, will pave the path for use of solar based farm machinery in urban and peri-urban farms. This is in line with IPCC's statement that in sectors where development of new technologies and new infrastructure is critical to achieving substantial emissions reduction (such as in the waste management sector), financial incentives may perform better than regulations or standards.

Urban agriculture addresses energy issues in food production beyond the adoption and use of non-polluting, zero carbon solar equipment. Utilizing a good network of consumers through local farmers' markets, CSAs and online networks such as http://locavores.com/ and http://www.gardenregistry.org/ to distribute the produce has an even smaller ecological footprint, since the fossil fuel used to transport the produce, and the energy used in refrigeration, packing etc. are significantly lower than conventional agriculture.

Novel for-profit businesses such as MyFarm (myfarmsf.com) in San Francisco, USA and CityFarmBoy (http://cityfarmboy.com) based in Vancouver, Canada, help their customers set up edible gardens, and grade and compost food scraps in their backyards to enrich their own gardens. The team of gardeners in MyFarm work by hand and travel mostly by bicycle. This reduces the carbon footprint of their produce considerably. Cityfarmboy also grows fruit and vegetables commercially in urban gardens and sells through the local farmers' markets, thus decreasing their carbon footprint by reducing food miles significantly.

By being local and small scale, urban agriculture has untapped the potential to establish a close connection between food production and consumption, and to keep the energy cycle tight. This connection becomes stronger with the utilization of local organic waste in local compost that can then be used back in local farms and gardens.

Another important resource, water, is fast becoming scarce. Water sources have become unpredictable; with excess leading to flooding and inundation in coastal and other areas and little or no rainfall leading to severe water shortages and drought-like conditions (Brown 2006; Dore 2005; Hopkin 2005) profoundly impacting the diverse farming regions of the world (McClean et al. 2005; FAO 2006; Revkin 2008). Not only is there a lack of water, but moving water around is highly energy dependent. In California alone, 20% of energy is spent in moving water across the state (Miller 2009). Urban agriculture also provides a logical approach to addressing the increasing demand for water resources through rebooting urban waterways, recycling of grey water and rainwater harvesting in urban and peri-urban farms.

Urban agriculture helps to use this scarce water resource more optimally. For one, it can reuse grey water and degradable biological wastes such as bio-solids and compostable wastes from cities. In the Sydney region of Australia, for example, water reuse in agriculture is thought to have the potential to save up to 32 billion litres of river water per year (DIPNR 2004). Together with the use of bio-solids from Sydney's sewage treatment plants, this has the potential to fulfil the "essence of community ecological management which is the principle of closed nutrition" (Smit 2000).

Urban agriculture can play an important role in municipal waste management (Nelson 1996) by redirecting organic wastes from landfills, and turning it into compost that can then be returned for use in local farms and gardens. Studies shared by Rich Flammer of Hidden Resources (hiddenresources.com) show that in the town of Annapolis Royal, Nova Scotia, to accomplish its zero waste goal, the city has generated an 85% participation rate in backyard and neighbourhood composting, putting out neighbourhood composters for use on streets and multi-family residences and successfully diverted 60% of organic waste into compost. Flammer's work has illustrated that incentives such as lower cost of garbage removal, especially in cities that have a PAYT (pay-as-you-throw) pricing structure, will help motivate people to adopt composting (Havaligi 2009).

Composting can thus be an environment friendly business venture, potentially diverting tonnes of urban organic waste from landfills back to urban and peri-urban farms to replenish the soils there. This produces numerous ecological and economic savings. Composting can receive carbon credits (chicagoclimatex.com). Cities stand to benefit in the long term by providing adequate funding of programmes, revising rules to promulgate composting, establishing good outreach programmes and training concerned stakeholders and agencies to understand the connection between composting, resource management, watershed quality, energy, food supply, and public health.

For urban agriculture to be a success it is important to elicit participation of all stakeholders: local people, farmers, government and municipal bodies, private and public sector educational, banking and marketing institutions. Feedback from interviews indicates that consumers like to make informed choices on the produce they buy.

Green accounting can help in this to get the full cost of the produce. This would include information on where, how, when it was produced and processed, and includes the environmental costs involved in the process until the produce is delivered for sale. Understanding these costs and taxes will provide information to policy makers to recognize current pricing structures, and their financial, ecological, and social impacts on both producers and consumers.

Policy reforms based on these changes will be positive for all areas affected – for urban development, for conservation efforts and for food security. It will also provide viable livelihood and consumption options to producers and consumers alike. Achievement of an efficient system of urban and peri-urban farms supporting the food needs of the city requires a commitment to transparency in decision-making by the various constituents.

Urban agriculture provides a great opportunity to enhance investments in local agriculture and conservation, in resolving the disconnection between the market and social values and in providing viable alternatives for strengthening local economies. Good solutions would require clarifying the appropriateness, need, and urgency of the required changes, in land use, in policies, and investment in supporting infrastructure (Gündel 2006).

Success of urban agriculture requires:

- Utilizing a stakeholder-driven and “bottom-up” approach to providing food security for cities. Stakeholders include, among others, urban and peri-urban farmers, consumers and local and national policy makers
- Providing good development mechanisms for cities to address the climate challenges
- Ability to focus and learn from past and recent climate experience of the local farming community
- Coordination and reevaluation of current research and development policies, priorities and commitments with current and predicted challenges for ecosystem services provided by biodiversity, water and other natural resources. This coordination and reevaluation must be rooted in realistic investments and activities to accomplish goals of sustainable use of resources

The main challenge for urban agriculture to be included in municipal, state and other government policies is to convince people about its urgency and need. This would require a demonstration of its practicality and benefits compared to a business-as-usual scenario in a climate-challenged world.

Achieving food security benefits through urban agriculture will also require a careful analysis of land use dynamics with respect to land used for urban agriculture and land used for other purposes.

Some guiding principles in making a case for urban agriculture in city plans based on feedback received for this research and other sources mentioned are (but not limited to):

- Placing urban agriculture in a food security, local employment and waste management context. Build on known geographical distribution of available land area, diverse community needs, local cultivars and cultivation practices shared between urban and peri-urban farmers
- Recognizing that urban agriculture occurs at different levels – backyards, community gardens, urban and peri-urban farms (FAO 2001)
- Placing emphasis on risks and opportunities of urban agriculture where action needs to be taken in the short, medium and long term
- Early introduction of urban agriculture into cities' plans to encourage wider participation and innovation
- Close coordination between different stakeholders at all levels of planning and implementation (FAO 2000)
- Detailed understanding of local food needs and crop diversity baseline.
- Clear land tenure and rights for the people involved in and practising urban agriculture (Thornton 2009)
- Knowledge of local and regional market policies
- Innovative ways to derive funding to urban agriculture such as carbon credits for composting, carbon credits for local food production and consumption, decreased tax on local produce, etc.

A good urban agriculture policies design will:

- Provide a framework for all stakeholders to develop their own responses to the risks and challenges they face
- Draw adaptation planning efforts, identify actions, delivery, roles and responsibilities across public and private sector organizations
- Determine roles and responsibilities for key organizations
- Provide a checklist to assess the actions needed to build capacity of a community or organization to adopt and practice urban agriculture
- Assist with the development of coordinated, coherent, cross-departmental policy changes with actions involving all stakeholders
- Evaluate value-adding mechanisms such as on-farm processing and direct marketing and seek out new and innovative ways to market urban agriculture products
- Set fair and realistic baselines, accounting for crop loss due to climate change, governance or market challenges, etc.
- Strengthen the capacity of communities to implement plant breeding and seed sharing programmes and develop locally-adapted crops and under-utilized species

Conclusion

If climate change mitigation goals are to be met, international climate policies, negotiations and treaties must consider the crucial role of agriculture (Nelson 2009). Countries urgently need to stimulate the recovery of their local, regional and national food producing capacity, specifically the capacity located in urban and peri-urban agriculture efforts.

Two frequently cited solutions to meet the growing energy and food demands of a population projected to approach nine billion in 2050 are:

- Raising productivity through large investment in fertilizers, irrigation and mechanization
- Extending farming to degraded, abandoned or pasture lands. These solutions would still leave food and energy supplies falling short of demand (Deutsche Bank 2009)

However, with increasing carbon emissions, constraints on resources such as water, land and energy, it is important to explore a "host of options" including "the re-emergence of small, self-sufficient organic farms, characterized as local, multi-crop, energy and water efficient, low-carbon, socially just, and self-sustaining", according to Mark Fulton, Deutsche Bank's global head for climate change investment research (Kanter 2009). Urban agriculture can benefit greatly by support from local banks and government policies. Agricultural growth in and around cities, securing food, and ensuring that people have food sovereignty are necessary criteria on which municipalities and governments must base their policies. This is required not only for global food, but for achieving several of the Millennium Development Goals.

Urban agriculture is a response to urbanization, industrialization and intensification of agriculture with strong national and global backing. It is being recognized as a collective response by us as a species, to establish a relationship of stewardship with the Earth and its resources. It is critically important that we engage in urban agriculture in its many forms where it is appropriate, with a focus on strengthening community-based regional agriculture (Havaligi 2009). With urban agriculture, we take a big step away from fossil fuel-dependent corporate agriculture and a step toward community based regional resource efficient agriculture (Havaligi 2009).

Choices that integrate urban agriculture into the fabric of urban landscapes have the potential to deliver resilience in economic, social and environmental terms, to reinforce the local character of a place in a global context, to build a sense of place and community (Havaligi 2009). By participating in urban agriculture, people understand food and value and respect the farmers who dedicate their lives to growing it.

By networking with local farms in a 150 mile radius, cities can become resilient and powerful by being locally adapted to the regional food system. Cities can strive toward zero waste goals by using urban agriculture to reuse the organic waste generated by the city. The "waste" will be captured and kept within the regional system in form of carrying capacity of the region. It will reduce the carbon footprint of city dwellers and decrease their dependence on fossil fuel.

Urban agriculture is a good way to address food production, food security, energy efficiency problems, which form a significant part of the climate change problem, while at the same time helping the local economies by keeping jobs and businesses in the country. This would also be more politically acceptable in today's economic downturn, rather than waiting for policymakers, governments and others debating the logic of carbon caps (Zeller 2009b) to come to a consensus. Never has the call been as urgent to all the stakeholders in the food system – producers, consumers, policymakers – to come together and work out local solutions through urban agriculture that can both help in adaptation to and mitigation of the global climate challenge.

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References

Armar-Klemesu M (2000) Urban agriculture and food security, nutrition and health. In: Bakker N, Dubbeling M, Gundel S, Sabel-Koschela U, de Zeeuw H (eds) Growing cities, growing food: urban agriculture on the policy agenda. A reader on urban agriculture. Deutsche Stiftung fur internationale Entwicklung (DSE), Germany

Bailkey M, Nasr J (1999) From brownfields to greenfields: producing food in north american cities. Community Food Security News Fall 1999/Winter 2000:6

Brook R, Davila J (2000) The peri-urban interface: a tale of two cities. Gwasg Ffrancon Printers, Bethesda, Wales

Brown P (2006) Global warming: the last chance for change. Dakini Books, London

CARE (2009) In search of shelter: mapping the effects of climate change on human migration and displacement. http://www.care.org/getinvolved/advocacy/pdfs/Migration_Report.pdf

CGIAR (2006) Urban and peri-urban agriculture (UPA). http://www.iwmi.cgiar.org/southasia/ruaf/UPA_Flyer.pdf

CityFarmer (2009) 60,000 Bees on green roof of new Vancouver convention centre. http://www.cityfarmer.info/60000-bees-on-green-roof-of-new-vancouver-convention-centre/#more-1297

Cummings HC (2009) http://www.clairehopecummings.com/

Davies GZ, Fullera RA, Lorama A, Irvineb KN, Simsa V, Gaston KJ (2009) A national scale inventory of resource provision for biodiversity within domestic gardens. Biol Conserv 142:761–771

Deutsche Bank, Climate Change Advise Division of Deutsche Bank, (2009 June) Investing in agriculture: far-reaching challenge, significant opportunity. http://www.dbcca.com/dbcca/EN/_media/Investing_in_Agriculture_July_13_2009.pdf

DIPNR (2004) Meeting the challenges – securing Sydney's water future, metropolitan water plan. Department of Infrastructure, Planning and Natural Resources, NSW, Sydney. http://www.sydneyfoodfairness.org.au/resources/urban_ag.pdf

Dore HIM (2005) Climate change and changes in global precipitation patterns: what do we know? Environ Int 31(8):1167–1181

Ehrlich PR, Pringle RM (2008) Where does biodiversity go from here? A grim business-as-usual forecast and a hopeful portfolio of partial solutions. PNAS 105(Suppl 1):11579–11586

Facciola S (1998) Cornucopia II: a source book of edible plants. Kampong, CA, USA

FAO (2000) Urban and peri-urban agriculture and urban planning. http://www.fao.org/urbanag/Paper3-e.htm

FAO (2001) Special programme for food security. Urban and peri urban agriculture. http://www.fao.org/fileadmin/templates/FCIT/PDF/briefing_guide.pdf

FAO (2006) Livestock a major threat to environment. FAO NewsRoom, 29 November 2006. http://www.fao.org/newsroom/en/news/2006/1000448/index.html
Fuller RA, Tratalos J, Gaston KJ (2009) How many birds are there in a city of half a million people? Divers Distrib 15:328–337
Galbraith K (2009) A funding roadblock ahead for clean energy. http://www.nytimes.com/2009/06/29/business/energy-environment/29iht-green29.html
Garnett T (1996) Growing food in cities: a report to highlight and promote the benefits of urban agriculture in the UK. National Food Alliance/SAFE Alliance, London
Gündel S (2006) A synthesis of urban and peri-urban agricultural research commissioned by the RNRRSS programme. http://www.research4development.info/pdf/ThematicSummaries/Synthesis_study_on_urban_and_peri-urban_agriculture_P1.pdf
Havaligi N (2009) Climate change and food security in the cities. In: Urban research symposium, Marseille, France, 28–30 June 2009. http://www.urs2009.net/papers.html#monday
Heckeroth S (2007) Living without polluting (slideshow shared via email). www.renewables.com
Heywood VJ, Watson RT (eds) (1995) Global biodiversity assessment. Cambridge University Press, Cambridge, UK
Hohenschau DL (2005) Community food security and the landscape of cities. http://199.175.219.1/commsvcs/socialplanning/initiatives/foodpolicy/tools/pdf/commfoodsecurity05aug.pdf
Hopkin M (2005) Amazon hit by worst drought for 40 years: warming Atlantic linked to both US hurricanes and rainforest drought. Nature News http://www.bioedonline.org/news/news.cfm?art=2094
Houston P (2005) Revaluing the fringe: some findings on the value of agricultural production in Australia's peri-urban regions. Geogr Res 43(2):209–223
IDRC/UN-HABITAT (2003) Guidelines for municipal policymaking on urban agriculture. In: Urban agriculture: land management and physical planning. IDRC, Canada
IPCC (2007a) In: Pachauri RK, Reisinger A (eds) Contribution of Working Groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. IPCC, Switzerland
IPCC (2007b) Working Group II report, impacts, adaptation and vulnerability climate change 2007 – impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the IPCC. IPCC, Switzerland. http://www.ipcc.ch/ipccreports/ar4-wg2.htm
IPCC (2007c) Summary for policymakers in Climate change 2007: mitigation, contribution of working group III to fourth assessment of intergovernmental panel on climate change. IPCC, Switzerland
IPCC Climate Change Report (2007) http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
IPCC, Geneva, Switzerland, http://www.ipcc.ch/ipccreports/ar4-syr.htm
Kanter J (2009) Farming for 9 billion people. http://greeninc.blogs.nytimes.com/2009/06/25/farming-for-nine-billion-people/?pagemode=print
McClean CJ, Lovett JC, Küper W, Hannah L, Sommer JH, Barthlott W, Termansen M, Smith GF, Tokumine S, Taplin RDJ (2005) African plant diversity and climate change. Ann MO Bot Gard 92(2):139–152
McCuaig A (2006) Social fertilizer: the big growth potential of urban agriculture. Energy Bull. http://www.energybulletin.net/print/20599 and http://thetyee.ca/Life/2006/09/12/UrbanAgriculture/
Miller J (2009) Rebooting urban watersheds. High Country News. http://www.hcn.org/issues/41.10/rebooting-the-urban-watershed-movement/article_view?src=me&b_start:int=3
Murphy C (1999) Cultivating Havana: urban agriculture and food security in the years of crisis. Development Report No 12
Nelson T (1996) Closing the nutrient loop. World Watch 9(6):10–17
Nelson GC (2009) Securing a place for agriculture at the international climate change. In: Negotiations 2020 panel discussion. http://www.ifpri.org/events/seminars/2009/20090327climate.asp

Nugent R, Drescher A (2000) Urban and peri-urban agriculture (UPA) on the policy agenda. In: virtual conference and information market. http://www.fao.org/sd/ppdirect/ppre0073.htm
Pirog R, Benjamin A (2003) Checking the food odometer: comparing food miles for local versus conventional produce sales to Iowa institutions. Leopold Center for Sustainable Agriculture, Iowa
Rees WE (1997) Why urban agriculture? Notes for the IDRC development forum on cities feeding people. City Farmer, Vancouver
Revkin CA (2008) New climate report foresees big changes. The New York Times http://www.nytimes.com/2008/05/28/science/earth/28climate.html
Schill SR (2008) Perfect storm for fertilizer prices. Ethanol Producer Magazine. http://www.ethanolproducer.com/issue.jsp?issue_id=84
Shattuck A (2008) A message for climate change negotiators: small farmers key to combating climate change. http://www.foodfirst.org/en/node/2323
Smit J (2000) Urban agriculture and biodiversity. Urban Agriculture Magazine 1(1)
SMUD (2009) http://www.smud.org/en/news/Documents/09archive/07-17-09_smud_feed-in-tariff.pdf
Thornton A (2009) Pastures of plenty?: Land rights and community-based agriculture in Peddie, a former homeland town in South Africa. Appl Geogr 29(1):12–20
UNEP (2008) http://www.unep.org/billiontreecampaign/CampaignNews/BiologicalDiversity.asp, quote by United Nations Secretary-General, Mr. Ban Ki-moon, 22 May 2008
UNFPA (2007) http://www.unfpa.org/pds/urbanization.htm
Vijoen A et al (2005) Continuous productive urban landscapes. Architectural, Burlington, MA
Wolff F (2004) Legal factors driving agrobiodiversity loss. Environ Law Netw Int 1:1–11
Zeller T (2009a) Making the case for climate as a migration driver. The New York Times. http://www.nytimes.com/2009/06/15/business/energy-environment/15iht-green15.html
Zeller T (2009b) Peacocks and passions on display in senate climate. The New York Times. http://www.nytimes.com/2009/07/20/business/energy-environment/20iht-green20.html

Chapter 8
Temporal Metaphor in Abrupt Climate Change Communication: An Initial Effort at Clarification

Chris Russill

Abstract Abrupt climate change has recently become the focus of significant attention. The belief that abrupt climate changes have not been given due weight in scientific reporting and policy discussion has become more vocal since the turn of the century. New research has incorporated these possibilities in terms of tipping points and tipping elements, and argued that projections of gradual change can lull society into a false sense of security. In this paper, I draw attention to the metaphorical quality of abrupt climate change discourse. I examine the discourse occasioned by such abrupt change warnings, and I illuminate how deeply embedded temporal assumptions orient evaluations of climate change danger. I suggest that many familiar points of dispute might be indexed to different visions of time and change, and I develop the role of metaphor for better understanding climate change communication on this matter, and more generally.

Keywords Abrupt climate change · Analogy · Climate change communication · Metaphor · Positive feedbacks · Punctuated equilibrium · Temporality · Time · Tipping point

Introduction

Abrupt climate change discourse is the subject of increasing scientific and popular attention. In 2000, Richard Alley's book, The Two Mile Time Machine, developed the idea that new knowledge of "[t]he existence of abrupt climate changes casts a very different light on the debate about global warming..." (p. 5). A year later, Mastrandrea and Schneider (2001) noted that integrated assessment models (IAM) assumed gradualist change, and they "confirmed the potential significance of abrupt climate change to economically optimal IAM policies, thus calling into question all

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previous work neglecting such possibilities" (p. 433). In 2002, a National Academy of Sciences report raised significant concerns when it suggested that gradual changes can push climate systems past thresholds and result in unexpectedly quick or jumpy shifts: "Just as the slowly increasing pressure of a finger eventually flips a switch and turns on a light, the slow effects of drifting continents or wobbling orbits or changing atmospheric composition may 'switch' the climate to a new state" (p. v). Today, several research groups are studying the potential for abrupt change and proposing the development of "tipping point" warning systems (Lenton et al. 2008; Scheffer et al. 2009).

An interesting quality of the earliest concerns with abrupt climate change is their analogical or metaphorical character. Generally, it is historical analogies that are considered most relevant. Broecker (1999), for instance, argued directly for the importance of historical analogy in questioning the reliance of climate policy on computer model simulations. Existing climate model simulations are misleading and even dangerous, Broeker and others have argued, since they privilege gradualist forms of change. Given these assumptions, "one can imagine that man might be able to cope with the coming changes" (Broecker 1987, p. 123). However, if we examine the palaeoclimatological record, we see it is littered with abrupt climate changes (cf. Alley 2000; Lenton 2009a). The climate has switched, flipped, flickered, jumped, tipped, or altered drastically, often over the course of only a few years, according to evidence compiled through deep sea and ice core analysis, as well as other sources. If we reason analogically, abrupt changes are quite possible, and model projections of gradual change risk lulling society into a false sense security (Broecker 1987; Lenton et al. 2008; Lenton 2009a).

Critics have argued that fears over abrupt climate change are unscientific or overblown. Proponents of abrupt climate transitions are said to rely on non-scientific discourses of catastrophe, which introduce unwarranted alarmism into the communication of climate change (Hulme 2006). It is prejudice or politics that motivate such analogies, not science, as alarmists rely upon the apocalyptic rhetoric characteristic of Judeo-Christian culture to make sense of climate change. Moreover, warnings of abrupt climate change might create initial urgency but will result in fatalism (Nature 2006; Lowe 2005), a criticism anticipated in the National Academy of Sciences (2002) report. Discussion of worst-case scenarios in warning of potential impacts has even been said to represent "climate porn", where audiences respond to the "secretly thrilling" experience of viewing catastrophic scenarios (Ereaut and Segnit 2006). Abrupt change and tipping point warnings are often viewed in this way.

There is genuine debate regarding the importance of abrupt climate change scenarios. There are valid arguments and well-regarded proponents on each side, indeed, on the many sides implicated in the abrupt change discussion. It is conducted in a range of forums, including national newspapers in the US, UK, and elsewhere; important scientific journals (Climatic Change, Global Environmental Change, Proceedings of the National Academy of Sciences, Philosophical Transactions of the Royal Society); influential blogs (Real Climate, Dot Earth); professional scientific organizations, consultancies, and many places besides, including popular culture (for example, Forbes Magazine, The Weather Channel, and the Hollywood film, The Day After Tomorrow).

How can disagreements regarding the danger of abrupt climate change be resolved or mediated, and what grounds can be articulated for preferring abrupt to gradualist projections of climate change? How should policy makers, politicians, and publics respond to abrupt climate change warnings? It is important not to view the wide array of different opinions simply in terms of a "contentious debate", but it is also necessary to articulate the grounds on which abrupt climate change danger is taken seriously or dismissed as irrelevant. In this paper, I suggest an indirect approach. I argue that greater acknowledgment of the analogical and metaphorical quality of climate change communication, and of temporal metaphor in particular, is needed in order to appraise the significance of arguments employing metaphor, and to better understand how people make sense of climate change.

Metaphor is ubiquitous in climate discourse. There are hothouses and greenhouses, atmospheric blankets and holes, sinks and drains, flipped and flickering switches, conveyor belts and bathtub effects, tipping points and time bombs, ornery and angry beasts, rolled dice, sleeping drunks, and even bungie jumpers attached to speeding rollercoasters. Perhaps most famously, there is Wally Broecker's (1997, 1999) warning that the climate is an "ornery" or "angry beast", which humans are poking with sticks. Other famous scientists have got into the game. Alley (2000) speaks of "the 'drunk' model of the climate system – when left alone, it sits; when forced to move, it staggers wildly" (p. 182). James Hansen (2005a) warns of a slippery slope, of a Faustian bargain, and of a timebomb, but has now settled on tipping points to convey dangers associated with abrupt climate change (cf. Russill 2008). The tipping point metaphor is a popular one, and has been promoted in scientific, policy, and media contexts (Kerr 2008; Russill and Nyssa 2009; Hulme 2009).

The failure to recognize the metaphorical quality of climate change discourse has several consequences. First, the deeply entrenched nature of metaphor in climate change communication is not acknowledged, and a limited understanding of analogy, metaphor, language, and communication is used to appraise its significance. Second, it means that disagreements rooted in competing temporal visions are explained in other ways, as the result of ignorance or a struggle for political advantage. Third, a wider range of temporal perspectives is not found or considered seriously in mainstream climate change communication. Some indigenous views, for example, are based in cyclical notions of temporality that challenge assumptions of linearity, progress, or abstraction from place (Deloria 1994). Fourth, the importance of metaphor to policy innovation and participatory sustainability efforts makes its recognition in climate discourse an important insight (cf. Gough et al. 2003; Ravetz 2003). Metaphor is central to the way climate change acquires public meaning. Metaphor is used to make complex science more accessible, but it also influences the very questions and problems driving social change. In short, climate change discourse may remain confused and overly exclusive if the metaphorical quality of communication is obscured or suppressed.

I open this line of inquiry by reviewing the research literature on metaphor in climate change communication generally. I then distinguish cyclical and directional metaphors of time using Steven Jay Gould's (1987) dichotomy for describing long-standing debates in the earth and biological sciences. I then describe the emergence of tipping point warnings of climate change danger as an instance of generative metaphor, and summarize the implications of accepting the metaphorical quality of climate change discourse.

Metaphor in Climate Change Communication

How much significance should be accorded to metaphor in climate change communication? Discussions of metaphor in climate change discourse are infrequent. Occasionally, scientists share their reasons for preferring a particular metaphor (Hansen 2005a), or recommend the use of metaphors for dealing with news media (Schneider 1988). It is much less common to develop systematically the assumptions and implications of acknowledging the metaphorical function of climate change communication. The benchmark collection on climate change communication contains only two brief discussions (Bostrom and Lashof 2007; Ungar 2007), and a recent review of expert recommendations on climate communication did not find any advice on metaphor (Thompson and Schweizer 2008). However, there are two influential academic literatures that advocate for greater attention to the role and scope of metaphor in climate change discourse, although the intellectual traditions, strategic goals, and cultural contexts of these researchers direct their conceptualization of metaphor along different paths.

In the United States, proponents of metaphor often argue for the importance of "framing" in climate change communication. Recommendations for framing climate change have been developed from research into the psychology of risk perception, and from cognitive science more generally (cf. Lakoff 1987; Nisbet 2009). In this tradition, all understanding is framed, and people make sense of climate change discourse by using specific frames to interpret the significance of a message. George Lakoff's work has been definitive and perhaps even foundational in building widespread acceptance of this perspective among social and political marketing professionals. Lakoff and his associates postulate that people understand messages in terms of conceptual frames, and that they reason metaphorically in terms of these frames when drawing conclusions. One's understanding of a message involving data, an argument, an event, a problem, etc., depends less on these message features than on the frame of the message, and the cognitive/cultural model that is made salient by the frame.

The result is that professional communicators have great power to shape public understanding, and to build support for specific conclusions by accessing deeply shared metaphorical systems. Proponents of framing often emphasize three features in making recommendations: the malleability of frames, the place of values in deciding whether support for policy change will emerge, and the importance of disciplined repetition of messages for inscribing a frame. In short, frames direct reasoning, and the reasoning process is very different from the one that is usually assumed, where conclusions and arguments are contested through an exchange of fact or evidence. Metaphor is of central importance in this process of reasoning and understanding; we “live by them”, to echo the title of Lakoff and Johnson’s (1980) famous book.

As applied to climate change discourse, frames emphasizing uncertainty or debate tend to result in a lack of public commitment to policy action. If climate change is framed as a debate among experts, or as uncertain, people will tend to reserve judgment; if it is understood as a war between energy companies and environmentalists, a polarized public will result and impede policy change (Nisbet 2009). If, however, climate change is intermixed with frames of economic progress and human health, wider public support for policy change will result (at least among certain classes of people in the United States).

In American applications of framing, metaphor use is often envisioned in a way that restricts public participation to expressions of policy support or dissent. Framing is used to popularize science, or to build support for pre-determined conclusions more often than it invites participation in the development of conclusions. The process through which public issues are framed and acquire meaning is conceived rather narrowly. It cannot be decided here whether the narrowing of public participation is entailed by the conceptual theory of metaphor preferred by Lakoff, or whether such uses reflect the preferences of those adopting Lakoff’s perspective. It is likely that the historical contingencies and exigencies of US politics and policy have shaped the use of Lakoff’s work, and of framing more generally, and that this accounts for the narrowness of many framing perspectives. Other perspectives on metaphor have broadened visions of public participation. Ungar (2007), for example, clearly values “bridging metaphors” as tools for involving of lay publics, an instance of the more general view that tropes can spark dialogue and the collaborative or negotiated search for meaning (Hellsten 2002, p. 22).

A more expansive vision of metaphor and its importance for public participation is found in post-normal science and participatory sustainability perspectives. Metaphor is considered in its poetic capacity, as generative of new meaning, insight, and creativity, and used to broaden public participation in domains typically dominated by scientists and experts. The strategy is to use metaphor to broaden public participation beyond “public perceptions gathering” (Gough et al. 2003, p. 42), and to develop dialogic, and pragmatic problem-responding capabilities (cf. Kasemir et al. 2003, p. 14). The inclusion of publics is conceived more broadly, and metaphor is important for illuminating and challenging a wider array of institutionalized epistemic and value commitments. Metaphor is understood in the context of power relations, and envisioned as a tool for making clear the tacit meanings of climate change discourse in order to force negotiation and debate, not unconscious adherence to expert policy preferences. These ideas resemble Mary Hesse’s (1966) regard for the productive value of the ambiguity generated by metaphor. Importantly, the discussion on metaphor is oriented to questions of creativity in scientific inquiry and debates in philosophy of science, not the social marketing concerns often dominating interest in climate change communication in North America.

Post-normal scientific perspectives attend closely to "the ways in which knowledge is condensed, packaged and brought into social discourse…" (Hulme 2009, p. 80), and an interesting dimension of this concern is the refiguring of computer model results as metaphorical. There are several well-elaborated positions in the philosophy of science that regard scientific models as analogical or metaphorical (Black 1962; Hesse 1966). In Ravetz's (2003) conception, computer models have a metaphorical function, and the relationship of experts and public participants is characterized in metaphorical terms (as a voyage). It is not simply that metaphor is important for simplifying or popularizing science. It is the capacity to generate novel insight and shifting perspectives that is encouraged. In fact, Ravetz argues that computer model results are misconstrued when evaluated in terms of prediction and control, and that efforts at integrated assessment modelling (IAM) will produce error and mistake if judged by those standards of evaluation. As Hulme (2009) puts the question of computer models, "Are they 'truth machines' to be believed in by all, or do they act more like metaphors to help us think about the future?" (p. 59). In post-normal science perspectives, the role of computer models in policy assessment, in issuing warnings, and in the envisioning of possible futures, requires an acceptance of their metaphoric function.

The post-normal science discussion has clear application to contemporary efforts to model abrupt change scenarios, and is supplemented in this paper with the pragmatic theory of generative metaphor developed in Donald Schön's work on problem setting in social policy. Schön (1979/1993) believed solutions to policy problems often emerged from the capacity of generative metaphor to create new perspectives on problems, and that policy disputes were usually rooted in "conflicting frames, generated by different and conflicting metaphors" (p. 139). Generative metaphor speaks mainly to the dislodging or displacement of a familiar description by "a different, already-named process…" (p. 141). Entrenched disputes are refigured by using metaphor to illuminate different aspects of complex situations, by rearranging these aspects in a new organizational pattern, and by re-weighting the importance or significance of these aspects. An initial effort might merely dislodge the prevailing description, and lead to the search for different metaphors during the process of trying to explain inappropriate or misplaced assumptions; initial efforts might also re-invigorate a metaphor that has become conventionalized – such that its metaphorical nature is recognized anew (cf. Brüning and Lohmann 1999). Perhaps most importantly, generative metaphors begin life as mistakes, and even a successfully developed metaphor is literally a mis-taking.

> "What makes the process one of metaphor making, rather than simply of redescribing, is that the new putative description already belongs to what is initially perceived as a different, albeit familiar thing…" (Schön, p. 141).

The emergence of scientific insight from mistake is often remarked upon in histories of scientific discovery, but not usually taken very seriously. Generative metaphor provides a way of acknowledging these accounts. Put schematically, there is an initial and unjustified use of metaphor, then the formulation of an analogy able to restructure perception of an existing situation, and only then the potential development of a concept or general model (pp. 142–143; for a more analytical discussion distinguishing different types of metaphor, see Brüning and Lohmann 1999). The movement from personal or common experiences to more abstract conceptual schemes emphasizes the importance of context, and of the context bound nature of experience required for interpreting and using metaphor. It is, as Brüning and Lohmann say, "a process of communication" (p. 400), and the old adage of learning from mistakes is accepted as more than a cliché. The understanding of metaphor as generative encourages greater inclusion of public participation in policy issues because mistakes are construed as initiating insight and learning, and as eliciting sense-making frameworks, not simply as illiteracy, falsehood, or error.

There are several difficulties in experimenting with generative metaphor. Generative metaphors sometimes look like a silly mistake, and they often are. It is also likely that multiple metaphors will be required to sharpen the contrasts among different perspectives. The most successful metaphors rarely bear the traces of the earliest efforts to apply them. For example, the great ocean conveyor belt no longer prompts much pause or reflection, since it is now conventionalized. Its first use was almost whimsical, as the example of a fun-house ride was used to explain nutrient distribution in the sea (Brüning and Lohmann 1999). Today, images and descriptions of the conveyor belt are used to explain and even model the global nature of ocean circulation. The result is that helpful generative metaphors might be abandoned prematurely, since they fail to fit the criteria for accepting a concept or model.

An important feature of pragmatic metaphor is its problem-setting or problematizing dimension, an aspect that is important to efforts to evaluate the appropriateness of a metaphor (cf. Fischer 2009, on Schön and problematization). The problem-dependent feature of generative metaphor is often overlooked, since poor metaphors are discarded as bad mistakes, while successful ones resolve matters in a way that elides traces of the previously problematic situation. In this respect, generative metaphor encourages a conception of social discourse similar to proponents of post-normal science. The important feature of public participation is not that it deals with problem solving, or that it treat social concerns as problems to be eliminated, but that participation is construed in terms of problem-setting and problem posing. As Schön argued, "the essential difficulties in social policy have more to do with problem setting than with problem solving, more to do with ways in which we frame the purposes to be achieved than with the selection of optimal means for achieving them" (p. 138). It is through a collective process of problem formulation that people are able to make sense of and govern themselves in conditions of climate change, and to influence scientific practices. Metaphor is an important tool in this respect and reflects the inclusion of broad cultural sensibilities in expert dominated domains.

> "When we examine the problem-setting stories told by analysts and practitioners of social policy, it becomes apparent that the framing of problems often depends upon metaphors underlying the stories which generate problem setting and set directions for problem solving" (Schön 1979/1993, pp. 138–139).

It is with this understanding of metaphor in mind that we can examine Gould's account of metaphor in geological and biological disputes before turning to the role of metaphor in warnings of abrupt climate change danger.

Steven Jay Gould's Dichotomy of Temporal Metaphor

Among the best examples of generative metaphor is Steven Jay Gould's book, *Time's Arrow*, *Time's Cycle*. Although Gould (1987) preferred to speak of these temporal metaphors as "eternal metaphors", due to their long-standing influence on western culture, it is clear that he views them as constitutive or generative of scientific and popular understanding (p. 194, 199). Gould's discussion is particularly relevant to considerations of temporal metaphor in abrupt climate change communication, since Gould felt that entrenched preferences for incremental, cumulative change have blocked intellectual consideration of other possibilities.

Gould (1987) develops the contrast between directional and cyclical metaphors of time to demonstrate how deeply entrenched certain visions of temporality are in western culture. These metaphors are almost inescapable in Gould's account, since temporal metaphors underpin and intermix with theories, data, observations, and even first-hand experiences of physical objects or biological processes. People have looked at the same rocks and seen 6,000 years of divine touch or the momentary shard of a billion years' history; they have seen catastrophic change or gradual erosion; they have assumed the earth's imminent demise, or that it has in James Hutton's famous phrase, "no vestige of a beginning, – no prospect of an end" (Gould 1987, p. 79). Gould argues that direct observation cannot decide the question of whether to privilege directional or cyclical notions of time; instead, temporal metaphor constitutes the conditions of intelligibility for a wide range of phenomena. If he is right, it should be no surprise that 400 million year old ice from the Antarctica provokes similar disagreements today.

According to Gould, earth scientists have waged an epistemic war on behalf of gradual or incremental visions of change, a view not derived from field data or direct observation, but from cultural commitments. In his first published article, Gould (1965) took a historical perspective to show that scholars wrongly understood the motivation and basis for catastrophic scenarios of geological change. In his theory of punctuated equilibrium, co-authored with Niles Eldredge, Gould weighted abrupt shifts over finely graded increments as the significant events in biological evolution at macro-evolutionary scales, while granting the significance of gradualist assumptions for other scales, such as ecological changes. In *Time's Arrow, Time's Cycle*, Gould tries to disabuse scholars of the hubris with which temporal visions are advocated or disparaged, and he models a pluralistic perspective designed to recover the significance and validity of employing the directional/cyclical metaphors to contemporary circumstances. Gould suggests the cultural roots of our various metaphors of time run deep, and he sets out to show how these shape understandings of geological time.

Geological or "deep time" suggests immensely long timescales against which human experience appears finite and insignificant. James Hutton is often credited with the recognition of deep time, and popular histories of geology and earth science argue for the importance of fieldwork and observational evidence in the making of his discovery. Gould offers a different account and argues that Hutton simply displaced directional accounts of time with a cyclical understanding of earth systems.

> "Hutton developed his theory by imposing upon the earth the most rigid and uncompromising version of time's cycle ever developed by a geologist" (Gould 1987, p. 79).

Why does this matter? In Gould's view, a narrow account of geological change won undue prominence by falsifying the history of its emergence, by employing spurious arguments, and by dismissing alternative possibilities out of cultural prejudice masked as scientific objectivity. The belief that significant geological change is the slow and gradual accumulation of insensibly fine increments has won out popularly through nefarious means, and the result is that non-linear, abrupt, or "punctual" change is not considered seriously.

Gould provides a revisionist history demonstrating how discussions of the significance of deep time have drawn upon and weighted differently the several aspects of time's passage. On the one hand, there is the metaphor of "time's arrow", which construes history as "an irreversible sequence of unrepeatable events", and where, "[e]ach moment occupies its own distinct position in a temporal series, and all moments, considered in proper sequence, tell a story of linked events moving in a direction" (pp. 10–11). On the other hand, there is "time's cycle", where "events have no meaning as distinct episodes with causal impact upon a contingent history. Fundamental states are immanent in time, always present and never changing. Apparent motions are parts of repeating cycles, and differences of the past will be realities of the future. Time has no direction" (p. 11).

Gould contrasts these metaphors to illuminate the genealogical development of temporal thinking. For instance, many modern views of history incorporate uniqueness and directionality, but these dimensions of time "arose at different times and in disparate contexts" (p. 13). Similarly, cyclical theories have become unfamiliar, even though the earliest proponents of deep time developed the idea "from their commitment to the unfamiliar view of time's cycle, and not (as the myth professes) from superior knowledge of rocks in the field" (p. 15).

Gould's goal is to recover the previous standing of cyclical visions of time, to argue that such visions were not defeated by empirical evidence or observation, and to suggest that the wrong-headed acceptance of spurious arguments has enshrined "a restrictive view about the nature of change" (p. 119). Cumulative change is the norm for interpreting geological and biological processes, and counter-examples or anomalies can always be resolved into theoretical frameworks presuming gradual, directional change. Visions of directional time are deeply embedded in cultural and religious belief systems, and these visions are expressed in metaphorical terms that guide theoretical understanding and scientific observation. The hegemony of directional metaphors has resulted in the privileging of "one narrow version of geological process as true a priori", with the consequence that, "we lose the possibility of weighing reasonable alternatives" (p. 114). Theorists inverting this process to interpret catastrophic or abrupt shifts as definitive events in the earth's formation have been scorned as unscientific and ridiculed as purveyors of religiously motivated superstition. Gould recovers these competing conceptions of time by treating them in terms of metaphor, and argues that they represent equally plausible possibilities.

Gould argues that temporal metaphors are generative, and that both directional and cyclical metaphors are needed since they illuminate ineradicable dimensions of reality. Directional and cyclical views of the world cannot be avoided, cannot be eradicated, cannot be synthesized, but must simply be lived with and drawn upon with pragmatic finesse, which is to say employed differently "depending on the question asked or the perspective assumed" (p. 200). How can this pragmatic touch be developed and evaluated? Gould raised the matter but did not propose an answer extending beyond his specific subject matter. His main concern was geological and biological phenomena and the final question of his book treated the questions of competing temporal assumptions in terms of rocks and fossils, "How, then, can we judge the interaction of time's arrow and time's cycle within each object?" (p. 199).

The same question is of pressing importance for contemporary climate change discourse. How do we proceed if, as Gould phrases it, "nature says yes to both" (p. 200)? If gradualist and abrupt visions of change are incommensurable in their purest form, cannot be reconciled in practice, yet explain selected aspects of climate change in acceptable scientific terms, how are we to proceed? How can these temporal assumptions be intermixed pragmatically? In the next section, I address these questions in the context of efforts to develop an abrupt climate change warning system with policy relevance.

Metaphor and Analogy in Warnings of Abrupt Climate Change

Abrupt climate change warnings have used a variety of metaphors. Broecker (1987) once claimed that, "inhabitants of planet Earth are quietly conducting a gigantic environmental experiment", which he characterized as, "Russian roulette with climate" (p. 123). Other metaphorical warnings include: Al Gore's (1992) sandpiles approaching self-criticality; Broecker's (1999) angry beast poked by sticks; Richard Alley's (2000) resting then staggering drunk, his bungy jumper attached to a roller coaster, or his idea of a flipped light switch and flickering climate states; the NAS (2002) report's diagram of balanced yet sensitive scales; and James Hansen's (2004) timebomb. Today, it appears that tipping point is the most systematically used and elaborated warning, and one suggestive of generative metaphor as described above (Russill and Nyssa 2009).

Tipping point, as a metaphor for abrupt climate change, has been discussed and clarified in terms of a number of more specific analogies. Winton's (2006) article, "Does the Arctic Sea Ice Have A Tipping Point?" primes the reader with the analogy of a slowly tipped glass that moves from an upright position to "a new stable equilibrium on its side" (p. 5). Lovelock (2006) uses tipping point as a synonym for threshold, and his book claims, "We are now approaching one of these tipping points, and our future is like that of the passengers on a small pleasure boat sailing quietly above Niagara Falls, not knowing the engines are about to fail" (p. 6). Hansen's (2005b) use of tipping point implies a similar sense of losing control and irreversible consequence: "we are on the precipice of climate system tipping points beyond which there is no redemption" (p. 8). Malcolm Gladwell's (2000) idea of tipping point is discussed in epidemiological terms and through ideas of contagious or infectious disease transmission. These metaphors suggest the ubiquity and significance of systems changes that are abrupt, and they are always contrasted against gradual or incremental assumptions.

In the examples of Lovelock, Hansen, and Lenton et al. (2008), the tipping point metaphor is intended to create urgency regarding the danger represented by an unanticipated form of change. The utilization of threshold-oriented language is designed to suit our usual experiences of crisis, and to meet the requirements of politicians in motivating policy change. It could be argued, however, that the metaphor encourages a completely different idea of climate, and how climate can change (cf. Hulme 2009, p. 60). If so, tipping point warnings are not a plea for citizens and policymakers to simply recognize new evidence, and to adapt policy frameworks accordingly. Instead, these warnings install a non-conventional view of climatic change, and a different understanding of the integrated nature of earth systems. Such paradigm shifts, if indeed tipping point warnings represent one, are not the result of unambiguously observed phenomena or evidence, or not decided merely on this basis. At any rate, it is clear that fitting geological timescales to ecological and policy timescales, and that sensitizing policy makers and the public to the idea of thresholds for change, has been done primarily through analogy and metaphor. Of particular interest is the intermixing of metaphors that remind of rather simple and familiar experiences with on-going conceptual innovation and model development.

Insight into Signals of Danger

It is in "the normative leap from findings of fact to policy recommendations" as Ogunseitan (2003) suggests, that generative metaphor is of special importance (p. 102). This leaping, like the flickering climate suggested in Alley's light switch metaphor, is likely to recur frequently before settling into a conventionalized and commonly accepted use. It is also important to recognize the communicative process involved in applying metaphor.

There is a tendency to consider metaphors in isolation, but the contrast among competing metaphors often produces important insight. The terrifying pull of a strong undertow inspires the urgency of Lovelock's metaphor, and irreversibility is suggested by his comparison to an "event horizon", where the pull of gravity from a black hole is invisible yet inescapable (p. 52). Alley's light switch is not terrifying in this sense, but it better attunes one to the possibility of flickering states of climate. Contrasting Alley's drunk with Broecker's beast is also useful. In the image accompanying Broecker's (1999) warning, the beast is a large dragon – mythical, dangerous, and probably difficult to anticipate in its response to poking. By contrast, Alley's sleeping drunk suggests a certain predictably. There might be no response to repeated prodding, or minute signs of unrest that fail to escape notice. Yet, the eventual response might well be out of all proportion with gentle prodding, and an exaggerated reaction can occur during particularly sensitive moments. If considered more deeply, the analogy suggests delayed or slowed response times to perturbations that would generally solicit an immediate reaction from a sober person, as well as wandering, stumbling physical movement that is exaggerated, but which still resembles normal human activity. In fact, such "oscillations to perturbations" are sometimes taken as good evidence of an inebriated person. In this sense, the metaphor sensitizes us to warning signals.

It is these exaggerated movements and delayed responses that Lenton et al. (2009) emphasize in their rolling ball analogy, which encourages the development of a signalling system for danger. The goal is to perceive signals and an early warning of an approaching tipping point (it is worth noting that Lenton et al. (2009) use tipping elements and tipping points to encompass many modes of non-linear change, not simply rapid or gradual change).

> Picture the present state of the system as a ball in a curved potential well (attractor) that is being nudged around by some stochastic noise process, e.g. weather. The ball continually tends to roll back towards the bottom of the well – its lowest potential state – and the rate at which it rolls back is determined by the curvature of the potential well. The radius of the potential well is related to the longest immanent time scale in the system. As the system is forced towards a bifurcation point, the potential well becomes flatter (i.e. the longest immanent time scale increases). Consequently, the ball will roll back more sluggishly. It may also undertake larger excursions for a given nudge. At the bifurcation point, the potential well disappears and the potential becomes flat (i.e. the longest immanent time scale becomes infinite). At this point, the ball is destined to roll off into some other state (i.e. alternative potential well) (Lenton et al. 2009, p. 879).

The analogy is used to clarify indications of an approaching tipping point generally. It does not help create a general perception of ocean circulation or changes due to thermohaline circulation (the subject matter of Lenton et al.'s 2009 article), which are more adequately understood in terms of a conveyor or other metaphors than a rolling ball for most purposes. Instead, Lenton's ball is more like Alley's drunk: slowing response time to prodding is indicated either by fewer reactions than expected to each poke, or by exaggerated or staggering movements, with longer periods required for the return to relative stasis or balance. A more rigorous comparison might be pursued with other metaphors. The mechanical scale diagram of the NAS (2002) report, where two curved scales are balanced and contain a single rolling ball, is helpful for envisioning conditions of sensitivity to threshold and state-change, or even the tipping nature of climate states, but less valuable for diagnosing greater proximity to tipping points in Lenton's definition.

The policy implications of Lenton's proposal remain to be worked out, but the conceptual element of generative metaphor, and its importance for developing policy implications from factual content through the generation of novel perceptions of familiar situations, is of significant value – both in popularizing complex ideas and in fostering new insights. The use of such metaphors, at least in the case of tipping points, should also be analysed in terms of three other elements: the intended domain of reference, over-extension and conflation, and conventionalization.

Theoretical References

The tipping point metaphor can elicit various theoretical frameworks for understanding abrupt change. Proponents of the term often have different domains in mind, and the use of more specific analogies can help clarify matters. Some scientists clearly intend no more than simple physical tipping (as when a glass or canoe is tipped), whereas others intend reference to chaos or complexity theory (of the sort inspired by Edward Lorenz work on non-linearity, or Rene Thom on catastrophe theory), or punctuated equilibrium (Gould), or epidemic change (Gladwell). Often, these theoretical frameworks are elicited differently as the referent shifts: non-linear science underpins reference to climatic or ecological sub-systems; Gould is a source of inspiration for policy analysts; Gladwell guides references to social change and communication. In most cases, however, the framework intended by the tipping point warning is not clear, and these four domains do not exhaust the range of possibility.

Overextension

Another problem is that proponents of specific metaphors are likely to overextend metaphors by intermixing or simply conflating different processes. Overextension can produce insight, nonsense, or damaging error. Broecker's earliest use of the conveyor metaphor, for example, did not address the connection of oceanic conveyor belt shutdown and global climate change. The connection was suggested by readers of his work and appears to have provoked Broecker to more seriously investigate the possibility, which he now endorses as a significant threat (Brüning and Lohmann 1999, p. 401). A less fortunate outcome has resulted from an overextension of the billiard ball metaphor for motion, a metaphor sometimes used to suggest a purely mechanistic universe. Richard Lewontin (1966) even suggests that "the most important event in the history of science" might be Descartes's use of the machine metaphor, "bête machine", the foundation of a deterministic worldview (p. 25).

The most remarkable and problematic feature of tipping point warnings of abrupt climate change is the frequent conflation of physical and social processes. For example, Hansen and Lenton are prone to conclude that the dangers of tipping points due to anthropogenic climate change can be countered by attention to tipping points in socio-economic phenomena. Why select this particular view of social change from the wide array of competing theories, and why fail to reference the research or provide evidence for this preference? The lack of argument or evidence provided suggests that their preference for tipping point social change is an overextension of their efforts to map a generative metaphor onto climate change matters. However, there is an important difference between invocations of climatic and social tipping points. Social references to tipping points lack concern over the resiliency of the system undergoing change; crossing tipping points is usually stated as a danger in climate systems, yet viewed as beneficial rather than dangerous when social systems are the referent, and tipped social systems are rarely discussed in terms of runaway effects or as out of control (Russill and Nyssa 2009). In these examples, it is clear that the crossing of tipping points is encouraged, as a solution to public policy and social change problems.

The overextension of tipping point metaphors might be expected for two reasons. First, tipping point references were in popular circulation before their application to climate system components, and to climate change issues more generally. Russill and Nyssa observed that bulk of tipping point references in US and UK presses occurred from 2003 onwards, and that climate change tipping points as part of this broader trend represented 6.5% and 16.1% of such references respectively. Second, concerns regarding abrupt change imply judgments about the capacity of sociopolitical systems to adapt and respond, a point elaborated below more thoroughly.

Re-description and Conventionalization

In Russill and Nyssa's (2009) study, they pointed to examples of re-description, where previous research was referenced and re-described in newer terms. Re-description is evident in the most sophisticated elaboration of tipping terminology in the scientific literature. Lenton et al. (2008) develop their tipping point perspective in explicit contrast to the IPCC AR4 to argue for greater attention to the urgency represented by abrupt transitions and non-linear change, and to provide a formal definition for determining tipping points in model simulations used in IPCC assessment reports. John Schellnhuber, a co-author of the research and probably the longest standing booster of climate change tipping point terminology, suggests the article is "a 'mini-IPCC-report' focusing on tipping elements" (Potsdam Institute for Climate Impact Research 2008, paragraph 16). It is a valuable and important article, yet the reference to IPCC processes indicates the desire to conventionalize tipping point warnings, as opposed to illuminating how the questioning of climate experts regarding tipping points compares to the construction of assessment reports by the IPCC.

In this case, the re-description and conventionalization is most evident in the accompanying press materials, which reference "Selected publications on tipping elements (from PIK authors)". Five papers are provided from associated Potsdam Institute for Climate Impact (PIK) scientists, yet none of these articles use tipping points or tipping elements terminology. It is hardly a matter of distortion; several articles speak of bifurcation points or a trigger point in a manner suggestive of the formulation of tipping elements and tipping points in Lenton et al. (2008) and Lenton (2009). Yet, none of the non-PIK authored research on tipping points is referenced in the press release, although it is discussed in the original article. In this respect, the press releases display the process of conventionalization through which a preferred metaphor is naturalized – given a deeper and more established intellectual trajectory and empirical base – without calling attention to the metaphorical elements of the process itself. The example also illuminates how institutional authority plays a central role in conventionalizing metaphor.

Implications

It is interesting that the ubiquity of analogy and metaphor in abrupt climate change communication is rarely noted, and that discussions of its importance are quite rare. What implications might result from better recognizing the role and scope of metaphor in climate change communication?

It is possible that familiar patterns in climate change discourse could be indexed to differences in temporal understanding. Ravetz (2003) and Lenton (2009) both suggest the preference for gradual over abrupt change has guided decisions to focus on global mean temperature or sea-level, as opposed to specific instances of non-linear impact, like sea-ice melt. Ravetz also hints that choices regarding that appropriate discount rate for economic modelling reflect such assumptions. Ideas about natural change may also influence decisions to emphasize the global importance of positive feedbacks (emphasized, for example, by Al Gore and James Hansen), or the stabilizing feature of negative feedbacks (a frequent feature in the sceptical discourse of Richard Lidzen). Hulme's (2009) idea that metaphor can amplify risk in climate change consideration is also of relevance, and he points specifically to institutional efforts to disseminate tipping point warnings (p. 203, 205).

If disputes were indexed to competing temporal assumptions, it would recast our understanding of why people disagree about climate change. Differing opinions could be explored and evaluated not simply in terms of factual content or predictive likelihood, although a wider range of perspectives might well produce new information and novel insights for regional and local impact models. Instead, these views would be explored and elaborated in terms of possible futures, and as Ravetz (2003) suggests, the emphasis would be placed on re-imagining the relationship of climate change to citizens in these futures. It is especially important that assumptions regarding social change be defined in ethical and political terms, and not disguised in technically oriented scientific and policy discussions, or as incontestable models. A good example, in this respect, is Michael Hulme's (2009) study of disagreement in climate change discourse. Hulme uses metaphor freely in characterizing the different kinds of stories structuring climate change discourse, and he uses metaphors that indicate how western culture is strongly defined by Judeo-Christian mythology (p. 329).

A second implication of accepting the significance of analogy and metaphor in climate change communication is the possibilities opened up for public participation. The important touchstones for warnings of the danger of abrupt climate change are scientific publications. Hansen et al. (2008) made his determination of dangerous anthropogenic interference at the 350 PPM CO_2e tipping point in a standard scientific paper. Lenton et al. (2008) identified several tipping points through an expert elicitation or survey. In both papers, the technical focus of the argumentation and discussion can obscure the potential role of generative metaphor in policy solutions, especially the assumptions made regarding sociopolitical change. If, however, the emergence of tipping point warnings is described in terms of generative metaphor, then a few important features become more evident.

First of all, warnings assume possible futures, and embed claims regarding the desirability of futures, as well as the capacity of people to respond to changing circumstances that will shape these futures. Tipping point warnings propose that a different temporal structure is required in order to make the dangers of climate change intelligible. Change might come as punctuation rather than progress or increment. This is a reasonable claim. The difficulty arises in selecting thresholds, and in the effort to fit geophysical phenomena to the timescales of policy and political change. There is no agreement or fixed understanding regarding how quickly policy and politics promote social change; a warning, by definition, makes assumptions regarding the adaptive or responsive capacities of people and societal institutions. All efforts to determine human resiliency have difficulty incorporating reflexivity, or the capacity to learn and act differently given awareness of a situation. Tipping point notions of social change, for example, tend to view social systems as expressions of universal laws of dynamical systems, not as one sociopolitical perspective among many. Thus, it is not simply that differences in temporal assumption underpin the appraisal of the possibility of abrupt climate change; these assumptions influence visions of social change as well. One implication of this position is that if the warnings of Hansen et al., and Lenton et al, are viewed as alarms, it means not only that the response capacity of humans is taken into account in deciding when to sound an alarm, but that the threshold for signalling danger must be sensitive enough to accept mistakes. Warnings based on crossing thresholds must permit adequate time for human response to danger, but also permit or account for error. In each case, judgments regarding sociopolitical and economic change are implied.

Second, it is evident that debates regarding the future involve values. It is important to recognize the role of values in the expression of opinions and preferences on climate change, as the "framing" researchers claim, and to avoid reducing disagreement to truth claims or factual statements regarding geophysical phenomenon. Yet, as Robert Cox (1982) reminds, we make implicit temporal assumptions in forming judgments of value, which means "we structure our existence in relation to certain ends – in relation to purposes which are realizable *within* time" (p. 232). If Cox is right, ways of acting in the world are woven through with assumptions about the nature of time and change, and disagreements expressed in terms of geophysical facts or human values rest on prior assumptions regarding the nature of time. Gould's dichotomy of temporal metaphor helps us explore the implications of different temporal assumptions in a more reflexive manner, while suggesting the importance of culture and context.

These features of climate change warnings and the assumptions they require might be illuminated by an account organized in terms of generative metaphor, and it could open opportunities for expanding public participation in the manner of participatory sustainability perspectives. The increasing emphasis on regional and local impact modelling represents a clear opportunity to extend the participatory integrated assessment model (IAM) perspective found in Kasemir et al. (2003), Gough et al. (2003), and Ravetz (2003).

Conclusion

Climate change communication is characterized by frequent recourse to analogy and metaphor in a variety of contexts. The implications of better recognizing the role and scope of metaphor in abrupt climate change warnings were explored in terms of generative metaphor and Steven Jay Gould's claims regarding the constitutive feature of temporal assumptions for scientific study. The proliferation of tipping point warnings of climate danger was examined as an exemplary case of generative metaphor, and the opportunities for better explaining entrenched disagreements and opening climate science to public participation were suggested. It is especially important to recognize advocacy for tipping points in public opinion and social systems as metaphorical if the conflation of climatic and social phenomenon is to be avoided, and if the political nature of enshrining a preferred conception of social change is to be recognized.

There are clear limitations to the work presented here. The analysis should be extended to include visual material and the rich diagrams that often accompany abrupt change warnings. There are myriad theories of analogy and metaphor that could be brought to bear on material covered in this paper, as well as research into non-metaphorical rhetorical figures important to scientific practice (Fahnestock 1999). It is also important to include a more perspicuous understanding of media systems, including the analysis provided by Carvalho and Burgess (cf. Hulme 2009, pp. 221–222). Public discourse would also be improved if greater clarity were gained on the paradigm of abrupt change assumed by various proponents of its possibility. At least four different theoretical frameworks have informed the recourse to abrupt change metaphors: simple physical examples (a tipped glass), the chaos and complexity theories developed from Lorenz's discussions of meteorological chaos and Thom's catastrophe theory, among other sources (one version of which informed Al Gore's *Earth in the Balance*), the "punctuation" thinking developed in Gould's work (put to good use by Frank Baumgartner), and the epidemiological model for tipping points found in Malcolm Gladwell's (2000) popular book (inspiring the visions of social change shared by a raft of experts and activists today). Finally, the weighting of temporal assumptions among other elements important for making sense of climate change needs greater attention.

References

Alley R (2000) The two-mile time machine: ice cores, abrupt climate change, and our future. Princeton University Press, Princeton

Alley R (2002) Foreword. In: Abrupt climate change: inevitable surprises. National Academy Press, Washington, DC, pp v–vii

Baumgartner F (2006) Punctuated equilibrium theory and environmental policy. In: Repetto R (ed) Punctuated equilibrium and the dynamics of U.S. Environmental policy. Yale University Press, New Haven, pp 24–46

Black M (1962) Models and metaphors. Cornell University Press, Ithaca

Bostrom A, Lashof D (2007) Weather or climate change? In: Moser S, Dilling L (eds) Creating a climate for change: communicating climate change and facilitating social change. Cambridge University Press, New York, pp 31–43

Boykoff MT, Boykoff JM (2004) Balance as bias: global warming and the US prestige press. Glob Environ Change 14:125–136

Brüning R, Lohmann G (1999) Charles S Peirce on creative metaphor: study of the conveyor belt metaphor in oceanography. Found Sci 4:389–403

Cox R (1982) The die is cast: Topical and ontological dimensions of the locus of the irreperable. Q J Speech 68:227–239

Deloria V (1994) God is red: a native view of religion. Fulcrum, Golden, Colorado

Ereaut G, Segnit N (2006) Warm words: how are we telling the climate story and can we tell it better? Institute for Public Policy Research, London

Fahnestock J (1999) Rhetorical figures in science. Oxford University Press, UK

Fischer F (2009) Democracy and expertise. Oxford University Press, UK

Gladwell M (2000) The tipping point. Little Brown, New York

Gough C et al (2003) Contexts of citizen participation. In: Kasemir B et al (eds) Public participation in sustainability science. Cambridge University Press, Cambridge, pp 37–61

Gould SJ (1965) Is uniformitarianism necessary? Am J Sci 263:223–228

Gould SJ (1987) Time's arrow, time's cycle. Harvard University Press, Cambridge

Hansen J (2004) Defusing the global warming time bomb. Sci Am 290:68–77

Hansen J (2005a) A slippery slope: how much global warming constitutes "dangerous anthropogenic interference"?: An editorial essay. Clim Change 68:269–279

Hansen J (2005b) Is there still time to avoid "dangerous anthropogenic interference" with global climate? A tribute to Charles David Keeling. Presentation given December, 2005, at the American Geophysical Union, San Francisco. http://www.columbia.edu/~jeh1/. Accessed 28 Feb 2007

Hansen J et al (2008) Target atmosphere CO_2: where should humanity aim? Open Atmos Sci J 2:217–231

Hellsten I (2002) The politics of metaphor: biotechnology and biodiversity in the media. Tampere University Press, Finland

Hesse M (1966) Models and analogies in science. University of Notre Dame, Indiana

Hesse M (1988) The cognitive claims of metaphor. J Speculative Philos 11:1–16

Hulme M (2006) Chaotic world of climate truth. BBC News, November 4. http://news.bbc.co.uk/1/hi/sci/tech/6115644.stm. Accessed 28 Feb 2007

Hulme M (2009) Why we disagree about climate change. Cambridge University Press, New York

Kerr RA (2008) Climate tipping points come in from the cold. Science 319:153

Kriegler E et al (2009) Imprecise probability assessment of tipping points in the climate system. Proc Natl Acad Sci 106(13):5041–5046

Lakoff G, Johnson M (1980) Metaphors we live by. University of Chicago, Chicago

Latour B (1987) Science in action. Harvard University Press, UK

Lenton T (2009) Tipping points in the earth system. Web page post. http://researchpages.net/ESMG/people/tim-lenton/tipping-points/. Accessed 14 July 2009

Lenton TM, Schellnhuber HJ (2007) Tipping the scales. Nat Rep 22 November (http://www.nature.com/climate/2007/0712/pdf/climate.2007.65.pdf)

Lenton TM et al (2008) Tipping elements in the Earth's climate system. Proc Natl Acad Sci 105:1786–1793

Lenton T et al (2009) Using GENIE to study a tipping point in the climate system. Philos Trans Roy Soc 367:871–884

Lewontin R (1966) Is nature probable or capricious. Bioscience 16:25–26

Lowe T (2005) 'Dangerous claims': is the way we perceive climate change leading to a precautionary approach or an irrational response? Tyndall Briefing Note 16:1–5

Mastrandrea MD, Schneider SH (2001) Integrated assessment of abrupt climatic changes. Clim Policy 1:433–449

Moser SC, Dilling L (2007) Toward the social tipping point: Creating a climate for change. In: Moser S, Dilling L (eds) Creating a climate for change: communicating climate change and facilitating social change. Cambridge University Press, New York, pp 491–516

National Academy of Sciences (2002) Abrupt climate change: inevitable surprises. National Academy Press, Washington, DC

Nature (2006) Editor's summary. Nature 441:785

Nisbet M (2009) Communicating climate change: why frames matter for public engagement. Environ Mag 51(2):514–518

O'Donnell TM (2000) Of loaded dice and heated arguments: putting the Hansen-Michaels global warming debate in context. Soc Epistemol 14:109–127

Ogunseitan OA (2003) Framing environmental change in Africa: cross-scale institutional constraints on progressing from rhetoric to action against vulnerability. Glob Environ Change 13:101–111

Potsdam Institute for Climate Impact Research (2008) Press release "Tipping elements in the earth's system". (http://www.pik-potsdam.de/news/press-releases/tipping-elements-in-the-earths-climate-system/view?set_language=en). Accessed 5 Feb 2008

Ravetz J (2003) Models as metaphors. In: Kasemir B et al (eds) Public participation in sustainability science. Cambridge University Press, New York, pp 62–77

Risbey JB (2008) The new climate discourse: alarmist or alarming? Glob Environ Change 18:26–37

Russill C (2008) Tipping point forewarnings of climate change: some implications of an emerging trend. Environ Commun 2:133–153

Russill C, Nyssa Z (2009) The tipping point trend in climate change communication. Glob Environ Change 19:336–344

Scheffer M (2009) Critical transitions in nature and society. Princeton University Press, Princeton, NJ

Scheffer M et al (2009) Early-warning signals for critical transitions. Nature 462:53–59
Schneider SH (1988) The greenhouse effect and the U.S. summer of 1988: cause and effect or a media event: An editorial. Clim Change 13:113–115
Schön DA (1979–1993) Generative metaphor: a perspective on problem-setting in social policy. In: Ortony A (ed) Metaphor and thought. Cambridge University Press, Cambridge, pp 137–163
Stommel H (1961) Thermohaline convection with Two Stable Regimes of Flow. Tellus 13: 224–230
Thompson J, Schweizer S (2008) The conventions of climate change communication. Paper presented to the annual meeting of the NCA Annual Convention, San Diego, CA, 20 Nov 2008
Ungar S (1998) Bringing the issue back in: comparing the marketability of the ozone hole and global warming. Soc Problems 45:510–527
Ungar S (2007) Public scares: changing the issue culture. In: Moser S, Dilling L (eds) Creating a climate for change: communicating climate change and facilitating social change. Cambridge University Press, New York, pp 81–88
Walker G (2006) The tipping point of the iceberg. Nature 441:802–805
Wiman BLB (1995) Metaphors, analogies, and models in communicating climate change uncertainties and economics to policy: a note on the pre-UNCED U.S. case. Ecol Econ 15(1):21–28

Chapter 9
The Increase of Global Temperature as a Result of the Greenhouse Effect: Assessing the Reasons for Disagreement Among Scientists

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Abstract This paper consists of two independent research projects which were carried out through the use of the same questionnaire. The questionnaire was completed by students of the Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace and by students of the School of Pedagogical and Technological Education in Athens. The two groups of respondents were asked to assess on a scale from 1 to 10 the reasons for disagreement among scientists regarding the increase of global temperature as a result of the greenhouse effect. The most important reasons are (1) the interdependence of science and economic activity (mean 7.33 for the students of Forestry and mean 7.22 for the students of the School of Pedagogical and Technological Education) and (2) the dependence of scientists on employers (mean 7.17 and 7.92). Reasons for disagreement are also the desire for personal fame (mean 6.88 and 5.92), the different scientific background and skills of every scientist (mean 6.68 and 5.88), the complexity of climate issues (mean 6.58 and 6.84), approaching the problem through emotion or logic (mean 6.57 and 6.19), the subjective element in each scientist which means seeing different things in the same picture (mean 6.65 and 6.00), the difficulty of proving hypotheses (mean 6.64 and 6.42), and access of scientists to different data (mean 5.55 and 5.40). Through the use of hierarchical analysis in clusters we have the following groups of variables: “financial dependence of scientists”, “possibilities regarding human and material potential”, “personality of scientists”, and “nature of the problem”. Generally, the scientific information regarding the increase of global temperature as a result of the greenhouse effect receives low grades by both the students of Forestry and the students of the School of Pedagogical and Technological Education (6.73 and 6.42). However, both groups believe that we should not wait for more convincing scientific information in order to adopt the necessary measures for confronting the problem (57.1% and 87.9%).

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Keywords Climate change · Credibility of science · Students of Forestry · Students of the School of Pedagogical and Technological Education

Introduction

In the field of the theory and methodology of science, it has been convincingly argued that there are no neutral tools for the analysis of objective reality. The existence of an objective scientific reality has been questioned by Thomas Kuhn (1962), while Paul Feyerabend (1975) has shown that science in general constitutes only one way of approaching reality. Social factors, as well as the personal convictions of the researcher, can affect scientific research in many ways, e.g. the choice of the subject of research or the interpretation of findings. Max Weber's (1949) view for a value-neutral science does not seem to be a rule in scientific activity (Chalmers 1999; Kothari 2006).

Our decision to research the subject of disagreement among scientists regarding the increase in global temperature as a result of the greenhouse effect was sparked by Adans (2001) and made on the basis of the following criteria, which are directly related to the issues under research in this paper:

The students of the Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace, tomorrow's scientists, whose study programme is directly related to the subject of environmental management and protection.

The graduates of institutions of higher education, either of a university or technological background, which at the time of this research were registered in the annual Programme of Pedagogical Training and the annual Programme in Counselling and Professional Orientation of the School of Pedagogical and Technological Education in Athens, who will soon be working mainly as teachers in secondary education schools and, in particular, schools with a technical–vocational orientation. As teachers, they will teach courses of their specialization which will be related to the study of the environment. In addition, they may also participate in specialized environmental education programmes as teacher-coordinators.

The graduates of institutions of higher education have different scientific backgrounds (they can be sociologists, engineers, medical doctors or agriculturalists). This variety of scientific specialization creates opportunities for a very interesting interdisciplinary dialogue. This gathering of all these different specialists under the same training programme is both rare and, for research purposes, very important.

The issue of the disagreement among scientists regarding the increase in global temperature as a result of the greenhouse effect is directly related to the field of education, which is the most important place for informing today's students – tomorrow's citizens – on matters relating to the protection of the environment

(Leal Filho 2008; Leal Filho et al. 2009). Therefore, it is of particular scientific and social importance to investigate the views of the above groups on possibly the most important contemporary problem of our planet. In addition, the differences between the two groups and in particular (a) the fact that the former are still undergraduates while the latter have already graduated and (b) the fact that the former are under 25 years old while the latter 25–45 years old, may make the study of the views of these two groups even more interesting.

The aim of this paper is to investigate the views of Forestry students at a Greek university and to compare and contrast these views with those of the students of the School of Pedagogical and Technological Education in Athens. These were two independent research projects which, however, were carried out through the use of the same questionnaire. Both groups of students were asked to assess, on a scale from 1 to 10, the extent to which they regard as credible the information they receive about the global increase in temperature as a result of the greenhouse effect, the views and causes which make scientists disagree on the above issue and whether or not we should wait for more convincing scientific evidence before we adopt drastic measures for confronting the problem of the increase in the global temperature.

Research Methodology

Both research projects were carried out through the use of a self-management questionnaire (Oppenheim 1973; Siardos 1999). As it was important to choose a suitable time to conduct the research (Daoutopoulos 1994), it was carried out during the examination period of February 2008. Generally speaking, the students took part in the survey willingly. The time required for filling in the questionnaire was 10–15 min.

The research area of the first project was the Department of Forestry and Management of the Environment and Natural Resources, of Democritus University in Thrace, which is located in Orestiada, Greece. The participants were the students who were being examined in at least one course, i.e. 245 students. The participating students were 60% male and 40% female. The distribution of the students from the first to the fifth year of study was the following: first year 20.8%, second year 19.6%, third year 19.2%, fourth year 20.4%, and fifth year 20%.

The research area of the second project was the School of Pedagogical and Technological Education at Athens. This project investigated the views of 132 graduates of institutions of higher education, who through the annual Programme of Pedagogical Training and the annual Programme in Counselling and Professional Orientation obtain the right either to teach or work in the field of counselling and in secondary education. Of the 132 graduates who completed the questionnaire, 111 were attending the annual Programme of Pedagogical Training and 21 the annual Programme in Counselling and Professional Orientation. 34.8% were male and 65.2% female.

Also, in order to find out the extent to which there are natural and useful groupings of data, we used cluster analysis and, in particular, the method of hierarchical clustering. Starting from each observation being by itself one cluster, in each step we associated the observations with the smallest distance, so that the data of one cluster were included in the data of the hierarchically next cluster (Behrakis 1999; Siardos 1999; Filias et al. 2000; Karapistolis 2001; Karlis 2005). Indeed, this hierarchically next cluster can function not only towards the direction of observation grouping, but also towards the direction of variable grouping (Siardos 1999).

As the unit of analysis is the variable, the measures of distance or similarity were calculated for all the pairs of variables. As measure of distance, we used the Pearson correlation coefficient and for combining the observations in clusters we used the method of the furthest neighbour. According to this method, the distance between two clusters is considered to be the one between their furthest points (Siardos 1999; Bartholomew et al. 2002). The analysis of the data was carried out through the use of SPSS.

Results

There can be little doubt that awareness of, and general concern for, global warming is almost universal (Dunlap 1994). However, global warming has all the characteristics of issues which are difficult to understand. It is a complex issue characterized by substantial uncertainty (Berk and Schulman 1995). Regarding what they think of the credibility of scientific information about the global increase in temperature as a result of the greenhouse effect, on a scale from 1 to 10 (1 refers to uncertainty while 10 to certainty), both the students of Forestry and the students of the School of Pedagogical and Technological Education gave low grades, the former 6.73 (s.d. 1.728) and the latter with 6.42 (s.d. 1.727).

For the public, making an assessment of how to respond to the threat of climate change requires, in part, assessing these uncertainties (Adans 2001). Assessing climate change also requires that the public improves its understanding of the nature of scientific controversy which surrounds the issue (McBean and Hengeveld 2000). Therefore, both the students of Forestry and the students of the School of Pedagogical and Technological Education were asked to assess the reasons for which scientists disagree about the global increase in temperature as a result of the greenhouse effect, giving marks from 1 to 10, where 1 means unimportant and 10 important. The results of the two research projects which were carried out are given in Table 9.1.

The students of Forestry mainly recognize four reasons of disagreement among scientists on the issue of global temperature increase: "The interconnection of science with economic activity" (mean 7.33), "the dependence of a scientist on his employer" (mean 7.17), "the desire for personal fame" (mean 6.88), "the different scientific background and skills" (mean 6.68).

Table 9.1 Assessment of the reasons scientists disagree on the global increase in temperature as a result of the greenhouse effect

	Reasons for disagreement among scientists	Students of Forestry			Students of the School of Pedagogical and Technological Education		
		n	Mean	s.d.	*n*	Mean	s.d
1	Access to different information	245	5.55	2.304	131	5.40	2.876
2	Scientists are characterized by different scientific background as well as different skills in managing and assessing information	245	6.68	2.129	131	5.88	2.611
3	Some scientists operate more on the basis of emotion while others on the basis of logic	245	6.57	2.371	131	6.19	2.459
4	What some scientists value most is personal fame. They believe that supporting extreme positions makes them special	245	6.88	2.371	131	5.92	2.571
5	The dependence of a scientist on his employer. Employers may be industries, environmental organizations, etc.	245	7.17	2.249	131	7.92	2.100
6	The difficulty of proving hypotheses. It is difficult to perform controlled experiments	245	6.64	2.119	131	6.42	2.314
7	The climate system is complex	245	6.58	2.410	131	6.84	2.307
8	Science is interconnected with economic activity	245	7.33	2.143	132	7.22	2.249
9	Two different people and, therefore, two different scientists may see different things in the same picture	245	6.65	2.464	131	6.00	2.431

The question, therefore, is whether research on climate change in the universities and research centres of our country should not only be financed by the state but also by the market, and whether the latter orients research and its results towards controlled directions. However, this disadvantage may become an advantage if we secure funding from different sources for different research teams which, however, research the same issue. So, in the long term, the analysis, synthesis, and publication of the results will lead to dominant scientific views. This seems to be correct, since regarding the increase in global temperature due to the greenhouse effect, both groups of students think of the reason “access to different data” as the least important reason of disagreement among scientists.

Lower in their assessment are reasons such as “the climate system is complex” (mean 6.58), “approaching the problem(s) on the basis of emotion or logic” (mean 6.57), “the human nature of scientists which means they see different things in the same picture” (mean 6.65), “the difficulty of proving hypotheses” (mean 6.64) and “access to different information” (mean 5.55).

Using hierarchical clustering we have four groups of variables which become obvious with complete linkage (Table 9.2) and a dendrogram of the variables (Fig. 9.1).

The “dependence of a scientist on his employer” is related to the view that “science is interconnected with economic activity” and in greater distance with the

Table 9.2 Complete linkage of variables and clusters with reference to students of forestry

Stage	Cluster combined		Coefficients	Stage cluster first appears		Next stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	5	8	0.403	0	0	6
2	3	4	0.340	0	0	7
3	6	7	0.330	0	0	5
4	1	2	0.280	0	0	5
5	1	6	0.176	4	3	8
6	5	9	0.139	1	0	7
7	3	5	0.002	2	6	8
8	1	3	−0.015	5	7	0

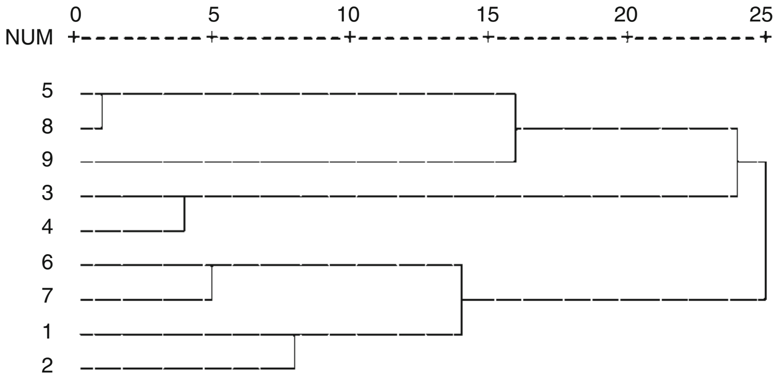

Fig. 9.1 Dendrogram of variables regarding reasons of disagreement with reference to students of Forestry

view that "due to human nature, scientists see different things in the same picture". This is the first cluster which can be named "economic dependence of scientists". The second cluster, "personality of the scientists", includes the reasons for disagreement among scientists with reference to "approaching the problem(s) on the basis of emotion or logic", as well as "the desire for personal fame" by a scientist. The views that there is "difficulty in proving hypotheses" and that "the climate system is complex" constitute the third cluster, which can be named "nature of the problem". The fourth cluster, "possibilities regarding human and material potential", includes "access to different information" and "different scientific background and skills".

The students of the School of Pedagogical and Technological Education think that the main causes of disagreement among scientists are "the dependence of a scientist on his employer" (mean 7.92) and that "science is interconnected with economic activity" (mean 7.22). Next come "the system of the climate is complex" (mean 6.84), "the difficulty in proving hypotheses" (mean 6.42), "approaching the problem(s) on the basis of emotion or logic" (mean 6.19) and "the human nature of scientists which means they see different things in the same picture" (mean 6.00).

As least as important are the views "desire for personal fame" (mean 5.92), "different scientific background and skills" (mean 5.88) and "access to different information" (mean 5.40).

Using hierarchical clustering in this case too, we have four groups of variables. The complete linkage (Table 9.3) and the dendrogram of variables (Fig. 9.2) show that the interconnection of the reasons is the same with regard to both populations, with the only differentiation the variable "the human nature of scientists which means they see different things in the same picture", which is connected with greater distance to the variables "access to different information" and "different scientific background and skills", which form the cluster "possibilities regarding human and material potential". Therefore, the only difference is that the students of Forestry believe that the difference in perception and analysis of information is due to interests originating in the relationship employee–employer, while the students of the School of Pedagogical and Technological Education believe in the skills of the scientists and the means available to scientists. Other clusters are "the economic dependence of scientists", "personality of scientists" and "nature of problem".

Table 9.3 Complete linkage of variables and clusters with reference to the students of the School of Pedagogical and Technological Education

Stage	Cluster combined		Coefficients	Stage cluster first appears		Next stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	1	2	0.614	0	0	5
2	6	7	0.438	0	0	7
3	5	8	0.380	0	0	8
4	3	4	0.377	0	0	6
5	1	9	0.251	1	0	6
8	1	3	0.188	5	4	7
7	1	6	0.012	6	2	8
8	1	5	−0.045	7	3	0

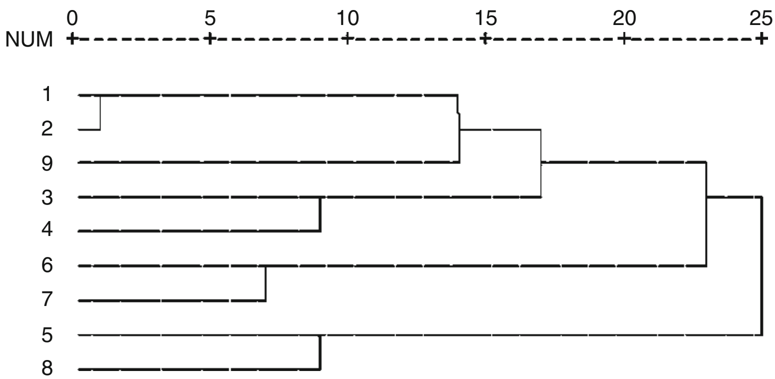

Fig. 9.2 Dendrogram of variables regarding the reasons of disagreement among scientists with reference to the students of the School of Pedagogical and Technological Education

One of the most basic policy questions which must be answered is whether action should be taken now or whether more research is needed (Adans 2001). Most of the students of Forestry (57.1%) declare that we should not wait for more conclusive scientific evidence before we take decisive action to confront the increase in global temperature as a result of the greenhouse effect. With reference to the students of Forestry, 32.7% disagree with this view, while 10.2% of the students do not answer the question. The students of the School of Pedagogical and Technological Education are more categorical since 87.9% of them believe that we should not wait for more conclusive scientific evidence before we take decisive action. 7.6% of the students of the School of Pedagogical and Technological Education believe that we should wait, while 4.5% of those students do not answer the question.

The differentiation of the views of the two groups of respondents may be due to differences in age, knowledge and social experience. Such differences may make the students of the School of Pedagogical and Technological Education perceive more clearly and more confidently how dangerous it might be to delay taking immediate measures for confronting the problem of the increase in global temperature as a result of the greenhouse effect. They may be more aware of the fact that scientific disagreement is a characteristic and acceptable feature of scientific activity and, therefore, we should not wait for a definitive agreement among scientists before we adopt the necessary measures simply because such an agreement may never occur.

Similarly, a study by Doble et al. (1990) found that 60% of their sample (402 adults from four US metropolitan areas) agreed with the statement, "If we wait for more conclusive scientific evidence before taking decisive action to deal with the greenhouse effect, it will be too late". On the other hand, only 29% of their respondents agreed with a converse statement, "Before taking decisive action to deal with the greenhouse effect, we should wait for more conclusive evidence".

Conclusions

In a scale from 1 to 10, where 1 means uncertainty and 10 certainty, both the students of Forestry and the students of the School of Pedagogical and Technological Education think that the information they receive from the scientific community regarding the increase in global temperature as a result of the greenhouse effect is a little above average.

In investigating the views of the study population regarding the reasons of disagreement among scientists on the increase in global temperature, we see that the first two positions in both research projects are occupied by "science is interconnected with economic activity" and "dependence of a scientist on his employer". Through the use of hierarchical analysis in clusters, we see that both of these variables constitute a cluster which we named "economic dependence of scientists".

Besides state funding, research centres and universities are also financed by other sources. This does not mean that the results are necessarily controlled by those who finance the research. However, some central mechanism with the task of assessing the credibility of the results must be created. Care should also be taken for the development of research areas which the private initiative is not particularly interested to finance.

Although the other reasons are assessed differently by the two populations, through the use of hierarchical analysis in clusters, we get four clusters which include the same variables. "Approaching the problem on the basis of emotion or logic" and the "desire for personal fame" of the scientists, constitute the cluster "personality of scientists". "The difficulty of proving hypotheses" and "the climate system is complex" constitute the cluster "nature of problem". The variables "access to different data" and the existence of "different scientific background and skills" constitute the cluster "possibilities regarding human and material potential".

Regarding the students of Forestry, the variable "due to their human nature scientists see different things in the same picture" is included in the cluster we named "economic dependence of scientists" whereas, regarding the students of the School of Pedagogical and Technological Education, the above variable is included in the cluster "possibilities regarding human and material potential". It seems, therefore, that the students of Forestry are stricter in their judgment and associate the different perceptions of scientists with the relationship employee–employer, whereas the connection for the students of the School of Pedagogical and Technological Education is the ability of and means available to scientists.

However, it is positive that both groups – with the students of the School of Pedagogical and Technological Education being more categorical – believe that we should not wait for more conclusive scientific evidence before we adopt the necessary measures for confronting the problem of the increase in global temperature as a result of the greenhouse effect. It seems that both groups firmly believe that the increase in the global temperature is a serious problem which our society should regard as a top priority.

References

Adans S (2001) Views of the uncertainties of climate change: a comparison of high school students and specialists. Can J Environ Educ 6:58–76

Bartholomew D, Steele F, Moustaki I, Galbraith J (2002) The analysis and interpretation of multivariate data for social scientists. Chapman and Hall, Boca Raton, FL

Behrakis T (1999) Multivariate data analysis: methods and applications. Livanis, Athens

Berk RA, Schulman D (1995) Public perceptions of global warming. Clim Change 29(1):1–33

Chalmers AF (1999) What is this thing called science? University of Queensland Press, St. Lucia, Queensland

Daoutopoulos GA (1994) Methodology of social research in rural areas, 2nd edn. Thessaloniki

Doble J, Richardson A, Danks A (1990) Science and the public: a report in three volumes, vol 3: Global warming caused by the greenhouse effect. Public Agenda Foundation, New York

Dunlap RE (1994) International attitudes towards environment and development. Green Globe Yearbook. Oxford University Press, New York

Feyerabend PK (1975) Against method: outline of an anarchistic theory of knowledge. Verso, London

Filias V, Pappas P, Antonopoulou M, Zarnari O, Magganara I, Meimaris M, Nikolakopoulos I, Papachristou E, Perantzaki I, Sampson E, Psychogios E (2000) Introduction to the methodology and techniques of social research. Gutenberg, Athens

Karapistolis DN (2001) Data analysis and market research. Annikoulas, Thessaloniki

Karlis D (2005) Multivariate statistical analysis. Ath. Stamoulis, Athens

Kothari CR (2006) Research methodology: methods and techniques. New Age International, New Delhi

Kuhn TS (1962) The structure of scientific revolutions. University of Chicago Press, Chicago

Leal Filho W (2008) Communicating climate change: challenges ahead and actions needed. In: Climate 2008 Online Conference, 3–7 Nov 2008. Available at http://www.climate2008.net/?a1=pap&cat=3&e=30

Leal Filho W, Manolas E, Pace P (2009) The contribution of education towards meeting the challenges of climate change. Paper presented to the Global Conference on Global Warming 2009, Istanbul, 5–9 July 2009. Available at http://www.gcgw.org/gcgw09/documents/GCGW09-program-v6.pdf

McBean GA, Hengeveld HG (2000) Communicating the science of climate change: a mutual challenge for scientists and educators. Can J Environ Educ 5:9–25

Oppenheim A.N. (1973) Questionnaire design and attitude measurement. Heinemann, London

Siardos GK (1999) Multivariate statistical analysis methods. Part 1: Exploring the relations between variables. Zitis, Thessaloniki

Weber M (1949) The methodology of the social sciences. Free, Glenncoe, IL, USA

Chapter 10
The Social Dilemma of Climate Change: Socio-economic Implications

Martin Beckenkamp

Abstract A social dilemma lies behind many environmental problems, such as climate change. Analytically separating temporal aspects from structural aspects of the environmental dilemma prevents wrong conclusions. This article concentrates solely on the structural aspects with different grades of complexity and different grades of ignorance in the dilemma. Dilemmas with sufficient complexity, such as climate change, and/or ignorance of the stakeholders are extremely vulnerable to individual defections. Therefore, governance is an absolute must and institutions are necessary. However, controls and sanctioning are key factors of institutions. Consequently, psychological approaches should not only target the individuals, but integrate in a multidisciplinary programme that focuses on governance tasks with respect to (1) the structural diagnosis of the social dilemma of climate change; (2) didactic instruments and methods that give addressees an insight into these structural problems; (3) the role of governance for the stakeholders on internalizing norms; and (4) the impact of structural knowledge on accepting institutions that help to solve the structural part of the sustainability problem. Psychological research in institutional ergonomics could help to create addressee-friendly governance, where the addressees know about the value and adequacy of certain restrictions for the sake of common welfare and sustainability.

Keywords Climate · Environmental psychology · Governance · Institutional design · Sanctioning · Social dilemma

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Introduction: Climate Change Is Essentially a Social Dilemma

Beyond many environmental problems, there is the structure of a social dilemma. Since Hardin (1968), environmental social dilemmas have been tagged as “the tragedy of the commons”, and it is well-known in environmental psychology that many environmental problems are social dilemmas: “The-tragedy-of-the-commons process underlies most problems of environmental pollution, just as it underlies the depletion of most natural resources” (Gardner and Stern 1996). This is especially true for climate change. The globally most challenging social dilemma is “the prevention of dangerous climate change. Reaching the collective target requires individual sacrifice, with benefits to all but no guarantee that others will also contribute” (Milinski et al. 2008). In this quotation, the authors describe very aptly the structure of the social dilemma with respect to climate change, but partially confound it with temporal aspects. This article concentrates on the dilemma and depicts some relevant implications.

Social Dilemmas

The very simplest form of an environmental dilemma is the prisoners’ dilemma (cf. Luce and Raiffa 1957). In its classical form, the prisoners’ dilemma is presented as follows: Two suspects are arrested by the police. There is a lack of evidence for a conviction. Therefore, the suspects are separated and individually interrogated. In this interrogation, the police offer a deal similar to a leniency. If the interrogated testifies (defects) for the prosecution against the other and the other remains silent (cooperates), the betrayer goes free and the silent accomplice receives the full 10-year sentence. If both remain silent, both prisoners are sentenced mildly for a minor charge. If both betray each other, both of them receive a 5-year sentence. What should the prisoners do? In either case (the other betrays or the other remains silent), betraying is the better choice (dominant strategy). However, if both follow this individual-rational consideration, both are worse off than if each of them had been silent. Betraying on the part of both is a win-win situation. However, this win-win situation is very unstable, because betraying of the other would absolve the prisoner (and lead to a very high sentence for the silent prisoner).

In this very simple social dilemma, there are only two stakeholders (individuals or interest groups) and only two choices to select from. Nevertheless, like all environmental dilemmas, the prisoners’ dilemma is a serious conflict between individual rationality and collective reason (Poundstone 1992).

International policies concerning climate change lead to a political Prisoners’ Dilemma. Governments have to decide whether or not to take action against climate change. Countries benefit if climate change is prevented, independent of whether they support such policies or not. This free-rider problem is hard to tackle.

Even worse, many environmental dilemmas are much more difficult than the prisoners’ dilemma. In the following, I would like to point to three issues that are mostly relevant with respect to climate warming (1) There is asymmetry in the dilemma; (2) there are more than two stakeholders in the dilemma; (3) there was a long period of blindness about being in the dilemma and it is not clear how blind the addressees are today; (4) besides the dilemma itself, there are complicated time dependencies that make the problem much more complex.

Climate Warming Is an Asymmetric Dilemma

Even this simplest form of an environmental dilemma, with two stakeholders and two options, respectively, can be enriched in complexity by introducing asymmetry. In this case, it is much harder to reach welfare and cooperation. Distributive justice plays a crucial role in conflicts with such asymmetries.

A reason for such asymmetries could be different costs of the consequences of climate warming, such that one nation ends up better off in mutual defection than the other. Data from the lab indicates that in asymmetric prisoners' dilemmas the phases of cooperation are much shorter and long phases of cooperation are extremely rare compared to the symmetric dilemmas (Beckenkamp et al. 2006). Magen (in preparation) assumes that dilemma experiments with unequal endowments reveal the ambiguity of fairness criteria in almost every experiment about asymmetric social dilemmas (see also Magen 2006).

Due to such justice conflicts, there is a special dynamic in asymmetric prisoners' dilemmas. Structural solutions that help to maintain welfare may become necessary. An important approach is to negotiate side payments. Other solutions, such as keeping the situation deliberately opaque with respect to the benefits (such a solution can often be found with respect to payments of employees), are hard to implement in the context of climate warming. Moreover, such an approach may yield the problem of "blind" dilemmas and the veil of ignorance described below. In the context of climate warming, it is also impossible to find good reasons that justify the inequalities in the consequences. Due to the asymmetries, climate warming is a topic where issues about distributive justice are entangled with issues about procedural justice (Ittner and Ohl 2006).

There Are Many Stakeholders in the Dilemma

In most of the environmental dilemmas, there are more than two stakeholders involved. This is especially true for climate warming. Like in the 2-person dilemma, there is a free-rider problem (see also van Lange et al. 1992). Therefore, the game-theoretic equilibrium falls apart from the welfare optimum, and the welfare optimum is unstable because there is always the temptation to defect for each of the stakeholders.

A serious problem is that reciprocal strategies are hard to implement or do not even make sense in N-person dilemmas. Some nations and stakeholders at least try to use reciprocal strategies by imitating what other stakeholders do and, moreover, making some leap of faith in their efforts against climate warming. Underlying this approach that tries to come to mutual cooperation, there is a strategy called "measure for measure" (cf. Beckenkamp 2009). Nevertheless, the efficiency of reciprocal strategies in N-stakeholder dilemmas is much worse than in 2-stakeholder dilemmas. Even worse, communication is also problematic, because with the growing number of participants in the dilemma, communication channels and rules are necessary. The difficult environmental dilemmas such as climate change could probably never be resolved without institutions.

Is Climate Warming Still a Blind Environmental Dilemma?

Traditionally, from a historic point of view, climate warming was also a very difficult environmental dilemma because in contrast to many laboratory experiments with social dilemmas, the stakeholders were not aware about the dilemma they were in. They had only limited information about their own situation, and no information about either the behaviour of others or about the others' measures against climate warming. It is plausible to assume that under such circumstances the stakeholder will learn defection instead of cooperation (cf. Beckenkamp 2009). Nowadays, most of the stakeholders are probably aware of important aspects of the social dilemma, although it is an open question as to how much they really know about it.

At the beginning of the initiation of policies against climate warming, many stakeholders seemed to be blind to the matrix of social interdependencies in which the decisions are made. Stakeholders made decisions without the intention of harming others, although their decisions were freighted with huge negative externalities. If the stakeholders had no insight into the structure of the "game", i.e. the social interdependencies of the decisions with other stakeholders, it seems rather obvious that they could not believe the scientific and political claims that less energy consumption could mean more welfare.

The general global trend in policies to deregulate in many domains and to create "efficient" markets may even have amplified such tendencies to care only about the impact of decisions for oneself. On the other hand, licences for CO_2 emissions are a powerful economic instrument to do away with the external costs of CO_2 waste production. The initiators now have to bear the costs themselves, and the stakeholders who avoid CO_2 waste production can benefit from their efforts. An efficient market means that there are no market failures and therefore no social dilemmas. In such cases, blindness poses no problem. Unfortunately, climate warming is a consequence of inefficient markets, and until now there has been no remedy that abolishes the market failures in sum. Until now, the licences have concerned only parts of the problem.

Temporal Aspects of Climate Warming

Milinski et al. (2008) describe environmental dilemmas not only from a structural aspect, but also with regard to its temporal side, by saying that "substantial emissions reductions are likely to have negative short-term economic effects, but failure to accomplish this reduction may well incur dangerous climate change later, resulting in substantial human, ecological, and economic losses" (Milinski et al. 2008). Although this is undoubtedly true, this temporal aspect should be separated from the structural aspect of the social dilemma. The temporal aspect is independent of social interdependencies and can also be a problem for a single person, as, for instance, in the case of addiction problems. It requires other interventions than the structural dilemma aspect. The temporal implications also need psychological instruments other than the structural implications.

Climate change is an extremely complicated environmental dilemma, because the dilemma structure itself is complex and because the time latencies and non-linearity of many causal interrelationships are very complicated. It is a political problem with the highest complexity in both the social interrelationships and the natural science foundations. The social dilemma implies a situation of social interdependencies, and it only occurs when there are at least two persons striving for maximal incomes (or minimal efforts). Therefore, climate change is not only a problem that is relevant for natural sciences. Trying to solve the dilemma without a consideration of the social interdependencies must fail. The social dilemma is an essential component of the environmental problem climate change, and this facet of the problem must be well understood and analysed in and of itself.

Implications of the Structural Complexity: Institutions Are Necessary

The success and applicability of reciprocal strategic reactions of stakeholders stands in close dependence to the complexity and structural form of the dilemma. A complex social dilemma such as climate change is extremely vulnerable to defections coming from minorities. In such cases, institutional solutions are necessary to help stabilize mutual cooperation. However, such institutions must not necessarily come from outside or top-down, because historic examples and current cases show that self-governance can be possible (Ostrom 1990). Yet, it should not be overlooked that not only governance from outside but also successful self-governance always includes monitoring and sanctioning – even in small groups governing a common-pool resource. Nevertheless, self-governance may outperform governance from outside, because the efficiency of controls and the adequacy of sanctions are highly dependent on context specificities. Often, nobody knows such specificities better than the addressees of institutions themselves. Nevertheless, in the context of climate change it seems implausible to assume that self-governance alone could be sufficient.

Empirical experiences demonstrated that in complex environmental dilemmas, it is hard to convince the individual of their individual impact on the destruction of their basis of existence. Many environmental studies report long-lasting mediation processes to overcome environmental dilemmas (cf. for instance, Ohl et al. 2008).

Focusing on the structural aspect of the dilemma could lead to new strategies in the mediation process and new tasks in education. People should learn about the question “If everybody knows that we are destroying our environment with heavy energy consumption, why do people continue as they do?” They should learn that is not necessarily the malignance of individuals that leads to this destruction, but also the structure of social interdependencies that may even force part of the people to behave defectively in order to guarantee their own existence and survival. People should learn more about the necessity of institutions that change these structures. Nobody wants to be controlled and sanctioned in cases of defection – an insight into the structural problem, however, can lead to an acceptance of such institutions (Yamagishi 1986).

Potentially, experimental games could help to communicate this issue. The games can illustrate the trap that stakeholders are locked in, and thus accelerate mediation processes. Why not make use of dilemma games about climate warming with the stakeholders themselves – games adapted to their situation that demonstrate that they could achieve a win-win constellation, but that this constellation is extremely vulnerable? This would be a completely new approach in institutional design. Instead of making use of experimental games in order to reveal data in the lab, such games can also be used both for data acquisition (i.e. the diagnosis of social interdependencies) and, after that step, for specific mediation in the dilemma conflict in order to come to a well-integrated institutional design. They could also help to foster the introduction of institutional solutions, and integrate the stakeholders’ knowledge in such an approach. This, again, would also lead to more self-governance and less governance top-down in the solution of the dilemma.

Experimental games could also be used for target-oriented data acquisition and lead to a game-theoretic valid model. This approach would take several steps. The first step is the identification of the relevant stakeholders within the environmental dilemma. How many players are there in the game or, accordingly, how many stakeholders are there in parts of the environmental dilemma? The answer to that question provides the relevant stakeholders. Ideally, such studies should be shaped in such a way that the number of different interest stakeholders is small, such that a rather big conflict (as, for instance, climate warming in general) can be partitioned into manageable sub-conflicts. Therefore, instead of integrating the conflict between private energy consumption, transportation and energy production, it would make sense to focus on the transportation conflict and within that, aviation, and to map other conflicts in other games, such that each conflict can be put on its own agenda.

Once the stakeholders of such a manageable conflict have been identified, the second step would be to try to identify the relevant action space of the respective stakeholders; this corresponds to the rows and columns in the examples given before. Then, in the last step, the ranks in the evaluation of the different combinations of actions for each of the stakeholders should be elevated. This would lead to preference tables that represent the “game” played by the respective stakeholders.

Such preferences could be revealed by requesting the whole combination of actions that can be ranked by the different stakeholders. When the “game” is identified, it can be used in confrontation with the stakeholders in order to check the validity of the diagnostic process. If the “game” fits well, the diagnosis of the environmental problem (which can be an environmental dilemma, but could also have a different, non-dilemma structure) is finished and the same game can be used to illustrate the structural problem beyond the stakeholders. If the game does not fit well, the diagnosis itself should be evaluated with respect to the differences between the answers the stakeholders gave and the denial of the stakeholders with respect to the game that has been identified on the basis of their answers. This could bring up relevant questions that had not yet been posed until that point of data acquisition.

Making use of experimental games in order to come to a valid diagnosis of conflicts is one issue where environmental psychology and experimental economics could tie in with institutional design. However, until now, institutional design has mainly been a topic in political science, law and economic theory. In social conflicts, psychology is mainly used for mediation and strategies of attitude and value change in the addressees.

Psychology could do more, because such a diagnosis could be a solid foundation for the support in interventions. Many environmental problems are complex social dilemmas (Brock and Xepapadeas 2003), and climate change is one of these problems. Such environmental dilemmas need both institutional solutions and insight into and support of such solutions by the addressees. The valid diagnosis of the “game”, i.e. a game-theoretic representation of the environmental dilemma that is not denied by the stakeholders with respect to its relevance and validity in relation to their situation, could be used as an illustration for the stakeholders about their strategic situation. Above all, the game can be used to illustrate that the stakeholders could strive for a win-win constellation – however, a win-win situation that is extremely reactive to defections. This raises the question of how to stabilize the win-win constellation, and thus the purpose of institutions can be illustrated, and the games used to discuss and prototypically implement different institutional solutions. The games would illustrate that there is a problem of trust, and that trust in norms could solve a big part of the problems. The instrumental question would be how a trust in norms can be established. In many cases, it would become obvious that institutions play an important role.

Both the diagnosis of the environmental dilemma and the intervention with a preparation of institutional solutions are tasks that fit psychological research goals and applications very well. Therefore, psychology could have a much better impact on institutional design. Beyond doubt, this is an ambitious task. Until now, psychology has mainly been ignored, probably with fatal consequences for the environment, because according to current research in psychology and other disciplines, it can be expected that the success of institutions in solving social dilemmas crucially depends on the addressees’ interpretation of the institutions.

This issue is closely connected to the question what role a structural insight into the dilemma plays, which the institution is about to solve. Should the research demonstrate that institution acceptance crucially depends on the insight into the problem the institution is about to solve, then this research would be extremely important. Although psychology is rich in relevant knowledge about how to give addressees insight into environmental problems, it does not yet have much experience about different methods that facilitate insight into environmental social dilemmas. This research could tie into a long tradition in psychological research about social dilemmas (cf. Liebrand et al. 1996).

This leads to a further research issue about the circumstances under which institutions are either seen as an intrusion from outside or as a help in solving a pressing problem. Institutions can only be successful if the latter is true, and psychology can contribute with research and know-how. This research is closely related to psychological research about justice and justice sensitivity (see, for instance, Gollwitzer et al. 2005).

Moreover, research should not only be concerned with improving institutions, but also with changing the impact of institutions on internalized norms. Both injunctive norms and descriptive norms are favourable for solving environmental dilemmas, and descriptive and injunctive norms are in a positive interaction (Thogersen 2008). Institutions probably play an important role in inducing cooperation in environmental dilemmas by modifying the belief that others cooperate (descriptive norm), and by modifying the belief that relevant others expect one to cooperate (injunctive norms). Within the domain of institutional design, psychological research about the role of institutions on the internalization of descriptive and injunctive norms is important. Under normal circumstances, controls and sanctions are usually bad. However, controls and sanctions can also be important to give positive signals on what society expects from the individual and what the individual can expect others to do.

This positive impact of institutions depends on whether the institutions are easy to understand, and whether it is easy to understand what institutions expect in a given situation. In political science, it is well known that institutions that are made to solve environmental social dilemmas – or, to be more specific, common-pool resource problems – have to be transparent, comprehensible and fair. According to Dietz et al. (2003) and Ostrom (1990), this is an essential feature of successful governance. Many of the institutions that are made for governing climate change and to attenuate the expected disasters seem still to be far away from these considerations, both due to the immense complexity of the problem and the lack of understanding as to the necessity of targeting on issues of social sciences.

Conclusion

Like many environmental dilemmas, climate change is extremely complex, even if it is only analysed from the point of view of a social dilemma: there are many stakeholders with asymmetric benefits from solutions against climate change, and they act in tangled hierarchies. Above this complex structure, with respect to the dilemma, there is also a complicated time trajectory with uncertainty and non-linearity. Nevertheless, the social dilemma problem in climate change also needs solutions of its own. Agreements alone are not sufficient, because due to the dilemma, there are many incentives to defect. Therefore, solving such a complex situation requires institutions with the power to monitor and sanction defections against agreements. The dilemma itself already has tremendous complexity, and therefore, until now, approaches that integrate solutions to handle temporal uncertainty with institutional solutions are far from reach. Instead, due to the temporal uncertainty, the conference in Copenhagen was far from coming to any institutional solution that could handle the social dilemma in climate change.

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References

Beckenkamp M (2009) Environmental dilemmas revisited: structural consequences from the angle of institutional ergonomics. Max-Planck Institute for Research on Collective Goods, Bonn

Beckenkamp M, Hennig-Schmidt H, Maier-Rigaud F (2006) Cooperation in symmetric and asymmetric prisoner's dilemma games. Max-Planck-Institute for Research on Collective Goods, Bonn

Brock WA, Xepapadeas A (2003) Valuing biodiversity from an economic perspective: a unified economic, ecological, and genetic approach. Am Econ Rev 93:1597–1614

Dietz T, Ostrom E, Stern PC (2003) The struggle to govern the commons. Science 302:1907–1912

Gardner GT, Stern PC (1996) Environmental problems and human behavior. Allyn & Bacon, Needham Heights, MA

Gollwitzer M, Schmitt M, Schalke R, Maes J, Baer A (2005) Asymmetrical effects of justice sensitivity perspectives on prosocial and antisocial behaviour. Social Justice Res 18:183–201

Hardin G (1968) The tragedy of the commons. Science 162:1243–1248

Ittner H, Ohl C (2006) Playing fair within climate protection policy? – Bringing together psychological and economic methods. ICFAI J Environ Law 1:34–53

Liebrand WBG, Van Lange P, Messick DM (1996) Social Dilemmas. In: Manstead ASR, Hewstone M (eds) The Blackwell encyclopedia of social psychology, 1st edn. Blackwell, Oxford

Luce RD, Raiffa H (1957) Games and decisions. Wiley, New York

Magen S (2006) Zur Interaktion von Recht und sozialen Normen bei der dezentralen Bereitstellung von Gemeinschaftsgütern. Max-Planck-Institute for Research on Collective Goods, Bonn

Magen S (in preparation) Gerechtigkeitserwartungen im Recht. Civil Law. University of Bonn

Milinski M, Sommerfeld RD, Krambeck H-J, Reed FA, Marotzke J (2008) The collective-risk social dilemma and the prevention of simulated dangerous climate change. PNAS 105:2291–2294

Ohl C, Johst K, Meyerhoff J, Beckenkamp M, Grüty sgen V, Drechsler M (2008) Long-term socio-ecological research (LTSER) in the context of biodiversity protection – a complex systems approach for the study of dynamic human-nature interactions. Ecological Complexity, Special Issue "Eco Summit 2007"

Ostrom E (1990) Governing the commons. Cambridge University Press, Cambridge

Poundstone W (1992) Prisoner's Dilemma: John von Neumann, game theory, and the puzzle of the bomb. Doubleday, New York

Thogersen J (2008) Social norms and cooperation in real-life social dilemmas. J Econ Psychol 29:458–472

Van Lange PAM, Liebrand WB, Messick DM, Wilke HAM (1992) Social dilemmas: the state of the art. In: Liebrand WB, Messick DM, Wilke HAM (eds) Social dilemmas: theoretical issues and research findings, 1st edn. Pergamon, Oxford

Yamagishi T (1986) The provision of a sanctioning system as a public good. Social Psychol Quart 51:110–116

Chapter 11
Towards a Psychology of Climate Change

Christian A. Kloeckner

Abstract This paper gives a structured overview about possible contributions of psychology to the climate change debate. As a starting point, it assumes that understanding people's behaviour related to climate change (mitigation and adaptation) is crucial for successfully dealing with the future challenges. Climate change-related behaviour includes voting, support for climate lobbyists, individual consumption, adapting new technology, and taking adaptive actions. A framework model is presented that assumes the following psychological processes to be relevant for people's climate related behaviour (1) experiencing climate change, (2) developing an understanding for climate change, (3) building up knowledge about climate change, (4) emotionally reacting to climate change, (5) the perception of risk, (6) making behavioural decisions, and (7) evaluating behavioural outcomes. Based on psychological theory and empirical findings, it is argued that climate change possesses certain features that make it hard for laypeople to develop an understanding, build correct knowledge, and react emotionally. Furthermore, explanations are presented for why the risk of climate change has a rather low perception among laypeople, and what possible factors there are that interfere with individual mitigation and adaptation. Finally, based on the presented findings, suggestions for climate policy are made.

Keywords Adaptation · Behaviour models · Climate change · Emotional reaction · Human dimension · Knowledge · Mitigating behaviour · Perception · Psychology · Risk assessment

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Introduction

Although psychology produces a quickly growing body of significant climate change-related publications and has been contributing to the climate change discussion for many years now, mainstream climate change research is still more or less ignoring psychological knowledge. If one scanned through the latest IPCC assessment report from 2007 (IPCC 2007a) and all its related working group reports (IPCC 2007b, c, d), for example, the words "psychology" or "psychological" can be found not more than approximately 20 times on almost 3,000 pages of text. The most "psychological" IPCC workgroup is workgroup 2 that included psychological findings on nine of their almost 1,000-page report about impacts, adaptation, and vulnerability. Analysing the proceedings of the big scientific climate change congress in Copenhagen in March 2009 (http://climatecongress.ku.dk/), it becomes obvious that only about 10% of the 58 sessions more or less directly relate to social sciences, including psychology, and even that seems like a big step forward compared to less recent conferences. It is astonishing that the human dimension that climate change obviously has, which means the effects of climate change on humans' experiences and behaviour as well as the psychological explanations behind humans' climate related behaviour, is not adequately reflected in an extensive use of psychological knowledge. Mostly, the human factor in the climate change discussion is still reduced to an economic and/or rational worldview, which assumes that people will behave in the desired way if we only inform them about climate change and use economic tools to guide their behaviour. This leads to intervention strategies, such as increasing prices of unwanted behaviour (or reducing prices of wanted behaviour) or informing people about climate change and possible scenarios. Although both approaches undoubtedly have some potential, they often fall short addressing the average human being and psychology has some answers to offer as to why it is that way.

One explanation for that the value of psychology in climate change mitigation and adaptation seems so much underestimated might be that non-psychologists often consider psychology to be basically clinical psychology, which means the science of understanding and curing mental diseases. However, psychology as "the science that makes use of behavioural and other evidence to understand the internal processes leading people and members of other species to behave in the way they do" (Eysenck 2000, p. 3) has a much broader focus and especially its sub-disciplines environmental psychology (analysing environment–person-interactions), social psychology (analysing people's relation to other people and society), and cognitive psychology (analysing internal processes such as perception, thinking, reasoning, and decision-making) provide a lot of useful non-clinical knowledge about climate change-related psychological processes. This short paper aims to give a brief structured introduction to psychological knowledge about climate change for non-psychologists. Of course, a 19-page paper is far from being comprehensive and there are more climate-related findings in psychological literature than I am able to report here. However, I hope to make a case for the relevance of psychology in the climate change debate. Findings from clinical psychology about the impact of climate change on mental health are explicitly excluded.

Figure 11.1 displays the theoretical framework for this paper, which distinguishes between different psychological processes related to climate change that will be analysed in more detail in the subsequent sections. Again, it has to be stated that the aspects mentioned are far from being the only relevant psychological

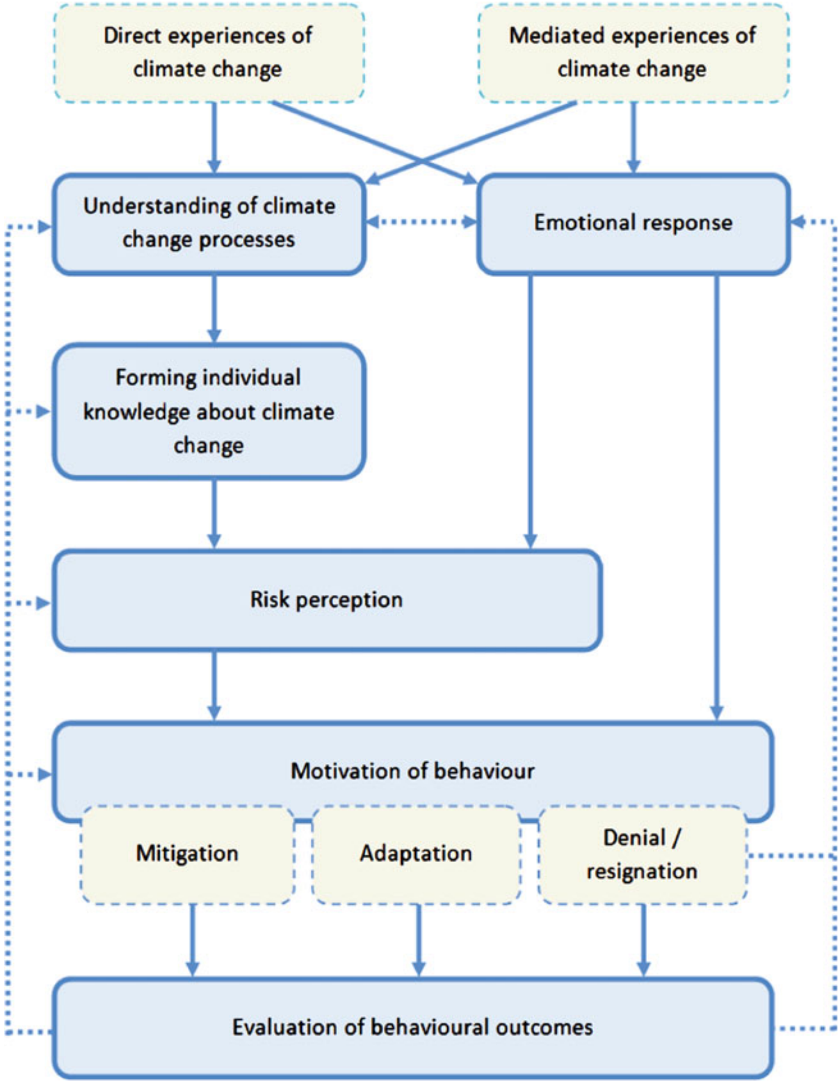

Fig. 11.1 A framework of psychological processes involved in people's climate change related experiences and behaviour

processes. The selection appears, however, to be a good starting point for pinpointing the genuinely psychological perspective on climate change. The theoretical framework assumes that people's reactions to climate change start with single or multiple experiences of climate change in their everyday lives. These experiences can either be direct, through, for example, personally witnessing extreme weather events or changes in the local flora and fauna, or mediated by media or conversations with other people. Both kinds of experiences can trigger immediate emotional responses as well as more deliberate cognitive processes. An important part in people's reaction to climate change seems to be if and how they develop an understanding of the underlying processes. Over time, more and more individual knowledge about climate change is built up, mental models of causes and effects with regard to the different components of climate change are formed, and assumptions about effective behaviour are made. Those individual constructions are usually simplified and to a certain degree incorrect, even if the person is an expert in climate change.

Emotional responses and the processes of understanding and forming knowledge about climate change interact with each other. Difficulties in understanding climate change might, for example, enhance negative emotions; initial emotional reactions are integrated into the network of knowledge. Both emotional responses and individually constructed knowledge initiate a personal evaluation of the risk to be affected by negative outcomes of climate change. This risk evaluation is one important motivator of climate change-related behaviour; other motivators are discussed in more detail in the respective section below. Risk evaluation, emotional responses, and other factors lead in a complex process to a motivation to personally contribute to mitigation of climate change, to personally take adaptive action, or under certain conditions to deny climate change or resign.

In a final step, the model assumes that the outcomes of the actions taken are evaluated and the result of this evaluation is in a feedback loop reintegrated into knowledge structures and emotional response systems. Motivation of climate change related behaviour is therefore assumed to be not a linear but circular process that evolves over time and is shaped by personal experiences and evaluations. The different stages of the model are analysed in more detail in the following sections and selected research findings are presented to underline the assumptions. The importance of each aspect for approaching the human dimension of climate change is outlined. In the conclusion of the paper, the model is used to derive suggestions for climate change policy.

Understanding Climate Change: Human Difficulties with Complexity

The world's climate and processes of stability and change within it are so complex that the human mind is challenged beyond its capacity to fully understand them. An uncountable number of different variables influence each other in a non-linear and highly interactive way. Causes and effects are often separated both geographically and temporarily. Most processes are slow, indirect and have long delays, others show stability for a very long time and suddenly destabilize (such as the melting of the summer ice cap on the North Pole). Most of the mechanisms are still not fully described scientifically. Furthermore, the processes of climate change affect people across different countries, societies, and cultures. These characteristics of climate change pose an interesting parallel to very complex technological or economic systems, which makes research about causes of accidents or breakdowns in those systems a promising approach for analysing humans' problems with understanding climate change.

Already in the late 1960s, Forrester (1969) had made the claim that systems with certain characteristics are too complex for the human mind to comprehend. How those systems behave over time cannot therefore validly be predicted by humans. Forrester (1971) argues that evolution led to human brains that are highly capable of dealing with simple, linear systems where cause and effects are not separated in time or space. People usually gather an understanding for such a system by a procedure of trial and error, observing the outcomes of simple manipulations of single variables in the system and correcting behaviour if the outcome does not match the desired state. If a system, however, involves a large number of variables, if those variables interact, if feedback loops lead to unpredictable resonating processes in the system, or if relations between variables are not linear human strategies for understanding, those systems fail. Understanding a system becomes especially difficult for humans if causes and effects are separated either temporarily (the effect is seen years after the cause) or geographically (the effect of a cause in one country is seen in another country on another continent). All of these characteristics can be found to a high degree in climate change: the number of variables interacting to form the world's climate seems virtually infinite, they interact in a highly complex way, the relations between them are often non-linear, and causes and effects are often largely separated both in time and space. Furthermore, complex systems often behave against human intuition (Forrester 1971). Reducing CO_2 emissions by refraining from burning fossil fuels, for example, might in the short run even increase global warming because the cooling effect of the comparatively short-lived aerosols is deteriorating much faster than the warming effect of the longer lasting CO_2 (Andreae et al. 2005).

Sterman and Booth Sweeney (2002, 2007) demonstrated in two experiments that even highly educated students have severe problems in accurately predicting the likely time-delayed reaction of the global temperature to different simple scenarios of development of CO_2 emissions. This is due to feedback loops and the response delay of the climate system. Sterman and Booth Sweeney used three simplified IPCC scenarios: a zero emission scenario, a 400 parts per million scenario stabilizing CO_2 emissions at a higher level in the year 2100, and a 340 parts per million scenario stabilizing CO_2 emissions at a lower level in the year 2100. Then they provided the students with some information about the dynamics of the system and asked how the students expect the global temperature to develop until 2100. Most of the students were totally wrong in their predictions. Sterman and Booth Sweeney

(2002) used a bathtub metaphor to make the observed effects comprehensible: they compare the students' false predictions to the assumption that a bathtub with a larger amount of water flowing in than out will not overflow even if the amount of inflowing water stabilized at a level still exceeding the level of water flowing out. This example demonstrates that even if the number of variables to take into account is limited, humans have severe problems understanding systems that include feedback and time delay. In a comparable experiment, Moxnes and Kerem Saysel (2009) demonstrate that providing participants with easy to understand analogies significantly increases the accuracy of their predictions.

Gardner and Stern (1996) identified another characteristic of climate change that interferes with the usual human trial-and-error learning strategy: climate change has the potential for catastrophic effects for the whole planet; at least some of them seem irreversible. Furthermore, due to the global nature of the climate system, people responsible for developing strategies against climate change in one part of the world usually do not have access to the results of their strategies in other parts of the world. This means that trying to adjust local strategies is most likely not to be successful with climate change.

Taken together, the presented findings suggest that due to a mismatch between human capacity for understanding complex systems and the highly complex characteristics of the climate system, people are in need of developing a simplified understanding of the processes. Often those simplified theories about climate change seem counterproductive. As it seems impossible to make people fully understand the climate system, communication about climate change should much more actively provide people with easy to understand analogies or metaphors. Ungar (2000) argued, for example, that the ozone hole problematic was much better understood by the public compared to climate change, because scientists made use of easy to understand metaphors there from the very beginning.

Forming Individual Knowledge

The next section is closely related to the previous, but aims to present some psychological findings that help to understand how people organize their knowledge about climate change. When psychologists speak about "knowledge", they analyse mental representations people form of objects (real world objects or objects of imagination). These representations store only a selection of information about the objects, and the way this information is stored can be very different. Eysenck and Keane (2000) distinguish between analogical and propositional representations. Analogical representations are considered to be simplified "image-like" representations of the object. They are holistic and linked to a specific sensory experience with the object. In contrast are propositional representations: "language-like" representations that store knowledge in an abstract system of objects and their relations to each other ("a bird sits on a tree"). Objects are discrete, rules about relations between the objects are explicit, and the representation is not connected to a specific sensory experience. Classical psychological concepts within the propositional way of storing knowledge are schemata (e.g. Bartlett 1932) and scripts (e.g. Abelson 1981). A schema is “a structured cluster of concepts” (Eysenck and Keane 2000, p. 252) that is used by people to form expectations about how the world behaves. It can be considered as an abstract and schematic blueprint of how things work together, about relations in the world, causes and effects, etc. People use their schemata to guide attention, reconstruct their experiences before storing them into memory and recollecting things. Schemata help people to create meaning. A script is a special type of schema storing information about sequences of “stereotypical” actions. On the one hand, knowledge structures such as schemata and scripts help us to structure our everyday life and enable us to deal with the virtually infinite amount of information floating into our system. On the other hand, the nature of those processes leads to the fact that we usually adapt information we get in a new situation to what we already know, or put very simply: it is very hard to see things we do not already expect.

In a survey of climate change experts, journalists, politicians, and laypeople in Sweden, Sundblad et al. (2008) show that general knowledge of the facts about climate change is comparatively high. They presented their participants with a list of 44 statements about the actual status of the world’s climate, the causes of climate change and the future consequences (for the weather, the sea and glaciers, and health) and asked if they were true or false. Although all groups performed better than chance (which means that all groups know at least something about climate change), there were differences between the groups: climate change experts had the most correct knowledge (81% correct answers), followed by journalists (75% correct answers), politicians (71% correct answers), and laypeople (67% correct answers). Furthermore, there was a difference between the domains: people in all groups knew most about the causes of climate change, less about the current state of the climate, and least about the future consequences (especially relating to health). In a study of 9–14 year old children in Germany, Klöckner et al. (2009) show that children have some understanding of measures to mitigate climate change and that they especially focus on individual mobility (66.9% of all answers to the open-ended question as to what mankind could do to mitigate climate change focused on mobility). Both studies show that there is a rather high level of abstract knowledge about climate change, however, with some significant blind spots.

However, studies by a number of authors (e.g. Bostrom et al. 1994) demonstrate that people consistently tend to confuse “climate change” and “ozone layer depletion” as being the same, and that people tend to confuse local weather phenomena with climate. Although most of those studies are rather old and some of those misconceptions might have been addressed in the mean time by intensive media coverage about climate change, the results display a typical psychological phenomenon that was introduced at the beginning of this section: people construct their knowledge about something like climate change by integrating new information into their already existing knowledge structures (e.g. schemata). When climate change made it into the headlines, ozone layer depletion had already successfully been communicated and most people had knowledge structures (and easy to understand analogies!) for this phenomenon. A lot of people therefore just adapted their knowledge structures and integrated climate change in an improper way. Their mental models of how climate change is caused and could be addressed were therefore faulty.

Böhm and Pfister (2001) suggest a multi-level framework of people's mental models about climate change: they assume a five-level causal chain that starts with people's attitudes and goals which motivate specific activities on level two. The activities cause emissions and pollution on level three, which on level four lead to global environmental changes. The last level is the level of long-term consequences for humans. A typical chain of reasoning according to this multi-level framework could be that people's laziness leads to use of cars instead of bicycles; this leads to air pollution, which leads to climate change. Climate change in the end might cause more storms and flooding with implications for humans. In their paper, Böhm and Pfister (2001) summarize some of their studies and report consistent support for their five-level framework. Recently presented and still unpublished data that builds on this five-level framework suggests that people's mental models with respect to climate change seem to be fragmented (Böhm 2009). This means that although some parts of the mental model on some levels are rather elaborate, the mental models have huge gaps and often lack connection between the levels. For example, emissions and pollution (level 3) and global changes (level 4) are often rather unconnected in the mental models.

To conclude this section, it can be stated that the psychological processes of knowledge organization can lead to misconceptions of climate change, its causes, and possible mitigation or adaptation strategies. It is therefore important to analyse what people know about and how they conceptualize climate change.

Emotional Responses to Climate Change and Their Role in Motivating Behaviour

The aspect of emotional responses to events and their importance for motivating people's behaviour is well researched in psychology. Emotional experiences include a combination of physiological reactions, expressions, action tendencies and cognitive appraisals of external stimuli. Parkinson (1994) proposed that cognitive appraisal of external stimuli or situations leads to simultaneous activation of bodily reactions (e.g. increased heart rate), facial expressions (e.g. the display of fear), and action tendencies (e.g. an impulse to take flight). All four aspects together form the emotional experience. Some psychological theories assume that emotion and cognition are separate systems that can work independently (Zajonc 1984); others conceive of cognitive appraisal as an essential part of emotions (Lazarus 1982).

Pfister and Böhm (2008) suggest a theoretical framework that analyses the role of emotions in decision-making and understands emotions as an integrated part of that process. They categorize emotions into four types that have different functions in decision-making: “reducible emotions”, such as joy or disliking, provide the decision-maker with additional information about the decision to make, which is integrated with other information like attitudes. “Affect programmes”, such as fear, disgust, or sexual lust, provide people with the possibility to quickly respond to specific stimuli without cognitive consideration. “Complex discrete emotions”, such as regret, disappointment, or envy, guide attention to specific characteristics of the decision to make, and thereby shapes the cognitive appraisal. Finally, “moral sentiments”, such as guilt, love, or anger, have primarily the function of social coordination and ensuring perseverance against obstacles in enacting the decision. What is appealing about Pfister and Böhm’s (2008) approach is that they broaden the view on emotions. The often mentioned emotion-related “fight or flight” impulse is only related to certain types of emotions, the positive-negative dimension is primarily related to another type of emotions, but complex emotions can have totally different functions in the decision-making process. Emotions seem to be multidimensional and multifunctional.

There are some studies that directly link climate change, emotional responses, and people’s behaviour. Meijnders et al. (2001) induced fear in one half of the participants of their experiment by showing a short emotional video about climate change. These participants processed given information about energy saving more deeply and developed a more positive attitude to energy saving than participants who were shown an emotionally neutral video providing the same information. Fear therefore seems to motivate the search for adequate behavioural strategies (which means searching for information about what to do). Böhm (2003) analysed people’s emotional responses to different environmental risks (among them sea level rise, storms, species extinction that can be understood as climate change-related) and categorized emotions into two main categories: consequence-based emotions such as regret, sadness, fear, or worry are motivated by evaluating anticipated or already occurred consequences. Ethic-based emotions such as disgust, anger, disappointment, guilt, or shame are motivated by violation of ethical principles; whether a consequence eventually occurs or not is not important for ethic-based emotions. Consequence-based emotions and ethic-based emotions should lead to different action impulses: whereas consequence-based emotions should lead to impulses to help, improve the situation, or prevent (further) consequences, should ethic-based emotions target the negative feelings directly by either showing moral behaviour or aggressive tendencies to punish the person responsible for the event. Böhm and Pfister (2000) were able to show that the type of emotional reaction to environmental risks decides the prevalence of specific action tendencies in the expected direction. Klöckner et al. (2009) showed that children, who experience a feeling of guilt (an ethic-based self directed emotion) when confronted with the discussion about climate change, have a higher motivation to engage in everyday pro-climate behaviour than children who react with fear or denial.

Given these results, it is important to analyse whether and how people emotionally react to climate change. Böhm (2003) shows that ethic-based self-directed emotions (which seem to be rather good motivators of generalized pro-climate behaviour because they are not linked to specific consequences) are rather weak compared to consequence-based emotions. Furthermore, Sundblad et al. (2007) show that compared to cognitive judgements about climate change, affective judgements are less strong. Women, however, had stronger worries about climate change in their study than men, even though they displayed the same cognitive risk judgement. Worry about climate change was greater the more people knew about the causes and consequences of climate change, which underlines the interdependency of knowledge and emotional reactions. In a study, Lorenzoni et al. (2006) analysed what images laypeople in the US and the UK associate with climate change and how their affective reaction to those images was. The differences between the images of climate change in the two countries were astonishing: for people in the US, ice melting, heat, impacts on non-human systems, and ozone were the most salient images; for people in the UK, they were changes in weather, global warming, ozone, and changing climate (which is just a rewording of climate change). The affective connotation of those images was considerably negative but only very few people mentioned personally relevant impacts, causes, and solutions to climate change. Most of the people reacted affectively on a very abstract level.

Interpreting the results together it seems that emotions may have a central role in motivating especially persistent pro-climate behaviour. Unfortunately, most people react either weakly to climate change or with types of emotions that do not lead to individual changes in behaviour. This might be explained by the way people perceive individual risk related to climate change (see next section) and that most experiences of climate change are indirect, which makes emotions less salient (Weber 2006).

The Perception of Individual Risk Related to Climate Change

How people perceive a large variety of risks is also a well researched area of psychology. Usually, the risk that experts calculate from objective numbers has little to do with people's individual risk perception (although there is a correlation between real and perceived risk). One of the most prominent approaches to explain deviations between objective and perceived risk is the so-called psychometric model (Fischhoff et al. 1978). The model proposes that perceived risk of a hazard is dependent on the evaluation of certain characteristics the risk has: something that is new or unknown is usually evaluated as risky; something that has the potential for dreadful outcomes is evaluated as riskier (even if the probability of such a dreadful event is very low); something that people volunteer to do is usually perceived to be less risky, etc. The dimensions Fischhoff et al. (1978) suggest can be reduced to three basic underlying dimensions: new vs. old, dread, and number of people exposed. Sjöberg (1996, as cited in Sjöberg 2000) demonstrated the need to extend the psychometric model by at least one factor that could be called unnatural and immoral risk. This last factor including aspects such as "tampering with nature", "violating moral principles", etc. could be especially important for people's perception of climate change as a risk. Unrealistic optimism is another phenomenon in risk perception: especially for risks that people perceive to have some control over (e.g. consuming alcohol, smoking, or sun tanning), they estimate the general risk for the public to be much higher than the personal risk (Sjöberg 1994, as cited in Sjöberg 2000). People tend to have the illusion of invulnerability. Sjöberg (2000) furthermore demonstrates that risk perception is also influenced by the attitude towards the risk object (which means that people who, for example, have a positive attitude towards nuclear power also consider it less risky), the general risk sensitivity of a person (some people perceive risks generally higher than other people – irrespective of the risk object), and a specific sensitivity to certain types of risks (e.g. everything that includes the risk to be radiated).

Leiserowitz (2006) showed that Americans have a moderate perception of the risks related to climate change. Furthermore, the participants expressed most concern for "people all over the world" (50% selected this as their primary concern related to climate change) and "non-human nature" (18% named this as a primary concern). Only 12% related the primary concern about climate change to themselves and their families. This shows that [unlike in the study by Sjöberg (1996, as cited in Sjöberg 2000)], climate change-related risk displays signs of optimistic bias (climate change will affect other people, not me). How high risks of climate change were estimated was predicted by how strong the affective reaction to climate change was, if people neglected climate change and/or human contribution to it, and if people had egalitarian values. Furthermore, females and members of environmental organizations gave higher risk ratings even if the other factors were controlled. A cross-country comparison showed that compared to "environment and health", "exploitation of natural resources", and "generation of waste", climate change generated the least extreme worries concerning future developments (EOS Gallup Europe 2002, as cited in Lorenzoni and Pidgeon 2006). However, there was a large variation in estimates between European countries.

McDaniels et al. (1997) analysed people's overall ratings of riskiness of several environmental influences on water environments based on the psychometric paradigm. Interestingly, climate change was rated as carrying the highest risk of having an ecological impact of all analysed aspects. At the same time, it was among the aspects which were judged most uncontrollable and least understood. In a study by Poortinga and Pidgeon (2003, as cited in Lorenzoni and Pidgeon 2006) climate change was rated moderate on the dimensions: dread, well-informed, and unfair distribution of risks. It was rated rather low on the control: any risks to the individual. A rather high rating was achieved for moral concerns, and the highest ratings for unknown consequences and risks to future generations.

Bord et al. (2000) analysed how risk perception and correct understanding of the causes of climate change predict willingness to engage in pro-climate action. Their analysis showed that people are more motivated if they have a correct understanding of the causes (in contrast to false assumptions) and if they consider global warming a societal threat. Pro-environmental values and a correct understanding of the causes of climate change were the most important predictors for supporting governmental initiatives against climate change. Considering climate change a societal threat also contributed to explaining political support.

An interesting question is why laypeople estimate the climate change-related risks to be relatively low in spite of scientists' alarming findings. A bundle of psychological explanations based on risk research might account for that (1) People tend to show an optimistic bias, usually downsizing personal risks compared to risks for others. The effect has been shown for climate change risks (Leiserowitz 2006). (2) The visible signs of climate change are ordinary natural phenomena (melting ice, storms, heavy rainfall, droughts, flooding, etc.). Mankind has thousands of years of experience of such events, which means that climate change might lack the characteristic of "newness" that the psychometric paradigm claims to be one factor determining a high risk evaluation. (3) Although climate change clearly has the potential for dreadful outcomes, there is an extreme degree of uncertainty connected to who, when, and where might suffer from climate change: scientists present highly diverse predictions of climate change effects, and especially on the local level, scenarios are extremely uncertain. Furthermore, changes usually occur slowly (in human dimensions) along decades or even centuries, which makes it hard for people to detect the dreadfulness. As no single weather event (e.g. a single hurricane) can be directly connected to climate change, the more dreadful events can easily be attributed to normal variations in weather. (4) The "tampering with nature" aspect of climate change risk evaluation might still be impaired by the long discussion about human impact on climate change. If climate change is understood as a natural variation in the world's climate (the idea that it has often happened in the history of the world), there is no "tampering with nature", which means risk should be evaluated lower. (5) A specific characteristic of climate change that also might affect people's risk perception is that the scale of climate change is so far removed from the ordinary risks humans usually deal with that people do not have the emotional and/or cognitive capacities to make an adequate risk evaluation. Never before has humankind been faced with a risk on such a global level. We do not have any experience of dealing with such risks and the discrepancy between globality and size of the risk and one's personal resources for dealing with it could hardly be greater. A mismatch between risk perception and coping resources usually leads to denial of a risk or resignation (as stated for example in Protection Motivation Theory, Rogers 1975).

Motivation of Behaviour: The Multi-determination of Behaviour

Environmental psychology has focused in recent years on explaining and changing people's behaviour with respect to the environment. A lot of different behaviours have been targeted, among which some are directly or indirectly related to climate change (e.g. car use, energy use, purchase decisions, voting behaviour, support for climate change policies, etc.). This paper is too short for a comprehensive description of behavioural models that have been developed and successfully tested in this domain. However, in the following section an attempt is made to present two possible models, one for behaviour related to mitigation of climate change, one for adaptive behaviour. This distinction, although somehow artificial as both mitigation and adaptation are relevant to face the problem of climate change, is characteristic for environmental psychology. Whereas the aspect of mitigation is already well researched and has been in the focus of environmental psychology for decades now, the aspect of adaptation and how to understand people's individual adaptive action has only recently entered the environmental psychological discussion.

Research in other domains of psychology has taught environmental psychologists that behaviour is very seldom determined by a singular cause. Usually, motivation behind people's behaviour is a balance of different, often contradictory individual aspects. Numerous psychological action models emphasizing different aspects in this decision-making process have been developed. Two of the most successful in environmental psychology are the Theory of Planned Behaviour (TPB) proposed by Ajzen (1991) and the Norm-Activation Theory (NAT) (Schwartz 1977). TPB focuses on people's intentions as the main motivation of behaviour and their interaction with perceived behaviour control, which is the feeling of being able to control one's own behaviour. NAT focuses on personal norms (which means feelings of moral obligation) as a main predictor of behaviour.

Klöckner and Blöbaum (2009) recently proposed a more comprehensive model of ecological behaviour that combines Ajzen's and Schwartz's theories and, furthermore, includes assumptions about the influence of routines or habits especially on everyday behaviour (such as energy use at home). This addition traces back to the work of Triandis (1980), who pointed out that behaviour that is performed very often is very unlikely to be under the control of deliberate processes. Finally, Klöckner and Blöbaum (2009) propose to analyse the situational context more thoroughly than the initial theories did. Figure 11.2 displays the Comprehensive Action Determination Model (CADM) as described by Klöckner and Blöbaum (2009).

The model conceives of behaviour to be predicted directly by three different motivational paths (1) What people intend to do has an impact on their behaviour or, in other words, a proportion of people's behaviour is assumed to be under the control of deliberate decision-making processes. Intentions are formed based (among other things, see below) on people's attitudes towards a certain action. An attitude is in turn the sum of all beliefs people carry about the action to be taken. They have assumptions about a number of possible positive or negative outcomes of the action in question and their probability. This links forming an attitude directly to perception of risks (and benefits) as described in the previous section, which means all biases that have been described there also apply to the processes described here. The selection of accessible beliefs may, for example, vary from situation to situation and can be changed by external cues. (2) People's behaviour is also under the control of the objective situational conditions and their subjective perception. If people have no possibility to perform the pro-climate action (there could be, for example, no mode of transport available that saves CO_2 emissions), or if they subjectively perceive their freedom of choice impaired, they will not enact an action even if they intended to do so. Thus, situational influences not only directly predict behaviour, but also moderate the relation between intentions and behaviour. Furthermore, over time, they contribute to reshaping attitudes (beliefs

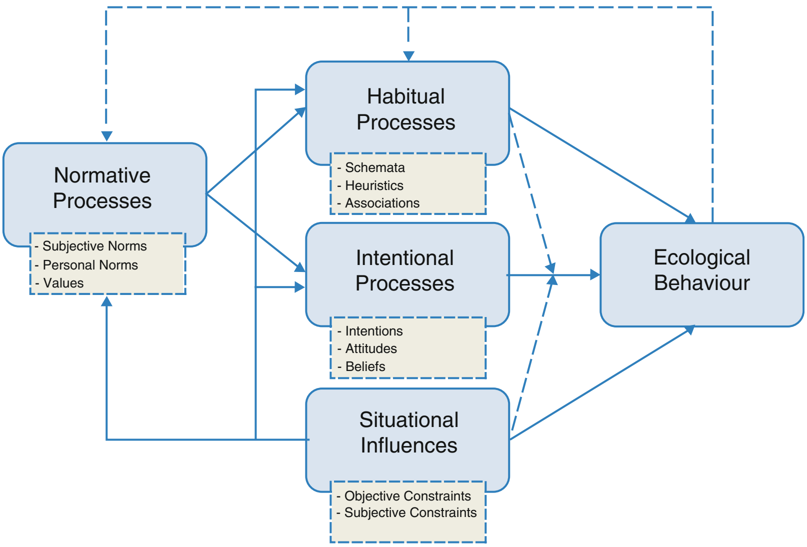

Fig. 11.2 The comprehensive action determination model for ecological behaviour (Klöckner and Blöbaum 2009)

are adjusted to situational conditions). (3) If people perform an action repeatedly, they start building routines and habits that, over time, take control over their actions. This mechanism has been described very often in psychology and serves the purpose of saving cognitive resources for situations that need attention and deliberation (Ouellette and Wood 1998). Usually, transferring control to automatic processes is a highly effective process that serves us well. Problems occur when our habits contradict new intentions (which happens often when people try to change health-related behaviour, but also related to pro-environmental actions). Therefore, habitual processes also have the power to moderate the relation between intentions and behaviour. Furthermore, habits are supposed to be linked to specific situations which connects them to the situational conditions. There are several theories what the cognitive basis of a habit might be, most prominently schemata (see section about knowledge above) and heuristics (simplified decision rules, rules of thumb), which are not discussed any further in this brief introduction.

The CADM finally assumes that normative processes, such as values, subjective norms (which are assumptions about the expectation of relevant other people or – briefly put – social pressure), and personal norms, do not directly influence behaviour but determine intentions together with attitudes. They might also decide about the set of salient beliefs that form the attitude of a person in a given situation. In accordance with the NAT, the CADM assumes that the normative aspects have to be activated in a situation, which means people have to go through a process of norm activation before norms are relevant in decision-making. This process is not described here due to limited space. See Klöckner and Matthies (2009) for a discussion. Because norms and values are stable constructs, a close connection to habits and routines is assumed. After an action is performed, the evaluation of this action is supposed to feedback on the model constructs, especially those with a relatively high stability over time (normative and habitual processes). The CADM makes no prediction about the relative importance of each of the four aspects in determination of a specific behaviour. This question has to be carefully analysed empirically for a specific behaviour, performed by a specific target group at a specific point in time. So far the model has been successfully applied to travel mode of choice of students (Klöckner and Blöbaum 2009), where situational influences were the strongest predictor of behaviour, and waste recycling by students (Oppedal and Klöckner in preparation), where the influence of habits came out comparatively strong for recycling behaviour that is performed regularly.

The CADM as one example of environmental psychological action models shows that people's decision-making is a complex process, integrating several aspects that might contradict each other. This makes it obvious that developing strategies to change people's behaviour with respect to pro-climate actions makes a thorough analysis of all influencing aspects active in a certain situation necessary. Furthermore, a segmentation of target groups characterized by a specific set of strong predictors of their behaviour (e.g. the "normatively guided" or the "habitualized") seems absolutely necessary for successful intervention planning, an approach that is also proposed by social marketing (e.g. Weinreich 1999).

Less well researched is the understanding of people's individual motivation of adaptive behaviour. Grothmann and Patt (2005) are one of the few that propose a complex model of private proactive adaptation to climate change (e.g. taking precautions against flooding). The core of their model is based on protection motivation theory (Rogers 1975). They assume that people's intention to take adaptive action is predicted both by a high climate change risk appraisal and a high adaptation appraisal. This means people take action if they feel threatened by climate change but also capable of taking effective adaptive actions. Climate change risk appraisal is a combination of perceived severity of personal climate change consequences and perceived probability. Adaptation appraisal is a combination of perceived adaptation efficacy (how effective are the measures), perceived self-efficacy (how capable am I to take the measures), and perceived adaptation costs. If a high risk appraisal is combined with a low adaptation appraisal, the model predicts avoidant maladaptation (fatalism, denial, or wishful thinking). Grothmann and Patt's (2005) model assumes that individual perceptions of the social discourse on climate change influence both risk and adaptation appraisal. Adaptation incentives (e.g. subsidies) can strengthen adaptation intentions (filtered through processes of individual perception), as the objective adaptation capacity is influencing adaptation appraisal also filtered through subjective perception. The objective adaptation capacity might also interfere with translating an adaptation intention into behaviour (as described in the CADM above). Grothmann and Patt (2005) describe, furthermore, three specific processes that influence risk and adaptation appraisal (a) Cognitive biases and heuristics might lead to unrealistic and simplified appraisals (see the section about risk perception). (b) Experience or familiarity with a certain risk (e.g. living on the riverbank for generations and being used to flooding) might bias risk appraisal. This could lead in both directions, increasing perceived risk and reducing it. An increase in risk appraisal would occur if people have vivid images of the outcomes of a risk factor in mind (as predicted by the availability heuristic). A decreased risk perception would be the result of mental adaptation to a risk over time. (c) Especially with adaptation to climate change, people might rely on public adaptation strategies. If people think that the authorities will take the necessary precautions, the individual risk appraisal is reduced, given people trust the authorities. Unfortunately, the model of private proactive adaptation to climate change has not been thoroughly tested empirically yet.

Comparing the two models, they show some similarities. Both assume that behaviour is determined simultaneously by several aspects and that most of those aspects are subject to individual perception and interpretation. Grothmann and Patt's model focuses more on the risk and adaptation appraisal as a central part; the CADM focuses on the integration of intentional, situational, and habitual processes. The CADM is more general and Grothmann and Patt's model may be integrated. However, both models underline that human behaviour is complex, and simple interventions strategies are likely to fail because people have the strong ability to shape reality according to their perceptions and mental models. Again, the claim can only be to carefully analyse predictors of people's behaviour before strategies are implemented.

Evaluation of Behavioural Outcomes

So far, this paper has described the processes depicted in Fig. 11.1 as a linear process leading from experiences with climate change to action through a series of well-defined steps. Cognition and behaviour, however, are by no means linear, but influence each other vice versa. Bem's (1972) Self-Perception Theory poses that – just as external observers – people infer their motives and attitudes by observing their own behaviour: "If I signed the petition for a pro-climate policy in the city centre, I have to have a positive attitude towards pro-climate acts". In this process, it seems to be rather irrelevant what led to signing the petition in the first place (perhaps it was just social pressure). Although Bem's theory might seem radical at first glance, there are studies that seem to make it likely that people at least sometimes do not go the way from attitudes to actions, but take the trip backwards.

The "foot-in-the-door" intervention technique builds on self-perception theory and works like this: first people are asked for a small favour which is related to the area (e.g. saving energy) but so small that hardly anyone denies it. After people have committed themselves to the first action, they are usually more likely to take another, much more demanding, action related to the first. The assumption is that people observe their own behaviour concerning the small favour and infer a positive attitude towards the behaviour and related behaviours. Katzev and Johnson (1983) used this technique to motivate people to save energy in their homes. They first asked the participants of their study to answer a questionnaire about energy saving.

Then they asked them to commit themselves to saving 10% energy in their homes. Compared to control groups that only answered the questionnaire, only were asked for the commitment to save 10%, or neither of the two, the foot-in-the-door group contained the highest percentage of energy conservers.

Self-perception is, of course, not the only way behaviour feeds back on cognitions. A much simpler assumption is that people analyse the outcomes of their actions and use the verdict if the outcome was satisfactory or not in order to determine whether they will repeat the same action the next time, when they face a similar situation. Once people have encountered a situation and made a decision about how to act, they learn more about the situation, which may change their beliefs, risk perceptions, adaptation appraisals, perceived behavioural control, etc. Although there are processes in human decision-making such as norms, values, or habits that provide for some stability in human action, decision-making is constantly changing because no decision is exactly like the one made before. This makes it even more difficult to understand how people make decisions related to climate change, because static models do not help. Like climate change itself, human behaviour related to climate change is also complex and non-linear.

Direct Versus Mediated Experiences of Climate Change

The final aspect of climate change this paper would like to address is related to the fact that climate change cannot be perceived directly by the individual. Unlike other risks (e.g. car traffic), it is impossible to directly experience the impact of climate change. People may experience weather events such as storms, floods, droughts, etc., but no single event can be clearly linked to climate change, which means the single experiences people have are only with a high degree of uncertainty related to climate change. Weber (2006) proposes that climate change does not concern most of us (yet), because of a lack of direct experience of single events with serious consequences. According to Weber (2006), the emotional reaction to climate change is especially reduced because of climate-related risk perception based on descriptions and not experiences. The section on emotional reactions underlined their importance in motivating behaviour and persevering. Weber (2006) suggests impressive simulations that might at least be a surrogate for a direct experience. Artistic approaches (films, music, paintings, etc.) could be another way to enable people to make direct emotional experiences related to climate change. After the 2004 blockbuster The Day After Tomorrow, studies were conducted on the effect on people who watched the movie, but the results are inconclusive: Leiserowitz (2004) found short-term influences on the viewer's risk perception related to climate change. Balmford et al. (2004) report that British people reported higher levels of concern after the movie, but displayed less understanding of climate change and an unchanged motivation to engage in personal pro-climate activities. Lowe (2006) found in a controlled experiment that viewers of the movie considered climate change to be a more distant threat than people who read information about climate change, perhaps because of the film posing a threat to people they felt incapable to deal with. It would be interesting to read studies that analysed the effect of Al Gore's more scientific movie An Inconvenient Truth (2006). Generally speaking, it seems that the impact of media on risk perception and ultimately behaviour, however, is smaller than expected (Wahlberg and Sjöberg 2000).

Conclusion

Taking all the presented findings together, psychology has a lot to say about how to design policy that deals successfully with climate change. Firstly, a careful analysis of behaviour is necessary. People's behaviour is related to climate change in many ways: people vote for parties that support more or less extreme climate change strategies; people support lobbyists for climate protection measures or they do not; people make decisions about what types of cars, household equipment, insulation, etc. they want to use; people make decisions about what kind of new technology they adopt; people implement CO_2-saving behaviour into their everyday lives or they do not; people decide where they want to live and how to protect themselves against predicted changes in their local climate. Understanding all these different types of behaviour and influencing them might be the key to successful mitigation and adaptation to climate change. I hope that the preceding sections have displayed how complex people's behaviour is and what psychological mechanisms are that have to be taken into account. I would like to finish this paper with just one suggestion for each section, based on theory and empirical findings about necessary changes in facing and communicating the challenge of climate change.

If we want people to show adequate mitigation of and adaptation to climate change, we have to make sure that the basic principles of climate change are understood. As the climate system is too complex to be fully understood, helpful but still sufficiently correct metaphors are necessary to communicate climate change to laypeople. People's mental models about climate change have to become more integrated; the link between personal behaviour and global processes have to be particularly addressed in the future. Climate scientists should not be afraid to simplify as much as necessary in order to connect to ordinary people's needs. Climate change needs to be experienced more directly and more emotionally by ordinary people. Powerful images, art, simulations, documentaries, or the use of symbolic icons that are emotionally loaded (like the polar bear) might help to achieve this more direct and emotional experience of climate change. Even if a single hurricane is probably not directly connected to climate change, it could become a symbol for a possible future where such events are much more likely. Examples of (possible) climate change effects "in the own backyard" might help decrease the personal irrelevance of climate change compared to the effects on people in other places in the world or non-human nature. The multi-determination of behaviour makes it necessary to identify relevant predictors of the behaviour in question in all important subgroups of people at a given time. Intervention strategies have to be tailored carefully to the result of this analysis. One intervention package that fits all people at all points in time does not exist. Finally, it is necessary to take people's feedback and experiences seriously. They determine how they organize their future behaviour. It seems that there is a need for much more psychology in the climate change debate.

References

Abelson RP (1981) The psychological status of the script concept. Am Psychol 36:715–729
Ajzen I (1991) The theory of planned behaviour. Org Behav Hum Decis Mak 50(2):179–211
Andreae MO, Jones CD, Cox PM (2005) Strong present-day aerosol cooling implies a hot future. Nature 435:1187–1190
Balmford A, Manica A, Airey L, Birkin L, Oliver A, Schleicher J (2004) Hollywood, climate change, and the public. Science 305:1713
Bartlett FC (1932) Remembering. Cambridge University Press, Cambridge, UK
Bem DJ (1972) Self-perception theory. Adv Exp Social Psychol 6:1–62
Böhm G (2003) Emotional reactions to environmental risks: Consequentialist versus ethical evaluation. J Environ Psychol 23:199–212
Böhm G (2009) Public perception of environmental risks. Presentation on a workshop at the Unit for Risk Psychology, Environment and Safety, Norwegian University of Science and Technology, Norwegia, 27 Mar 2009
Böhm G, Pfister H-R (2000) Action tendencies and characteristics of environmental risks. Acta Psychol 104:317–337
Böhm G, Pfister H-R (2001) Mental representation of global environmental risks. Res Social Probl Public Policy 9:1–30
Bord RJ, O'Connor R, Fisher A (2000) In what sense does the public need to understand global climate change? Public Underst Sci 9:205–218
Bostrom A, Morgan MG, Fischhoff B, Read D (1994) What do people know about global climate change? Risk Anal 14(6):959–970
Eysenck MW (2000) Psychology – a student's handbook. Psychology, Hove, UK
Eysenck MW, Keane MT (2000) Cognitive psychology – a student's handbook. Taylor & Francis, Philadelphia, PA
Fischhoff B, Slovic P, Lichtenstein S, Read S, Combs B (1978) How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sci 9 (2):127–152
Forrester JW (1969) Urban dynamics. MIT Press, Cambridge, MA
Forrester JW (1971) Counterintuitive behaviour of social systems. Technol Rev 73:53–68
Gardner GT, Stern PC (1996) Environmental problems and human behaviour. Allyn & Bacon, Boston
Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change. Glob Environ Change 15:199–213
IPCC (2007a) Climate change 2007: synthesis report. In: Core Writing Team, Pachauri RK, Reisinger A (eds) Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. IPCC, Geneva, Switzerland
IPCC (2007b) Climate change 2007: the physical science basis. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK
IPCC (2007c) Climate change 2007: impacts, adaptation and vulnerability. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Contribution of working group II to the

fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK
IPCC (2007d) Climate change 2007: mitigation. In: Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (eds) Contribution of working group III to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK
Katzev RD, Johnson TR (1983) A social-psychological analysis of residential electrical consumption: the impact of minimal justification techniques. J Econ Psychol 3:267–284
Klöckner CA, Blöbaum (2009) A comprehensive action determination model – towards a broader understanding of ecological behaviour using the example of travel mode choice. Manuscript under review
Klöckner CA, Matthies E (2009) Structural modelling of car-use on the way to university in different settings – the interplay of norms, habits, situational restraints, and perceived behavioural control. J Appl Social Psychol 39:1807–1834
Klöckner CA, Beisenkamp A, Hallmann S (2009) Klimawandel aus der Sicht 9-14jähriger Kinder – Emotionen, Bewältigungsressourcen, Klimaschutzmotivation und Umweltschutzverhalten [Climate change from the perspective of 9-14 year-old children – emotions, resources, motivations to protect the climate, and conservation behaviour]. Manuscript submitted for publication
Lazarus RS (1982) Thoughts on the relation between emotions and cognition. Am Psychol 37:1019–1024
Leiserowitz A (2004) Before and after the day after tomorrow: A U.S. study of climate change risk perceptions. Environment 46(9):22–37
Leiserowitz A (2006) Climate change risk perception and policy preferences: the role of affect, imagery, and values. Clim Change 77:45–72
Lorenzoni I, Pidgeon NF (2006) Public views on climate change: European and USA perspectives. Clim Change 77:73–95
Lorenzoni I, Leiserowitz A, De Franca DM, Poortinga W, Pidgeon NF (2006) Cross-national comparison of image associations with "global warming" and "climate change" among laypeople in the United States of America and Great Britain. J Risk Res 9(3):265–281
Lowe DL (2006) Is this climate porn? How does climate chance communication affect our perceptions and behaviour? Tyndall Center for Climate Change Research Working Paper 98. Received online 27 Apr 2009 http://www.tyndall.ac.uk/publications/working_papers/twp98.pdf
McDaniels TL, Axelrod LJ, Cavanagh NS, Slovic P (1997) Perception of ecological risk to water environments. Risk Analysis 17(3):341–352
Meijnders AL, Midden CJH, Wilke HAM (2001) Role of negative emotions in communication about CO_2 risks. Risk Anal 21(5):955–966
Moxnes E, Kerem Saysel A (2009) Misperceptions of global climate change: information policies. Clim Change 93:15–37
Oppedal IO, Klöckner CA (in prep) Applying the comprehensive action determination model to students' waste recycling. Manuscript in preperation
Ouellette JA, Wood W (1998) Habit and intention in everyday life. The multiple processes by which past behaviour predicts future behaviour. Psychol Bull 124(1):54–74
Parkinson B (1994) Emotion. In: Colman AM (ed) Companion encyclopedia of psychology, vol 2. Routledge, London
Pfister H-R, Böhm G (2008) The multiplicity of emotions: a framework of emotional functions in decision making. Judgem Decis Mak 3(1):5–17
Rogers RW (1975) A protection motivation theory of fear appeals and attitude change. J Psychol 91(1):93–114
Schwartz SH (1977) Normative influences on altruism. Adv Exp Social Psychol 10:221–279
Sjöberg L (2000) Factors in risk perception. Risk Anal 20(1):1–11
Sterman J, Booth Sweeney L (2002) Cloudy skies: assessing public understanding of global warming. MIT Sloan Working Paper No. 4361-02. Available at SSRN. http://ssrn.com/abstract=306983

Sterman J, Booth Sweeney L (2007) Understanding public complacency about climate change: adults' mental models of climate change violate conservation of matter. Clim Change 80:213–238

Sundblad E-L, Biel A, Gärling T (2007) Cognitive and affective risk judgements related to climate change. J Environ Psychol 27:97–106

Sundblad E-L, Biel A, Gärling T (2008) Knowledge and confidence in knowledge about climate change among experts, journalists, politicians, and laypersons. Environ Behav 41:281–302

Triandis HC (1980) Values, attitudes and interpersonal behaviour. In: Howe HE, Page MM (eds) Nebraska symposium on motivation. University of Nebraska Press, Lincoln, NE

Ungar S (2000) Knowledge, ignorance and the popular culture: climate change versus the ozone hole. Public Underst Sci 9:297–312

Wahlberg AAF, Sjöberg L (2000) Risk perception and the media. J Risk Res 3(1):31–50

Weber EU (2006) Experience-based and description-based perceptions of long-term risk: why global warming does not scare us (yet). Clim Change 77:103–120

Weinreich NK (1999) Hands-on social marketing: a step-by-step guide. Sage, Thousand Oaks, CA

Zajonc RB (1984) On the primacy of affect. Am Psychol 39:117–123

Chapter 12
Worldviews and Climate Change: Harnessing Universal Motivators to Enable an Effective Response

Judith Ford

Abstract Anthropogenic climate change is undoubtedly a complex phenomenon, measured and argued in detailed terminology indecipherable to all but the most educated of scientists; not typical fodder for global conversation (Elliott 2007). However, it is difficult today to find any source of mainstream media – print, television or digital – on any given day that fails to mention it. The sustained and mainstream interest indicates that anthropogenic climate change has hit a nerve deep within western society. Perhaps it is because its effects are so unpredictable and disrespectful of human-constructed borders [primarily through extreme weather and the resultant conflicts wrought by scarcities of water, arid land, and other natural resources (Ackerman and Stanton 2008; Heinz Center and CERES 2009)]; westerners can no longer rely on centralized policy and technology to keep them safe. Perhaps it is because climate catastrophe has been a common theme throughout past and current mythologies around the world, in which climate catastrophe is seen as a punishment for irresponsible human behaviour; climate change may strike some universal fear inherent in humankind. Perhaps it is because the majority of western society finally understands humankind is altering its very habitat and sees extreme weather as an assertion of nature's power over man. Whatever the reason, just as the polar bear has become the poster child – or metaphor – for anthropogenic climate change, so has anthropogenic climate change itself become a metaphor in the west for humankind's broken relationship with the natural world. A break that, if some of the more dire predictions are to be believed, has already crossed the "point of no return". How could the most intelligent and socially developed species in the history of the earth have allowed this to happen? To what extent can anthropogenic climate catalyze the effective, long-term societal and behavioural changes needed to heal this break?

Keywords Capitalism · Cultural relativism · Deep ecology · Globalization · Indigenous · Neo-imperialism · Universalism · Western worldview

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Introduction

Worldviews are collective beliefs about the nature of life through which humankind understands its relationship to the spiritual world, the natural world and to each other. They are created in response to humankind's universal quest for meaning (Campbell 1949). These worldviews are shaped by multiple factors, but they are most heavily grounded in collective religious beliefs and shaped by historical events and geography. In our global-mobile world, any given nation or set of nations today includes multiple worldviews. However, every nation has one predominate worldview, which, while not shared by all of its citizens, becomes institutionalized over time and shapes the very way that public problems and solutions are envisioned.

The western nations of North America, Europe, and Australasia, which have historically contributed disproportionately to anthropogenic climate change, share a common dominant worldview (Devall and Sessions 1985; Cramer 1998).[1] While there are clearly a myriad of cultural differences and degrees of environmental responsibility between and within these nations, their common worldview has been shaped by the same three forces: Protestantism, Cartesian science, and global capitalism.

For the first 100,000 years of human inhabitation on earth (Morrison 2006), the human species lived in agrarian or nomadic societies directly affected by natural forces. Even after a few millennia of increasing urbanization, its cities and cultivated fields were still seen as vulnerable islands surrounded by a larger and savage nature (McKibben 1989). Even though humankind already "suspected that human activity could change the climate" (Weart 2007), religious songs, prayers and rituals continued to revolve around natural events, such as weather (Sleeth 2006), which were seen to be outside human control.

About 500 years ago, the Enlightenment movement and the Reformation inspired Cartesian and Protestant thought, respectively. Cartesian science held that humankind possessed both a material body, as well as a non-material mind. However, non-human species – the plants and animals – possessed only material bodies, which could be explained and wholly understood through physical laws. There were no divine or natural phenomena. This view separated humans from the laws of nature.

Up to this point, western Christianity had a long tradition of dualism between a patriarchal, heaven-bound, rational male (Apollonian) kind of god and a more ancient, emotional, mystical, Earth-bound feminine spirit (Dionysian). Jung (1968) explained, "the archetypal mother was a part of the collective unconscious of all humans [. . .] and precedes the image of the paternal father". "The power of nature – and of women – to give and withhold life (formed an) ancient and deep

[1]This "first world" is not only made up of citizens of western nations; it includes the cosmopolitan, "globalize[d] from within" (Beck 2002) group of professional elites living in large urban centres around the globe (Harris 2008).

identification of women with nature [. . .] our birth from the bodies of our mothers and our nourishment from the body of the earth" (McFague 1991). Anthropologists have shown that in societies where women had high political status, for instance, menstruation itself was regarded as "supernatural potency". By contrast, in societies where women lacked power, this same menstruation was viewed as "pollution" (Knight et al. 1995). The leaders of the Reformation embraced the dualism of the "Cartesian split" and rejected the earth-bound "female" mysticism.

While religious and scientific leaders have battled over ideas of truth and right for these last 500 years, they do share this one critical belief: that humankind is separate from and superior to nature. This separation was further widened by the technological advancements of industrialization into the belief that humankind could actually control the natural world. Soon "industrial society was based on 'to measure is to know, to know is to predict, to predict is to control'" (Ginneken 2003, p. 184).

This separateness and feeling of control further enabled the global spread of capitalism. "Protestant values better facilitated the progressive force of capitalism" (American Environics 2006, p. 23). The natural world was seen as an unlimited market of resources, which could be quantified, owned, trademarked, bought, and sold. This exploitation was fuelled by public–private collaboration, in which the private sector was seen to more efficiently create public good, where success meant progress and growth, and happiness meant individualism and material possession. Public–private sector collaboration on international commerce goes back to the colonialism of the British East Indies Company and the Dutch United East Indian Company (VOC) in the late sixteenth and early seventeenth centuries.

Throughout the earliest centuries of colonialism and continued industrialization, western nations dominated commerce and politics around the globe. Under the pressure of the industrial revolution in the late eighteenth century, mercantilism gave way to early capitalism. In the twentieth century, capitalism "defeated" fascism (following World War II) and communism (following the collapse of the Soviet Union) as alternative market ideologies.[2] As the "ideological victor", capitalism became embedded in the predominate western worldview, and in the second half of the twentieth century, the global spread of capitalism intensified. It is no coincidence that the European nations which ultimately triumphed in their colonial pursuits were Protestant. Two of the strongest Protestant-led nations, Britain and

[2]This paper acknowledges that other worldviews exist which have wrought environmental destruction. One could argue that the institutionalized Soviet worldview was an extreme expression of the belief in Cartesian science, e.g. the complete denial of spirituality, the belief that science could "correct nature's mistakes". As one reviewer rightly noted, the "conquest of nature" was one of Stalin's main slogans. Yet this paper focuses on the western worldview both because it is the dominant worldview in the nations ultimately most responsible for the anthropogenic component of climate change, as well as because it has been universalized and institutionalized to such an extent that it shapes policy and societies throughout the world, regardless of whether or not the individuals it affects subscribe to its core beliefs.

the Netherlands, colonized what would later become the United States, the strongest modern force behind global capitalism. Although the US eventually won independence from direct control by either of these nations, the Protestant, Cartesian, capitalistic western worldview, which justified "the conquest of nature" (White 1967), was institutionalized within its legal and social structures.

Furthermore, over the last 50 years, public and private sector leaders in the west have subjugated the universalist discourse associated with human rights to *globally* market and institutionalize this worldview around the world through the global institutions they largely control, such as the World Bank, International Monetary Fund (IMF), World Trade Organization (WTO), Organization for Economic Cooperation and Development (OECD), and parts of the United Nations, e.g. Global Compact.

This "universalizing" has marginalized alternative worldviews as dissenters counter to some sort of natural and universal aspiration to economic progress, as measured by material acquisition and profitability. Multinational profits have soared, along with the political influence of the west. The result has been an exponential spread of destructive environmental policy – as well as intertwined policies on agriculture, health, and finance, and culture – into non-western areas of the world as well.

We might argue that the environmental degradation caused by the western worldview was justified if humankind was actually better for it, but growing evidence shows that it has the opposite effect. In stark contrast to the separateness, superiority and materialistic western worldview, interdisciplinary research has shown that humankind derives meaning through a combination of deep contentment and purpose. As Wilson's (1984) work on *biophilia* has shown, deep contentment comes through contact with nature. As Csíkszentmihályi's (1990) work on *flow* has shown, purpose comes with engagement in a consuming task. And, Haidt (2006, p. 238 and 242) later put this engagement in the context of community, when he showed "we were shaped by group selection to be hive creatures who long to lose ourselves in something larger. Whenever groups of people come together to try and change the world [. . .] they are pursuing a vision of virtue, justice or sacredness". Not surprisingly, those who live in pursuit of these truly universal quests for meaning also maintain more socially and environmentally sustainable lives. Cramer (1998) called this a "deep ecology" worldview. Deep ecology focuses on a *bioregionalist* harmony with nature, instead of domination, e.g. appropriate technology and non-dominating science; believes all nature possesses intrinsic worth, e.g. *biospecies equality*; recognizes Earth's "supplies" are limited; and argues that elegantly simple material needs and living with just enough meets the larger goal of self-realization, the highest need defined by Maslow (1954).

Unfortunately, the deep ecology worldview is often framed as a life of abstention and sacrifice in which we must give up the things we love and the progress we have made to return to a more primitive life in order to save the earth. In fact, the western worldview of superiority, individualism, and exploitation and its corresponding lifestyle actually deprives humankind of its inherent desires – the need for contact with the natural world and engagement in a higher purpose. Recent psychological research argues, "The very things that [. . .] make people happy [. . .] (are the same things that have always helped groups, going back to) [. . .] the [time of] hunter-gatherer [societies] – relatedness, autonomy, curiosity, and competence" (Velasquez-Manoff 2008, p. 2). The chasm between the predominant western worldview and this more humanitarian worldview is the root of the world's current environmental (and social) problems. Breeching this chasm can help solve them both.

Paper

The key to reconciling what appear to be two dichotomous worldviews lies not in simply shifting the surface frames of these lifestyles. It is not simply about eco-consumerism: "keep shopping, but be green about it". It is not simply about more campaigns with polar bears on melting icebergs to shame the public into caring. In fact, part of Haidt's (2006, p. 198) research discovered that while images of the natural world trigger oxytocin, the neurological impulse associated with bonding and elevation, in human beings, only vital engagement triggers the neurological impulses associated with action. Most environmental publicity campaigns focus on natural imagery to prompt action. Unfortunately, these images only promote a bonding feeling. These campaigns fail to show the connection between the imagery of the natural world and humans as an element of that world and their vital engagement to it.

Instead of surface reframing or polar bear campaigns, radically shifting world-views requires a three step *global interpretive frame transformation* (Snow et al. 1986; Snow and Benford 1988, my emphases):

1. *Defining the problem* and causes, which I briefly outlined above
2. Predicting what solutions, strategies, and tactics could *address the problem*
3. *Understanding* how and why should *others* take action

Defining the problem requires an understanding of the actual phenomenon of anthropogenic climate change and the way the problem of and solutions for it are framed. By looking at the discourses invoked within public, private and civil discussion, we can identify the underlying worldview which informs those discourses. Fully understanding the worldview, however, requires us to unmask the deeper influences which first created it.

Universal drivers of human nature can help predict what solutions, strategies, and tactics could *address* shift the deep frames (Lakoff 2006) of the western worldview and ultimately inform how and why *others* should take action. This last point moves us from the theoretical back towards the more practical and strategic.

Aligning universal drivers of human nature to shift the deep frames starts first with *bridging the Cartesian split* found in Protestantism and Cartesian science to allow a revival of mysticism and humility vis-à-vis the natural world. Some may argue that this would require religious revival or conversion, a rejection of scientific objectivity, or a return to primitive living. However, it simply acknowledges what we have always known. First, as climate change has shown us again, we are a part of this natural world, regardless of what we may believe comes after, and at its mercy. Second, the natural world is more complex, uncontrollable, and unknowable than ever before. We may be able to understand certain processes and be able to interfere with them, but we cannot control them, let alone recreate them. Finally, it is important that these two groups, religious and science leaders, who seem perpetually at war, finally recognize the common group between them in addressing anthropogenic climate change. As E.O. Wilson (2006) has said, "science and religion are potential allies for averting mass extinction". Even though scientific and heaven-bound religious worldviews clearly approach the subject of climate change from different motivations and backgrounds, those that hold them share a common interest in protecting the earth.

The second step in addressing the problem lies in *reshaping the north–south*[3] *relationship*. For centuries, the relationship between the "north" and the "south" has been an unequal relationship of power and money. The west has largely seen the rest as a market for its products and ideas, as well as a resources for its industries. Although the west has originated most of the environmental destruction, weapons production, warfare, enslavement and colonization of the rest of the world in modern times, it also sees itself as the champion of universal human rights, democracy and progress. While the west's contribution to the latter ideals should not be minimized, its complicity in the former have compromised its reputation, despite better intentions. In addition, the focus on western contributions to universal values has led to feelings of superiority in which the flow of ideas and learning has been largely uni-directional.

This superiority has blinded the west to learning from the rest; this must change. Inspiration for a more meaningful and sustainable lifestyle can be found from those communities which have maintained a better harmony with the natural world, which see "[divine] spirit in every tree, river, animal and bird" (White 1967). Instead of simply "farming" indigenous societies for their raw materials and specific medicinal knowledge and "exporting" universal notions, such as human rights, the west *should begin to* "import" larger notions, which guide a normative, southern "deep ecology" community. These communities minimize waste and maximize sustainability, exemplifying what the west now labels a carbon neutral or low footprint lifestyle (McDonough Architects 1992; McDonough and Braungart 2002; Smart Growth 2007). This reversal in the flow of ideas should prove interesting for a "north" more accustomed to exporting the supposed western notions of free trade and individual freedoms to a weaker "south".

[3]This paper acknowledges that the metaphorical north–south discourse does not map directly onto the northern and southern hemispheres. Instead, it roughly translates into the western nations of North America, Europe and Australasia and the rest of the world.

Embracing "Historical Obligation"

Dobson's (2004) notion of *ecological citizenship* provides the first critical step in reshaping the north–south relationship. One problem with the universal moral arguments made by people such as Al Gore for dealing with climate change is an assumption that as a universal right, all humans maintain an obligation to each other. Whether intentional or not, this can lead to quid pro quo arguments from the powerful north (west) for mutual obligation from the less powerful south. This was exemplified by Todd Stern, the special envoy for climate change of the US State Department, when he said, "[we] are keenly aware that the United States, as the largest historic emitter of greenhouse gases, and China, as the largest emitter going forward, need to develop a strong, constructive *partnership* to build the kind of clean-energy economies that will allow us to put the brakes on global climate change" (Wong and Revkin 2009, my emphasis). The counterargument from China reflects an ecological citizenship stance. "It's difficult for China to take quantified emission reduction quotas [...] because this country is still at an early stage of development. Europe started its industrialization several 100 years ago, but for China, it has only been dozens of years". One could easily argue that unless China makes some commitment, as the largest future emitter, efforts of smaller emitters would be pointless. However, the argument is not about whether or not China will take the steps, but who will pay for them. Considering that emissions cuts will be made from now into the future, it is arguable that China's total emissions will never reach that of the US.

Taking an ecological citizenship approach will have a larger effect, however, beyond simply requiring historical emitters to fund their historical damage; this approach shifts the conversation about the nature of these payments away from the current benevolent "aid" discourse, and creates an obligation from the north to the south for "damages", instead of forcing the south to continue to beg for aid. This shift will help eliminate the superior northern perspective of the south as a cheap resource and easy market, essentially creating an equity that is non-existent today. Proponents of Contraction and Convergence (Global Commons Institute 2009) argue that, as the world is forced to contract its use of fossil fuels, the west should have to contract more in order to converge at a common global per cap emission rate. "Accelerating convergence to equal shares per head, relative to the global rate of contraction [...] is the constitutional way of solving the climate's opportunity-cost to developing countries while sharing future constraint at rates that avoid dangerous climate change".

Reframing Climate Change from Private to Public Interest

The greatest from the north–south relationship, however, will only come from greatly *reducing the influence of the private sector* on public policy. This is not to demonize the private sector at all. I myself worked in the private sector for nearly

17 years. Private sector organizations simply work from a self-centered profit motive that does not and cannot, by its very nature, truly take public good into account in its decision-making processes. However, many in this sector truly believe they hold the keys to public problems such as climate change and believe themselves to be working in good faith for the common good. All too often, public officials are happy to depend on the private sector for easy, silver bullet technologies, instead of making brave policy decisions. The World Bank is often seen as an enabler of the very free market economic policies blamed for globalization, poverty, the food crisis, climate change, etc. However, their tagline reads, "Working for a world free of poverty", and the imagery they employ is typically African families.

It is possible that the spiral of crises in the global financial systems, which began in late 2007, will eventually discredit capitalist ideology but the actual reversal of its influence has not yet materialized. Despite mounting evidence, and a public push for more market nationalization, regulation and protection, the structure and base beliefs of free market capitalism, embodied by the *ecological modernization* (Hajer 1996) frame, still dominate the way policy issues and solutions are framed in the western public and private sectors. *Ecological modernization* frames climate change as an economic issue, e.g. the Stern Report, and often a business opportunity as well, which centralizes the way both the problem of and solutions for climate change are imagined, e.g. focusing on carbon trading and technology development instead of localized, community-based solutions. Even the ostensibly scientist-based Intergovernmental Panel on Climate Change emphasized in its Summary for Policymakers (Climate Change 2007, p. 14) "there is high agreement and much evidence of substantial economic potential for the mitigation of global GHG emissions over the coming decades".

Even in the discourse about the staggering government investment being pumped into financial institutions has upheld the basic tenets of free market capitalism: that the market will eventually solve public problems; the markets will self-correct and public policy should play the role of market enabler. Even the deliberate decision by the US Treasury to only use the US$700 billion bailout for intervention in financial institutions instead of easing individual foreclosures resounds with the logic of Reagan's *trickle-down economics*. Unfortunately, the US public discourse on economic stimulus programmes, where the personal savings rate is effectively zero (Ferguson 2005), focuses on getting Americans to spend money again on consumer goods.

One major western tenet that has such a dramatic effect on the environment is the commercial notion of progress and growth. It is a commonly held and unquestioned belief in the commercial world that an organization must grow to survive. There is no room in the market for a solid business which earns the same year after year from a stable and happy group of customers but does not grow. This was less of a problem in the past, when companies were more often private, family-run operations. In the modern reality of public companies, i.e. a company whose shares are traded on the stock market, growth is what drives stockholder returns. Theoretically, the difference in a stock's price from one moment, day, year to the next is the expectation of an increase in value of the company. This increase in value is typically driven by an increase in earnings. Public companies have the option of simply sharing its profits with its investors in the form of dividends. However, in the trade speculation mania and short-term profit mentality that has characterized the past couple of decades, dividends alone are not often sufficient motivation to invest. Companies come under increasing pressure from stockholders to drive up the price, and this is translated down the organization into the need to drive up earnings. Hence, the attraction of growth. Unfortunately, this focus on short-term growth (typically quarterly) is not always healthy; not for the company, employees or customers. At the expense of employees and natural resources, this growth relies on marketing to push a consumption which is greater than need. Constraints on speculation and marketing, as well as policies which reward company health instead of growth and restrict marketing activities to vulnerable groups (e.g. people with lower incomes, children, schools), could have a large ripple effect.

Finally, in the discourse on anthropogenic climate change western societies are often faced with *false discursive choices*, two ideals which appear mutually exclusive by nature and imply that society must choose one or the other. Addressing climate change will require stakeholders to *replace this false choice discourse with "common" or mutuality discourse* (Fellman 1998), for "discourses of opposites are limiting, violent and exclusionary of the richer variety of possibilities in the middle". Two of the most potent false choices surrounding the problem of and solutions for anthropogenic climate change are "environmental justice *versus* social justice" (Hawken 2007) and "economic health *versus* environmental sustainability".

In the final step, we need to understand how and why others should take action. Addressing climate change requires the engagement of millions of individuals performing multiple steps to reach a rather esoteric goal in collective, massive, public synchronization. The good news is that westerners largely understand the urgency of climate change, and, more importantly, are prepared to do their part in addressing it (WPO and CCGA 2007). In one typical study, the Royal Institute for Public Health and the Environment in the Netherlands (Rijksinstituut voor Volksgezondheid en Milieu 2004) found that 70% of Dutch citizens see climate crisis as a social dilemma, expect the government to organize a response, and are prepared to adjust their own behavior if others around them do as well.

The bad news is that policy makers, academics, the private sector and the media reporting on climate change often severely underestimate the willingness of individuals to engage in this process. Assumptions are made that "lifestyles must be maintained" by business and governments, who, not coincidentally, may benefit from increases in energy usage.

Following the attacks on 11 September 2001, most US citizens were prepared to sacrifice a lot in order to prevent another attack. Unfortunately, instead of calling for a reduction in arms proliferation or oil usage, or for an increase in diplomacy and personal reflection, former US President Bush (2001) told Americans to go shopping. This was supposed to show the terrorists they would not beat the American public by changing the (consumer) lifestyle. This is in sharp contrast to the calls for rationing during WWII, the oil crisis-induced run on energy-efficient cars in 1973–1974, and water rationing during the California drought in 1976–1977.

During the California droughts, residents were not allowed to wash their cars or run their water sprinklers. They were encouraged to take short, military-style showers. Even in the most Libertarian-Republican types of neighbourhoods, this kind of specific policy was welcomed. It was a collective cause around which neighbours rallied, made jokes, and used social pressure to ensure the reluctant conformed. This constituted what Turner and Killian call an "emergent norm", whereby "a shared understanding [. . .] of what sort of behavior is expected in the situation [. . .] encourages behavior consistent with the norm, inhibits behavior contrary to it, and justifies restraining action against individuals of dissent" (van Ginneken 2003). Emergent norm is often referred to in layman terms simply as peer pressure.

Building public engagement on climate change and the broader issues of environmental degradation, requires *a leap of faith in the willingness of the western public to engage* in the process, instead of leaving them to the human tendency towards environmental fatalism, which has been documented since the first century BC (Hudson 1993).

Secondly, public engagement must *re-conceptualize the "pursuit of happiness"* in the west. McKibben's (1989) finds that the same lifestyle practices which lower carbon emissions – living closer together, re-localizing food production, consuming less – are the same lifestyle practices which ultimately make humankind happy. According to the findings of the World Values Survey, Puerto Rico and Colombia, while not economically wealthy, are the second and third happiest countries in world. Wealth beyond a basic standard of living – about £10,000 a year – shows no direct correlation to happiness. In fact, in some cases the "standard of living (in the western world) has increased dramatically and happiness, [. . .] in some cases has diminished slightly" (Rudin 2006, p. 2). Inglehart et al. (2008, p. 276) conclude: "The relationship between economic development and happiness follows a curve of diminishing returns". In other words, once a foundation of economic security is achieved, initial *subjective wellbeing* peaks. Further economic growth does not buy additional happiness. They postulate that the US reached this economic peak in the mid-1940s and note: "Happiness is shaped by social and psychological factors at least as much as it is by economic and genetic ones" (p. 274). The Happy Planet Index (New Economics Foundation 2008) rated the US the 150th happiest nation out of 178 countries (about the same level as the Ivory Coast, Rwanda or Sierra Leone), based on how ecologically efficient nations provide for the wellbeing of their citizens. American Environics (2006) has tracked this decrease in economic wellbeing and noted the increasing focus on pure survival, as well as polarization, in the US. In the same period, the strong safety nets of western Europe and Canada allowed its citizens to focus on fulfilment, i.e. self-actualization. In contrast to the production-oriented measures of western nations, Bhutan promotes national gross happiness (NGH) as a measure for policy success. Conversely, "insecurity fosters a materialistic approach to life. Policies that combat insecurity – universal healthcare, say, or good, affordable education – promote happiness [. . .] advertising promotes consumption, fosters insecurity, and hinders self-acceptance, another predictor of lasting well-being" (Velasquez-Manoff 2008, p. 3).

This alternative pursuit of happiness will require a general de-mobilizing of western lifestyles and a re-acquaintance with local sources. The United Nations identified transport and commercial livestock as problematic market sectors. Food philosopher Michael Pollan (2009) believes that anthropogenic climate change scares westerners because it will likely force them to do more tasks for themselves that they have become accustomed to outsourcing. Examples include growing food, making clothes, cooking meals, building and fixing things, raising animals (i.e. husbandry). However, these kinds of changes will greatly contribute to Local Economies (Berry 2001) and food security, as well as reinstalling the confidence brought by self-sufficiency. These arguments are cited by multiple social movements, including Slow Food (versus fast food), farmer collectives, and vegetarianism, and cross political lines. Part of re-localizing communities rejects the current "throw-away" culture and reinstates a "repair" culture in which it makes financial sense again to fix or retrofit electronics, appliances, computers, and vehicles instead of dumping them for an upgrade.

Finally, mobilization relies on engaging the public on a personal flow level, but on a mass scale. For clues into how contact with nature can be used for engagement, human ecologist David Key (2003) proposes that: "Outdoor activity and immersion in nature can stimulate opportunities for self-actualization (again calling to Maslow's "hierarchy of needs"); peak experience, self-actualization and nature are inextricably linked". This finding is backed by Paul Maiteny's (2000, p. 248) interdisciplinary research on influencers and predictors of positive environmentally responsible behavior, which finds that: "Only behavioural change that is meaningful to the individuals will itself be sustainable in the long term. The more it promises to satisfy the inner existential yearnings, the more meaningful it will be. And the less satisfaction of the yearnings is believed to result from consumption of physical resources, the more ecologically sustainable it will be". Personal experience especially associated with those personally unique activities, which put individuals into a state of flow, clearly has the ability to reshape environmental behaviour.

According to a study by Nancy Wells and Kristi Lekies of Cornell University "participation with "wild nature", e.g. walking, playing or hiking in natural areas; camping; or hunting or fishing, [. . .] before the age of eleven [. . .] has a significant, positive association with both adult environmental attitudes and behaviors" (Wells and Lekies 2006, p. 13). Their research indicates the importance of early exposure to wild nature and unstructured play. In their own words, "To interact humbly with nature we need to be free and undomesticated in it [. . .] allowing for extensive, spontaneous engagement with nature". Yet today, American children spend an average of thirty minutes (or one per cent) of unstructured time outdoors each week and 27% of their time watching television (Hofferth and Sandberg 2001). The American Academy of Pediatrics even recommended vitamin D supplements for children (Associated Press 2008), something unnecessary with basic exposure to the sun. Policy initiatives, such as the No Child Left Behind movement originated by Richard Louv (2007), could reverse this trend and promote responsible environmental behaviour in future generations.

Finding "Flow"

Experiential design is the art of telling a compelling story about an often complex subject in a three-dimensional, physical space in a way that engages the general public without losing credibility with the experts. One of the secrets of experiential story designers is to ask the subject experts about the origin of their specific passion, whether it be sports or plants, ancient history or modern science. Inevitably, their passion was sparked by something that happened when they were about 12 or 13 years old. In fact, the most successful Hollywood films, besides being based on the universal Hero's Journey, are targeted to this same age group. Once the designer understands what hooked these professionals to their chosen field, that hook becomes a critical key in developing the visitor experience. Some examples follow:

1. While one firm was designing the Abraham Lincoln Presidential Library and Museum, the librarian–historians disclosed that the sense of discovery they experience when delving into old documents and books – the sense that they could discover something that no one had noticed about Lincoln before them – drove them into library science and the study of Lincoln.
2. On an individual level, Jane Goodall's love of chimpanzees stemmed from her favourite childhood books: *The Story of Dr. Doolittle, The Jungle Book*, and *Tarzan* and she dreamed of one day becoming a literal "Jane of the Jungle". By the age of 11, Jane Goodall dreamed of going to Africa to live with animals, which was a radical aspiration in those days for a young girl, but Jane had encouragement from her mother.
3. A top British volcanologist revealed that a single teacher and a field trip to the Lake District when he was 12 years old sparked the amazing career that led him to climb volcanoes on six continents, culminating in a recent expedition to Antarctica.

This hook illustrates that humankind is most easily motivated when engaged in its own unique skills and interests.

Collective "Flow"

Pine's (1992) theories on *mass customization* may demonstrate how this hook, i.e. vital engagement or flow, could be realized on a massive scale. The basic concept was to build flexibility into the components of the products themselves so that each consumer saw their product as tailor-made, e.g. mobile phones with customizable ringtones, sleeves, and screensavers. Organizations were encouraged to "make it ever easier and less costly for [. . .] (disparate parts) to come together to satisfy unique customer requests" (Pine et al. 1993).

This kind of constant shifting of components into ever changing wholes is reflected in the social sciences through the concept of dynamic "social assemblages".

The basic theory holds that the influencers and people who make up any social group are infinitely complex and constantly evolving, in direct contrast to the linear and static ways in which they are often categorized and studied. Any given influencer or person can be part of any number of groups at any given time. Groups assemble, evolve and disassemble, dynamically dependent upon the changing needs which the group addresses. Mexican philosopher Manuel de Landa explains: “Assemblages are made up of parts which are self-subsistent and articulated by relations of exteriority, [. . .] so that a part may be detached and made a component of another assemblage” (DeLanda 2006, p. 15).

The key to mass vital engagement lies within policy that is flexible and changeable, depending upon the unique interest of the receiver and situation at hand. Some internet activist organizations, such as Amnesty International and the Natural Resource Defense Council, provide interesting role models for how these dynamic social assemblages can be created and leveraged to engage the masses on a vital, flow level.

Conclusion

Of course, one PhD dissertation cannot answer all of the questions I have raised herein. The purpose of my dissertation is to begin this critical discussion, not to end it. Furthermore, the ideas and concepts outlined above are by no means conclusive. Encouragingly, though, there is rising concern not only to address climate change but also our broken relationship with the natural world. Some readers may accuse me of placing too much blame for anthropogenic climate change and the broader ramifications of environmental destruction on the west. I offer in response the parable of the pond and the rock:

> A rock is thrown into a still pond, and it creates waves. The rock sinks from view but remains a silent presence the pond must navigate around. The pond shifts, and the waves reverberate. If the waves cause the pond to overflow its bank and do harm, which is to blame?
>
> The rock, the thrower, or the waves?
>
> The west threw the rock of an individualistic, realistic, and materialistic worldview.
>
> How can we blame the waves?

References

American Environics (2006) Evolution of global values. American Environics. Available from Apr 2006 at www.americanenvironics.com/PDF/Evolution_of_Global_Values_AE.pdf

Associated Press (2008) Doubling of vitamin D for children is urged. New York Times, 12 Oct 2008. Available at www.nytimes.com/2008/10/13/health/policy/13vitamind.html?_r=1&e

Berry W (2001) The idea of a local economy. Orion Magazine, Winter edition. Available at www.orionmagazine.org/index.php/articles/article/299. Accessed Aug 2008

Bush GW (2001) President discusses war on terrorism in address to the nation. Available from 8 Nov 2001 at www.whitehouse.gov/n%20ews/releases/%202001/11/20011108-13.html. Accessed June 2008

Campbell J (1949) Hero with a thousand faces, 3rd edn. New World Library, Novato, CA, USA

Intergovernmental Panel on Climate Change (2007) Climate change 2007: synthesis report – summary for policymakers. Available at www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf. Accessed Mar 2008

Cramer P (1998) Deep environmental politics: the role of radical environmentalism in crafting American environmental policy. Praeger, London

Csíkszentmihályi M (1990) Flow: the psychology of optimal experience. Harper Perennial, New York

DeLanda M (2006) A new philosophy of society: assemblage theory and social complexity. Continuum, New York

Devall B, Sessions G (1985) Deep ecology: living as if nature mattered. Peregrine Smith, Salt Lake City, UT, USA

Dobson A (2004) Citizenship and the environment. University Press, New York, USA

Fellman G (1998) Rambo and the Dalai Lama: the compulsion to win and its threat to human survival. State University of New York Press, Albany

Ferguson N (2005) Sinking globalization. Foreign Affairs 84(2):64–77

Ginneken J (2003) Collective behavior and public opinion: rapid shifts in opinion and communication. Lawrence Erlbaum, Mahwah, NJ USA

Global Commons Institute (2009) Contraction and convergence. Available from Feb 2009 at www.gci.org.uk

Haidt J (2006) The happiness hypothesis: finding modern truth in ancient wisdom. Basic, New York

Hajer M (1996) Ecological modernisation as cultural politics. In: Lash S, Szerszynski B, Wynne B (eds) Risk, environment and modernity: towards a new ecology. Sage, London, pp 246–268

Hawken P (2007) Blessed unrest: how the largest movement in the world came into being and why no one saw it coming. Viking Penguin, New York

Hofferth S, Sandberg J (2001) Changes in American children's time 1981–1997. In: Hofferth SL, Owens TJ (eds) Children at the millennium: where have we come from, where are we going? Elsevier Science, Oxford

Hudson RJ (1993) Origins of wildlife management in the western world. In: Hawley AWL (ed) Commercialization and wildlife management – dancing with the devil. Krieger, Malabar, FL, USA, pp 5–21

Human survival. State University of New York Press, Albany, USA

Inglehart R, Foa R, Peterson C, Welzel C (2008) Development, freedom, and rising happiness: a global perspective (1981–2007). Assoc Psychol Sci 3(4):264–285

Jung CG (1968) [1934–1954] The archetypes and the collective unconscious (translated) Hull, R.F.C. Collected Works Bollingen Series XX. Bollingen, Princeton, NJ, USA

Key D (2003) The ecology of adventure. Centre for Human Ecology, Edinburgh

Knight C, Power C, Watts I (1995) The human symbolic revolution: a Darwinian account. Camb Archaeol J 5(1):75–114

Lakoff G (2006) Thinking points: communicating our american values and vision: a progressive's handbook. Farrar, Straus and Giroux, New York, USA

Louv R (2007) Leave no child inside. Orion Magazine, Mar–Apr edition. Available at www.orionmagazine.org/pages/om/07-2om/Louv.html

Maiteny P (2000) The psychodynamics of meaning and action for a sustainable future. Futures 32:339–360

Maslow A (1954) Motivation and personality. Harper and Rowe, New York

McDonough Architects (1992) Hannover principles, design for sustainability. McDonough Architects. Available at www.mcdonough.com/principles.pdf. Accessed Jan 2005

McDonough W, Braungart M (2002) Cradle to cradle: remaking the way we make things. North Point, New York
McFague S (1991) An earthly theological agenda. The Christian Century, Available from 2–9 Jan 1991 at www.religion-online.org/showarticle.asp?title=54. Accessed Nov 2008
McKibben B (1989) The End of Nature. Random House, New York
Rijksinstituut voor Volksgezondheid en Milieu (2004) Duurzame kwaliteit van leven: een kwestie van kiezen [Sustainable Quality of Life: A Question of Choosing (Translated from Dutch)]. National Institute for Public Health and the Environment. Available at www.rivm.nl/persberichten/2004/duurzaamheidsverkenning.jsp. Accessed at Dec 2007
Morrison D (2006) Ask an astrobiologist. National Aeronautics and Space Administration. Available at http://astrobiology.nasa.gov/ask-an-astrobiologist/question/?id=1522. Accessed June 2008
New Economics Foundation (2008) Happy planet index. Available from June 2008 at www.happyplanetindex.org/listactual.htm
Pine J (1992) Mass customization: the new frontier in business competition. Harvard Business School Press, Cambridge, MA, USA
Pine BJ, Victor B, Boynton A (1993) Making mass customization work. Harv Bus Rev 93509:109–116
Pollan M (2009) Lecture in defense of food. John Adams Institute. Available from 11 Feb 2009 at http://tjai.nl/michael_pollan/. Accessed June 2009
Wong and Revkin (2009) Experts in U.S. and China see a chance for cooperation against climate change. New York Times, 4 Feb 2009. Available at www.nytimes.com/2009/02/05/world/asia/05china.html?_r=2&p. Accessed Mar 2009
Rudin M (2006) The science of happiness. BBC News. Available from 30 Apr 2006 http://news.bbc.co.uk/2/hi/programmes/happiness_formula/4783836.stm. Accessed Aug 2008
Sleeth M (2006) The greening of the faithful. Interview with Wildesmith S. Wild Side News Radio Show, 19 Oct 2006. www.wildsidenews.com/101906.htm. Accessed at Mar 2007
Smart Growth (2007) Available from May 2007 at www.smartgrowth.org
Snow DA, Benford RD (1988) Ideology, frame resonance, and participant mobilization. Int Soc Mov Res 1:197–217
Snow DA, Rochford EB, Worden SK, Benford RD (1986) Frame alignment processes, micromobilization, and movement participation. Am Sociol Rev 51:464–481
Velasquez-Manoff M (2008) Why your happiness matters to the planet: surveys and research link true happiness to a smaller footprint on the ecology. Christian Science Monitor. Available from 22 July 2008 at http://features.csmonitor.com/environment/2008/07/22/why-your-happiness-matters-to-the-planet/
Weart S (2007) The discovery of global warming summary. American Institute of Physics Center for History of Physics. Available at www.aip.org/history/climate/summary.htm. Accessed Nov 2008
Weiss K (2008) U.S. close to decision on polar bears: it could be the first species to be listed as threatened with extinction primarily because of global warming. Los Angeles Times, 3 Feb 2008. Available at www.latimes.com/news/local/la-me-polar3feb03,0,1976402.story
Wells N, Lekies K (2006) Nature and the life course: pathways from childhood nature experiences to adult environmentalism. Child Youth Environ 16(1):1–24
White L (1967) The historical roots of our ecological crisis. Science 155:1203–1207
Wilson EO (1984) Biophilia. Harvard University Press, Cambridge, MA, USA
Wilson EO (2006) The creation: an appeal to save life on earth. W. W. Norton, New York, USA
WorldPublicOpinion.org and Chicago Council on Global Affairs (2007) Poll finds worldwide agreement that climate change is a threat. WPO and CCGA. Available from May 2007 at www.worldpublicopinion.org/pipa/pdf/mar07/CCGA+_ClimateChange_article.pdf

Part II
Economic Aspects of Climate Change

Chapter 13
Analysis of Green Investment Scheme for Energy Efficiency Measures in Latvia

Andra Blumberga, Gatis Zogla, Marika Rosa, and Dagnija Blumberga

Abstract Latvia has the unprecedented opportunity to be the first country in the world to sell assigned amount units under Article 17 of the Kyoto Protocol – International Emissions Trading. Negotiations are ongoing with a number of buyers for pilot transactions with a cumulative volume of 8–10 million assigned amount units (AAUs) out of 40 million AAUs earmarked by Latvia's government for total sales. Signed agreements are expected in 2009. Latvia's government has indicated their interest in exploring options to sell the full volume of available AAUs by the end of 2012. The main goal of these activities is "greening" – increasing the market value of Latvia's AAUs and alleviating buyers' concerns regarding the environmental integrity of transactions. The Latvian government has agreed to "green" the transaction and channel the revenues to projects or programmes with environmental benefits. The Ministry of Environment, representing the government, has indicated its interest to buyers in pursuing greening during the pilot transaction in the following areas: biomass and biogas heating, energy efficiency improvements in public sector buildings and residential buildings. Pilot transactions will be followed by other transactions for other renewable energy sources.

All activities are covered by Latvia's Climate Change Financial Instrument (CCFI). This article focuses solely on programmes related to energy efficiency in buildings.

Keywords Energy efficiency · Financial instruments · Funding energy efficiency · Hot airclimate change instruments · Renewable resources

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Introduction

Latvia signed the UNFCCC in 1992. The Parliament of the Republic of Latvia ratified the Convention in 1995 and the Kyoto Protocol in 2002. In accordance with the Kyoto Protocol, Latvia has to reduce total emissions of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 by 8% within the period 2008–2012, compared to the emissions level in 1990. In fact by 2004, total GHG emissions expressed in CO_2 equivalents had been reduced by much more −58%, although this began to increase slightly afterwards.

Based on a 2004 inventory, total GHG emissions expressed in CO_2 equivalents amounted to 10,746 Gg (i.e. 10.7 Mt), which accounted for 42% of 1990 emissions (Fig. 13.1). This figure excludes the LULUCF (carbon sinks) sector.

Most (69%) of all GHGs emitted from Latvia in 2004 were CO_2. The main CO_2 emission source in 2004 was the energy sector with 72% of the total GHG and 96% of total CO_2 emissions. Of this, energy industries accounted for 28% of total CO_2 emissions, manufacturing industries and construction 14%, other energy sectors 17%, and transport 37%. Industrial processes accounted for 3%, solvent and other product use 0.65%. Net CO_2 removals from the land-use, land-use changes and forestry sector were 3.2 Mt CO_2 in 2004.

By 2004, emissions of the second most significant greenhouse gas, methane, were reduced by 47.5%, compared to the 1990 level. The main sources include municipal waste dumpsites and enteric fermentation of livestock. Other significant methane emission sources are losses from natural gas programmes and burning biomass in the household sector.

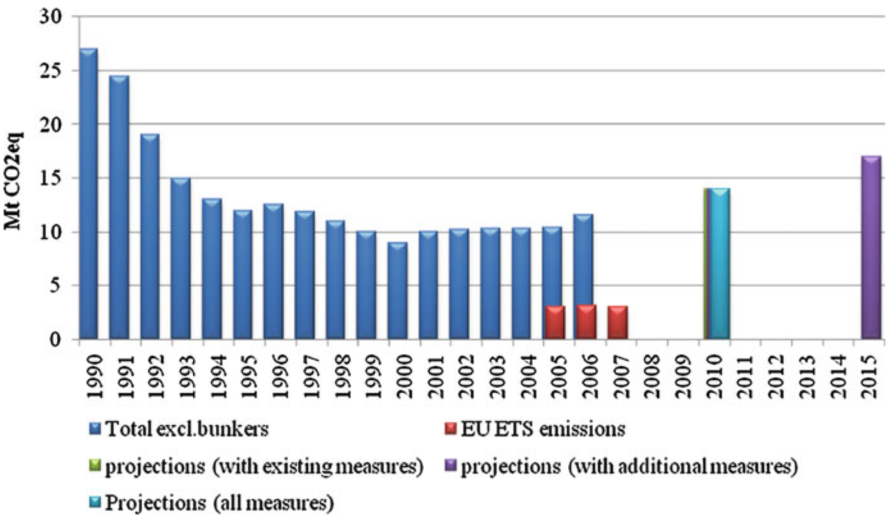

Fig. 13.1 Greenhouse gas emissions in Latvia

Total N_2O emissions have decreased by 62%, compared to the 1990 level. The main N_2O emission source is agricultural lands, contributing 74% in 2004. Other sources include transport, combustion of biomass in the household, trade and other sectors, as well as waste and wastewater handling. HFCs and SF_6 emissions have increased considerably, but their absolute share is small.

Despite a significant reduction in GHG emissions, Latvia remains a relatively carbon-intensive economy, compared to the rest of the EU. In 2003, GHG emissions amounted to 1,753 tonnes in CO_2eq per million euros of GDP, compared to the average of 536 tonnes in the EU15 and average 607 tonnes in the EU-25.

The latest document, “Climate Change Mitigation Programme for 2005–2010”, was adopted by the Cabinet of Ministers on 6 April 2005, and it aims to ensure that, beginning in 2008, total GHG emissions do not exceed 92% of the 1990 level.

GHG emissions are likely to increase in the future, although more slowly than Latvia’s GDP. Ministry of the Environment simulations, even under the most pessimistic scenarios for carbon intensity and fossil fuel use, show that Latvia will have a significant surplus of assigned amount units during the first Kyoto Protocol commitment period.

International Emissions Trading

A core element of the Kyoto Protocol is the provision for international mechanisms that allow flexibility in achieving GHG emissions reduction for 2008–2012. A group of instruments, including International Emissions Trading (Article 17 of the Kyoto Protocol) allow transfers of emission reduction efforts between countries, in order to minimize the overall costs of reaching Kyoto targets. International Emissions Trading relies not on the transfer of emission reduction credits, but rather on the trading of the units of national emission “quotas”, called assigned amount units (AAUs) between the eligible Annex B Parties to the Kyoto Protocol.

To estimate the volume of tradable AAU surplus, the total assigned amount (AA) is divided into tradable and non-tradable baskets. First, AAUs needed to comply with Kyoto emissions commitments are set aside and, for EU member states, this basket has three components – National Allocation Plan (NAP), actual emissions not included in the NAP and obligatory commitment period reserve (Fig. 13.2).

On 12 April 2006 the Cabinet of Ministers approved participation in International Emissions Trading under Article 17 of the Kyoto Protocol as proposed by the Ministry of the Environment. The Cabinet designated the Ministry of Environment to coordinate preparations and earmarked 40 million units of AAUs for potential sale during the first Kyoto commitment period. The Cabinet also decided that the Latvian AAUs would be “greened”, i.e. that AAU revenues would be used to finance environmental expenditures. These revenues can increase energy security, efficiency and environmental quality in Latvia in line with national development priorities.

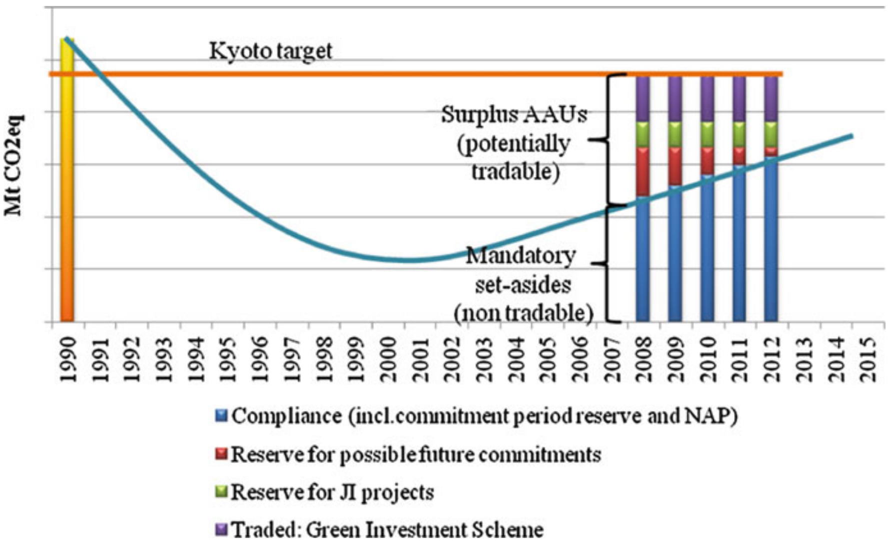

Fig. 13.2 Assigned amount distribution in tradable and non-tradable baskets

Latvia has an unprecedented opportunity to secure several hundred million euros of additional public revenues by selling AAUs. Negotiations are ongoing with a number of buyers for pilot transactions with a cumulative volume of 8–10 million AAUs. Signed agreements are expected in 2009. Latvia's government has indicated its interest in exploring options to sell the full volume of available AAUs by the end of 2012.

Green Investment Schemes

"Green Investment Schemes" (GIS) are mechanisms established by the countries selling to assure buyers that AAU proceeds will be used to finance agreed environmental projects and programmes.

There is no widely accepted definition of "greening" and the GIS has no legal basis in either the UNFCCC or the Kyoto Protocol. Decisions by the COP or COP/MOP also do not include any provisions on how AAU revenues should be used.

Buyers and sellers can embed greening activities in AAU purchase agreements. In the strictest interpretation, "greening" may require that every AAU transferred is matched by an emission reduction of one tonne of CO_2eq of GHG or captured carbon, similar to Joint Implementation or Clean Development Mechanism projects. Other approaches link the trasfer of AAUs to the implementation of measures that generate GHG emissions reduction that are more difficult to measure or provide wider environmental benefits. "Greening" can also refer to using AAU revenues to achieve local environmental benefits, or develop environmental policies or institutions.

Regardless of how greening is achieved, suitable monitoring and verification measures would need to be adopted to ensure accountability for expenditure outcomes, credibility, and transparency. In return, the buyer country would provide GIS financing under the terms of a negotiated contract.

A properly designed, implemented, and supervised GIS can enhance AAU value and marketability, partially restore marketable AAU assets, increase public acceptance of international emissions trading and facilitate long-term GHG reductions and environmental sustainability of development.

There are many broad categories under which the government of Latvia could spend AAU proceeds for "greening". These categories will be subject to bilateral negotiations with buyers. Each category will have specific requirements – subject to negotiations – for additionality, project selection, verification, monitoring, and reporting results. The most commonly discussed options include GHG emissions reduction, emission reduction of local pollutants, capacity building for GIS and for climate policy, monitoring and verification of environmental effects of GIS, R&D, raising awareness and capacity building, adaptation to climate change, poverty reduction, and improvement of welfare.

Countries (both on the sellers' and buyers' side) will have different priorities and interests as to how the AAU revenues are spent. The following graph (Fig. 13.3) illustrates relative positions of greening activities on the two most typical scales of buyers' preferences: measurability of results and UNFCCC relevance.

Conceptually, the GIS project cycle could be as follows:

- Eligible project owner applies for financing through a nationally established mechanism managed by a responsible agency
- The responsible agency appraises project proposals using procedures and criteria developed during AAU pilot project negotiations and embedded in the Operational Manual

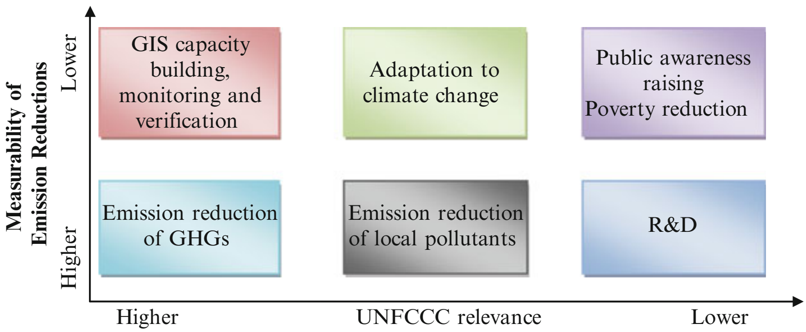

Fig. 13.3 Relative positions of greening activities

- Following the agency's appraisal and the Governing Board approval, agency concludes financing contracts with project owners. Financing contracts include, inter alia, pollutants covered, payments, payment schedule, payment conditions (performance indicators), and a protocol for monitoring and verifying outcomes
- After implementing projects and commencing operation, a project owner monitors and reports on emissions to agency through verification agencies, according to the protocol embedded in financing contract
- Upon verification of results, the project owner would invoice agency, which would submit a disbursement request to the Ministry of Finance directly or through the Ministry of the Environment
- The Ministry of Finance would disburse from the special Treasury account to agency, or directly to project owner, or to commercial bank escrow accounts for direct payment to debt service or contractors

This procedure continues in cycles during the agreed period to be approved with the buyers. Beneficiary enterprises must be able to finance up-front capital investments internally and/or through borrowing (Fig. 13.4).

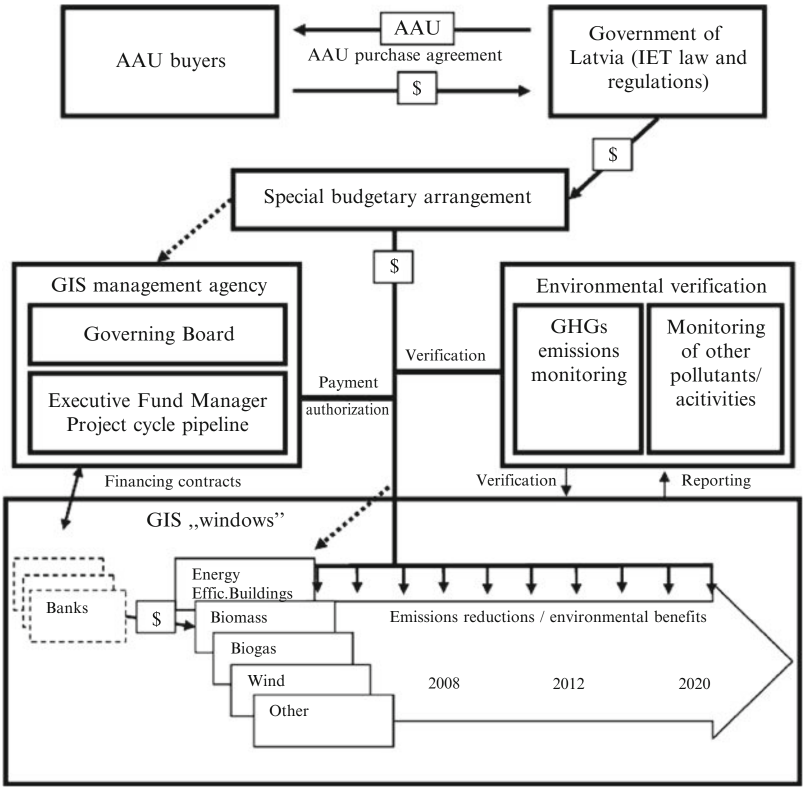

Fig. 13.4 Generic GIS structure and financial flows

Project Idea Note (PIN) form is used for project evaluation in each of the GIS "windows". The form includes four information groups: information about the applicant; project description; its type, location, and schedule; expected environmental and social benefits; and financial data. This information provides a possibility to evaluate the environmental performance of the project and to compare project applications that belong to one group. Using PIN will ensure that eligible projects meet the following criteria: satisfying buyers' needs for legitimate "greening"; demonstrating significant "greening" potential and technical feasibility; meeting legal requirements (e.g. clarifying ownership, confirming eligibility for public support, complying with Latvian and EU laws); confirming economic justification (or cost-effective emissions reduction); demonstrating financial feasibility with carbon revenue and some additionality (e.g. GIS revenues should address barriers that otherwise would prevent or delay project implementation, and should not crowd out committed finance); demonstrating potential for rapid implementation – not later than 2010 (e.g. competent project sponsor/developer identified, permits/licenses/power purchase agreements obtainable); demonstrating verifiable environmental or other benefits during the crediting period agreed with AAU buyers; and supporting wider sustainable development objectives of Latvia.

Economically viable options to further reduce GHGs are limited in Latvia. Based on realistic but conservative assumptions, economic potential for further GHG reductions is estimated at 7–8.6 Mt CO_2eq during the 10-year crediting period. This is less than one quarter of 40 million AAUs potentially available for sale. The potential for GHG emissions reduction is hampered by the relatively low carbon intensity of the Latvian power sector – reliance on hydro and renewable energy sources means that the CO_2eq emission factor for grid electricity is 2.3 times lower than in EU15 countries. The EU Emissions Trading Scheme further reduces the potential to use AAU revenues to achieve GHG reduction because of state aid constraints.

As a result, Latvian GIS may need to include a relatively high share of greening measures that do not generate immediate and easily measurable GHG reductions. They can be divided into three broad categories (a) greening measures crucial to GIS implementation (e.g. capacity building for GIS management, monitoring and verification); (b) greening measures that generate local environmental benefits while mitigating climate change; (c) greening measures that prevent future increases of GHG emissions or facilitate adaptation to climate change.

Rough cost assessments of proposed greening programmes and analysis of available public funding convincingly illustrate significant potential demand for funding under the GIS. It appears likely that potential AAU revenues can be absorbed by the portfolio of priority environmental programmes, for which baseline funding is inadequate. Some 18 greening programmes have been tentatively identified as options for the Latvian GIS: biomass heating – only boilers; efficient use of biomass and geothermal energy in households; combined heat and power; small hydro power and wind power; solar energy; production and promotion of biofuels; biogas utilization; energy efficiency in energy generation; district heating rehabilitation; energy efficiency in buildings; environmentally friendly transportation system; capacity building for GIS management; monitoring and verification of GIS; capacity for climate policy development and management; emission reductions of local pollutants (VOCs); climate change adaptation; R&D and promotion of low carbon; best available technologies and clean production; building awareness and capacity. Programmes consist of multiple projects and other activities, and total greening potential can be expanded to match available funding.

Climate Change Financial Instrument

The main goal of Latvia's Climate Change Financial Instrument (CCFI) is greening – increasing the market value of Latvia's AAUs and alleviate buyers' concerns regarding the environmental integrity of transactions the government of Latvia has agreed to "green"; channelling the revenues to projects or programmes with environmental benefits. The Ministry of Environment, representing the government, has indicated its interest to buyers in pursuing greening during the pilot transaction in the following areas: biomass and biogas heating, and energy efficiency improvements in public sector buildings and residential buildings. The largest portion of the revenues from pilot AAU transactions will be earmarked to support a pilot programme targeting building energy efficiency. These revenues will be disbursed to eligible greening programmes in the form of grants with the objective of maximizing greenhouse gas emission reductions. Pilot transactions will be followed by other transactions for other renewable energy sources. During the implementation process, the Latvian Ministry of Environment is consulting the World Bank.

Existing Situation of Energy Efficiency in Buildings

State-Owned Buildings

State-owned buildings form one of the main opportunities for energy efficiency improvements. For example, the Ministry of Health resides in state-owned buildings. Energy efficiency measures have been implemented in approximately 25% of hospitals to date, and a further 16 hospitals have identified energy efficiency upgrades for the period 2008–2012. Financing requirements are estimated at around 14 million lats and span a range of measures including upgrade/replacement of ventilation and air conditioning systems; electrical networks; windows and doors; wall insulation; and internal and external heat networks and boiler systems. While individual hospitals are responsible for energy efficiency upgrades, the Ministry of Health is allowing hospitals to retain any savings resulting from energy efficiency measures for the improvement of other health services. Hospitals have generated prioritized investment/development plans but the main barrier for implementation is financing.

The main challenges in this sector include delays associated with state budgeting processes and difficulty coordinating across ministries; investment financing; lack of qualified energy auditors; high entry hurdles for consultants and Energy Service Companies (ESCO).

Municipal Buildings

Many municipalities are taking steps to renovate and improve the efficiency of municipal buildings (e.g. town halls, schools, kindergartens, etc.). The speed of implementation is determined by budget availability and the municipality's capacity to leverage co-financing, such as EU structural funds. A review of the nine largest cities and towns in Latvia still shows significant potential for energy efficiency improvements, with over 500 general education buildings needing co-financing for energy efficiency, reconstruction, and renovation.

The main challenges in this sector are delays related to the need to provide upfront investment financing and municipal budget processes; low implementation capacity in most municipalities; lack of qualified energy auditors; high entry hurdles for consultants and ESCOs; municipal elections to be held in 8 months could impact the ability to engage on energy efficiency programmes in the short term and hence deliver results within the CCFI timeframe.

Residential Buildings

Residential apartment buildings – the largest opportunity for energy efficiency, but also the most complex to implement, resides in the residential sector. There are approximately 30,000 apartment buildings in Latvia. More than two thirds of apartments are privately owned and the remainder are owned by municipalities; there are a higher proportion of municipal-owned apartment buildings in Riga. Most municipalities view the residential sector as a main concern for energy efficiency and several (e.g. Ventspils, Liepaja, Valmiera) have introduced schemes to support energy audits and renovation works to incentivize owners.

The majority of apartment buildings work on the basis of a contract with Housing Management Companies that is signed by individual apartment owners but covers services for the entire building; about 95% of the Housing Management Companies are under municipal ownership, 3% are under an older style Soviet cooperative structure and 2% are private. The remainder work through privately owned building associations for utility services. Several housing management companies (both municipal owned and private) are already working with apartment owners and banks to jointly apply for loan financing and implement energy savings programs. Housing Management Companies, irrespective of the majority rule required by the Apartment Ownership Law, typically work on the basis of a 75% majority agreement with apartment owners to increase the building maintenance fee before applying to commercial banks for a loan on behalf of the residents. The maintenance company subsequently signs sub-agreements with each household regarding the increased maintenance fee. However, in practice, apartment owners could still veto such projects if Housing Management Companies are unwilling to move forward with a loan if they fail to get 100% signature to this sub-agreement. Banks take the credit risk, screen all loan applications, require investment grade energy audits and typically have a 1–3 month buffer zone for payments. Energy savings of 30–50% have been demonstrated for a number of projects implemented to date. There have been a few good examples where this has worked – mostly in buildings working through building associations (Kuldiga, Valmiera). In Daugavpils, an energy efficiency programme has been implemented by the maintenance company. The key factor in reaching consensus was a champion residing within the building itself, although implementation without subsidies has been slow compared to the potential opportunity.

Challenges that are faced in this sector are difficulties in reaching agreement among individual apartment owners regarding pre-financing of audits/feasibility studies and investment financing (partially provided by some municipalities); timing (this is likely to be slow to start); institutional arrangements and awareness; lack of capacity in housing owner associations and housing management companies; lack of qualified energy auditors; willingness to assume risk (banks, owners, housing owner associations and housing management companies).

Implementation of the Climate Change Financial Instrument in the Building Sector

The major issue for Latvia's CCFI is the level of pro-activity that CCFI implementation will need to demonstrate to buyers (and can realistically achieve). Since most energy efficiency investments in the building sector will demand individual attention on a building-by-building level, the only way to achieve significant scale-up is through de-centralization and launching market-based bottom-up approaches where possible. This means that it will be important to focus on robust implementation arrangements that are tailored for each targeted project type, and to run these in parallel to achieve scaling up effects in the timeframe available. The best approach will be a combination of different tools for the different sub-sectors. CCFI funds would be provided to eligible projects in the form of a subsidy in the pilot phase to ensure rapid uptake of opportunity and implementation of demonstration programmes.

State and Municipal Buildings

AAU revenues could add value in two ways:

1. Advancing planned energy efficiency activities for municipal buildings through the provision of co-financing in the form of a subsidy.
2. Supporting the introduction of an energy service company (ESCO) approach to enable municipalities and state to outsource large scale energy efficiency programmes to an ESCO that would be paid through energy savings that the ESCO guarantees. To demonstrate the viability of an ESCO approach and its potential for scale-up, the pilot phase of the CCFI could consider focusing on one or two energy efficiency programmes in the larger cities in Latvia. If limited interest is expressed by ESCOs in such activities, an additional option for the CCFI may be to introduce a portfolio guarantee instrument, whereby an ESCO would receive a guaranteed set percentage of delinquent payments in the portfolio.

State and municipal buildings will be eligible for an 85% subsidy for eligible energy efficiency activities/investments in buildings including kindergartens, hospitals, schools, and other publicly owned buildings. Project applications will be solicited through a series of calls for tender that will each be separately appraised. Since funds allocated for each call will be finite, applications will need to be ranked to prioritize projects for subsidy award. The ranking will be based on the cost–benefit ratio (measured as costs in lats per tonne of projected CO_2 reduced over the technical life of the energy efficiency measures planned). Projects with the lowest cost–benefit ratio will receive higher priority for a subsidy award, and those with the lowest may not receive financing depending on the availability of CCFI funds for that tender call.

Residential Buildings

In contrast, and due to the rolling nature of the tender process, it is proposed that the subsidy for residential buildings will be allocated on a sliding scale according to the proposed investment programme and projected energy efficiency savings (measured in lats) as a ratio to the greenhouse gas savings (measured in tonnes of carbon dioxide equivalent emissions). The lower the lats/CO_2 ratio, the higher the subsidy provided. The subsidy will be capped at 50% of eligible energy efficiency activities/investments and have a lower bound of 25%. A minimum level of energy efficiency investments is required to attract a subsidy.

The following approach has been based on data that is gathered in the course of a standard investment grade energy audit. The approach taken is to allocate CCFI funds on a grant basis to projects that can demonstrate energy and carbon dioxide (CO_2) savings in line with the Ministry of Environment's commitments to buyers, and to reward projects that demonstrate a minimum level of benefits and to provide a higher payment where the efficiency of delivery of these benefits is greater (measured in terms of the investment cost per tonne of CO_2 reduced).

The principles for calculating the subsidy is as follows:

- Cost–benefit ratio – a cost–benefit ratio (measured in costs in lats per tonne of CO_2 reduced over the technical life of the energy efficiency measure) will be calculated for eligible projects. Those with a lower cost benefit ratio will receive a higher subsidy
- Subsidy – will be bounded with the minimum level set at 25% of eligible costs (i.e. including energy efficiency investment costs, agreed energy audits, feasibility studies) for qualifying projects and the upper bound capped at 50% of eligible costs
- Allocation of subsidy – will vary according to the energy efficiency measures implemented by the beneficiary and will be linked to a predefined cost–benefit ratio that will be bounded. Below the minimum predefined cost–benefit ratio, beneficiaries will receive the maximum subsidy of 50%, and above an upper bound on this ratio, beneficiaries will not receive a subsidy

The subsidy allocation for energy efficiency measures falling between the maximum and minimum range for the cost–benefit ratio will be calculated on a proportional basis as follows:

$$S = Smax - Smin \times [CB - CBmin]/[CBmax - Cbmin]$$

$S = Smax$, if $CB < CBmin$

$S = 0$, if $CB > CBmax$

where,

S subsidy (%)

Smax upper bound on subsidy (50%)

Smin lower bound on subsidy (25%)

CB cost–benefit ratio (lats/tCO_2)CBmin lower bound on cost–benefit ratio for given energy efficiency measure (lats/tCO_2)

Table 13.1 Cost–benefit ratio and subsidy amount for energy efficiency measures

Energy efficiency measure	Cost–benefit ratio (CB) (lats/tCO_2)		Subsidy (S) (%)	
	CBmin	CBmax	Smax	Smin
Walls	100	150	50	25
Attic	30	60	50	25
Roof	120	160	50	25
Basement	120	210	50	25
Window replacement in common areas	60	140	50	25
Miscellaneous energy efficiency measures (insulation of main pipes, replacing main entrance doors, etc.)	150	300	50	25
Full energy efficiency upgrade	60	160	50	25

CBmax upper bound on cost–benefit ratio for given energy efficiency measure (lats/tCO_2)

Cost–benefit ratio and subsidies for energy efficiency measures are shown in Table 13.1 below.

Calculations have been performed as follows:

Energy efficiency calculations have been based on energy performance requirements for the design of building elements for new and renovated buildings determined in the Latvian Building Code (LBN 002-01) "Heat Engineering of the Envelopes of Buildings", which entered into force on 1 January 2003.

CO_2 savings are based on Latvia's National Allocation Plan: Second Phase (2008–2012). An emission factor of 0.3 tonnes CO_2 per MWh saved is used and is calculated as follows:

$$CO_2 \text{ factor} = 0.2 \text{ tCO}_2/\text{MWh} \times 0.9 \times 0.8$$

where,

Emission factor (natural gas): 0.2 tCO_2/MWh

Boiler efficiency: 90%

Losses in district heating network: 80%

Discussions

The results of the first call for applications (application deadline was set for 25 August 2009) showed a deep interest by the public sector to achieve the highest possible reduction of energy consumption.

Sixty-nine applications were submitted for a total number of 253 buildings where energy efficiency improvements need to be performed. In total, the amount claimed by applicants was 36.52 million lats, which significantly exceeded the amount of financing that had been approved for the call by the Cabinet of Ministers, and was equal to 17 millions lats. The results of the first call for project proposals made it possible to assess the feasibility of the first Green Investment Scheme:

Many problems that appeared were related to the performance quality of energy auditors involved in the GIS due to the knowledge differences and gaps in the related legislation; experts who performed an evaluation of the projects were not ready due to the fact that the databases and computer models were being developed during the process of application evaluation.

Two rounds of project applications are needed, and must be implemented stage by stage: selection of applications as the first round and presentation of demands for technical documentation as the second round.

Experts have different opinions regarding the limit value of the GIS co-financing part that accounted for 85% of the total project amount. Even though AAU purchasing countries were interested in a lower possible co-financing percent rate for the projects, the GIS implementation unit considered it necessary to provide the most attractive initial conditions for project applicants in order to create a viable GIS financing mechanism.

Although the term “energy efficiency” is well-known and understood among municipalities, it is not related to climate change mitigation projects and GHG emission reduction. Information flow still is an issue and it needs to be addressed.

Conclusions

Latvia is the first country in the world that has started to implement GIS. A pre-feasibility study was followed by the preparation of national legislative documents based on the project evaluation methodology. Project evaluation methodology includes detailed analysis of potential projects in each of the thematic project groups (GIS “windows”) – evaluation of project description, type, location, expected environmental and social benefits, and financial analysis.

The cost–benefit ratio lats/tCO_2 is used for project comparison and evaluation. The approach taken is to allocate CCFI funds on a grant basis to projects that can demonstrate energy and carbon dioxide (CO_2) savings in line with the Ministry of Environment’s commitments to buyers, and to reward projects that demonstrate a minimum level of benefits, and to provide a higher payment where the efficiency of delivery of these benefits is greater (measured in terms of the investment cost per ton of CO_2 reduced).

Even though cost–benefit ratio was used in the first call for project proposals for public buildings, and a project with the lowest cost–benefit ratio would receive higher priority for a subsidy award, those with the lowest ratio may not have received financing depending on the availability of CCFI funds for that call for tenders. Cost–benefit ratio will be related to the volume of subsidies in the further project tenders; the same way as is done for residential buildings.

It is necessary to reduce GIS co-financing volume to 50% maximum in further project tenders.

The first results showed that there is a deep interest among municipalities regarding GIS projects.

References

Peszko G, Matsuki T, Haemekoski K, Klapare S, Letachowitz B, Shimazaki K, Kuloveski K, Blumberga A, Circene B, Jurkans J, Karklins A, Ruza S, Vigants E (2007 Apr) Latvia’s participation in international emmissions trading. In: ECSSD Sustainable Development Paper No. 47, The World Bank, Geneva

Roadmap for Implementing an Energy Efficiency Program Targeting Buildings, Latvia Climate Change Financial Instrument, The World Bank, 5 Oct 2008

Chapter 14
Carbon Credit Currency for the Future

Neeraj Singhal and Himani Gupta

Abstract Carbon credits have the potential to be the next great currency. It might be almost mandatory to have carbon credits one day and there seems to be no alternative world currency that escapes local political intervention that we can all trust. Carbon credits are going to hold the same value wherever you are because CO_2 has a global impact. The world carbon market grew by 37% in Q1 2009 compared to the previous quarter, reaching 1,927 Mt. This was 128% higher than the first quarter in 2008. By the end of 2009, the carbon market is expected to be $121 billion. The carbon market is forecasted to touch $408 billion by 2012 and $2.1 trillion by 2020. This paper reviews the carbon market in terms of volume and value, market classification, and the future of the carbon market beyond 2012.

Keywords Carbon credit · Carbon market · Market classification

Introduction

The dramatic imagery of global warming frightens people. Melting glaciers, freak storms, and stranded polar bears (the mascots of climate change) show how quickly and drastically greenhouse gas (GHG) emissions are changing our planet. Such graphic examples, combined with the rising price of energy, drive people to want to reduce consumption and lower their personal share of global emissions. But behind the emotional front of climate change lies a developing framework of economic solutions to the problem. Two major market-based options exist, and politicians around the world have largely settled on carbon trading over its rival, carbon tax, as the chosen method to regulate GHG emissions.

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Global warming is the increase in the average temperature of the earth's near-surface air and oceans since the mid-twentieth century and its projected continuation. Global warming is caused by many things. The causes are split into two groups, man-made and natural causes. Natural causes are causes created by nature. One natural cause is the release of methane gas from arctic tundra and wetlands. Methane is a greenhouse gas. A greenhouse gas is a gas that traps heat in the earth's atmosphere. Another natural cause is that the earth goes through a cycle of climate change. This climate change usually lasts about 40,000 years. Man-made causes probably do the most damage. Pollution is one of the biggest man-made problems. Burning fossil fuels is one thing that causes pollution.

Fossil fuels are fuels made of organic matter such as coal or oil. When fossil fuels are burned, they give off a greenhouse gas called CO_2. Mining coal and oil also allows methane to escape. How does it escape? Methane is naturally in the ground. When coal or oil is mined, you have to dig up the earth a little. When you dig up the fossil fuels you dig up the methane as well. Another major man-made cause of global warming is population. More people mean more food, and more methods of transportation. That means more methane because there will be more burning of fossil fuels, and more agriculture. Because more food is needed, we have to raise food. Animals such as cows are a source of food which means more manure and methane. Another problem with the increasing population is transportation. More people mean more cars and more cars mean more pollution. Also, many people have more than one car.

Since CO_2 contributes to global warming, the increase in population makes the problem worse because we breathe out CO_2. Moreover, the trees that convert our CO_2 to oxygen are being destroyed because we are using the land that we cut the trees down from as property for our homes and buildings. Hence, we are not replacing the trees (an important part of our ecosystem), which means we are constantly taking advantage of our natural resources and giving nothing back in return.

Regulatory Mechanism: Kyoto Protocol

The concept of carbon credits came into existence as a result of increasing awareness of the need for controlling emissions. It was formalized in the Kyoto Protocol, an international agreement between 169 countries. The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro, Brazil, from 3 to 14 June 1992. The treaty is intended to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

The Kyoto Protocol establishes legally binding commitments for the reduction of four greenhouse gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride), and two groups of gases (hydrofluorocarbons and perfluorocarbons) produced by "Annex I" (industrialized) nations, as well as general commitments for all member countries. Under Kyoto, industrialized countries agreed to reduce their collective GHG emissions by 5.2% compared to the year 1990. National limitations range from 8% reductions for the European Union and some others to 7% for the United States, 6% for Japan, and 0% for Russia. The treaty permitted GHG emission increases of 8% for Australia and 10% for Iceland.

Kyoto includes defined "flexible mechanisms" such as Emissions Trading, the Clean Development Mechanism and Joint Implementation to allow Annex I economies to meet their greenhouse gas (GHG) emission limitations by purchasing GHG emission reductions credits from elsewhere, through financial exchanges, projects that reduce emissions in Annex II economies, from other Annex I countries, or from Annex I countries with excess allowances. The Intergovernmental Panel on Climate Change (IPCC) has predicted an average global rise in temperature of 1.4°C (2.5°F) to 5.8°C (10.4°F) between 1990 and 2100. Proponents also note that Kyoto is a first step to meeting the UNFCCC; it will be modified until the objective is met, as required by UNFCCC. The treaty was negotiated in Kyoto, Japan in December 1997, opened for signature on 16 Mar 1998, and closed on 15 Mar 1999. The agreement came into force on 16 Feb 2005 following ratification by Russia on 18 Nov 2004. As of 14 Jan 2009, a total of 183 countries and 1 regional economic integration organization have ratified the agreement (representing over 63.7% of emissions from Annex I countries).

Carbon Market

Carbon markets are primarily aimed at dealing with the problem of increasing concentrations of greenhouse gases in the atmosphere due to human activities. Carbon markets can also be attributed to technological and industry development, as well as a new area for employment growth. Carbon markets are seen by policy makers and economists as the most efficient policy measure available for reducing greenhouse emissions. Carbon markets operate through the use of tradable certificates, much like a stock exchange, with each certificate (credit) symbolizing a unit of exchange such as a megawatt hour of renewable energy or tonnes of carbon dioxide (Fig. 14.1).

The carbon market was valued at $1 billion in 2004 and reached $11 billion during 2005, with $8 billion from EUETS and $3 billion from primary CDM projects. The market reached $31 billion in 2006 and $64 billion in 2007, with $50 billion from EUETS, $7 billion from the primary CDM market, $5 billion from the secondary CDM market, and $2 billion from other markets. The market reached $120 billion in 2008, which is 120 times more than the 2004 figure of $1 billion.

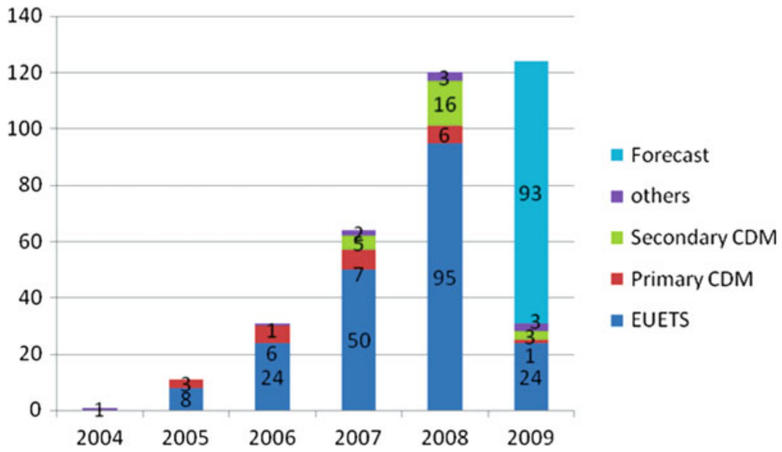

Fig. 14.1 Carbon market size 2004–09(billion $)
Source: New Carbon Finance

Introduction to Carbon Credits

Carbon credits are a key component of national and international emissions trading schemes. They provide a way to reduce greenhouse effect emissions on an industrial scale by capping total annual emissions and letting the market assign a monetary value to any shortfall through trading. Credits can be exchanged between businesses or bought and sold in international markets at the prevailing market price. Credits can be used to finance carbon reduction schemes between trading partners and around the world.

There are also many companies that sell carbon credits to commercial and individual customers who are interested in lowering their carbon footprint on a voluntary basis. These carbon offsetters purchase the credits from an investment fund or a carbon development company that has aggregated the credits from individual projects. The quality of the credits is based in part on the validation process and sophistication of the fund or development company that acted as the sponsor to the carbon project. This is reflected in their price; voluntary units typically have less value than the units sold through the rigorously validated Clean Development Mechanism. Emissions trading involves the exchange of emissions certificates.

Operators of large energy production plants or energy-intensive industrial companies are assigned a predetermined number of emissions certificates by their governments. These initial certificates are free, and authorize the companies to emit a specific amount of CO_2. If a company exceeds its allowance it must buy in additional certificates. When a company reduces its emissions, it can sell its excess certificates for profit. Companies face penalties when they do not acquire enough certificates to balance out the CO_2 they have emitted.

In addition to the emissions certificates allocated by the state, companies can also make use of other "flexible mechanisms". If they invest in emissions reduction projects in other countries, for example, they receive additional emissions allowances, which are the equivalent of emissions certificates. These can also be traded. The use of these market mechanisms ensures that the reductions in emissions are made where the costs of reduction are lowest. Thus, for all companies involved, emission trading makes both ecological and economic sense.

Need for Carbon Credits

Carbon credits came into existence as a result of increasing awareness of the need for pollution control. It took its formal form after the international agreement between 141 countries popularly known as the Kyoto Protocol. Carbon credits are certificates awarded to countries that are successful in reducing the emissions that cause global warming. The Kyoto Protocol aims to reduce greenhouse gas emissions by 5.2% below 1990 levels by 2012. Major contributors of greenhouse gas emissions are cement, steel textiles, and fertilizer manufactures.

The Kyoto Protocol provides for three mechanisms that enable developed countries with quantified emission limitation and reduction commitments to acquire greenhouse gas reduction credits. These mechanisms are:

Clean Development Mechanism

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission reduction or emission limitation commitment under the Kyoto Protocol (Annex I) to implement an emission reduction project in developing countries. Developed countries can implement projects that reduce emissions or remove carbon from the atmosphere in other developing countries in lieu of CERs (Certified Emission Reductions). These CERs can be used to meet the emission targets. The Protocol stresses that such projects are to assist the developing countries host parties in achieving sustainable development. Furthermore, the Protocol prevents developed countries from using CERs generated out of nuclear facilities to meet the targets. Table 14.1 shows decline in volume during 2008 in comparison to 2007, related to the primary CDM market, with a threefold rise in value and volume in the secondary CDM market during 2008 over 2007 figure.

Joint Implementation

The mechanism known as Joint Implementation' (JI), defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex I) to earn emission reduction units (ERUs)

Table 14.1 Market classification

Markets	Volume ($MtCO_2e$)		Value (US$ million)	
	2007	2008	2007	2008
Voluntary OTC	43.1	54.0	262.9	396.7
CCX	22.9	69.2	72.4	306.7
Other exchanges	0.0	0.2	0.0	1.3
Total – voluntary Markets	66.0	123.4	335.3	704.8
EU ETS	2,061.0	2,982.0	50,097.0	94,971.7
Primary CDM	551.0	400.3	7,426.0	6,118.2
Secondary CDM	240.0	622.4	5,451.0	15,584.5
Joint Implementation	41.0	8.0	499.0	2,339.8
Kyoto (AAU)	0.0	16.0	0.0	177.1
New South Wales	25.0	30.6	224.0	151.9
RGGI	–	27.4	–	108.9
Alberta's SGER	1.5	3.3	13.7	31.3
Total – regulated markets	2,919.5	4,090.0	63,710.7	119,483.4
Total – global markets	2,985.5	4,213.5	64046.0	120,188.2

Source: Ecosystem Marketplace, New Carbon Finance

from an emission reduction or emission removal project in another Annex I Party, each equivalent to one tonne of CO_2, which can be counted towards meeting its Kyoto target.

Developed countries can implement projects that reduce emissions or remove carbon from the atmosphere in other developed countries in lieu of ERUs. These ERUs can be used to meet the emission reduction targets. JI projects must have the approval of all Parties involved and must lead to emission reductions or removals that are additional to any that would have occurred without the project. ERUs can only be issued from 2008 onwards, although JI projects can be started from 2000 onwards. Joint Implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

Emissions Trading

Emissions trading (ET), as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare – emissions permitted them but not "used" – to sell this excess capacity to countries that are over their targets. It is an administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. It is sometimes called "cap and trade". A central authority (usually a government or international body) sets a limit or cap on the amount of a pollutant that can be emitted. Companies or other groups are issued emission permits and are required to hold an equivalent number of allowances (or credits), which represent the right to emit a specific amount. The total amount of allowances and credits cannot exceed the cap, limiting total emissions to that level. Companies that need to increase their emission allowance must buy credits from those who pollute less. The transfer of allowances is referred to as a trade. In effect, the buyer is paying a charge for polluting, while the seller is being rewarded for having reduced emissions by more than was needed.

The European emissions trading market rise in terms of value during 2008 reached the figure of US$94,971.7 million; the 2007 figure was US$50,097 million.

Market Structure

Allowance-Based Markets

The European Union Greenhouse Gas Emission Trading System (EU ETS) is the major market for greenhouse gas (GHG) emission allowances, and is the engine, perhaps even the laboratory, of the global carbon market. Its major achievement is that it helps discover the price of emitting GHGs in Europe. Several exchanges transparently disclose prices at which allowances change hands: for example, the EU emission allowance (EUA) for December 2008 delivery has traded in the €20–25 price band since May 2007. This price signal also encourages project developers to reduce emissions globally through climate-friendly CDM Projects in developing countries and JI projects in Annex I countries that generate carbon credits for sale into the EU ETS.

EU ETS

The EU ETS continued to dominate the global carbon market in 2008, both in transaction volume as well as monetary value. The European emission trading market rise in terms of value during 2008 reached US$94,971.7 million; the 2007 figure was US$50,097 million.

New South Wales

With the election of the Australian Labor Party with Kevin Rudd as Prime Minister, the year 2007 ended with a landmark decision by Australia to ratify the Kyoto Protocol. According to recent projections, Australia is on track to meet its Kyoto target (+8% above 1990 levels). The expected outcomes of the new Rudd Labor Government measures (in particular the 20% Renewable Energy Target by 2020) are also expected to help bridge the Kyoto gap.

Chicago Climate Exchange

Members of the Chicago Climate Exchange (CCX) made voluntary but firm commitments to reduce GHG emissions 6% below a baseline period of 1998–2001 by 2010. 2007 closed with record-breaking transacted volumes on CCX of 23 $MtCO_2e$ representing slightly more than a doubling of volumes over 2006. This 2007 volume represented a value of US$72 million or €53 million (nearly twice the value recorded in 2006). By the end of March 2008, volumes transacted since the beginning of the year almost equalled 2007 volumes with 19.7 $MtCO_2e$ traded, while market value had already surpassed that of 2007 by some 12% at US$81 million (€54 million). Moreover, CCX also pursued an expansion strategy to other schemes and other regions. In August 2007, CCX started listing futures on CER contracts, followed in September 2007 by futures on EUA contracts and, in December 2007, listing CER options.

Project-Based Markets

CDM basically accounts for most of the project-based market activity (at 87% of volumes and 91% of value transacted). JI and the voluntary market as a whole each experienced a doubling of transacted volumes and a tripling of transacted values. The dynamic of the project-based market changed in early 2008, as buyers became more cautious in response to a combination of mounting delivery and issuance challenges; higher perceived credit risks had the generally bearish sentiment in the financial markets, as well as continuing uncertainty about the role of and demand for CDM and JI in the post-2012 climate regime. These market trends, as well as the limits to demand from the EU ETS, have the potential to leave behind, in particular, projects in poorer countries which have only just begun to take advantage of the carbon compliance market. Many of these sellers have begun to look increasingly toward voluntary and pre-compliance markets for buyers.

Market Classifications

There are two types of markets where trading of carbon credits takes place.

European Climate Exchange

The European Climate Exchange (ECX) is a leading market place where trading of carbon dioxide (CO_2) emissions takes place in Europe and internationally. ECX currently trade two types of carbon credits:

1. EU Allowances (EUAs) – They are the climate credit which are used in the European Union Emission Trading Scheme (EU ETS). EU allowances are issued by the EU member states into Member State Registry accounts. In January 2005 the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) commenced operation as the largest multi-country, multisector greenhouse gas emission trading scheme worldwide.
2. Certified Emissions Reduction (CERs) – Certified emission reductions are the climate credit issued by the Clean Development Mechanism (CDM) Executive Board for emission reductions achieved by CDM projects and verified under the rules of Kyoto Protocol. CERs are either long term (lCER) or temporary (tCER), depending on the likely duration of their benefit. Both types of CER can be purchased from the primary market (purchased from original party that makes the reduction) or secondary market (resold from a marketplace).

What Are Futures?

Futures contracts are exchange traded derivatives. A futures contract is a standardized contract to buy or sell. A futures contract gives the holder the right and the obligation to buy or sell a certain underlying instrument at a certain date in the future, at a pre-set price. In the case of ICE ECX EUA Futures Contracts, the underlying units of trading are EU allowances (EUAs) of carbon dioxide (CO_2). One ICE ECX EUA Futures Contract ("lot") represents 1,000 EU allowances. EUA contracts differ from our CER contracts in that the underlying commodity that is delivered is different. Our CER products ensure delivery of Certified Emission Reduction (CERs) units which are credits generated from greenhouse gas emission projects which fall under the Clean Development Mechanism (CDM) of the Kyoto Protocol. Both parties of a "futures contract" must exercise the contract (buy or sell) on the settlement date. To exit the commitment, the holder of a futures position has to sell his long position or buy back his short position, effectively closing out the futures position and its contract obligations. ECX EUA Futures Contracts allow users to lock-in prices for delivery of carbon emission allowances (EUAs) at set dates in the future, with guaranteed delivery provided by the clearing house ICE Clear Europe.

The Role of Markets

Futures and options markets are derivative markets (though certainly not the only types of derivative products), which means that they exist in relation to spot markets, which are the underlying primary markets in which actual physical commodities are bought and sold. Because futures and options contracts allow for the delivery of the underlying commodity upon expiration, there is a strong tendency for spot, futures and option prices to move in the same direction and react to the same economic factors.

Where Do They Develop?

Derivatives markets tend to develop in large, competitive spot markets that have volatile prices. In the case of the EU ETS, however, the forward and futures markets have developed faster than the spot market. Approximately 95% of the total volumes in the European carbon market are seen in derivative trades (forwards, futures and options) with the remaining in spot trades. This can partly be explained by the initial delay of national registries and final allocations in many of the EU Member States which prevented the execution of instant delivery for spot contracts. Another reason may be that in such a new and volatile market, derivative instruments are crucial tools to optimize the value of your emissions portfolio.

What Does Trading Derivatives Involve?

Derivatives involve the trading of obligations (futures) and rights (options) based on an underlying product, without necessarily directly transferring that underlying product. The most familiar derivative instruments are exchange-traded futures and options based on an underlying product. On the European Climate Exchange, the underlying units of trading are the EU allowances (EUAs) which are granted to companies under the EU Emissions Trading Scheme (EU ETS).

ECX Derivatives

The ECX CFI Futures and Options Contracts provide an example of standardized terms of trade. The standardized nature of futures and options markets makes them inexpensive and reliable to use for those with a commercial interest in the EU ETS. Because futures and options contracts attract industrials, utilities, and financials of various nature, futures and options of a commodity often develop into a deep and liquid market. Market depth and liquidity means trades can be executed quickly without displacing prices. In sum, derivatives are traded either on exchanges (where trading is public, multilateral and closely regulated by governments and the exchanges themselves), or between two or more parties in over-the-counter markets (where trading is non-public and largely outside government regulation).

Twofold Role of Derivatives

Derivative markets have two central roles: risk transfer and price discovery. For market participants, the primary purposes of derivatives markets are:

To transfer the risk of adverse changes in commodity prices from those who wish to reduce risk to those willing to accept it. Commercial firms (that produce or use the commodity) shift part of the risk of price change to proprietary traders, who willingly assume that risk for the opportunity to earn a profit on their venture capital.

The revelation of price information that reflects a multitude of market opinions. These are the views of the various traders involved in the markets. Because futures and option markets funnel large quantities of bids and offers that result in publicly disseminated transaction prices, futures and options markets often become the primary source of price discovery for the related commodities.

Derivatives and the EU ETS

Derivative markets play an important role in the EU ETS. By allowing market participants to reduce exposure to price risk, buyers and sellers can better plan their businesses. By revealing the market's summary of the value of the underlying product, derivative markets inform those with a major stake in those commodities and financial instruments. The availability of these markets has provided the means to allow greater risk to be absorbed, thus facilitating growth and efficiency in each of the associated industries. Market users have improved predictability of future business conditions, which allows for expansion of lending and commodity production and facilitates borrowing for business growth. These results can lead to reductions in prices and interest rates paid by consumers.

Chicago Climate Exchange

Chicago Climate Exchange (CCX) is the world's first and North America's only active voluntary, legally binding integrated trading system to reduce emissions of all six greenhouse gases (GHGs), with offset projects worldwide. CCX employs independent verification and has been trading GHG emission reductions since 2003. CCX Members that cannot reduce their own emissions can purchase credits from those who make extra emission cuts or from verified offset projects.

Trading on the Exchange

Members of the Exchange earn Carbon Financial Instrument (CFI) contracts for any reductions that they are able to achieve below their defined reduction amount. CFI contracts represent 100 metric tonnes of carbon dioxide and all transactions are completed through the electronic trading system. In addition to companies receiving CFI contracts for their reductions, members may also obtain contracts by completing an approved offset project and having it verified by a third party. For this exchange there is no trading floor, as with all other commodities exchanges, because all of the trading is done electronically.

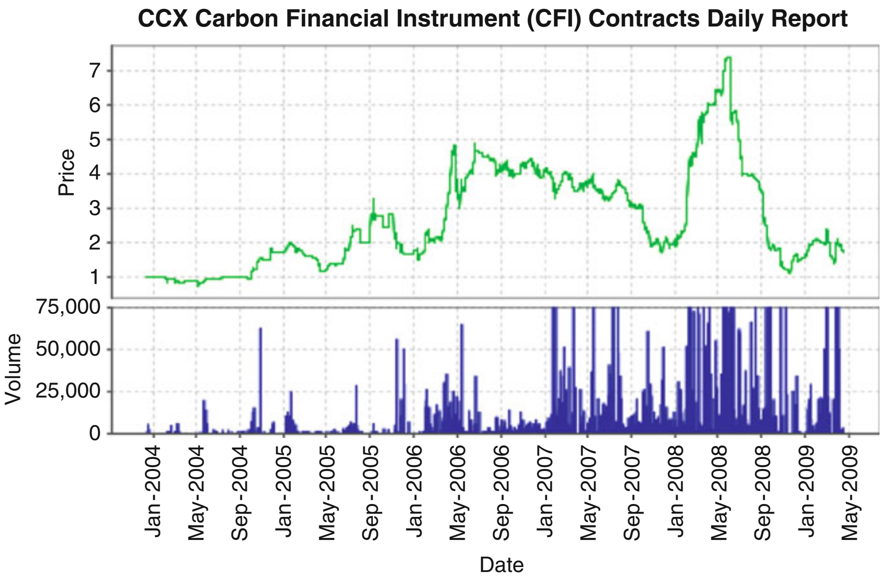

Fig. 14.2 CCX Carbon Financial Instrument (CFI) Contracts Daily Report (Jan 2004–May 2009) *Source*: http://www.chicagoclimatex.com/market/data/summary.jsf

Figure 14.2 shows trading done on CCX from Jan 2004 till May 2009, both in terms of price as well as volume. As can be seen from the graph, there were ups and downs in the price, as well as volume; however, in May 2008 and June 2008, the price of CCX Carbon Financial Instruments was at its peak at $7.40 metric tonnes of CO_2. After that, there was a fall in the price until Dec 2008. In Jan 2009, the price showed a further rise till Mar 2009, and in Apr 2009, there was again a fall in the price. Volumes also fluctuated from Jan 2004 till May 2009.

Future of the Carbon Market

Voluntary Market: Gaining Momentum

Some of the more optimistic estimates for the size of the voluntary market by 2010 are as high as 400 $MtCO_2e$. Earlier this year, US analysts estimated that US demand alone for offsets under the voluntary market could almost double annually from today to 250 $MtCO_2e$ by 2011. Consider, for example, that per capita, every American emits 20 tCO_2e annually.[1] More than 100 million Americans have one or more credit cards. If it were possible to reach 1% of American credit card holders a year every year for the next 5 years, one could imagine a customer base addition

[1]Based on 137 survey respondents.

Table 14.2 Historic volume growth in the voluntary carbon markets ($MtCO_2$)

Year	OTC	CCX	Other exchange
Pre-2002	42	–	–
2002	10	–	–
2003	05	–	–
2004	09	02	–
2005	10	01	–
2006	10	15	–
2007	43	23	0.1
2008	54	69	0.2

Source: Ecosystem Marketplace, New Carbon Finance

Table 14.3 Historic value growth in the voluntary carbon markets (million USD)

Year	OTC	CCX	Other exchange
Pre-2002	171	–	–
2002	43	–	–
2003	23	–	–
2004	35	02	–
2005	39	03	–
2006	61	38	–
2007	262	72	01
2008	393	307	01

Source: Ecosystem Marketplace, New Carbon Finance

of one million customers a year. Assuming each customer offsets his or her own per capita share, this gives a potential demand of five million customers offsetting 50 million tonnes annually by 2012. Double that rate of market penetration and one could see demand for 100 million tonnes annually (Tables 14.2 and 14.3).

The growth of the voluntary markets is a welcome indicator of the appetite that ordinary individuals and companies across the world need to take personal responsibility for the problem of climate change. Governments also need to participate in the effort to spur innovation towards a low-carbon future by taking various steps to reduce their emissions.

Beyond the Carbon Market

There is a tendency to believe that carbon markets will save the world from global warming, but it would be wise not to assume that markets will provide a painless, magical way to lessen climate change.

- First, the market does not set the level of the cap, policy makers do. It can only be a tool to help achieve that target
- Second, policy makers need to set targets and support mechanisms that meet two massive challenges. They have the responsibility of taking into account the risks

of climate change, especially on the poorest, as well as the opportunity of expanding clean development choices to meet the basic needs and aspirations of billions worldwide, many without access to electricity or clean water

- Third, the integrity of a market rests on the clarity and simplicity of its rules, the transparency of information and on institutions that guard against fraud and manipulation
- Fourth, it is not fair to expect "cap and trade" or emissions trading to work in all sectors globally. Clearly, housing and transport are sectors that do not lend themselves easily to an elegant emissions cap and trade approach
- Fifth, a solution to the urgent problem of climate change will require sustained effort from all of us. Policy has a role, in the same way that individual action by each of us does. It will also require applying market-based principles to the likely need for society, especially its most vulnerable members, to adapt to climate change

Is There a Post-2012 Market?

Preliminary findings from IETA's recent Market Sentiment Survey indicate that more than 90% of respondents believe that the GHG market is an established instrument that will continue post-2012. In addition, more than 65% of those surveyed anticipated that a global market will be established in the next 10 years.

The recent EU announcement regarding its climate and energy policy for 2012–2020 and beyond appears to have been taken seriously by the business community. Developments in the EU, USA, Canada, and Australia have helped kick off a modest post-2012 market in abatement domestically; however there is much ambiguity about the extent to which CDM and JI will play a role in compliance (Table 14.4).

Since there is still some uncertainty at play about details of each of these post-2012 regimes, there is some risk that origination of new carbon projects tapers off. This should not imply, however, a weakening of prices for CERs and ERUs in the short run, as there still is some strong residual demand before 2012 to be met. Furthermore, if the emerging North American regimes encourage early action and

Table 14.4 Transactions in world carbon market regions to 2020 (million US$)

	2009	2012	2020
Europe	101,577	216,315	980,723
North America	972	116,425	860,716
Australia	154	19,863	50,974
Kyoto	15,619	48,335	194,758
Other (voluntary Japan)	384	55,646	28,527
Carbon market total	118,706	408,249	2,115,698

Source: New Carbon Finance

banking of CERs, this could stimulate further demand. The uncertainty about demand post-2012 may justify a lower price – given the uncertain compliance value of the credits that may be generated.

Conclusion

If the carbon market is to play a significant role in helping to achieve the deeper reductions from current emission paths required over the next 20 years, decision makers will need to consider how best to broaden and deepen the reach of the market. Experience to date and our understanding of the nature and limitations of emissions trading and project-based mechanisms suggest that several key issues will need to be addressed.

- Countries need to consider how to better engage developing countries in the carbon market in a way that supports the transfer of low-carbon technology and investments in sustainable energy and other sectors.
- The uncertain cost of emissions abatement presents a barrier to both broader participation and deeper reductions. Options to manage cost uncertainty without compromising long-term emission reduction goals.
- Domestic policies such as domestic emissions trading systems or crediting mechanisms are needed to enhance the participation of the private sector in the international carbon market. These domestic systems or schemes also determine the extent of coverage of the carbon market and the number of sources that face a common price signal.
- In order for the carbon market to impact investment decisions, there must be some assurance that there will be a value for emission reductions beyond 2012. Since the value of the commodity traded in the international carbon market is entirely based on policies adopted by governments, the market requires a clear signal on the longevity of the limitation and reduction targets by policy makers.

The EU's decision to continue the EU ETS beyond 2012 shows there is little certainty about the path that international climate change policies will take. Countries may want to consider whether and how an early signal might be provided.

Glossary

AAU	Assigned Amount Units
AB 32	Assembly Bill 32: California's Global Warming Act
ACG	Asia Carbon Group
ACR	American Carbon Registry
ACX	Australian Climate Exchange
ACX	Asia Carbon Exchange

AES	AES Corporation
BoNY	Bank of New York Mellon
CAR	Climate Action Reserve (also known as The Reserve)
CARB	California Air Resources Board
CCAR	California Climate Action Registry
CCB	Climate, Community, and Biodiversity Standards
CCBA	Climate, Community, and Biodiversity Alliance
CCFE	Chicago Climate Futures Exchange
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFC	Chlorofluorocarbon
CFI	Carbon Financial Instrument (unit of exchange on CCX)
CFS	Carbon Fix Standard
CFTC	Commodities Futures Trading Commission
CO_2	Carbon dioxide
CPRS	Carbon Pollution Reduction Scheme (Australia)
CRT	Climate Reserve Tonne
ECCM	Edinburgh Centre for Carbon Management
ECIS	European Carbon Investor Services
ECX	European Climate Exchange
EPA	US Environmental Protection Agency
EPA CL	US Environmental Protection Agency Climate Leaders
ERT	Environmental Resources Trust
ETS	Emissions Trading Scheme
EUA	European Union Allowance
EU ETS	European Union Emission Trading Scheme
ERU	Emission Reduction Unit
FINRA	Financial Industry Regulatory Authority
FTC	US Federal Trade Commission
GE	General Electric
GF	Greenhouse Friendly
GHG	Greenhouse Gas
GS	Gold Standard
GWP	Global warming potential
HFC	Hydrofluorocarbon
IIED	International Institute for Environment and Development
ISO	International Standards Organization
JI	Joint Implementation
KWh	Kilowatt-hour
LULUCF	Land Use, Land Use Change and Forestry
MAC	California Market Advisory Committee
MGGRA	Midwestern GHG Reduction Accord
$MtCO_2e$	Millions of tonnes of carbon dioxide equivalent

MW	Megawatt
MWh	Megawatt-hour
NGAC	New South Wales Greenhouse Abatement Certificate
NGO	Non-governmental Organization
NOx	Nitrogen oxides
N2O	Nitrous oxide
NREL	US National Renewable Energy Laboratory
NSW GGAS	New South Wales Greenhouse Gas Abatement Scheme
OTC	Over-the-Counter (market)
RE	Renewable energy
REC	Renewable Energy Credit
REDD	Reducing Emissions from Deforestation and Degradation
RGGI	Regional Greenhouse Gas Initiative
SGER	Specified Gas Emitters Regulation
SO2	Sulfur dioxide
tCO_2e	Tonne of carbon dioxide equivalent
TREC	Tradable renewable energy credit
XXX	The Reserve Climate Action Reserve
UNFCCC	United National Framework Convention on Climate Change
U.S. EPA	United States Environmental Protection Agency
VCS	Voluntary Carbon Standard
VCU	Voluntary Carbon Units
VER	Verified (or Voluntary) Emission Reduction
VERR	Verified Emission Reductions-Removals
VOS	Voluntary Offset Standard
WBCSD	World Business Council for Sustainable Development
WCI	Western Climate Initiative
WRI	World Resources Institute
WWF	World Wildlife Fund

References

Amram M, Kulatilaka N (2009) The invisible green hand: how individual decisions and markets can reduce green house gas emissions. Calif Manage Rev 51(2):194–218

Boccaletti G, Löffler M, Oppenheim JM (2008) How IT can cut carbon emissions. McKinsey Report Oct 2008. McKinsey and Co, Chicago

Bohringer C (2002) Industry-level emission trading between power producers in the EU. J Appl Econ 34:523–533

Bohringer C, Hoffmann T, Lange A, Loschel A (2004) Assessing emission regulation in Europe: an interactive simulation approach. Energy J 26(4):1–22

Bonini SMJ, Hintz G, Mendonca LT (2008) The Mckinsey report on addressing consumer concerns about climate change. McKinsey Quart Mar:1–9

Brickman C, Ungerman D (2008) The Mckinsey report on climate change and supply chain management. McKinsey Quart July

Brinkman MW, Hoffman N, Oppenheim JM (2008) How climate change could affect corporate valuations. McKinsey Rep Fin 29:1–7

Bryan E, Akpalu W, Yesuf M, Ringler C (Dec 2008) Global Carbon markets are there opportunities for Sub-Saharan Africa? IFPRI Discussion Paper 00832. IFPRI, Washington DC
Capoor K, Ambrosi P (2006) State and trends of the carbon markets 2006. The World Bank Report. World Bank, Geneva
Capoor K, Ambrosi P (2007) State and trends of the carbon market 2007. The World Bank Report. World Bank, Geneva
Capoor K, Ambrosi P (2008) State and trends of the carbon markets 2008. The World Bank Report. World Bank, Geneva
Cohen SM (2002) Carbon-based conservation strategies in Latin America: an innovative tool for financing environmental conservation. Geneva Pap Risk Insurance 27(2):255–267
Corong EL (2008) Tariff reductions, carbon emissions, and poverty an economy-wide assessment of the Philippines. ASEAN Econ Bull 25(1):20–31
Dinan T, Rogers DL (2002) Distributional effect of carbon allowance trading: how government decisions determine winners and losers. Natl Tax J 45(2):199–221
Edwards C, Rousso A, Merrill P, Wagner E (1998) Cool code: federal tax incentives to mitigate global warming. Natl Tax J 51:465–484
Enkvist PA, Naucler T, Rosander JM (2007) A Cost Curve for greenhouse gas emission. McKinsey Report. McKinsey and Co, Chicago
Enkvist PA, Naucler T, Riese J (2008) What countries can do about cutting carbon emissions. McKinsey Report. http://www.mckinseyquarterly.com/What_countries_can_do_about_cutting_carbon_emissions_2128
Farrell D, Remes JK (2008) How the world should invest in energy efficiency. Mckinsey Report July 2008. McKinsey and Co, Chicago
Farrell D, Nyquist SS, Rogers MC (2007) Curbing the growth of global energy demand. Mckinsey Report July 2007. McKinsey and Co, Chicago
Forrest W, Kaplan JM, Kindler N (2008) Data centers: how to cut carbon emissions and costs. Mckinsey Report. McKinsey and Co, Chicago
Gorte RW, Ramseur JL (2008) Forest carbon markets: potential and drawbacks. CRS Report for Congress, Washington DC
Grubb M (2000) Economic dimensions of technological and global responses to the Kyoto protocol. J Econ Stud 27(1–2):111–125
Hall DC (1996) Geoeconomic time and global warming: renewable energy and conservation policy. Int J Soc Econ 23(4–6):64–87
Henry LA, Sundstrom LM (2007) Russia and the Kyoto protocol: seeking an alignment of interests and image. Glob Environ Polit 7:4
Hill MR (2001) Sustainability, greenhouse gas emissions and international operations management. Int J Oper Prod Manage 21(12):1503–1520
Hill MR (2006) The European Union's Emissions trading scheme: a policy response to the Kyoto protocol. J Contemp Eur Stud 14(3):393–410
Hirschland MJ, Oppenheim JM, Webb AP (2008) Using energy more efficiently. McKinsey Report July 2008. McKinsey and Co, Chicago
Jorgenson AK (2006) Global warming and the neglected greenhouse gas: a cross-national study of the social causes of methane emissions intensity, 1995. Soc Forces 84(3):1777–1796
Kolk A, Pinkse J (2008) A perspective on multinational enterprises and climate change: learning from 'an inconvenient truth'? J Int Bus Stud 39:1359–1378
Larson DF, Philippe A, Dinar A, Rahman SM, Entler R (2008) Carbon markets, institutions, policies, and research. The World Bank Policy Research Working Paper 4761. World Bank, Geneva
Macdicken Kg (1997) Project specific monitoring and verification: state of the art and challenges. Mitigation Adaption Strateg Glob Change 2:191–202
McKibbin WJ, Wilcoxen PJ (2002) The role of economics in climate change policy. J Econ Perspect 16(2):107–129
Murdiyarso D (2004) Implications of the Kyoto protocol: Indonesia's perspective. Int Rev Environ Strateg 5(1):145–156

Ogonowski M, Helme N, Movius D, Schmidt J (2007) Reducing emission from deforestation and degradation: the dual market approach. Centre for Clean Air Policy, Europe
Olson EG (2008) Creating an enterprise-level green strategy. J Bus Strateg 29(2):22–30
Pearce D (1991) The role of carbon taxes in adjusting to global warming. Econ J 101:938–948
Persson TA, Azar C (2003) The cost of meeting the Kyoto protocol dealing with the carbon surplus in Russia and the Ukraine. Manage Environ Qual 14(4):488–507
Poterba JM (1993) Global warming policy: a public finance perspective. J Econ Perspect 7(4):47–63
Purvis N (2004) The perspective of the United States on climate change and the Kyoto protocol. Int Rev Environ Strateg 5(1):169–178
Ren Z, Yin L (2001) Global warming and its astro-causes. Kybernetes 30(4):411–432
Sathiendrakumar R (2003) Greenhouse emission reduction and sustainable development. Int J Soc Econ 30(12):1233–1248
Shimada K (2004) The legacy of the Kyoto protocol: it's role as the rulebook for an international climate framework. Int Rev Environ Strateg 5:3–14
Stankeviciute L, Criqui P (2008) Energy and climate policies to 2020: the impacts of the European "20/20/20" approach. Int J Energy Sector Manag 2(2):252–273
Suryanarayana MH (2008) Morbidity profiles of Kerala and All-India: an economic perspective. IGIDR working paper WP-007. IGIDR, Mumbai
Tisdell C (2008) Global warming and the future of Pacific Island countries. Int J Soc Econ 35(12):889–903
Twining JDR (2008) Banking on carbon assets. McKinsey Report Dec 2008. McKinsey and Co, Chicago
Vanden FK (2003) The effect of market reform on structural change: implications for energy use and carbon emission in India. Energy J 24(3):27–62
Ward M (2008) What might a future global climate change deal look like? Policy Quart 4(4):35
Yeoh P (2008) Is carbon finance the answer to climate control? Int J Law Manag 50(4):189–206

Chapter 15
Climate Change and Agricultural Production in Vietnam

Nguyen Van Viet

Abstract This report will discuss some results of a case study on climate change and agricultural production in Vietnam, showing the trend of agro-climate element changes such as average temperature; the dates of beginning and ending temperature through 20 and 25°C; absolute minimum temperature; sunshine duration; rainfall, by month, season and year in all agro-economical regions. Moreover, it aims to show that climate change and sea level rise have impacted on agricultural production such as rice crop areas and production of maize, soybean and groundnut in the Red river delta, Central Region, Mekong River Delta and other regions. Furthermore, it provides suggested strategies to cope with climate change and sea level rise by different scenarios in 2050 and after 2050.

Keywords Adaptation strategy · Agriculture · Climate change

Introduction

The World Bank (WB) and UNDP case study pointed out that Vietnam is one of the five countries in the world which has had bigger losses under the impact of climate change (Dasgupta et al. 2007). According to the first assessment, a million hectares of land will be under water, more than a million people would lose their houses because of the rise in sea level. Meanwhile, gross output of food will decrease, threatening national food security. At the same time, it will cause more dangerous problems if we do not prepare to cope with them or adjust the socio-economic plan for sustainable development in general and agriculture in particular.

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As is well-known, in Vietnam, people living and working in rural agriculture are estimated to make up more than 73% of the population (in 2006), most of whom are poor people in the countryside. They are directly influenced by climate change, which, with sea level rise, will affect agriculture, through effects on cultivation areas, crop production, soil, weeds, pests, and diseases, and also livestock, water supply and hydrology, ecosystem and conservation, and environment. Studying climate change and agricultural production in Vietnam is therefore very important. It is the first priority in the national target programme to respond to climate change, Decision No. 158/QD-TTg dated 22 December 2008 (MONRE 2008).

Methodology and Data

Methods for statistical analysis are used in climate and agro-climatology. Meteorological data was collected from 1961 to 2006 in the main stations in seven agro-economic regions of Vietnam (Fig. 15.1): North Mountain and Midlands (I); Red River Delta (II); North Central (III); South Central (IV); Central Plateau (V); Northeast South (VI); Mekong River Delta (VII) since 1961 up to 2006.

The Trend of Climate Change

Air Temperature

According to the First Report of Vietnam to the United Nations Framework Convention on Climate Change, the monthly average temperature increased about 0.07–0.15°C per decade.

- In the Northern Mountain and Midland Region, average temperature in January decreased about 0.2–0.3°C, and temperature in July decreased 0.2°C; while annual temperature did not change
- In the Red River Delta, temperature in January, July and annually increase 0.2–0.4°C
- In the North Central January temperature increases 0.4°C, July increases 0.2°C, annual increase 0.2–0.4°C
- In the South Central region, January temperature increased 0.8°C, July increased 0.3°C, annual increase 0.5°C
- In Tay Nguyen Central Plateau, January temperature increased 1.0°C, July increased 0.9°C, annual increase 1.0°C
- In the Northeast South, January temperature and July saw no change, annual increase 0.2°C
- In Mekong River Delta, January temperature increased 0.5°C, July increased 0.5°C, annual increase 0.5°C (Table 15.1)

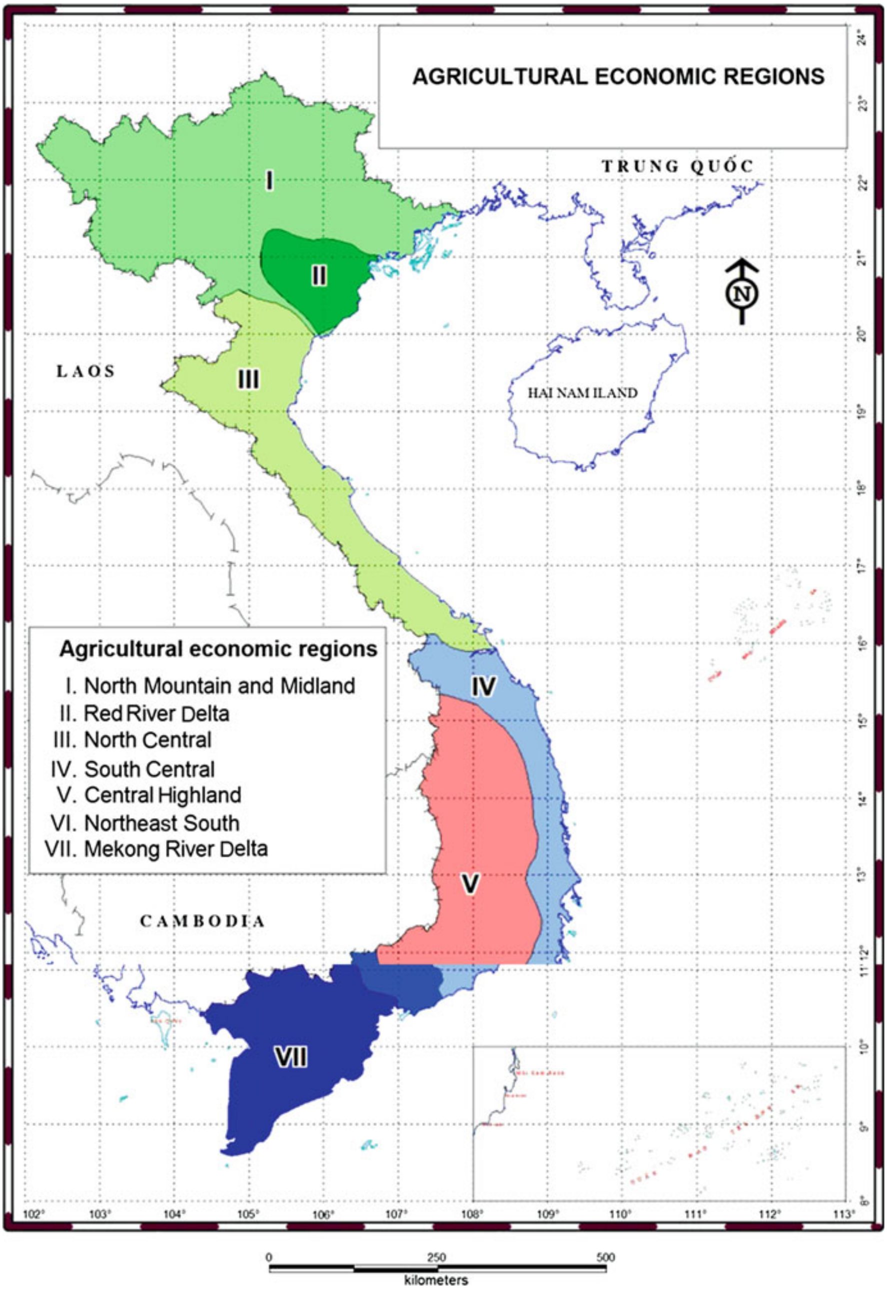

Fig. 15.1 Agricultural economic regions (Viet 1998)

Table 15.1 Variation and trend of average temperature in Vietnam

Station	January (°C)	July (°C)	Annual (°C)
Bac Giang	−0.3	−0.2	0
Ha Noi	+0.4	+0.4	+0.4
Hai Duong	0	0	0
Namdinh	0	0	+0.5
Vinh	+0.4	+0.3	+0.3
Danang	+0.8	+0.3	+0.5
Nha Trang	0	0	0
Playku	+1	+0.9	+1
Buonmathuot	+0.9	+0.4	+0.5
Saigon	0	0	+0.2
Can Tho	+0.5	+0.5	+0.5
Baclieu	+0.2	−0.2	0

Table 15.2 Trend of beginning and ending dates of temperature 20°C

Station	Beginning dates	Ending dates	Duration of winter
Ha noi	1 day early	6 days later	Shorter
Nam dinh	10 days later	13 days later	Shorter
Da Nang	10 days early	5 days later	Shorter
Playku	9 days early	3 days later	Shorter
Banmethuot	10 days early	5 days later	Shorter

The beginning and ending dates of temperature of 20°C

The beginning and ending dates of temperatures of 20°C and 25°C, respectively, are very important for defining the crop calendar and crop rotation, especially for defining the growing period for agriculture in the North and in the Mountain regions.

- The following table (Table 15.2) shows the beginning and ending dates of the temperature 20°C
- In the Mountain and Midland region, the beginning date is normal; the ending date is 1 day earlier than normal
- In the Red River Delta, the beginning date is 1 day earlier than normal; the ending date is 6 days later than normal
- In the North Central region, the beginning date is 1 day earlier than normal; the ending date is 7 days earlier than normal
- In the South Central mountain region, the beginning date is 10 days earlier than normal; the ending date is 5 days later than normal
- In the Tay Nguyen Plateau, the beginning date is 9 days earlier than normal; the ending date is 8 days later than normal

The beginning and ending dates of temperature of 25°C

- In the Mountain and Midland region, the beginning date is earlier than normal by 2 days; the ending date is later than normal by 2 days
- In the Red River Delta, the beginning date is normal, the ending date is normal too

- In the North Central region, the beginning date is earlier than normal; the ending date is 12 days earlier than normal
- In the South Central mountain region, the beginning date is 12 days later than normal; the ending date is 12 days earlier than normal
- In the Tay Nguyen Plateau, the beginning date is earlier than normal; the ending date is 10 days later than normal (Table 15.3)

Absolute Minimum Temperature

Ascertaining the absolute minimum temperature is crucial for the distribution of perennial plants such as industrial crop coffee, rubber, tea, and fruit trees such as lemon, orange, banana, longan, and litchi.

- In the Mountain and Midland region, it increased 1.0–3.0°C
- In the Red River Delta, it increased 0.4–1.0°C
- In the North Central region, it increased 0.4–1.0°C
- In the South Central region, it increased 0.5°C
- In the Northeast South region, it increased 1.0°C
- In the Tay Nguyen Plateau, it increased 0.2–1.2°C
- In the Mekong River Delta, it increased 0.5–1.2°C (Table 15.4)

Table 15.3 Trend of beginning and ending dates of temperature of 25°C

Station	Beginning dates	Ending dates	Duration of summer
Ha noi	0	6 days later	No change
Nam dinh	3 days early	2 days later	Longest
Da Nang	2 days later	1 day early	No change
Playku	13 days later	12 days early	No change
Banmethuot	1 day early	10 days later	Longest

Table 15.4 Trend and variation of absolute minimum temperature

Region	Station	Variation (°C)
Northwest	Lai Chau	+1.5
	Sapa	+1
	Van Chan	+2
Northeast	Cao Bang	+2
	Lang Son	+1.8
Midland	Phu Tho	+1
	Bac Giang	+1
Red River Delta	Ha Noi	+1
	Hai Duong	+0.4
North Central	Vinh	+0.4
South Central	Nha Trang	+0.5
Northeast South	Saigon	+0.8
Plateau Taynguyen	Playku	+0.2
	Buonmathuot	+1.2
Mekong River Delta	Soctrang	+0.5
	Rach Gia	+1.2

Sunshine Duration

It is known that sunshine duration is crucial for the photosynthesis process of agricultural plants:

- In the Mountain and Midland region in January, sunshine duration decreased by 20 h, in July by 10 h, annually 45 h, in winter by 40 h, in summer by 1 h
- In the Red River Delta in January sunshine duration decreased by 10–20 h, in July by 20–30 h, in winter and summer by 50–70 h
- In the North Central region in January sunshine duration decreased by 5–7 h, in July and annually it decreased, as well
- In the South Central region in January, in July and annually it increased, as well
- In the Tay Nguyen Plateau, it increased compared to normal
- In the Mekong River Delta, it decreased, as in the North of Vietnam (Table 15.5)

Rainfall

- In the Mountain and Midland region, rainfall in January saw no change, but in July it increased; seasonally and annually it also increased
- In the Red River Delta in January, July and winter it increased; however annual rainfall increased a little
- In the North Central region in January, July, and in summer rainfall decreased; in winter it increased
- In the South Central region, rainfall increased (annually, in summer and in winter); in July rainfall decreased; in January rainfall saw no change
- In the Tay Nguyen plateau, rainfall decreased in January; July rainfall was in season and annually it increased
- In the Mekong River Delta, rainfall in January and in Winter decreased; in July it increased; seasonally and annually rainfall saw no change (Table 15.6)

Storms in Vietnam

Vietnam is a tropical monsoon climate and is one of five storm centres in the Asia-Pacific. Since 1950, there have been more than 212 storms in Vietnam. Every year,

Table 15.5 The trend of sunshine duration

Station	January (h)	July (h)	Annual (h)	Summer season (h)	Winter–spring season (h)
Bac giang	−20	−10	−50	−10	−40
Ha Noi	−20	−30	−200	−100	−100
Nam dinh	−10	−60	−250	−160	−100
Vinh	−8	−20	No change	−5	−15
Banmathuot	+15	+10	No change	−40	+10
Bac lieu	−15	−20	−140	−60	−100

Table 15.6 The trend of rainfall

Station	January (mm)	July (mm)	Annual (mm)	Summer season (mm)	Winter–spring season (mm)
Bac giang	0	+60	+150	+110	+15
Ha Noi	+12	+20	0	−10	+60
Hai duong	+12	−20	−180	−180	+10
Nam dinh	+5	+50	−50	0	+50
Vinh	−20	−50	−40	−100	+10
Da nang	0	−10	+200	+180	−20
Playku	−2	−10	0	0	+60
Sai gon	−5	0	0	−50	+50
Can tho	−1	+30	0	−20	0
Bac lieu	−30	+125	−100	−50	−20

Table 15.7 Monthly and annual frequency of typhoons in Vietnam 1950–1999

Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
1950–1959	0	0	0	1	1	4	5	11	9	9	7	3	50
1960–1969	0	1	0	1	1	5	11	13	19	12	8	1	72
1970–1979	0	0	0	0	2	9	7	13	18	15	10	4	78
1980–1989	0	0	2	0	1	9	10	9	9	24	11	2	77
1990–1999	0	0	0	1	0	6	8	10	12	14	15	5	71
Total frequency per year	0	0.02	0.04	0.06	0.1	0.66	0.82	1.12	1.34	1.48	1.02	0.3	6.96

Vietnam has had around 4–6 storms from May to November, mainly in coastal provinces. Vietnam had 18 storms in 1964, 12 storms in 1973, 12 storms in 1978, and 10 storms in 1989 (MONRE 2003; Ngu 2008. A clear shift in the storm season in Vietnam has also been noted. The peak month in 1950 was August, while in both 1960 and 1970, it was September. It shifted to October in 1980 and even to November in 1990 and the first decade of the twenty-first century. There has therefore been a clear delay trend in the storm season during the latter half of the twentieth century and the first half of the twenty-first century, which should be investigated in the future (Ngu 2008; Viet 2000). See Table 15.7 for more information.

The Impact of Climate Change and Sea Level Rise on Agriculture

The Impact of Climate Change

In order to study the impacts of climate change on food crop yields (rice, maize, groundnut, and soybean) in different agro-economic regions, an analysis of data series of food crop yields in different crop seasons was undertaken, to calculate differences in food crop yield and differences in climate elements between this year and the previous year, from 1960 to 2006.

In order to calculate food crop yields before harvest time the following equation was used:

$$Yt + 1 = Yt + \Delta Y$$

Where: Yt + 1 is calculated yield this year

Yt is crop yield in the previous year

ΔY is difference food crop yield

The equation was used for calculating the rice crop yield in Table 15.8, the maize yield in Table 15.9, the groundnut yield in Table 15.10, and the soybean yield in Table 15.11.

Table 15.8 Equations for calculating the differences in rice yield (ΔY) (Viet 2008)

Region	Winter–spring crop	Coefficient
Red River Delta	$\Delta Y = 0.714 - 2.422\Delta T_{III} + 0.024\Delta R_{II} + 0.020\Delta S_{XI}$	$R = 0.686$
North Midland	$\Delta Y = 0.451 - 1.156\Delta T_{III} + 0.095\Delta R_{II} + 0.041\Delta S_{IV}$	$R = 0.708$
Northwest	$\Delta Y = 1.049 + 0.437\Delta TX_{II} + 0.013\Delta R_{III} - 0.007\Delta S_{III}$	$R = 0.569$
South Central	$\Delta Y = 1.030 - 0.826\Delta T_{XI} + 0.018\Delta R_{II} + 0.011\Delta S_{I}$	$R = 0.404$
Mekong River Delta	$\Delta Y = 0.708 + 1.095\Delta T_{II} + 0.296\Delta R_{II} - 0.042\Delta S_{XII}$	$R = 0.471$
	Summer crop	
Red River Delta	$\Delta Y = 0.159 + 3.406\Delta T_{VII} - 0.002\Delta R_{VII} + 0.002\Delta S_{V}$	$R = 0.644$
North Midland	$\Delta Y = 0.397 - 2.034\Delta T_{VIII} - 0.010\Delta R_{X} + 0.008\Delta S_{VII}$	$R = 0.607$
Northwest	$\Delta Y = 0.065 + 2.021\Delta T_{VII} - 0.001\Delta R_{VI} - 0.004\Delta S_{VIII}$	$R = 0.587$
South Central	$\Delta Y = 0.221 + 2.144\Delta T_{X} - 0.020\Delta R_{V} - 0.023\Delta S_{VII}$	$R = 0.843$
Mekong River Delta	$\Delta Y = 0.851 - 0.613\Delta T_{VII} + 0.011\Delta R_{VII} - 0.106\Delta S_{VI}$	$R = 0.655$

Table 15.9 Equations for calculating the differences in maize yield (ΔY) (Viet 2008)

Regions	Equations	Coefficient
Northwest	$\Delta Y = -0.363\ \Delta T_5 - 0.010\ \Delta S_{10} - 0.014\Delta\ R_1 + 0.284$	$R = 0.56$
Red River Delta	$\Delta Y = -1.110\Delta T_4 + 0.036\Delta S_4 + 0.009\Delta R_3 + 0.664$	$R = 0.65$
Northeast	$\Delta Y = -0.067\Delta T_7 - 0.012\Delta S_7 - 0.007\Delta R_6 + 0.943$	$R = 0.72$
North Central	$\Delta Y = -0.688\Delta T_8 - 0.008\Delta S_5 + 0.024\Delta R_2 + 0.867$	$R = 0.49$
South Central	$\Delta Y = -5.555\Delta T_6 - 0.054\Delta S_2 + 0.030\Delta R_8 + 2.066$	$R = 0.62$
Central Plateau	$\Delta Y = 0.175\Delta T_{12} + 0.045\Delta S_1 + 0.004\Delta R_7 + 1.008$	$R = 0.60$
Mekong River Delta	$\Delta Y = 2.592\Delta T_4 - 0.157\Delta S_9 - 0.342\Delta R_2 + 2.335$	$R = 0.71$

Table 15.10 Equations for calculating the differences in groundnut yield (ΔY) (Viet 2008)

Regions	Equations	Coefficient
Northwest	$\Delta Y = -0.165\Delta T_9 + 0.006\Delta S_2 - 0.001\Delta R_7 + 0.100$	$R = 0.61$
Red River Delta	$\Delta Y = 0.767\Delta T_{10} - 0.021\Delta S_2 - 0.043\Delta R_{12} + 0.790$	$R = 0.79$
Northeast	$\Delta Y = -0.277\Delta T_8 - 0.010\Delta S_4 + 0.009\Delta R_3 + 0.409$	$R = 0.54$
North Central	$\Delta Y = -0.025\Delta T_3 + 0.027\Delta S_1 + 0.016\Delta R_4 + 0.324$	$R = 0.68$
South Central	$\Delta Y = -2.220\Delta T_8 - 0.010\Delta S_7 - 0.035\Delta R_7 + 1.119$	$R = 0.62$
Central Plateau	$\Delta Y = -0.002\Delta T_{11} + 0.017\Delta S_{11} - 0.002\Delta R_1 1 + 0.349$	$R = 0.56$
Mekong River Delta	$\Delta Y = 1.375\Delta T_7 - 0.008\Delta S_{11} + 0.004\Delta R_{11} + 0.367$	$R = 0.63$

Table 15.11 Equations for calculating the differences in soybean yield (ΔY) (Viet 2008)

Regions	Equations	Coefficient
Northwest	$\Delta Y = -0.177\Delta T_{10} + 0.001\Delta S_8 - 0.002\Delta R_3 + 0.256$	$R = 0.46$
Red River Delta	$\Delta Y = -0.416\Delta T_{12} + 0.018\Delta S_6 + 0.004\Delta R_9 + 0.720$	$R = 0.58$
Northeast	$\Delta Y = 0.437\Delta T_6 + 0.013\Delta S_5 - 0.00016\Delta R_9 + 0.458$	$R = 0.59$
North Central	$\Delta Y = 1.047\Delta T_8 + 0.018\Delta S_4 - 0.002\Delta R_7 + 0.454$	$R = 0.74$
Central Plateau	$\Delta Y = -0.857\Delta T_9 - 0.010\Delta S_9 + 0.008\Delta R_9 + 0.562$	$R = 0.76$
Mekong River Delta	$\Delta Y = -0.270\Delta T_5 - 0.029\Delta S_1 + 0.002\Delta R_{11} + 0.608$	$R = 0.76$

The Impact of Sea Level Rise

As is well-known, Vietnam has 3,000 small islands with an area of 1,636 km^2 and two big islands called Hoang Sa and Truong Sa. The waters of Vietnam are 12 sea miles longer than the basic sea line. The offshore bench (including seabed and entrails of the earth) spreads over an area of 1 million km^2. The sea plays a very important role in socio-economic development (transport, oil and mineral exploitation, tide energy, coastal ecosystems, tourism, people's health). Transgressing sea is an inevitable way of seeking and developing materials, energy, and space for future life. Climate change is harmful to that transgression process due to the impact of sea level rise. As mentioned above, the Red river delta and Mekong delta will be submerged by a large area. In a scenario of a sea level rise of 1 m, 10% of people will be directly affected, leading to a 10% loss of GDP. In another scenario of a 3 m rise in sea level, 25% of people will be directly affected, and the loss of GDP will reach 25% (MONRE 2003, 2008; Ngu 2008).

The problem of salinity intrusion (SI) should be considered as troublesome as droughts and floods. It causes losses to crops, affecting agriculture production fields that use freshwater. A wide variation in climate conditions boosts SI and has the following consequences:

SI reduces the amount of freshwater, therefore droughts become harder in the dry season. As the next link in the chain, droughts lead to a reduction in agricultural productivity and threaten national food security. The regions where people depend on freshwater from underground and surface water will be in difficulty when freshwater is lacking.

In the rainy season, a long inundation period spreads pesticides, manure, pushes waste disposal from households and farms into the lakes, ponds, and rivers, and causes pollution. The water supply constructions are damaged by the salt in the water and cannot function properly.

Red River Delta

In 1983 (before the regulation of Hoa Binh reservoir) the salt level of 4% came up to the outlets of the Day, Ninh Co, Ba Lat rivers by 20–25 km, and Lach Tray and Bach Dang rivers by 30 km. After the regulation of Hoa Binh reservoir, the salt boundary was pushed back to 5–10 km inland. When a series of reservoirs had been built (Tuyen Quang, Son La, Huoi Quang, Ban Chat), the salt boundary was driven back towards the sea by 5–7 km in the Red river system, and 2–5 km in the Thai Binh river system. The driven back distance could not be reduced further towards the sea because of the need for freshwater in the dry season (Ngoc et al. 2009; Ngu 2008; Viet 2006).

Mekong River Delta

Before, the coastal plain in the South could not improve agriculture because of SI. The farmers in this location usually had one crop a year in the rainy season and their lives were uncertain. They did not have enough freshwater to use in their daily lives and bought expensive freshwater tanks from other places. Before water-freshening projects were undertaken, the area affected by SI was 2.5 million ha. In the Vam Co Tay river, SI penetrated to Moc Hoa by 110 km from the sea. At Tieu and Dai gate in the Tien river, SI came to My Tho by 50–60 km from the sea. SI encroached 45–50 km from the sea in to the Ham Luong, Co Chien and Hau rivers. In the peninsula of Ca Mau, over 1 million ha had absolute salinity in the dry season. Towards Rach Gia and Ha Tien, SI was transmitted through the canal system and came in to the Giang Thanh River by 30 km. After the implementation of a major development programme against SI, it is reported that SI had affected 1.78 million ha in the entire delta. In 1998, under the extra impact of El Nino, the area affected by SI was a record 2.43 million ha (Ngoc et al. 2009).

If the authorities and related organizations do not provide a solution to improve the situation, SI will continue to damage life, especially when the need for water rises in the dry season. As a matter of fact, the actions to deal with SI will not be easy because the local meteorological and hydrological regime and ecological conditions are complicated (Viet 2000, 2009).

Central Coastal Provinces

The salt boundary often crosses from the plain to the mountainous areas in the dry season. In recent years, the unplanned outbreaks of shrimp hatching compound SI by exhausting, salinizing and contaminating the freshwater. Moreover, both domestic and international research has concluded that climate change has great impacts on coastal zones. The rising sea level makes physical and bio-chemical conditions in the coastal areas get worse. In addition, higher temperature accelerates the accumulation of organic minerals and affects the food chain while also reducing species of fish. The variations in temperature along the seabed also has an impact on the ecological environment: the ecological population will change in structure, components, and additional reserves. Fish are threatened, gradually disappearing or migrating to another sea.

The mangrove forests, sea grass and coral reefs are also going to be affected by sea level rise. These plant populations are used as main food sources for aquarium species. They are also the home of many aquatic organisms such as fish and shrimp for breeding and hiding from offshore enemies. If they cannot survive, the lives of the aquatic organisms will be threatened. So will those of the people who depend on the aquatic organisms.

The destruction of mangrove forests brings about a number of changes in the area's ecological environment. Without vegetation cover, the land is divided into small parts and becomes shrimp hatches; crop fields and the canal system, which are rapidly degraded by erosion, flush away pollution and SI. As a result, shrimp are reported to have died in large numbers in coastal areas.

Obviously, SI is harmful to such traditional agricultural ecosystems as rice, river fish, fruit, and edible trees. In the meantime, the action plans do not meet up to the standards required. The authorities and local people are in confused about what to do to complete the irrigation system, rotate crops and shrimp hatching, prevent SI, and reduce alum in the land and water.

In a case study of shrimp hatching in the Mekong River Delta, it was found that breeding shrimp in mangrove forests seriously damages the quality and sustainable development of integrated coastal zone management. The profit that shrimp hatching could bring is not small, but damage to the environment is inevitable. The waste from the hatching procedure is especially deleterious and puts a burden on the environment.

Adaptation Strategies for the Agricultural Sector

For Agriculture

- To develop crop patterns suitable for climate change
- To effectively use irrigation water
- To upgrade irrigation systems for agriculture
- To develop new varieties that can withstand severe environmental conditions
- To store local crop varieties to establish a crop seed bank
- To develop farming techniques appropriate to climate change
- To build reservoirs with a total additional capacity of 15–20 billion m^3 for containing flood water to mitigate losses caused by floods and regulate water during low flow season. High priority should be given to the East of South Vietnam, the Central highlands and the mountainous regions of North Vietnam
- To upgrade and raise the scale of the drainage system
- To upgrade existing sea and river-mouth dykes and gradually build new sea dykes
- More importantly, to actively limit the population growth rate and organize new resettlement areas to avoid the effects of sea level rise (especially in coastal areas)
- To reclaim areas, especially in the hilly midland regions in the north of Vietnam, for agricultural production
- It is necessary to use water scientifically and effectively with special attention paid to increasing run-off during the low flow season, regulated by reservoirs

- To exploit while protecting water resources
- To conduct studies in long-term water resources prediction; seasonal, inter-annual predictions of water sources for planning rational and safe use of surface water resources
- To use irrigation water effectively and enhance irrigation systems for agriculture

For Forestry

- Enhancing afforestation, firstly in watershed, re-greening, protecting and developing mangrove forest are the most essential
- Then protecting natural forest and preventing forest fire
- Establishing seed banks of natural forest trees in order to protect some valuable varieties as well
- Lastly, selecting and developing plant varieties suitable to natural conditions taking into account climate change

For Water Resources

- To upgrade and raise the level of the drainage system
- To actively limit the population growth rate and redistribute residential areas to avoid the effects of sea level rise (especially in coastal areas)
- To cooperate in whole basin activities for efficient water use with special attention paid to increasing run-off during the low flow season, regulated by reservoirs upstream
- To conduct studies in long-term water resources prediction; seasonal, inter-annual predictions of water sources for planning rational and safe use of surface water sources
- To implement the “Living with Floods” strategy

For Aquaculture

- To import and develop valuable aquaculture varieties that could adapt to high temperatures, such as sump prawn, green clawed crayfish, lobster, white bass, black bass, etc., and increase the depth of fish lakes and ponds to create a suitable temperature and mitigate losses caused by increased evaporation
- To change farming structure in some wet areas from a rice monoculture to a fish-rice rotation system
- To take into account sea level rise and temperature increase when building infrastructure, quays, ports, warehouses, etc.
- To build storm shelter port systems along the coast, as well as close to islands
- To establish natural ecological reserves, especially coral reefs and atolls

Major investments have already been committed to upgrading national and provincial dyke systems. For example, a US$750 million dyke system for HCMC has been approved and a similar system is being planned for Hanoi. The Ministry of Agriculture and Rural Development (MARD) is carrying out a national plan worth US$109 million to restore mangroves along Vietnam's coastline. Site-specific plans are also being funded. The government recently approved a plan for the port city of Hai Phong to grow 2,800 ha of mangroves to mitigate the effects of rising sea levels (MONRE 2003; Ngu 2008).

Other adaptation activities are being implemented as part of the Second National Strategy and Action Plan for Disaster Mitigation and Management in Vietnam 2001–2020 and the Strategy on Flood Management and Mitigation. The National Strategy stresses the notion of *living with floods*. This includes various mandatory requirements for flood safety and security in residential areas. A programme to raise house foundations and make them more flood-secure has been ongoing for some time already. Low-level dyke systems already control saltwater intrusion and early flooding, and water management in the Mekong Delta, focusing on irrigation water supply and prevention of saline water intrusion. This already enables two rice crops per year in most parts, a winter–spring and a summer–autumn crop. Following the 2000 floods, the government issued guidelines for the early planting and harvesting of the summer–autumn crop, and promoted the use of short duration varieties. Farmers in flood-prone areas were also warned not to attempt a third crop, which would mean that the risk of flood damage would be very high (Ngu 2008).

Some Responses to the Impacts of Climate Change on Future Agriculture

In response to climate change simulations and scenarios in the Vietnam Initial National Communication submitted to the United Nations Framework Convention on Climate Change in 2003, the length of period with air temperature lower than 20°C would decrease by 10–20 days by 2010, 20–30 days by 2050, and 30–50 days by 2070. In contrast, the length of period with air temperature of 25°C would increase by 10–15 days by 2010, 15–45 days by 2050, and 30–50 days by 2070. This shows the difference in period length with average temperature lower than 20°C and higher than 25°C in 2010, 2050, and 2070 in comparison with the present day in various ecological areas. Similarly, the annual sum of temperature would increase by 110–180°C by 2010, 400–660°C by 2050, and 550–910°C by 2070. In the mountain and midland areas of North Vietnam and the Central Highlands, the sum of temperature would increase much more than in other areas. Meanwhile, absolute minimum temperature would also increase with the same rate of average temperature.

Thus, the adaptation time for tropical crops would be extended, while for subtropical crops, it would decrease (MONRE 2003; Viet 2002, 2006). The planting boundary of tropical trees and crops would move towards the high mountainous region and northwards. On the other hand, the adaptation area of subtropical plants would become narrower. By the 2070s, the mountainous tropical trees would be able to grow at an altitude 100–550 m higher and 100–200 km further north than at present. Due to abnormal changes in rainfall intensity, floods and droughts would occur more frequently. Significant cultivation areas in the Mekong and Red River Deltas would be under saltwater due to the rise in sea level.

Response to Climate Change by 2050

Mountain and Midland (Region I)

The growing period will be long and suitable for rice; the low temperature for rice will decrease gradually. Rice and other crops will influenced by rainfall conditions more than temperature conditions. Therefore, the most important factor for agricultural production is water management. Cultivation of medicinal crops and subtropical crops day by day will decrease and migrate to the highest mountains. In contrast, the quantity of tropical crops will develop (due to the increase in absolute minimum temperature).

Red River Delta (Region II)

The role of temperature is minor compared to rainfall. First, because of the gradually decreasing low temperature days, the spring crop will come earlier, and the spring and summer crop will be the major crops and be extended. Second, due to the change in the rainy season, drought frequency in summer and flood frequency in autumn will increase. Finally, evaporation in the water balance equation will increase, meaning that the problem of water management will be more important. Some of the original crops will die off gradually at high latitudes (the winter vegetable crop having its origin in temperate and subtropical regions) and will be replaced by other typical tropical crops.

Coastal Northern Centre (Region III)

Extreme temperature will make winter–spring crops gradually decrease. Moreover, the effects of drought on winter rice will continue. In addition, the effects of storms and heavy rainfall on sprouting summer rice will be greater than at present. The frequency of dry and hot wind will increase in some areas. In this region, the problem of water management is essential.

Coastal Southern Centre (Region IV)

The impacts of climate on agriculture will not show signs of change. Only in the southeast region will drought frequency increase, making the water management plan necessary.

Central Highlands (Region V)

Production of coffee, rubber, cocoa, and other typical tropical industrial crops will not be limited by low temperatures. The drought and dry season will be more severe so water management is the major problem.

Northeast South and Mekong River Delta (Region VI, VII)

Agricultural production is not expected to change. But drought frequency will increase and have bad effects on agricultural production.

Response to Climate Change After 2050

Research shows that after 2050 some of the agro-meteorological and agro-climatological conditions will see large changes as a result of climate change. Vietnamese climatic regions will gradually move towards the equator, and the duration of the cold season will decrease by 30–50 days. In contrast, the duration of the hot season will increase by more than 30–60 days. In addition, the growing season (rainfall is more than half of evaporation and transpiration) will be shorter. Drought and flood frequencies will increase. Therefore, sea level rise is a worrying and significant problem in Vietnam.

The impact of climate change scenarios on different regions is presented as follows:

Mountain and Midland (Region I)

The plan of agricultural production will be changed in principle. Subtropical and medicine crops would be replaced by tropical crops. The cultivation crop must be rearranged to adapt with the climate. Meanwhile, more attention must be paid to the problem of water management. The price of agricultural products will also increase.

Red River Delta (Region II)

The natural flood regions will not exceed 443,000 ha and the flood regions of rice production will not exceed 25% of the area. Of course, the area of cultivation will be smaller, in particular in coastal provinces. The plan of cultivation with other crops will not change. The role of other cereals will become more important. The impacts of flood and drought will be increasingly severe. Crop rotations must be considered. Low temperature days will decrease and the role of spring rice will become increasingly important. Finally, more attention must be paid to the problem of water management and the control of coastal dykes.

Coastal Centre (Region III, IV)

The natural flood regions will decrease and the area of rice production will increase. The rivers and streams must be developed to ensure water for agricultural production and aquaculture. The plan of cultivation with different crops must be rearranged. Some of the tropical industrial crops such as rubber and coffee will gradually move to the mountains and midland area. The crops will be essentially changed. Crop rotations of rice must be redefined for high and sustainable yields. After that, spring rice will not be affected by extreme temperatures. The water for it must be carefully regulated and prevented from floods and drought for summer–autumn and summer rice. Storms will be stronger and more severe, and so have a greater effect on the region's socio-economic structure. There needs to be an interest from finance in supporting agricultural production in the region.

Central Highlands (Region V)

The tropical industrial crops will not be affected by temperature at high altitude levels. But drought will develop and the price of agricultural production will increase. Floods will increase and the area of rice production will decrease.

Northeast South and Mekong River Delta (Region VI, VII)

The area of rice production will increase because of the increase in salt marsh. Drought frequency will increase. The price of food and cereals will significantly increase. All the agricultural regions will lead to failure because of climate change. However, the failure will be concentrated in the most important socio-economic regions: Red River Delta, coastal centre and Mekong River Delta. The impact of climate change will affect the cultivated regions in particular because of the sea level rise, making lowland salty, so it may cause degradation of natural resources. The research into crop modelling in many different countries has given the result that crops will decrease at low latitudes. Measures for adaptation must therefore be: first, to develop an agricultural production plan appropriate for the climate; second, to rearrange crop rotations in the country as a whole and in individual regions; thirdly, to develop water management and irrigation. Finally, research must be made into suitable measures for mitigating the impact of climate change and selecting suitable technologies for each of the regions.

Conclusion

Climate change in Vietnam is a part of global climate change. If it occurs, it will definitely affect agriculture; there, the climate change elements in the various agro-ecological regions are different. In general, temperature is increasing, sunshine duration is decreasing, typhoons are moving southwards, while the change in rainfall is not clear for every region. Meanwhile, the effect of climate change on agriculture is not the same in each of the agro-ecological regions of Vietnam. A strategic goal to minimize the impacts of salinity intrusion caused by climate change will need to be decided on by the authorities and people. The establishment of inter-organizations to implement the National Target Programme is also necessary, so that the programme will be effective in localities. More sea dykes in coastal areas, in particular, will have to be built. Sustainable development in agriculture and strategy adaptation to cope with climate change will have to be implemented, including changing the cropping calendar, cropping pattern, cropping rotation in all the agro-ecological regions, and selecting adapted varieties for all the agro-ecological regions and for every crop season.

References

Dasgupta et al (2007) The impact of sea level rise on developing countries: a comparative analysis. World Bank Policy Research Working Paper No.4136. http://ssrn.com/abstract=962790

Ministry of Natural Resources and Environment (2008) National target program to respond to climate change. Decision No. 158/QD-ttg dated 2 Dec 2008, p 30

Ministry of Natural Resources and Environment (MONRE) (2003) Vietnam initial national communication. Submitted to the United Nations Framework Convention on Climate Change. MONRE, Vietnam, p 138

Ngoc TTB, Van TT, Thai TH (2009) Impact of climate change on salinity intrusion in Vietnam. In: Proceedings of IMHEN 2nd Youth Scientific Conference, April 2009, pp 195–198

Ngu ND (2008) Climate change. Scientific and Technological house press, USA, p 390

Viet NV (1998) Climate disaster and changing cropping pattern in central coastal region of Vietnam. Scientific report. Institute of Meteorology and Hydrology, Vietnam, p 198

Viet NV (2000) Impact of ENSO on climate and agriculture in Vietnam. Scientific report. Institute of Meteorology and Hydrology, Vietnam, p 175

Viet NV (2002) Climate change impact on agriculture in Vietnam and some adaptation measures. Sci J Meteorol Hydrol 10:1–10

Viet NV (2006) Climate change and adaptation strategies for sustainable development on agriculture in Vietnam. The reports from the National Environment Conference, 6–10 Oct 2005

Viet NV (2008) The impacts of climate change and disasters on food crop yields and some measures to cope with them for food security and sustainable development on agriculture in Vietnam. In: International Symposium on Geo-Informatics for SIDEAS, Hanoi, 4–6 Dec 2008

Viet NV (2009) Agro-climate resources of Vietnam. Hanoi Agricultural Publishing House, Hanoi, p 406

Chapter 16
Climate Change and Economic Uncertainty in the Wine Sector: A Case Study of the Maule Region, Chile

Monica Hadarits

Abstract Climate change poses challenges for many economic and societal sectors, particularly the wine sector. The wine sector is of particular importance to many economies, especially in the context of Chile, where it has contributed significantly to the country's economic development, as in 2005, wine accounted for 10% of exports. This paper assesses the vulnerability of the wine sector to climate change in the context of other stresses via a case study of the Maule Region, Chile. The research used a vulnerability approach, which is based on the empirical documentation of exposures, adaptive strategies and adaptive capacity. Problematic climatic exposures, including spring frosts, wet falls and drought, were identified and placed in the context of other forces important to producers, including market price, currency fluctuations, national and international rules and regulations, and labour availability. Producers' experiences with climate have not warranted the development of an extensive suite of adaptation strategies to manage climate risks. The results indicate that the current strategies may not be effective in the future because they are not suited to anticipated changes in water availability and the temperature regime. Although future climate change may be beneficial and create opportunities, many of the producer-identified climatic exposures are projected to be exacerbated in the future, and the current management systems may not have the capacity to address climate variations beyond the currently experienced regime. This has considerable implications for the sector's viability and economic profitability. With this in mind, large producers have greater access to capital than their smaller counterparts, placing them in a better position to take advantage of opportunities and successfully manage risk.

Keywords Adaptation · Agriculture · Chile · Climate change · Grapes · Vulnerability · Wine

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Introduction

Climate change and variability are projected to significantly alter the world's agricultural landscape (Smit et al. 2000; IPCC 2007, 2001; Easterling et al. 2007; Wilbanks et al. 2007). The wine sector is of particular interest in the context of climate change and agriculture because of its fine sensitivity to climate, its high site specificity, and the longer timeframe of decisions associated with perennial crops such as wine grapes (Jones et al. 2005; White et al. 2006; IPCC 2007). Climate, manifested as weather, significantly influences the success of the wine sector (Gladstone 1992); baseline climate determines the varieties that can be cultivated in a region as well as wine style, and climate variability accounts for year-to-year differences in wine yields and quality (Jones and Hellman 2003; Jones 2005; Battaglini et al. 2009). Climate change scenarios project an increase in average, maximum and minimum temperatures, a decrease in precipitation, and an increase in the magnitude and frequency of extreme events (e.g. greater variability in precipitation), all of which have implications for wine style, yield, quality and commodity prices (IPCC 2007; Jones et al. 2005). These projections, coupled with producer observations, have stimulated a growing body of scholarship seeking to understand the impacts of climate change on the wine sector (Jones et al. 2005; White et al. 2006; Hall and Jones 2009).

The grape and wine industry constitutes a major economic sector in many countries, and the effects of climate change are already being reported in France, South Africa, Australia, Chile, and many others (AFP 2004; AP 2006; Kakaviatos 2006; Berger 2007). Chile's wine sector contributes greatly to the national economy, and it has experienced substantial growth over the past two decades, with production and exports increasing by 63% from 1984 to 2000 (Benavente 2006). In 2005, wine constituted over 10% of Chile's exports, valued at US$883 million (Benavente 2006). The importance of climatic conditions for quality wine production and the implications of climate change for the wine sector, combined with the fact that the wine sector is such an important player in Chile's economy, underline the need to better understand how climate change will affect the industry, and how the industry might respond (Jones 2005; Battaglini et al. 2009).

The majority of studies seeking to understand the impacts of climate change on agriculture have employed a top-down, scenario-based approach (Rosenzweig 1985; Smit et al. 1989; Smit and Skinner 2002). This approach begins by generating a climate change scenario and modelling the interactions between future climate conditions, mainly average temperature and precipitation, and various selected attributes of agriculture, mainly yields and quality (Feenstra et al. 1998; Jones et al. 2005). The role of human agency in managing risk and taking advantage of opportunity is not developed in these types of assessments (Parry et al. 1998; Smit and Skinner 2002). Although climate impact assessments provide insights into the seriousness of climate change, a number of assumptions are made, including the relative importance of various climatic attributes to producers and the actions they might take in response to changing conditions.

The emerging vulnerability assessment field builds on these climate change impact assessments by identifying the conditions that are relevant to producers and documenting producers' responses to these conditions, thereby highlighting the role of farm-level decision-making in the adaptation process (Brklacich et al. 1997; Chiotti et al. 1997; Smit et al. 1997, 1999; Smit and Skinner 2002; Wall et al. 2004; Reid et al. 2007). The vulnerability approach is distinct from climate impact assessments because it requires researchers to gain insights from the affected system itself as to the variables or factors that are important for decision-making; that is, these variables are not assumed a priori. It also recognizes that there are numerous forces influencing a system (i.e. climate is not experienced in isolation of other forces), and that an improved understanding as to how these forces manifest to create multiple risks and opportunities is needed to fully know the vulnerability of a system. The approach acknowledges that these forces are context-specific and dynamic in nature and may change over space and time and according to climatic and economic as well as political, social, and environmental circumstances. Vulnerability assessments have been successful in understanding the multitude of forces that influence decision-making and in discovering the role of human agency in the adaptation process (Belliveau et al. 2006; Tschakert 2007; Kelkar et al. 2008; Toni and Holanda 2009).

The purpose of this paper is to assess the vulnerability of the wine sector to climate change via a case study in the Maule Region of Chile. More specifically, it documents the forces to which the sector is sensitive and the adaptive strategies it employs in response to these forces, and uses this as a basis for assessing how the industry will fair under a changing climate. This paper begins with a synthesis of the concept of vulnerability and the analytical framework adopted in this study, followed by a description of the study area and methods. The findings are then discussed according to the components of the analytical framework – current and future exposure-sensitivity, adaptive strategies and adaptive capacity.

Vulnerability Approach: Conceptual Model of Vulnerability

The term "vulnerability" has taken on a variety of meanings due to its widespread applicability, although definitions typically refer to the potential for loss or harm (Vogel et al. 2007; Cutter 1996; Füssel 2007). The notion of vulnerability has been widely applied in the climate change scholarship (IPCC 2007). It is commonly conceptualized as a function of the exposure and sensitivity of a system to a stressor and the adaptive capacity of the system to manage or cope with the stressor (Fig. 16.1) (Smit and Pilifosova 2003). As a system's exposure and sensitivity increase, its vulnerability also increases, and as its adaptive capacity increases, its vulnerability decreases (Smit and Pilifosova 2003).

Exposure and sensitivity are inherent properties of a system and refer to the interaction of the characteristics of both the system and a stimulus. They reflect the manner in which a system experiences conditions to which it is sensitive

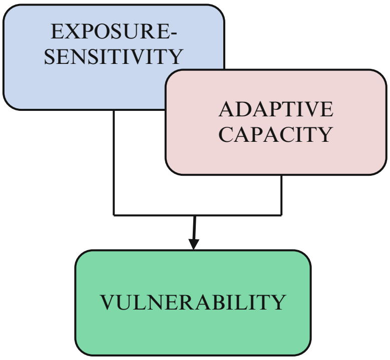

Fig. 16.1 Conceptual model of vulnerability used in the climate change literature

(Smit and Wandel 2006). In the climate change and agriculture scholarship, many view exposures as the susceptibility of a system to conditions that pose risks or present opportunities (Belliveau et al. 2006; Wall et al. 2007).

Adaptive capacity refers to a system's ability to adjust to or manage exposures to which it is sensitive (Wheaton and McIver 1999; Smit and Pilifisova 2002; Yohe and Tol 2002). It is socially constructed, as adjustments to climate change are dependent on both the availability of resources and the degree to which individuals or groups are entitled to their use (Adger and Kelly 1999; Adger 2003). A number of determinants of adaptive capacity that stem from social vulnerability discourse have been identified in the literature, including economic wealth, technology, information, the availability and distribution of resources, social and human capital, institutional structures, and risk perception (Adger and Kelly 1999; Smit and Pilifosova 2003). These determinants vary from system to system as a result of differing contexts and circumstances. The way in which a system adapts, or the adaptive strategies it employs to manage exposures, and the effectiveness of these strategies, are reflective of a system's adaptive capacity. Systems with highly effective adaptive strategies tend to have a high adaptive capacity.

Adaptation is a complex process that does not occur in isolation (Koch et al. 2007). It can be influenced by the spatial and temporal properties of an event; the rapidity of their onset; their magnitude; and the economic, political, social, and institutional circumstances in which the stimuli are experienced (Smithers and Smit 1997; Nelson et al. 2007). Exposure-sensitivity and adaptive capacity within this framework are not mutually exclusive (McLeman and Smit 2006). That is, exposures can, for example, prompt adaptations that modify or create new exposures and/or serve to enhance or reduce adaptive capacity.

The vulnerability model is a useful conceptual framework that identifies broad categories of forces, which involve interactions between human and biophysical systems, and which combine to influence the susceptibility of sectors to the impacts of climate change. It also offers a holistic, bottom-up approach to understanding the nature of a system's vulnerability (Luers et al. 2003; Ford and Smit 2004; Adger 2006; Füssel 2007).

Analytical Framework

Vulnerability assessments have been successful in discovering the role of human agency in the adaptation process and understanding the climatic and non-climatic forces that are both relevant to the system and play an important role in decision making (Adger and Kelly 1999; Tschakert 2007). They have been particularly useful in understanding the vulnerability of agricultural sectors to climate change (Belliveau et al. 2006; Reid et al. 2007; Wall et al. 2007; Tschakert 2007; Kelkar et al. 2008).

The vulnerability approach is based on the empirical documentation of exposure-sensitivities, adaptive strategies and adaptive capacity. It begins by gaining insights from the system itself regarding the climatic and non-climatic conditions that are important to it and how it responds, based on the logic that the system can best articulate these factors (Smit and Wandel 2006; Tschakert 2007). Conditions are not assumed a priori. The system for the purposes of this research is the wine sector, using a case study in the Maule Region, Chile.

In order to understand how future climate change might affect the wine sector, it is necessary to understand the conditions that have affected the sector in the past and how it has managed with them. An illustration of this approach is shown in Fig. 16.2. The assessment of current vulnerability requires the identification of both past and current climatic and non-climatic conditions that have been problematic or beneficial to the wine sector, along with the documentation of management strategies used to help deal with them. It also requires an understanding of the factors facilitating or constraining the adaptation process. Future vulnerability is assessed in light of current vulnerability and is accomplished by estimating future exposures to changing conditions via probabilities in changes in the identified current exposures, by identifying new future exposures, and by assessing producers' ability to cope with or accommodate these conditions.

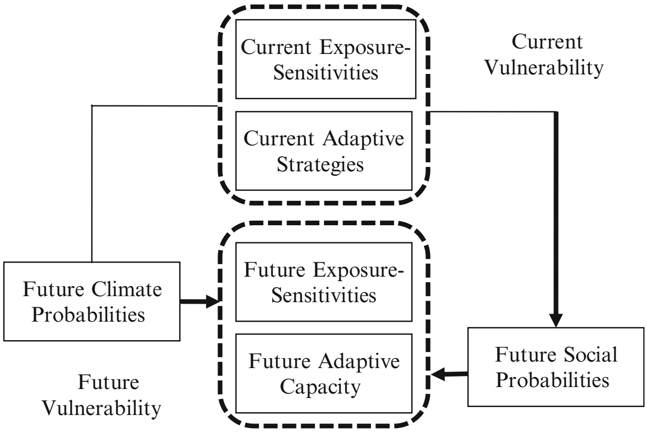

Fig. 16.2 Analytical framework for vulnerability assessment. Adapted from Ford and Smit (2004)

Case Study: Maule Region

The Maule Region (Fig. 16.3) is located in central Chile, and its expansive 30,000 km^2 land base is devoted to silvoagricultural production, primarily cellulose, tender fruit, and grapes for wine. Maule is considered the heart of grape and wine production in Chile. It is the region with the most hectares of planted vineyards in all of Chile and accounts for approximately 50% of Chile's wine production and exports (Vinos de Chile 2010, 2008). The Maule, Lontué, and Teno rivers are major water sources that supply irrigation water via canals to agricultural producers (Díaz 2007). The success this industry enjoys stems from favourable environmental conditions as well as favourable adjustments to recent economic and political changes, such as the agrarian reform, market and competitive advantages, aggressive foreign investment, and the adoption of neoliberal economic policies, among others. As a result of agricultural restructuring policies, many agriculturalists have moved away from traditional crops (e.g. wheat, maize, sugarbeet, potato, and beans) towards non-traditional crops (e.g. tender fruit and wine grapes) (SAG 2006). Traditional *Vitis vinifera* grape varieties such as País that were well-suited to the climate, vigorous, and easy to maintain have been widely replaced with more market-popular *Vitis vinifera* varieties such as Cabernet Sauvignon and Carménère; while these new varieties are more climate-sensitive and require irrigation, they benefit from higher demand and prices (del Pozo 1998; Muñoz et al. 2008).

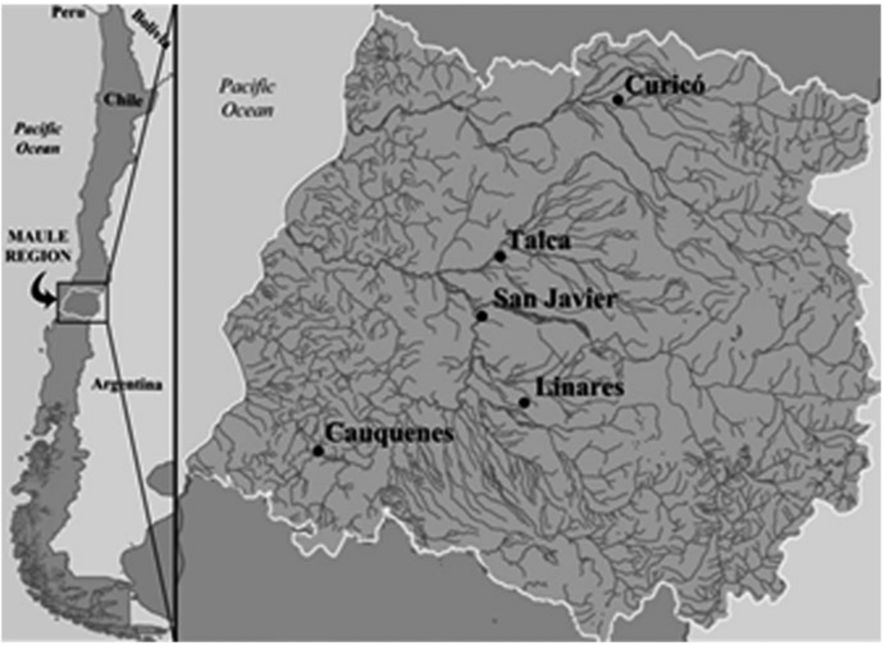

Fig. 16.3 Map of Chile and the Maule region

The full range of wine grape varieties cultivated in Chile can be found in the Maule Region. The conditions conducive to wine grape production occur in the central portion of the region, where the climate is considered Mediterranean and characterized by heavy winter rains and a dry period in spring and summer (Vinos de Chile 2010, 2008). The coastal mountains and Pacific Ocean to the west and the Andes Mountains to the east moderate the temperature and permit the cultivation of several different grape varieties at different elevations (Lobos 2006). The dry period facilitates excellent grape maturation, and since excessive rainfall during the fall harvest is uncommon, grape quality remains rather consistent. The sharp contrast that exists between maximum and minimum daily temperature assists grape cultivars in developing colour, aroma, and gradual maturation (Vinos de Chile 2010, 2008). Climate graphs for the two major cities in the Maule Region, Curicó and Talca, are illustrated in Figs. 16.4 and 16.5.

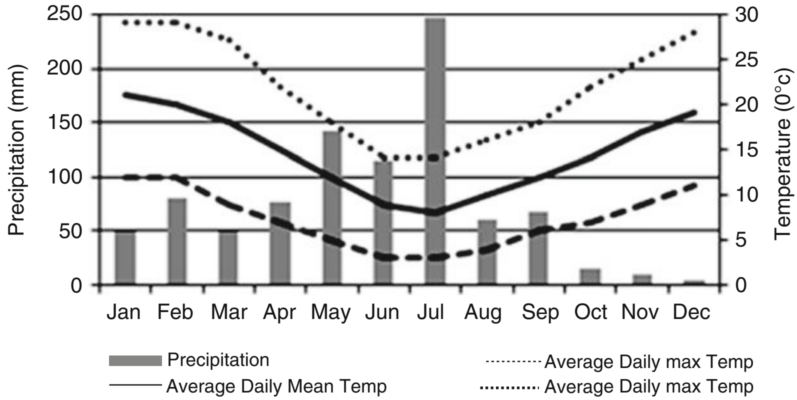

Fig. 16.4 Average precipitation and temperature for Curicó
Data sources: CustomWeather (2008); The Weather Channel (2008)

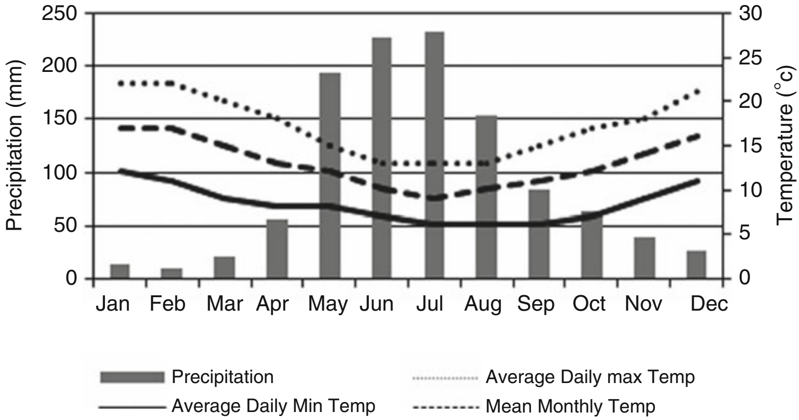

Fig. 16.5 Average precipitation and temperature for Talca
Data sources: CustomWeather (2008); The Weather Channel (2008)

Vineyards closer to the Andes tend to experience a cooler climate and great diurnal temperature fluctuations, preferred conditions for white grapes, whereas the higher temperatures towards the Pacific coast are preferred for reds (Vinos de Chile 2010, 2008).

Methods

Forty-six in-depth semi-structured interviews were conducted with grape growers and wine makers in the Maule Region between April and August 2008 to identify the forces creating risks and opportunities for their operations, the management strategies used to manage these forces, and the factors influencing their ability to manage risk and opportunity. The interviews were conducted in the language most comfortable for the interviewee (Spanish or English) by a bilingual interviewer. The majority of the interviews took place in the vineyard, winery, or homes of interviewees. Interviewees were first asked to identify the conditions that made years above average for their operations, and then the conditions that made years below average. This approach was used as a basis for recording conditions which were favourable and unfavourable, and these conditions were used to develop the exposure-sensitivities that will be discussed in this paper. The data collected in the interviews was complemented by direct observations in the field and secondary sources, including publications, documents, government and historical records, climatological data, and any other pertinent material that related to risks, opportunities, and adaptation. Future climate probabilities were obtained from Chile's Environment Commission and future vulnerability was assessed in light of current vulnerability.

Results

Exposure-Sensitivities

Interviewees revealed that weather, economic, and production forces create opportunities, while weather, economic, production, social, and institutional forces create risks. All the forces identified as creating either opportunities or risks influence financial returns and profitability. These forces do not act in isolation; they are highly interactive and complex. Figure 16.6 illustrates some of the main interactions among the exposures experienced by producers in Maule. Climate and weather exposure-sensitivities, including high growing season temperatures, droughts, wet springs, wet falls, spring frosts, dry harvests, and dry and warm springs, have implications for grape and wine yields and quality, and subsequently income, as most grape growers are paid according to volume harvested, and wine

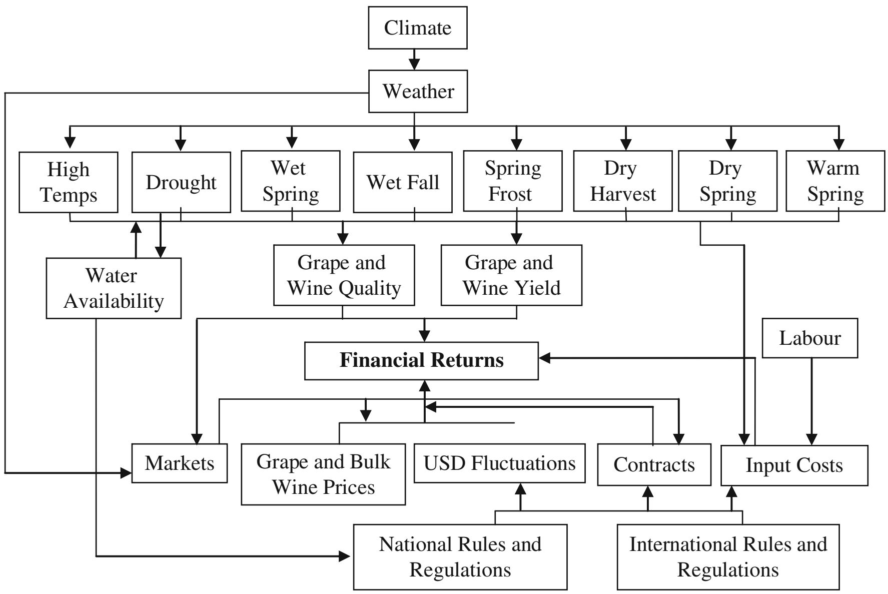

Fig. 16.6 Relationships among exposures creating risks and opportunities in the Maule wine sector

makers according to quality. Markets, commodity prices and currency fluctuations, contracts, input costs and access to labour contribute greatly to income generation and are important to producers. National and international rules and regulations also affect the profitability of producers' operations.

Current Opportunities and Adaptive Strategies

Favourable growing season conditions create opportunities for producers in Maule. A dry autumn and a warm and dry spring are advantageous for producers (Fig. 16.6). A dry autumn allows vineyards to reach preferred maturity without botrytis disruptions, and a warm, dry spring facilitates even flowering and eliminates the potential for frost damage. These climatic conditions tend to facilitate high grape yields and quality. Growers are paid by the kilogram, and high yielding years provide them with the opportunity to generate more income, leading to greater financial security. Similarly, high yielding years create financial opportunities for wine makers because they have more wine to produce, market and sell. High quality grapes and wine typically warrant higher prices in the marketplace, creating yet another income-generating opportunity.

Producers modify their operations to take advantage of the opportunities created by these climatic conditions. All actions they utilize are short-term strategies that are effective over one growing season. Producers seek to maximize financial returns by undertaking strategies that seek to increase yields or quality. In order to achieve high yields in the face of weather variations, growers adjust their irrigation schedules and, so long as water is available, irrigate more than normal; plenty of irrigation during the growing season was noted as facilitating higher yields at harvest. There is a trade-off however – very high yielding vines typically produce low quality grapes. Pruning and thinning techniques are employed to facilitate the preferred ripening of grapes and increase quality, while fungicide and pesticide are applied to prevent unwanted pests and disease that can damage crops, reduce yield, and compromise quality.

High prices create opportunities for producers to increase their profits (Fig. 16.6). Producers often cannot maximize their financial returns when prices are high because they were commonly identified as being accompanied by low yields. Selling grapes rather than processing them into wine when grape prices are high, and processing grapes into wine when bulk wine prices are high are two short-term adaptive strategies used to take advantage of high prices. Wine makers also sell any excess wine stock they have in their inventory. A few longer-term adaptive strategies employed include putting money aside in savings to offset years when prices are low, and expansion through the acquisition of more land to plant vineyards, with the motivation of encompassing new terroirs and microclimates to produce new varieties. Producers also replace less marketable varieties with more marketable varieties and upgrade equipment.

Current Risks and Adaptive Strategies

Producers are particularly sensitive to weather-related conditions because they reduce farm profitability (Fig. 16.6). High temperatures during grape maturation can result in sunburnt and dehydrated grapes, especially if it is too late, or too costly, to carry out vineyard management strategies such as leaf thinning to accommodate these high temperatures. Grape quality is compromised in this situation and yields reduced. Drought during maturation is problematic because grapes cannot develop their juices and therefore weigh much less than grapes that have not experienced water stress, and since growers are paid according to harvested weight, profits decrease. Excessive rain during bloom hampers fruit set, resulting in uneven grape development (Jackson and Schuster 2007), which creates challenges during harvest because grapes in the same vineyard are at different stages of phenological development. Spring rains can also facilitate the development of powdery mildew, a fungus that impedes and may even prevent fruit set and can severely damage crops. Excessive rain during maturation and harvest is extremely disadvantageous as it facilitates the onset of botrytis, a problematic fungal disease that effectively rots grapes and compromises yields and quality (Jackson and Schuster 2007). Frost events in spring during bud burst and early shoot growth create risk because buds and primary shoots are damaged and may be killed if frosts are severe or last for a long period of the night, causing the less fruitful secondary shoots to grow (Jackson and Schuster 2007). Yield and quality are reduced in this case and ripening delayed.

The weather events described above create risks for producers in Maule because they affect grape yields and quality, which subsequently reduce farm income, putting farmers' livelihoods in jeopardy. Producers have developed both short-term and long-term strategies to try to reduce the effects these weather risks have on their operations. These strategies involve vineyard, winery, business, and financial management techniques. When temperatures are high, producers reduce leaf thinning in order to shelter vines from sun exposure and reduce the risk of sunburn and dehydration. During droughts, producers adjust their irrigation schedules and ration water; so long as water is available, producers irrigate more often to avoid water stress. If excessive rainfall is experienced in spring, producers often harvest the same vineyard twice or three times to ensure grapes are harvested when preferred maturation is reached, otherwise, the entire vineyard – at various stages of phenological development – is harvested at once, causing a decrease in quality. Once the threat of botrytis becomes reality, producers harvest their crop as quickly as possible. This, however, requires harvesting prior to preferred maturation, which influences wine style and quality. In order to maintain quality, grapes infected with botrytis are removed before processing. Growers also spray fungicide in an attempt to stop the spread of fungal spores and further infection, while wine makers reduce the amount of maceration prior to fermentation and add the juice of a variety with intense colour, *Tintorero*, to red wines to compensate for colour lost to botrytis. A longer-term strategy less frequently used involves grafting or replanting varieties. To reduce exposure to spring frost, for example, producers graft late budding varieties onto early budding varieties' rootstocks. Grafting is preferred over replanting as it is more cost effective – grafted plants produce fruit much quicker than seedlings.

Low grape and bulk wine prices, and particularly the large fluctuations in prices (Figs. 16.7 and 16.8), create financial stress for producers because they reduce

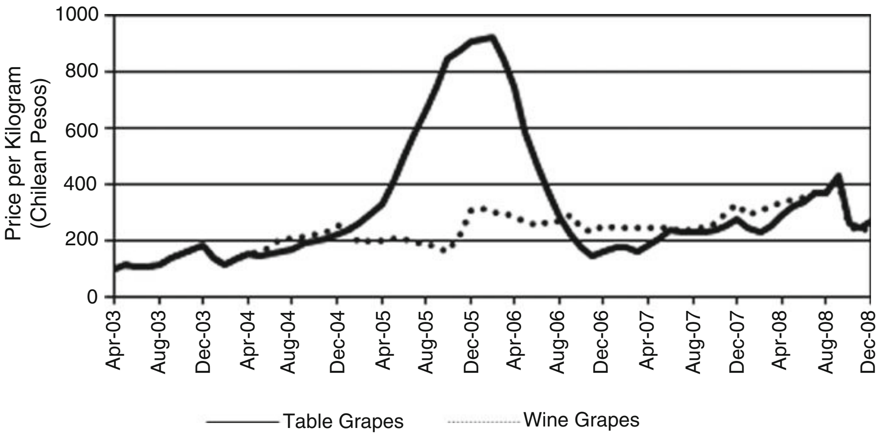

Fig. 16.7 Average wine and table grape prices from April 2003 to December 2008
Data source: ODEPA (2009)

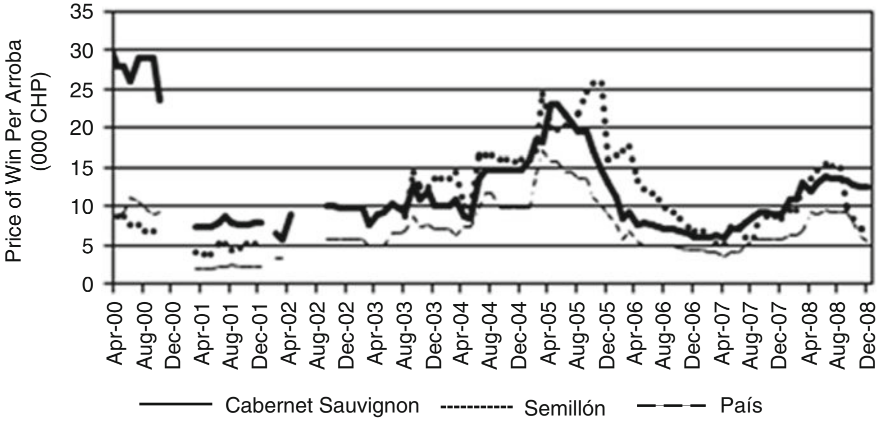

Fig 16.8 Average bulk wine prices from Apr 2000 to Dec 2008. Note: 1 arroba = 40 l
Data source: ODEPA (2009)

Fig. 16.9 Exchange rate from United States dollars to Chilean pesos, 2000 to 2008
Data source: Bank of Canada (2009)

profitability and make financial planning and decision-making challenging and highly uncertain (Fig. 16.6). One grower stated that he did not harvest his grapes one year in the recent past because input costs exceeded prices. Prices are nearly impossible to predict as they are influenced by a variety of factors, including the exchange rate relative to the United States dollar (USD), production, markets, and wineries' inventory. The highly variable USD creates uncertainty in Maule's wine sector (Fig. 16.9). Fluctuations in the USD have implications for various aspects of the sector. Bulk wine, for example, is sold on the international market in USD, and a low exchange rate translates into reduced financial returns. High input costs also reduce profitability (Fig. 16.6); fertilizer and human labour costs have increased substantially over the past decade. Figure 16.10 shows the drastic increase in

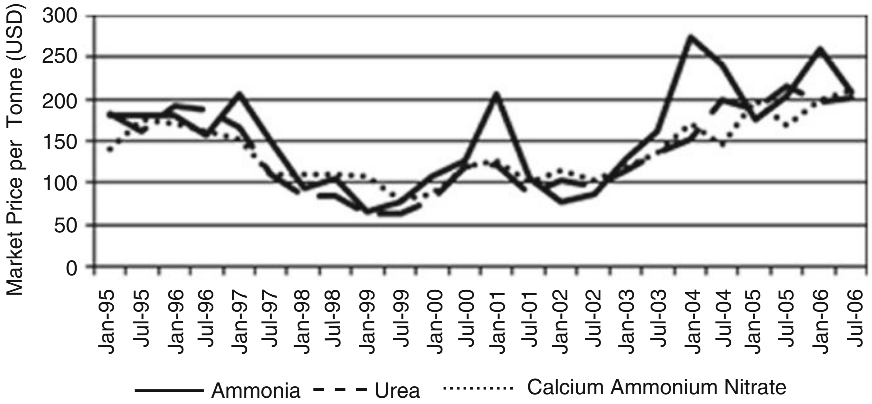

Fig. 16.10 Market prices for three commonly used fertilizers from Jan 1995 to July 2006
Data source: Yara (2009)

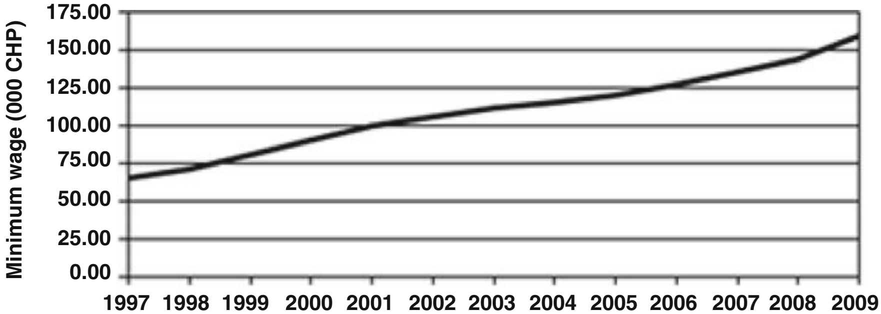

Fig. 16.11 Minimum wage in Chile from 1997 to 2009
Data source: BCC (2009)

fertilizer prices from 2000 to 2006. Similarly, minimum wage – the average price paid to labourers – has almost tripled since 1997 (Fig. 16.11). Rises in input costs and minimum wage have negatively affected profitability because income has not increased proportionately.

Reducing input costs is a common short-term adaptive strategy used to combat low prices, a low USD and rising input costs. Where possible, producers reduce the amount of chemical applied or the amount of hired labour by reducing the amount of work done in the vineyard or by doing it themselves. Those with access to wine-making facilities opt to process grapes and sell wine when grape prices are low, and when wine prices are low, they either sell their grapes or store their wine until prices go up. Others enter contracts to secure prices prior to harvest.

Producers enter contracts to reduce the risks associated with low prices. Contracts secure prices and ensure a buyer at harvest. Contracts are also problematic because they typically involve handing over control of the vineyard to the contractor (Fig. 16.6). The contractor assumes control of all decisions made in the vineyard. Many contracts are often not honoured at the end of the growing season because the decisions made during the growing season compromised quality, the vineyard work did not satisfy the terms of the contract, or because the contractor does not have the funds to pay for the grapes come harvest. This leaves growers scrambling to find buyers at the busiest time of the growing season. On the other hand, one benefit of entering a contract is that contractors often provide professional technical assistants to growers, a very helpful and useful tool for some.

National and international rules and regulations create financial burdens for producers (Fig. 16.6). Many countries have stringent importing guidelines and require certain affirmations relating to quality and the way in which a product was produced. These typically require growers and producers to register for environmental certification programmes, which often necessitate financial investment. They also require meticulous documentation of day-to-day operations, a daunting task for many of the growers who are illiterate and are not accustomed to this way of doing business. Chilean labour laws have become more demanding in the recent past with respect to working conditions, including access to restrooms, chemical application and worker transportation. There is little financial support from the government to undertake these changes, or ideas as to how to implement them. Many believe the laws are excessive and nearly impossible to carry out, both practically and financially. Adaptive responses to these rules and regulation are limited as producers fear losing buyers or having their operations shut down.

Labour during harvest is become increasingly scarce in the Maule Region. A shortage of labour when grapes are mature and need to be harvested is extremely problematic because yield and quality may be compromised, which negatively affects income. Growers have begun hiring labour from neighbouring towns that require transportation at the grower's expense, when in the past labour was hired in the same town in which the vineyard is located and transportation was the worker's responsibility. More young people are moving to the cities, leaving fewer and fewer labourers in the countryside, and as a consequence, fruit producers in Maule find themselves competing for labour. Because there is growing competition for labour, labourers are demanding higher compensation. In response, producers have invested in technology to reduce reliance on human labour as they foresee major problems in the future regarding labour availability. Automated harvesters and pre-pruners are becoming more prevalent in Maule. However, operations cannot rely solely on automatic harvesters because many delicate varieties require manual harvesting, otherwise growers run the risk of oxidization which reduces quality.

Future Exposure-Sensitivities

Climate change is expected to generate significant risks and opportunities for the Chilean wine sector (CONAMA 2006). Climate change scenarios generated by

Table 16.1 Summary of climate change scenarios generated by CONAMA (2006). "+" indicates an increasing trend; "−" indicates a decreasing trend

	Temperature (°C)			Precipitation (%)	Frequency of warm days (>25°C) (%)	Frequency of cold days (<0°C) (%)
	Avg.	Max.	Min.			
Summer	+ 2–5	+ 3–5	+ 2–4	− 25–70	+ 150–300	− 0–20
Autumn	+ 2–4	+ 2–4	+ 1–3	− 50–90	+ 100–300	− 20–50
Winter	+ 1–3	+ 1–4	+ 1–3	− 50–90	+ 100–300	− 20–50
Spring	+ 2–4	+ 2–5	+ 1–3	− 25–70	+ 100–300	− 10–50

Chile's National Environment Commission were derived using the HadCM3 with SRES A2 and B2 emissions scenarios used by the IPCC for 2071–2100. SRES A2 represents a scenario with a moderate reduction in greenhouse gases, while SRES B2 represents a scenario with aggressive reductions. The PRECIS regional climate model (RCM) was embedded within the HadCM3 run to dynamically downscale the GCM model output. Climate change projections for the Maule Region can be found in Table 16.1. The model projects an increase of between 1°C and more than 5°C in average temperatures over the next century. The most pronounced change is to be experienced in spring and summer. This may be beneficial for some grape varieties planted in Maule, but also problematic in that there may be a greater incidence of sunburn and dehydration, causing further reductions in yields, quality and income. Water supplies could diminish as a result of high temperatures and increased evaporation, and the number of pest outbreaks could also increase (IPCC 2007). Conversely, the cultivation of new varieties may be facilitated by warmer temperatures, perhaps creating a market advantage.

Future average maximum and minimum temperatures are projected to increase by 2–5°C and 1–3°C, respectively. The most pronounced change again is in spring and summer. Producers may benefit from an extended growing season resulting from increasing temperatures. The number of warm days (>25°C) are projected to increase by 150–300% during the grape growing season, supporting the notion that sunburn and dehydration may be a more likely occurrence in the future.

Seasonal precipitation is projected to decrease in the Maule Region by 25–90% in the next 100 years, with the most pronounced decrease in precipitation expected in autumn and winter at 50–90%. Decreases in autumn precipitation are beneficial for producers, as they may allow grapes to reach preferred maturity with a reduced risk of botrytis outbreaks, contributing to future increases in grape and wine quality and securing producer income. Decreases in winter precipitation could be extremely problematic. The region relies on winter precipitation to recharge water resources. Less winter precipitation may result in reduced river flows and irrigation water shortages, and reduced yields, quality, and income. Conflicts over water use may also arise.

The frequency of spring frosts is projected to decrease, particularly in the spring, when cold temperatures have the potential to damage crops. Fewer incidences of spring frost serves to benefit the wine sector in Maule, as crops will be less susceptible to cold snaps in spring.

A few producers are already making investments which are driven, at least in part, by climate change. Growers are planting vineyards in higher elevations to try a new climate, encompass new terroirs and reduce some of the risks anticipated for Maule under climate change. Wine production and areas are expanding to the south of Maule, as many believe these areas have the potential to produce quality wine given the projected changes in climate. The industry's ability to respond under a changing climate will be an important determinant in its success or failure. The following section delves into the factors influencing producers' ability to adapt under changing climatic conditions and estimates the utility of current adaptive strategies under future climate change.

Future Adaptive Capacity

Adaptations reflect a system's adaptive capacity, which in this case refers to the ability of grape growers and wine makers in Maule to manage changing climatic exposure-sensitivities. The adaptive capacity of the wine sector in Maule is constrained by institutional arrangements, market forces, organizational ability, and education.

The Chilean government both facilitates and constrains adaptation. The government offers training programmes to certify wine quality and land-use practices in order to meet certain environmental standards; however, producers found that the more programmes they are enrolled in, the more intensely they are monitored. They find the guidelines too strict and the punishments for not abiding too harsh. The government also offers irrigation project subsidies, which increase water use efficiency and are necessary given the estimated declines in water supplies. The problem is that these subsidies are not accessible to all growers, particularly small ones whose water use is relatively low compared to larger growers. Many have applied for an irrigation subsidy more than once and have been unsuccessful. The government also offers subsidies to wineries who are travelling abroad to promote their wines, but most small- and medium-sized wineries cannot take advantage of them because the government funds just a small portion of the trips, and the winery does not have the financial capital to fund the remainder. These measures implemented at the national level are meant to facilitate adaptation but actually hinder the ability of producers to adapt to climate change.

Labour laws not only represent an exposure but also a factor constraining adaptation. These laws require heavy financial investment. Funds that producers would devote to improving their operations are tied up, reducing the amount of capital available to spend on other aspects of the operation and impeding producers' ability to respond to climate-related risks and opportunities.

Large wineries in Chile have a monopoly over the wine sector in Maule. These large wineries are powerful in that they control the market for grapes and wine by setting prices. Most wineries wait for the large wineries to reveal their prices and then set theirs accordingly; there is no competition. This power structure leaves producers with no alternatives for obtaining better prices and hinders their ability to manage their operations because their fate is ultimately determined by these wineries. Low prices are already problematic and small producers fear they will not be viable in the future if this situation continues, leaving them with relatively few options but to sell their operations to larger producers.

Contracts are a common response to market fluctuations but they also facilitate and constrain adaptation, depending on the nature of the contract. Growers essentially lose control of their vineyard when they enter contracts and are limited in the adaptive strategies they can employ in response to climate risks and opportunities. On the other hand, contracts can increase adaptive capacity via the technical expertise that is often provided when a grower is contracted.

Agricultural producers in Chile have an extremely difficult time organizing. This may be attributed to a variety of factors, including the violent restriction of social organization during the military coup, mistrust among producers, and producers' individualistic attitudes. Producers realize the advantages of organizing but are unable to effectively unite to exploit opportunities. For example, many small growers are, or at one time were, members of a cooperative. Cooperatives create opportunities for growers to process their grapes and produce a value added product for which they can demand a higher price. Producers also feel they have a more powerful voice in the sector if they act in a unified manner. Unfortunately, cooperatives in Maule have had little to no success. If there were greater coordination among producers, more opportunities could be realized. Wine tourism, for example, could be further developed and producer-groups established to facilitate better responses to future changes.

Producers believe climate change will bring positive changes for the region and the sector, which highlights the general lack of awareness of what future climate change might mean for the wine sector in Maule. Producers, for example, did not consider that water resources, particularly for irrigation, could ever change. They recognize that water supplies fluctuate but assert that the Andes Mountains have ample water reserves and will always provide water. There was little concern as to future changes in climate-related conditions. Producers' positive perceptions of future climate change may explain, in part, why they employ just a small number of anticipatory adaptations. The reactionary nature of adaptations puts the sector at risk because they are not considering or preparing for any potentially hazardous changes.

Maule has a low literacy rate. Producers who are illiterate are in a disadvantageous position because the information they can access and use to make informed decisions regarding their operations and climate change is significantly lower than those who are literate. Their illiteracy does not cater to the way business is done in the wine sector, and vice versa. Producers are unable to understand the terms and conditions of contracts, for example, and people take advantage of that. They are also unable to apply for programmes that may be relevant to their operations and help them cope with future change and uncertainty.

Conclusion

Climate change poses significant challenges and opportunities for the wine sector worldwide. The sector is of immense economic importance in many areas, many of which have already begun to experience changes in their climate regime (e.g. rising temperatures and greater variability). Through the application of the vulnerability approach to a case study in the Maule Region, Chile, this research identified the risks and opportunities that most influence grape growers and wine makers and the strategies they have developed to manage these. It also assessed how effective these strategies will be under a changing climate. The study found that the wine sector is facing a multitude of risks and opportunities stemming from a variety of forces operating at several scales, and producers manage these forces simultaneously. Producers' key sensitivity is income, which is highly affected by numerous climatic and non-climatic conditions that are complex and interactive. Economic profitability is the primary driver of decision-making. The strategies currently used to manage risks and opportunities are sufficient and focused on maintaining or increasing profitability. A changing climate is projected to benefit some varieties and exacerbate risks already problematic for producers. The suite of adaptive strategies from which producers draw may not be adequate in the future, as climate change may present risks beyond the sector's coping range. The forces constraining adaptation need to be addressed for effective adaptations to be undertaken and for the sector to be better prepared for the future, otherwise financial successes may be compromised. Large producers with access to capital and the information to make decisions are better equipped to manage future climate change. Although the sector is currently thriving, its viability and profitability is threatened by a changing climate.

References

Adger WN (2003) Social capital, collective action, and adaptation to climate change. Econ Geogr 79(4):387–404

Adger WN (2006) Vulnerability. Glob Environ Change 16(3):268–281

Adger WN, Kelly PM (1999) Social vulnerability to climate change and the architecture of entitlements. Mitigation Adaptation Strateg Glob Change 4(3–4):253–266

Agence France-Presse (AFP) (2004) Climate change affecting Italy's Chianti Wine. AFP, 23 Aug 2004. http://www.terradaily.com/2004/040823154413.qfio6b8z.html. Accessed 5 Nov 2008

Associated Press (AP) (2006) Warming seen wiping out Calif. wine industry: study says area for grapes could fall by up to 81 percent by 2100. AP, 11 July 2006. http://www.msnbc.msn.com/id/13803270/. Accessed 27 Jan 2008

Bank of Canada (2009) Rates and statistics: Exchange rates. http://www.bank-banque-canada.ca/en/rates/exchform.html. Accessed 24 Jan 2008

Battaglini A, Barbeau G, Bindi M, Badeck FW (2009) European winegrowers' perceptions of climate change impact and options for adaptation. Reg Environ Change 9(2):61–73

Belliveau S, Smit B, Bradshaw B (2006) Multiple exposures and dynamic vulnerability: evidence from the grape and wine industry in the Okanagan Valley, British Columbia, Canada. Glob Environ Change 16(4):364–378

Benavente JR (2006) Wine production in Chile. In: Chandra V (ed) Technology, adaptation, and exports. The World Bank, Washington DC, pp 225–242

Berger D (2007) As the climate changes so does our wine. Appelation America, 17 Dec 2007. http://wine.appellationamerica.com/wine-review/522/Global-Climate-Change.html. Accessed 27 Jan 2008

Brklacich M, McNabb D, Bryant C, Dumanski J (1997) Adaptability of agriculture systems to global climate change: a Renfrew County, Ontario, Canada pilot study. In: Ilbery B, Chiotti Q, Rickard T (eds) Agricultural restructuring and sustainability: a geographical perspective. CAB International, Wallingford, pp 185–200

Chiotti Q, Johnston TRR, Smit B, Ebel B (1997) Agricultural response to climate change: a preliminary investigation of farm-level adaptation in southern Alberta. In: Ilbery B, Chiotti Q, Rickard T (eds) Agricultural restructuring and sustainability: a geographical perspective. CAB International, Wallingford, pp 167–183

Comisión Nacional del Medio Ambiente (CONAMA) (2006) Estudio de la variabilidad climatic en Chile para el siglo XXI: Informe final, Departamento de Geofísica. Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Santiago

CustomWeather (2008) Almanac: historical information. Custom Weather. http://www.myforecast.com/bin/climate.m?city=54697&metric=true. Accessed 27 Mar 2008

Cutter SL (1996) Vulnerability to environmental hazards. Prog Hum Geogr 20(4):529–539

del Pozo J (1998) Historia del Vino Chileno. Editorial Universitaria, Santiago

Díaz JO (2007) Family farm agriculture: factors limiting its competitively and policy suggestions. In: OECD review of agricultural policies. University of Talca, Talca

Easterling WE, Aggarwal PK, Batima P, Brander KM, Erda L, Howden SM, Kirilenko A, Morton J, Soussana J-F, Schmidhuber J, Tubiello FN (2007) Food, fibre and forest products. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge

Feenstra J, Burton I, Smith J, Tol R (1998) Handbook on methods for climate change impact assessment and adaptation strategies. Institute of Environmental Studies, Amsterdam

Ford J, Smit B (2004) A framework for assessing the vulnerability of communities in the Canadian Arctic to risk associated with climate change. Arctic 57(4):389–400

Füssel H-M (2007) Vulnerability: a generally applicable conceptual framework for climate change research. Glob Environ Change 17(2):155–167

Gladstone J (1992) Viticulture and environment. Winetitles, Adelaide

Hall A, Jones GV (2009) Effect of potential atmospheric warming on temperature-based indices describing Australian winegrape growing conditions. Aust J Grape Wine Res 15:97–119

Intergovernmental Panel on Climate Change (2001) Summary for policy makers. Climate change 2001: impacts, adaptations and vulnerability. IPCC, Geneva

Intergovernmental Panel on Climate Change (2007) Climate change 2007: Synthesis report. Cambridge University Press, Cambridge

Jackson D, Schuster D (2007) The production of grapes and wine in cool climates. Dunmore, Wellington

Jones G (2005) Climate change in the western United States grape growing regions. International Society for Horticultural Science: VII International Symposium on Grapevine Physiology and Biotechnology, Davis, June 2004, Acta Horticulturae 689

Jones G, Hellman EW (2003) Site assessment. In: Hellman EW (ed) Oregon viticulture. Oregon State University Press, Corvallis

Jones GV, White MA, Cooper OR, Storchmann K (2005) Climate change and global wine quality. Clim Change 73(3):319–343

Kakaviatos P (2006) Climate change forcing migration: Torres. Decanter, 1 June 2006. http://www.decanter.com/news/85946.html. Accessed 3 Nov 2008
Kelkar U, Narula KK, Sharma VD, Chandna U (2008) Vulnerability and adaptation to climate variability and water stress in Uttarakhand State, India. Glob Environ Change 18(4):564–574
Koch IC, Vogel C, Patel Z (2007) Institutional dynamics and climate change adaptation in South Africa. Mitigation Adaptation Strateg Glob Change 12(8):1323–1339
Luers A, Lobell D, Sklar L, Addams C, Matson P (2003) A method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico. Glob Environ Change 13 (4):255–267
McLeman R, Smit B (2006) Migration as an adaptation to climate change. Clim Change 76 (1–2):31–53
Muñoz L, Romero H, Vásquez A (2008) La vitivinicultura moderna en Chile: Caracterización de su evolución reciente y dificultades para el desarrollo local. Universidad de Chile, Santiago
Nelson DR, Adger WN, Brown K (2007) Adaptation to environmental change: contributions of a resilience framework. Annu Rev Environ Resour 32:395–419
Oficina de Estudios y Politicas Agrarias (ODEPA). (2009), Estadísticas y precios/Series de precios. http://www.odepa.gob.cl/odepaweb/jsp/precios/precios.jsp;jsessionid=9705E86B09094A8903314D4E06704A14. Accessed 22 Mar 2009
Parry M, Arnell N, Hulme M, Nicholls R, Livermore M (1998) Adapting to the inevitable. Nature 396:741–742
Reid S, Smit B, Caldwell W, Belliveau S (2007) Vulnerability and adaptation to climate risks in Ontario agriculture. Mitigation Adaptation Strateg Glob Change 12(4):609–637
Rosenzweig C (1985) Potential CO^2-induced climatic effects on North American wheat producing regions. Clim Change 7(4):367–389
Servicio Agrícola y Ganadero (SAG) (2006) Catastro vitícola nacional. División Protección Agrícola – SAG/Subdepartamento Viñas y Vinos, Santiago
Smit B, Pilifisova O (2002) From adaptation to adaptive capacity and vulnerability reduction. In: Huq S, Smith J, Klein R (eds) Enhancing the capacity of developing countries to adapt to climate change. Imperial College Press, London, pp 1–18
Smit B, Pilifosova O (2003) From adaptation to adaptive capacity and vulnerability reduction. In: Smith JB, Klein RJT, Huq S (eds) Climate change, adaptive capacity and development. Imperial College Press, London
Smit B, Skinner MW (2002) Adaptation options in agriculture to climate change: a typology. Mitigation Adaptation Strateg Glob Change 7(1):85–114
Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Change 16(3):282–292
Smit B, Brklacich M, Stewart RB, McBride R, Brown M, Bond D (1989) Sensitivity of crop yields and land resource potential to climatic change in Ontario. Clim Change 14(2):153–174
Smit B, Blain R, Keddie P (1997) Corn hybrid selection and climatic variability: gambling with nature? Can Geogr 41(4):429–438
Smit B, Burton I, Klein RJT, Street R (1999) The science of adaptation: a framework for assessment. Mitigation Adaptation Strateg Glob Change 4(3–4):199–213
Smit B, Burton I, Klein RJT, Wandel J (2000) An anatomy of adaptation to climate change and variability. Clim Change 45(1):223–251
Smithers J, Smit B (1997) Human adaptation to climatic variability and change. Glob Environ Change 7(2):129–146
The Weather Channel (2008) Average weather for Talca, Chile. The Weather Channel. http://www.weather.com/outlook/travel/businesstraveler/wxclimatology/monthly/graph/CIXX0021?cm_ven=USAToday&promo=0&site=www.usatoday.com&cm_ite=CityPage&par=usatoday&cm_pla=WxPage&cm_cat=www.usatoday.com. Accessed 27 Mar 2008
Toni F, Holanda E Jr (2009) The effects of land tenure on vulnerability to droughts in Northern Brazil. Glob Environ Change 18(4):575–582

Tschakert P (2007) Views from the vulnerable: understanding climate and other stresses in the Sahel. Glob Environ Change 17(3–4):381–396

Vinos de Chile 2010 (2008) Vinos de Chile 2010. http://www.vinosdechile2010.cl/indust/index3.htm. Accessed viewed 27 Mar 2008

Vogel C, Moser SC, Kasperson RE, Dabelko GD (2007) Linking vulnerability, adaptation, and resilience science to practice: pathways, players, and partnerships. Glob Environ Change 17 (3–4):349–364

Wall E, Smit B, Wandel J (2004) Canadian agri-food sector adaptation to risks and opportunities from climate change. Position paper on climate change, impacts and adaptation in Canadian agriculture, Canadian Climate Impacts and Adaptation Research Network (C-CIARN). University of Guelph, Guelph

Wall E, Smit B, Wandel J (eds) (2007) Farming in a changing climate: agricultural adaptation in Canada. UBC Press, Vancouver

Wheaton EE, McIver DC (1999) A framework and key questions for adapting to climate variability and change. Mitigation Adaptation Strateg Glob Change 4(3–4):215–225

White MA, Diffenbaugh NS, Jones GV, Pal JS, Giorgi R (2006) Extreme heat reduces and shifts United States premium wine production in the 21st century. Proc Natl Acad Sci 103: 11217–11222

Wilbanks TJ, Romero Lankao P, Bao M, Berkhout F, Cairncross S, Ceron J-P, Kapshe M, Muir-Wood R, Zapata-Marti R (2007) Industry, settlement and society. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge

Yohe G, Tol RSJ (2002) Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. Glob Environ Change 12(1):25–40

Chapter 17
Critical Parameters for Mass-Cargo Affine Industries Due to Climate Change in Germany: Impacts of Low Water Events on Industry and Possible Adaptation Measures

Anja Scholten, Benno Rothstein, and Roland Baumhauer

Abstract Most economic models ignore specific information at industry or company level concerning impacts of low water situations on logistic chains and production processes of mass-cargo affine industries. But particularly mass-cargo affine companies are affected by these events, especially regarding their security of supply and transport costs. In order to identify these effects, a survey was conducted. The first results of this survey and of a media analysis on this topic are presented in this publication. The survey included, e.g. the quantity of transported goods, preferred ship sizes, storage capacity, and the perception of sensitivities. Interviewed persons were people in key positions from affected industries (e.g. pharmaceutical and chemical industry, steel production, and hard coal power plants), inland navigation, ports, associations, and research.

Based on these interviews, a flow chart of consequences of low water situations on these companies was developed. The most important critical parameters are water level, bearing capacity of ships, transport expenses, storage capacity, and potentials for traffic relocation. These parameters will be illustrated by giving practical examples of one exemplary company.

It can be assumed that nearly all interviewed firms have already had difficulties in terms of transport because of extreme events (e.g. storms, heat waves, low or high water levels). They anticipate further climate change-induced difficulties. Therefore, the analysis of existing measures and adaptation options is essential to be prepared for possible future changes.

Keywords Climate change · Industry · Inland navigation · Vulnerability

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Introduction

Industries which rely on cheap mass transportation and cooling water often settled along waterways, such as the river Rhine. Examples of these are hard coal-fired power plants (transport of hard coal), chemical industries (transport of chemical base material), and the steel industry (transport of ore and hard coal).

Unfortunately, inland navigation strongly depends on weather and climate, as load capacity of vessels not only depends on the size of the ship, but also on draught (see also Rothstein et al. 2009). At low gauge especially, large vessels are restricted in their amount of transported goods. This is exceptionally difficult for logisticians of mass-cargo affine industries, as the request for transport from the industry does not change during periods of low water levels. In the worst cases, companies have had to stop their production because of a lack of transportation. Companies are left only with the choice of transferring goods to train or truck transport, which have very restricted free capacities, or to fall back on their (small) stocks. Although logisticians and experts on this topic are aware of the restrictions of inland navigation vessels due to low water levels, few publications on further details exist.

Because industries along the river Rhine depend on inland navigation as a cheap way of transport and because low water might appear more regularly due to climate change, it is essential to analyse the economic impact of low water. This is also true for methods used by companies to reduce the impact of low water levels on their production, as these might help to develop long-time adaptation methods to climate change. On the other hand, a thorough status-quo analysis might help to see deficiencies in currently available methods; for example, shifting goods to other carriers often fails because of limited capacities.

For this analysis, not only interviews with experts were performed, but a survey of companies and a media analysis were also carried out. The first results of these studies, which were undertaken within the framework of the research programme KLIWAS of the Federal Ministry of Transport, Building and Urban Affairs, are presented in this paper. Additional information about the research programme and (first) results can be found in BMVBS (2009).

Data and Methods

To analyse the impact of low water periods on example companies, a survey was carried out. First, all harbours handling more than 2,000,000 tonnes per year along the river Rhine were identified, based on data from Destatis, the German Federal Statistical Office. For each harbour the top three categories of goods were considered (see Appendix) and the companies that handle these goods were identified and contacted. Depending on location, between 60% and 100% of the handling of the harbour is represented by the selected goods. To estimate the explanatory power of the survey, the amount of transported goods of the companies that took part in the survey was compared to the amount of handled goods of the harbour.

Parallel to this, interviews were carried out with experts who in their daily business or research are confronted with the topic of low water, for example, inland sailors, harbour masters, logisticians, or scientists. These interviews were used to identify specific problems of inland navigation and economy with low water periods in preparation for the survey and to discuss first results of the survey and data analysis.

To gain additional information, a media analysis was performed on three examples of transport shortages. Here, the low water periods since 1998 were considered, as well as an inland navigation accident (25 Mar 2007), during which 32 containers were lost in the navigation channel and a strike by the major train unions occurred. During the container accident, the Rhine was blocked for 5 days near Cologne. This accident is a good example because it caused a relatively short but complete and sudden stop of inland navigation along the river Rhine. The train union strike did not have a direct influence on inland navigation but delivered a transport shortage similar to low water situations for many companies. Thus, the effects on companies and their adaptation measures could be analysed. Some of these measures might also be helpful during low water periods.

Results and Discussion

Besides the first results of the survey, the results of the media analysis are presented here. Additionally, a case study on the impact of low water on one exemplary company is presented.

Interim Results of the Survey

The examination of the survey was quantitative as well as qualitative, with a focus on the qualitative analysis. This is due to the relatively small return of questionnaires, which hindered a broad quantitative analysis. For the same reason, the results are not divided into Rhine sections or industries, although traces of differences exist. As the survey continues, a small upgrade of data bases may be anticipated.

The numbers of contacted companies and answers divided in Rhine sections and industries are presented in Table 17.1. In addition to the listed companies, 19 companies denied answers to the questionnaire, because of trade secrets or because they do not use inland navigation, for example. Some others denied without giving reasons.

A summary of the interim results is presented in Table 17.2.

For some industries and locations, about 100% of the handling of special goods in the harbour is covered by this survey. Here the explanatory power of the survey is

Table 17.1 Number of contacted companies and answers, divided into Rhine sections and industries

	Lower Rhine Contacted (Answered)	Middle Rhine Contacted (Answered)	Upper Rhine Contacted (Answered)
Energy industry	3 (0)	0 (0)	10 (2)
Chemical industry	32 (9)	3 (0)	31 (8)
Steel industry	45 (13)	4 (1)	8 (4)
Food industry	19 (5)	6 (1)	11 (2)
Refineries	13 (0)	3 (1)	7 (2)
Building materials industry	15 (3)	13 (1)	11 (2)
Semi-finished products	11 (2)	3 (1)	3 (1)
Total	138 (32)	32 (5)	81 (21)

very good. For other industries and/or locations only very little or, in the worst cases, no information, is available. Therefore, it is not possible to verify if the results of one location are transferable to others. The same is true for transfer between different industries.

For most companies, the river Rhine was an important location factor for settlement. But this was not only due to inland navigation, but also due to the availability of cooling and process water.

The storage capacity gives a first hint as to how vulnerable a company might be if transport shortages occur. How long a company might be able to produce without transport differs by company, industry, and location. Whilst companies in the energy industry often have bigger storage capacities of about a month or more, producers of semi-finished products prefer "just in time" transport and therefore have a storage capacity of only 1 or 2 days.

While interpreting these answers, it has to be taken into account that some companies specify the duration of production without transport based on their maximum storage capacity. But as the stock is seldom full (or empty in case of product stock) before low water events, the maximum storage capacity is rarely available during low water events. This kind of preparation, however, may be possible in the future due to enhanced prognoses of water levels.

The impact of transport shortage on inland navigation due to low water levels also depends on the regularity of transport. Companies with a daily transport demand are affected directly whilst companies with monthly ship transport might not be affected at all. Just-in-time transport also is affected very strongly. About one third of the answering companies demand daily transport, and 15% prefer just-in-time transport.

More than 50% of the questioned companies have three transport connections, 15% have four, and another 25% have just two. Theoretically, an increasing number of transport connections reduces the vulnerability of the company, as it increases the (theoretical) possibilities of shifting goods to other transport modes.

Most companies (about 60%) prefer ships with a bearing capacity of between 1,000 and 2,000 tonnes, followed by ship sizes of 2,000–3,000 tonnes, and those of over

Table 17.2 Summary of the interim results of the survey

Explanatory power of the survey:
About 100% covered: steel (3 locations), chemical industry (3 locations), energy (1 location)
At other locations and other industries nearly no information
River Rhine as a location factor:
True for over 70% of companies
Production without transport:
Varies strongly with industry and location
By trend bigger storage capacities for energy industry
By trend smaller storage capacities for semi-finished products and food industry
Shift of goods to other transport modes:
Measure named by most companies
Shift to additional ships
Shift to train or truck
Transport connections:
3 connections by about half of the companies
2 connections for about a quarter of the companies
4 connections for about 15% of the companies
Regularity of transport: (multiple answers possible!)
About a third of the companies have a transport demand on a daily basis,
About a third of the companies transport as required
Amount of goods per ship:
Varies strongly with industry and location
About 60% favour ship sizes of 1,000–2,000 t
Followed by sizes of 2,000–3,000 t and over 3,000 t
Choice of transport mode:
Especially important: price, infrastructure (of customer), reliability, amount of goods
Less important: environmental qualities, distance
Critical water levels:
Usage of local water levels
Limit values often identical to low water surcharge limits or equivalent water level
Companies at the Upper Rhine use Kaub as a reference
Experiences with extreme events:
About 70% of the companies have experienced extreme events
Mostly high and low water events
Prospects for the future:
Basis of information: media
About 70% expect increasing problems
Precautionary measures:
More than half of the companies have no precautionary arrangements
About 25% have precautionary arrangements
Others plan precautionary arrangements
Relocation:
More than half of the companies exclude relocation because of transport shortage
For less than half of the companies relocation is an adaptation option

3,000 tonnes. Whilst bigger ships offer an economic advantage, especially companies with less transport demand prefer smaller ship sizes, which match their needs.

Which water levels are acceptable for what period of time without resulting in transport shortages is undetectable. But many companies use local levels as references, which are also used in the calculation of low water freight surcharge or equivalent water level. Companies at the Upper Rhine, south of Kaub, often use the water level of this bottleneck as reference. Most companies have already experienced extreme events, mostly with low or high water levels.

A lot of company representatives still remember the impact of the heat period of 2003 or storms such as "Kyrill" in 2007. But not all extreme events are equally interesting for this study. For example, during storms, cranes have to stop and the setting and removal comes to a halt. Sometimes infrastructure is even damaged. Storm floods lead to closed sea harbours and hinder the importing and exporting. Some companies even report sunken coasters. But storms only last a few hours, whilst low water events might last several weeks or even months.

Most company representatives pay attention to information on climate change in the media. Therefore, most expect increasing problems with extreme events in the future. In particular, the heat waves and low water periods, such as those in 2003, are expected to occur more often.

Although most companies expect more difficulties with extreme events, only 25% already have precautionary arrangements and another 20% plan preventative arrangements, whilst the majority have no plans yet. Planned or existing arrangements are mostly flood control measures, enlargement of storage, or an altered mixture of transport modes.

Another possible adaptation option is relocation. More than half of the questioned companies exclude relocation as an adaptation option, mostly because the regional investment is too high and at least partially immobile. Nevertheless, about 40% think of relocation as a possible adaptation measure.

Media Analysis on Company Behaviour During Transport Shortages

As an addition to the survey and to verify its results, three media analyses were made. Recent events were chosen, which induced or could have induced transport shortages. As mentioned in the introduction, the low water events since 1998 were analysed, as was a container ship accident near Cologne in 2007 and a strike by a railway labour union in 2007.

The main focuses of this analysis were the impact on and reaction of companies due to transport shortages. In contrast to the survey, by means of the media analysis it was possible to also consider public awareness of the chosen events and the different modes of transport.

Impact of Low Water Events Since 1998

In total, 85 articles on low water events were analysed for the years 1998 to 2007 (2003 $\pm$ 4 years in comparison) (see Table 17.3). It is remarkable that in 2006, even more articles on low water levels could be found than in 2003, although the low

Table 17.3 General overview of the analysed articles on low water periods since 1998

	Number of articles
Total	85
Information on:	
Development of the low water event	35
Consequences for inland navigation	48
Consequences for industries	7
Consequences for harbours	7
Cost effectiveness of low water periods	17
Mentions of possible adaptation measures	12

water period in 2006 was shorter and less intense than that of 2003. Possibly this was due to an increasing awareness of low water levels as a result of the intense low water event in 2003 and its various impacts. More evidence of an increasing awareness of low water events after 2003 are the references to comparisons with this year in articles published later.

Table 17.4 gives a general overview of the results of this analysis. Most articles focus on the development of the low water events and water levels. Therefore, most articles focused on the local gauges near the headquarters of the paper they were published in. Often several gauges were presented, either different gauges in the area or the most important gauges for inland navigation.

Besides the characteristics of the low water event, most articles presented the associated consequences for inland navigation. Specifically, increased risk of accidents and the reduction of bearing capacity were considered.

Only 7 articles named consequences for industries, mostly regarding cooling water. The same number of articles reflected the consequences for harbours. This might be due to ignorance towards the connection between reduced bearing capacity of inland navigation and transport shortages for companies. As the survey showed, many companies are very strict about giving information on impacts of low water events on their production. This might be one reason for the lack of information in the articles. Cited companies, besides the harbours, are from the chemical, steel, or energy industry.

More articles (17) consider the cost effectiveness of low water periods due to increasing expenses for inland navigation. Most detailed information on this topic is found in newspapers from Switzerland. This might be due to the long distance from the sea harbours and the resulting relatively high costs of transport.

Especially in 2003 and 2006, possible adaptation measures were discussed. These included measures taken by companies, inland navigation, and harbours, as well as possible measures such as river engineering measures. Although these methods here are named as adaptation measures because they were measures taken by companies to adapt to the situation, this term was not used in any of the newspapers. The measures mentioned were the employment of additional vessels or lighters and shifting goods to other transport modes such as trucks or trains (WAZ 2003; DPA 2003a). An additional measure discussed was the discharge of

Table 17.4 Impacts of low water events on industry and (possible) adaptation measures

Consequences of low water levels:
Increased risk of accidents for inland navigation vessels, brought up by:
Difficulties with heavy current (Schulze 2003)
Small distances between ships (Mohr 2003), etc.
Due to heavy current, additional tugboads needed (Schulze 2003)
Reduced load capacity per vessel (losses of up to 75%) (dpa 1998; Koc 2003; Seidel 2003; WAZ 2006; dpa 2006)
Increasing transport costs (Neue Züricher Zeitung 2003)
Enhanced competition of inland navigation with train and truck transport (expenses for train transport lower than for ship transport between Düsseldorf and Karlsruhe) (Koc 2003; dpa 2003a)
Switching of ships to channels with constant water levels (Neue Züricher Zeitung 2003)
Decrease in handling in harbours and therefore losses of up to 35% (dpa 2004a, b)
Filled storage capacities (dpa 2003b)
Dry cooling water pumps
Adaptation measures of companies:
Usage of additional cooling water pumps (Eberhardt 2003)
Digging of channels to existing cooling water pumps (Eberhardt 2003)
Going without cooling water (dpa 2001)
Usage of additional ships and lighters (up to 33% additional ships at the Lower Rhine) (Seidel 2003; WAZ 2003; Koc 2003)
Shifting of goods to train or truck (dpa 2003a)
Shifting of goods is limited due to limited capacities in sea harbours (Neue Züricher Zeitung 2003)
Further discussed adaptation measures:
Logistic concepts (e.g. enhanced cooperation between harbours and trains) (dpa 2004b; Berger 2007)
River engineering measures:
Deepening of navigation channel (Kupke 2007)
Built-in components for rivers (e.g. movable spur dykes) (dpa 2007)
Bed load channels (dpa 2007)
Usage of more manoeuvrable ships (dpa 2007)
Discharge of water of tributary streams (Merck 2003)

water from tributary streams of the river Rhine, which has severe side effects on hydroelectric power plants, inland navigation, and tourism there, and would only have increased the water level of the Rhine for 24 h (Merck 2003). Others considered movable built-in components, for example spur dykes, which would increase water levels during low water events with no effects on high water. Further recommendations were channels for bed load, as they are already used for the upper Rhine to reduce blockage of the navigation channel and deeper channels inside the navigation channel (Kupke 2007). Alternatively, more manoeuvrable ships or smaller ships were considered (DPA 2007). Even without changes in ship design or river engineering, logistical options for adaptation exist. For instance, the employment of additional and bigger ships during periods with good water levels to balance the reduced handling during low water events was mentioned (Berger 2007).

Impact of the Container Ship Accident in 2007

The accident befalling a container ship near Cologne (25 Mar 2007) had similar impacts to a severe low water event or a blockade due to high water levels: for 5 days no ship was allowed or able to pass Cologne. This event presented additional information on how companies react to unforeseen blockades of the river Rhine, as well as if a complete blockade (not only a limitation as during low water events) of inland navigation for 5 days already has an impact on production. Even a blockade due to high water levels is not comparable to this blockade as it might last longer (up to 12 days at the upper Rhine), but is predictable in most cases (Clement 2007; Frankfurter 2007). Fifty-seven articles on this topic, from 29 newspapers, were analysed (see Table 17.5).

Table 17.6 gives a brief overview of the impacts of the described accident on inland navigation and the economy. The impact on the economy is judged differently, depending on the source. Whilst the Association of Materials Management, Purchasing, and Logistics (ANMPL) states that the industry "got off lightly" (Huethig and Rehm 2007), the Bundesverband der Binnenschifffahrt (BDB) took up the position that the industry has enough storage capacity to survive such short blockades. The BDB also stated that time-critical goods were shifted to other transport modes such as trains or trucks, whilst the ANMPL claimed that shifting of goods was not possible in most cases because of the limited free capacities of trains and trucks and the poor capability of trucks for mass-cargo transport (Huethig and Rehm 2007).

Regarding the normal amount of goods transported on the river Rhine via inland navigation (200 ships with the bearing capacity of about 3,000 trucks pass Cologne per day), it becomes even more clear that shifting of goods to other transport modes is difficult (Huethig and Rehm 2007). The 5 days without inland navigation from harbours south of Cologne to the sea harbours led to delayed delivery, missed connections, displeased customers, and capital lockup for the companies (Huethig et al., 2007). But according to ANMPL, it could have been even worse; if the accident had happened 100 km to the north, the supply of the Ruhr region with ores and hard coal would have been at risk. If the blockade had persisted any longer, some companies might have had to stop their production, as multiple companies

Table 17.5 General view of the analysed articles on the container ship accident 2007

	Number of articles
Total	57
Information on:	
Consequences for inland navigation	36
Consequences for industries	5
Cost effectiveness of the container accident	20
Mentions of possible adaptation measures	4

Table 17.6 Impacts of the container ship accident on industry and (possible) adaptation measures

Consequences of the container accident:
Container in the navigation channel (FAZ.net 2007; Rhein-Zeitung 2007; Morcher 2007)
Blocking of the river Rhine between Sürth and Niehl for 6 days (Rhine km 675 to 695) (FAZ.net 2007; Rhein-Zeitung 2007; Morcher 2007)
No alternate routes for North-South connection via waterways (Main-Rheiner 2007)
Consequences for inland navigation:
"Congestion" of ships on Rhine and Main (Kölner Stadtanzeiger 2007; N24 2007)
100 in the first 24 h (Sueddeutsche.de 2007)
500 in total (Sueddeutsche.de 2007)
Departure of ships "Perlenketten-Prinzip" after removal of the blockage
Consequences for economy:
Association of Materials Management, Purchasing and Logistics (ANMPL):
Delayed delivery (Huethig and Rehm 2007)
Missed connection (e.g. sea ships) (Huethig and Rehm 2007)
Displeased customers (Huethig and Rehm 2007)
Capital lockup (Huethig and Rehm 2007)
German Association of the Inland Shipping Companies (BDB):
Few restrictions for industry due to adequate storage capacities (Huethig and Rehm 2007)
Adaptation measures of companies:
Association of Materials Management, Purchasing, and Logistics (ANMPL):
Shifting of goods to other transport modes very limited (very few free trucks and goods wagons) (Huethig et al., 2007)
German association of the inland shipping companies (BDB):
Shifting of time-critical goods to other transport modes (Huethig et al., 2007)

only have a storage capacity for about a week (Huethig and Rehm 2007). As it was, companies north of Cologne had no bigger problems with the blockade (Clement 2007).

Impact of a Railway Labour Union Strike in 2007

Similar to low water events, the strike by a railway labour union led to a shortage in transport for this transport mode, but not a complete stop. Consequently, an analysis of this event could also unearth information on the impacts of transport shortages on companies and their reaction, which might be used for comparison with the impacts of low water events. This is even more true because the focus of the newspapers was not only on the ongoing negotiation and the impact on passenger transport, but also on the impact on the economy. As a result, many case studies on different industries were presented, including descriptions of mitigation and adaptation measures. Some of these might also be deployed during low water periods; therefore, this analysis can be used as an addition to the survey on this topic.

Another special feature of the railway strike was the quantification of economic losses due to transport shortages. Whether these are comparable to those during low water periods is unknown, because many companies without a demand for inland

Table 17.7 General overview of the analysed articles on the railway strike of 2007

	Number of articles
Total	64
Information on:	
Consequences for industries	59
Cost effectiveness of the train strike	14
Mentions of possible adaptation measures	37

navigation were affected by this event, but this still provides the first informational basis for quantification of economic losses due to transportation shortages.

Contrary to low water periods, the strike was relatively easy to predict and foreseeable due to short token strikes. Following these, most companies prepared themselves for the strike. Transferring this information to low water events, better forecasts could support companies in their transport logistics and enable the companies to be prepared for transport shortages.

To analyse the strike, 64 articles regarding two longer phases of the strike (8–10 Nov 2007 (42 h) and 13–16 Nov 2007 (62 h)) have been reviewed (see Table 17.7). This is a relatively small number of articles compared to the number of articles published on this topic, but only articles which focus on the impact on the economy are mentioned here. Other topics, such as the impact on passenger transport or ongoing negotiations, have not been regarded.

Almost all regarded articles contained information on the impact of the train strike, whilst the cost effectiveness of it was described in only 14 articles. In 37 articles, information on adopted and/or possible adaptation options was described.

Each day, about 5,000 freight trains with the capacity of roughly 100,000 trucks travel through Germany (Wenkel 2007). Of these, approximately 1,000 are “Versorgerzüge”, which are essential for the supply of the chemical industry and power plants (Uken 2007). During the first strike (8–10 Nov 2007 (42 h)), 700–1,000 trains stopped. This is about one fifth to one seventh of all freight trains per day (Stumm 2007; Spiegel 2007d). Additionally, hundreds of trains had to stop at German borders. In eastern Germany, almost all freight transport by train was stopped; in western Germany, about two thirds (Spiegel 2007e).

Even in advance of this strike, industries were afraid of the consequences of it. They often assumed there would be massive operational disturbances (Tagesschau 2007; NDR 2007; Tagesspiegel 2007a; Schwarz et al. 2007; Uken 2007). This, as well as the token strikes, led to well-prepared companies with broad emergency plans (see Table 17.8) (Tagesschau 2007; Finanznachrichten 2007; Der Westen 2007). But still, due to the usage of just-in-time transport and the following reduction of storage capacity, many companies are especially vulnerable to transport shortages because they need regular and timely transport (Schwarz et al. 2007; Uken 2007; Wenkel 2007; Finanznachrichten 2007). Many companies have storage for only a few days (Manager Magazin 2007; Fokus 2007). According to the Association of Materials Management, Purchasing, and Logistics, about 22% of

Table 17.8 Impacts of transport shortage due to the train strike of 2007 on industry and (possible) adaptation measures

Consequences of the train strike:
Time delays of transport and production
Transport shortages for many companies causing:
Supply difficulties (Burdas and Schwenn 2007; Stuttgarter Nachrichten, 2007)
Scarcity of raw materials (Burdas and Schwenn 2007; Stuttgarter Nachrichten 2007)
Limitation/halting of production (Spiegel 2007i)
Additional expenses of up to €45 million per day (N-TV 2008)
Loss of reputation for companies with supply difficulties
Accumulation of goods in harbours
Missed connections (e.g. seagoing vessels)
Transport restrictions in European neighbouring countries
Adaptation measures of companies:
Set up of crisis squads (incl. practices for emergencies) (Tagesschau 2007; Finanznachrichten 2007; Der Westen 2007)
Reduced working hours (Spiegel 2007k)
Shutting down of production (Spiegel 2007j; Spiegel 2007g; Financial Times 2007)
Shifting of goods to private train operators, pipelines, trucks and inland vessels (Spiegel 2007c; Tagesschau 2007; Der Westen, 2007; Manager Magazin, 2007)
Setup/usage of interim storage (Financial Times 2007)
Timely restock (Rudzio 2007; Uken 2007)
Pre-drawing of transport (Manager Magazin 2007)
Supply of raw materials out of other facilities
Further discussed adaptation measures (long term):
Rethinking concerning means of transportation (Schwarz et al. 2007; TVaktuell 2007; DAZ-online 2007)
Rethinking just-in-time transport
Rethinking storage capacity (enlargement of storage capacity)

companies using train transport have no security stock at all, and another quarter can only bridge a day (RP 2007). Most dependent on timely deliveries are the steel, car, chemical, and engineering industries, which is why these industries were most afraid of the train strike (Tagesspiegel 2007a; Finanznachrichten 2007). Some companies announced reduced working hours in preparation (Spiegel 2007a).

During the first strike period, 8–10 Nov 2007 (for 42 h), some industries immediately suffered from it, whilst others were well enough prepared to sit it out (Burdas and Schwenn 2007). Therefore, the industry was not lured into chaos as was feared (Stuttgarter Nachrichten 2007). The second strike period, 13–16 Nov 2007 (62 h), led to supply difficulties and some loss of production (Spiegel 2007j).

Previously, the costs of the train strike for the economy were numbered between €25, €50, and €100 million per day (Finanznachrichten 2007; Der Westen 2007; Wenkel 2007; Tagesspiegel 2007b; Trimborn 2007). For a strike of more than 7–10 days, even daily costs of €500 million were assumed (Der Westen 2007; Tagesspiegel 2007b; Rudzio 2007; Uken 2007). Afterwards, the costs of the strike for the economy were calculated to between €35 and €45 million, €500 million in total. In the total sum, expenses for cleaning up and resuming work in shut-down productions were also included (N-TV 2008).

Impact of Low Water on One Exemplary Company: Frankfurt Airport

To clarify the impact of low water events on companies, the impact on one exemplary company, Frankfurt airport is presented here.

Most of the kerosene needed by the airport is supplied by inland navigation along the river Rhine (Hillmer 2005; DPA 2007), which is why this company is presented here, even though it is not located along the river. Whilst the airport is also connected to the railway and road network, only pipelines and inland navigation are used for kerosene supply. On the airport grounds, there are ten tanks with a capacity of 186 million l (about 186,000 m^3). These are filled through 4 km of pipelines leading to the harbour in Kelsterbach (FRAPORT 2001–2008). Here, tankers land to supply kerosene for the system. Another harbour with additional tanks with a capacity of 180,000 m^3 is located in Raunheim, about 7 km from the airport. These tanks are also connected to the airport by pipelines (Unitank.de n.d). The airport is also connected to the NATO pipeline system CEPS (FRAPORT 2001).

Each year since 2004, about 5.5 million m^3 of kerosene was used by the airport (FRAPORT, 2005–2008). This is about 15,068 m^3 per day. With equal use each day, the tank on the airport grounds would last for 12 days, the one in Raunheim for an additional 11 days, assuming that all tanks are filled completely and only used to supply the airport. But the tanks in Raunheim also provide oil products to local petrol stations and consumers (Unitank.de n.d). And there are also days with peak consumption of 16.5 (10 Aug 2003) or 17.8 million l (29 Aug 2004). In August 2005, a peak consumption of 500,000 m^3 per month was reached (FRAPORT, 2004–2008). This means that during periods with peak consumption, the aforementioned tanks would only last for 20 days. Consequently, during periods of low water, the security of supply of the airport with kerosene might be at risk quite soon, depending on the water level, ship capacity, and storage.

If the average daily fuel demand is translated into number of ships, assuming the largest ships allowed on the Main are deployed and optimal water levels, about six ships are needed per day and 2,207 ships per year (see Fig. 17.1, dark grey bars). In months with peak demand, nearly 7 ships per day are needed. The number of needed ships not only depends on the transport demand of the airport but also on the water level, as this has a strong impact on the bearing capacity of the ships. To illustrate this, the yearly transport demand of the airport was transferred into the number of ships needed when real water levels are taken into account (light grey bars). As the Main is a regulated river, the depth of the navigation channel does not change much. That is why during low water periods, the river Rhine is the regulatory factor for the bearing capacity of the deployed ships. In order to enter the Main, Kaub has to be passed; each time the depth in the navigation channel here drops below the level of 2.9 m, this gauge is taken as a reference. In all other

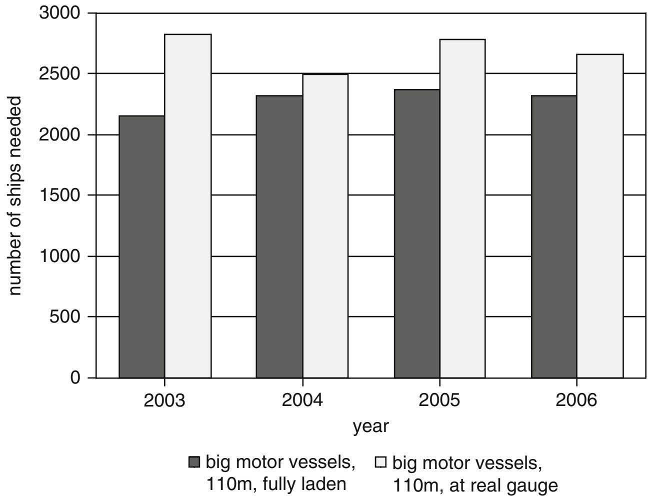

Fig. 17.1 Number of ships (big motor vessels with a length of 110 m, with maximum bearing capacity on the Main) needed by Frankfurt airport fully laden (*dark grey*) or at real gauge (*light grey*). *Source*: own calculations based on Fraport (2003–2006)

cases, a loaded draft of 2.6 m is assumed, as this is the maximum loaded draft for the Main.

Whilst both bars, the light and dark grey ones, vary slightly with the transport demand, the changes due to changing water levels in the light grey bars are more severe. Even so, the transport demand of the airport in 2003 was lower than in the following years; the number of ships needed at real gauge, compared to ideal water levels, clearly increased (673 ships, 31% more were needed). It becomes clear that also for destinations at the river Main, low water levels at the river Rhine have an articulated impact.

Parallel to the increasing number of ships needed, the costs of transport rise. As Jonkeren et al. published in 2007, the expenses per journey do not change much with changing water level. This means that even if a ship only may carry half of its normal amount of goods, (almost) the full freight charges have to be paid. Additionally, for the transport of kerosene twin-hulled craft have to be deployed. For these, not only the investment for the ships is higher, but their empty draught is also higher, so that this kind of ship is even more hindered by low water levels and sooner (Schubert 2008).

To secure the supply of the airport and to keep the expenses for transport mostly constant, an additional pipeline is planned. This pipeline should connect the airport directly to a big tank in Mainz-Gustavsburg as well as to the pipeline net from Rotterdam (Reckmann 2008). This pipeline may be regarded as an adaptation option, as the decision to build it might have been influenced by experiences made during the low water period in 2003.

Interpretation and Conclusion

As the media analysis and the survey show, the impact of transport shortages (e.g. due to low water events, ship accidents, or strikes) is strongest on those companies with a high transport demand of mass cargo or containers.

In public, the vulnerability of companies to these events is noticed quite differently. Whilst most articles concerning the strike contain information on the impact on the economy and on single companies, very little information on this topic could be found concerning low water events or the container ship accident. There might be multiple reasons for this. Because per year freight transport by ship is about as high as by train, 80% of this via the river Rhine, differences in shipping volume cannot be a reason. But whilst the freight transport by ship is bound to separate regions, for example the Rhine region, the strike could have affected most of the economy (directly or indirectly). Another reason might be the different levels of knowledge of the impact of transport shortages on the economy for different transport modes. Whilst shortages in train transport have a direct impact on the economy, the impact of low water events and river blockades are more indirect via inland navigation. The fact that disturbances of inland navigation also might affect production processes might be less well-known or of less interest.

In contrast to the media, most companies which use inland navigation are well aware of low water problems, as became clear in the survey. Many companies deal with this subject and are very interested in the possible development of water levels under climate change conditions. Some have already developed long-term adaptation options, such as a change of modal mix or insurances. Relocation was not excluded by all companies.

In the media coverage, financial aspects were mostly presented regarding higher costs of transport, loss of production and other internal effects of the company. In connection to low water events, the focus was on rising transport costs, whilst in the context of the other two events, mostly additional costs due to the blockade of inland navigation (e.g. anchorage) or loss of production were described. This might be because low water surcharges are directly linked to freight rates, whilst the impact of the train strike on freight rates does not play a prominent role. On the one hand, the financial aspects of the train strike were a focus of the media coverage during this event, as many articles include information about the calculated costs of it. The adaptation measures on the other hand were not quantified.

The most important, most common adaptation measures of the industry were very similar during all three events and were also mentioned by most companies in the survey. Some of these are:

- Shifting of goods to other transport modes (mentioned by almost all companies)
- Deployment of additional ships and lighters
- Deployment of smaller ships
- Shut down of production (if no other options exist)
- Deployment of (intermediate) storage (especially mentioned in reference to the car industry)

Companies which are situated along rivers often use inland waterway navigation as well as trains for transport. If one mode of transport is hindered, they try to switch to the other one. Additionally, in almost all the cases considered, shifts of (small amounts of) goods to road transport took place. Whilst concerning the shift to train and road transport the limited capacities were mentioned, this was true in only one case (the steel industry during the rail strike) for inland navigation. Capacities in rail and road transport are not only limited by the capacities of the infrastructure and vehicles, but also by missing necessities (for example (locomotive) drivers). Additionally, it became quite clear that companies with three transport connections were better off than those with two.

As most harbours provide connections to at least three modes of transport, transport shortages on all modes have impacts on harbours. Whilst during low water events transport fluxes bypassed the harbours and, in consequence, their handling was reduced, the rail strike had the opposite effect: the goods did not reach the harbours (in time) or got stuck there, which is why here, shortages in storage capacities occurred. Remarkably, the effect on harbours during the rail strike was more often discussed than during the low water events.

Continuing research on this topic, more case studies on selected companies (one for each kind of goods and/or part of the river rhine) might be helpful. To identify the importance of inland navigation and the effects climate change might have, it is also necessary to consider forecasts on the development of transportation of cargo, as this development, combined with climate change, might increase existing transport problems during low water periods. Additional adaptation methods besides the above mentioned ones, possibly including geo-engineering, should also be regarded.

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Appendix

Table 17.9 Handling on regarded harbours along the river Rhine with their top three categories of goods. Source: Binnenschiffahrt 2005; Umschlagsstruktur der wichtigsten Häfen, DESTATIS (2006a, b)

Harbours and categories of goods	Handling in tonnes per year (t)
Duisburg	49,242,400
Ore and scrap metal; iron, steel and nonferrous metals	30,134,200
Hard coal	6,861,900
Köln	14,975,800

(*continued*)

Harbours and categories of goods	Handling in tonnes per year (t)
Crude oil, crude oil products, and gas	7,417,600
Chemical products	4,447,900
Earth and stone	1,462,100
Mannheim	8,107,100
Hard coal	2,481,600
Other food and feeding stuff	1,467,500
Chemical products	1,329,000
Ludwigshafen	7,220,700
Chemical products	2,662,200
Crude oil, crude oil products, and gas	2,530,600
Earth and stone	984,500
Karlsruhe	6,513,600
Crude oil, crude oil products, and gas	4,410,600
Hard coal	899,600
Earth and stone	384,600
Neuss	6,136,800
Other food and feeding stuff	1,855,100
Other (semi) finished goods	1,035,200
Ore and scrap metal	845,300
Kehl	3,337,300
Ore and scrap metal; iron, steel and nonferrous metals	2,310,400
Crude oil, crude oil products, and gas	344,800
Krefeld-Uerdingen	3,380,300
Chemical products	1,486,800
Agricultural and forestry products	660,100
Earth and stone	481,600
Wesseling	3,178,800
Crude oil, crude oil products, and gas	2,587,800
Chemical products	591,000
Rheinberg	2,940,000
Hard coal	1,438,600
Earth and stone	784,200
Ore and scrap metal	456,200
Andernach	2,562,600
Earth and stone	1,115,800
Crude oil, crude oil products and gas	505,700
Iron, steel and nonferrous metals	455,200
Mainz	2,780,100
Other food and feeding stuff	1,144,800
Other (semi) finished goods	1,103,200
Earth and stone	240,900
Düsseldorf	2,382,100
Other (semi) finished goods	635,300
Other food and feeding stuff	550,700
Earth and stone	338,400
Leverkusen	2,265,200
Chemical products	1,197,600
Earth and stone	715,200
Hard coal	166,900

References

BMVBS (2009) Tagungsband KLIWAS Auswirkungen des Klimawandels auf Wasserstraßen und Schifffahrt in Deutschland, 1. Statuskonferenz am 18. und 19. März 2009, BMVBS (Federal Ministry of Transport, Building and Urban Affairs), Bonn, http://www.bmvbs.de/Anlage/original_1102027/KLIWAS-Tagungsband-der-1.-Statuskonferenz-am-18.-19.-Maerz-2009-in-Bonn.pdf

DESTATIS (2006a) Binnenschifffahrt – Umschlagstruktur der wichtigsten Häfen. In: Statistische Ämter des Bundes und der Länder (ed.), Wiesbaden

DESTATIS (2006b) Statistisches Jahrbuch 2006 für die Bundesrepublik Deutschland. Statistisches Bundesamt Deutschland (DESTATIS), Wiesbaden

Fraport (2001–2008) Zahlen, Daten, Fakten 2001 zum Flughafen Frankfurt

Jonkeren O, Rietveld J, and Ommeren P (2007) Climate change and inland waterway transport; welfare effects of low water levels on the river Rhine. J Transp Econ Policy 41(3):387–411

Jonkeren O, Ommeren P, Rietveld J (2009) Low water levels and trade imbalances in inland waterway transport revisited: interaction effects on transport prices. Working paper. VU University Amsterdam/Netherlands, Department of Economics, Amsterdam, Netherlands

Reckmann (2008) Kerosin-Röhre – Pipeline macht Bogen um Ticona. http://www.fr-online.de/frankfurt_und_hessen/nachrichten/hessen/1598824_Pipeline-macht-Bogen-um-Ticona.html

Rothstein B, Scholten A, Nilson E, Baumhauer R (2009) Sensitivity of bulk-cargo dependent industries to climate change – first results of a case study from the River Rhine. In Leal Filho W (ed) Interdisciplinary aspects of climate change. Peter Lang Scientific, Frankfurt, pp 469–486. ISBN 978-3-631-58153-7

Schubert (2008) Ticona blockiert Kerosin-Pipeline – Streit um dritte Kerosin-Zufuhr zum Frankfurter Flughafen. http://www.echo-online.de/suedhessen/template_detail.php3?id=652817

Unitank.de (n.d.) Das Tanklager Raunheim. http://www.unitank.de/

References for Media Analysis

Berger (2007) Die Aussichten sind gut am Plochinger Neckarknie, Stuttgarter Zeitung, 31 May 2007, p. 26

Brudas and Schwenn (2007) Güterverkehr – Unternehmen federn die Folgen des Streiks ab, Frankfurter Allgemeine Zeitung (F.A.Z.). NET 8th November 2007. http://www.faz.net/s/RubD16E1F55D21144C4AE3F9DDF52B6E1D9/Doc~E9C309A0324974EBCA264D80-BA2A3A22B~ATpl~Ecommon~Scontent.html

Clement (2007) Binnenschiffer hoffen auf baldige Freigabe – Rhein ist einzig: Sperrung eine Katastrophe, Westdeutscher Rundfunk (WDR), 26 Mar 2007. http://www.wdr.de/themen/panorama/unfall06/koeln_frachtschiff_gekentert/070326_a.jhtml

DAZ ONLINE (2007) Sachsens Wirtschaft: Bahnstreik beschädigt Wettbewerbsposition, Döbelner Allgemeine Zeitung (DAZ), 7 Nov 2007. http://www.doebelner-allgemeine.de/aktuell/content/46137

Der Westen (2007) Wirtschaft befürchtet «drastische Schäden» durch Bahnstreik, Der Westen, 2 Nov 2007. http://www.derwesten.de/nachrichten/nachrichten/wirtschaft-und-finanzen/2007/11/2/news-2326172/detail.html

dpa (1998), Wenig Wasser im Rhein: Behinderungen zwischen Iffezheim und Mainz, Deutsche Presse Agentur (dpa) Landesdienste, 23 Aug 1998, No. 823, p. 13

dpa (2001) Gewässerkundler rechnet mit mehr Niedrigwasser des Rheins, Deutsche Presse Agentur (dpa) Landesdienste, 11 Aug 2001, No. 811, p. 4

dpa (2003a) Mehr Güter auf Schiene wegen Niedrigwasser – Einbußen für Schiffer, Deutsche Presse Agentur (dpa) Landesdienste, 30 Sept 2003, No. 930, p. 58

dpa (2003b) Binnenschiffer und Häfen leiden unter anhaltendem Niedrigwasser, Deutsche Presse Agentur (dpa) Landesdienste, 2 Oct 2003, No. 1002, p. 38

dpa (2004a) Binnenschifffahrt bricht durch heißen und trockenen Sommer 2003 ein, Deutsche Presse Agentur (dpa) Landesdienste, 27 Feb 2004, No. 227, p. 80

dpa (2004b) Niedrigwasser ließ Umschlag der Rheinhäfen deutlich schrumpfen, Deutsche Presse Agentur (dpa) Landesdienste, 23 Jan 2004, No. 123, p. 42

dpa (2006) Wasserstände im Rhein bringen erste Einschränkungen für Schifffahrt, Deutsche Presse Agentur (dpa) Landesdienste, 25 July 2006, No. 725, p. 35

dpa (2007) Wasserbau-Experten planen für wetterbedingte Extreme an Flüssen, Deutsche Presse Agentur (dpa) Landesdienste, 7 May 2007, No. 507, p. 55

Eberhardt (2003) Für die Schiffe wird es im Rhein immer enger – Umschlag in den Häfen Karlsruhe und Mannheim geht drastisch zurück – Großabnehmer wechseln auf Straße und Schiene, Stuttgarter Zeitung, 1 Oct 2003, p. 6

FAZ.net (2007) Gesperrter Rhein – Das ist ganz großer Mist, Frankfurter Allgemeine Zeitung (F.A.Z.).NET, 27 Mar 2007, http://www.faz.net/s/RubB08CD9E6B08746679EDCF370F87A4512/Doc~E72A55623BA634770860675E9321CCD33~ATpl~Ecommon~Scontent.html?rss_googlefeed

Financial Times Deutschland (2007) Die Pläne der Wirtschaft für den Bahnstreik, Financial Times Deutschland, 8 Nov 2007, http://www.ftd.de/unternehmen/handeldienstleister/276463.html

Finanznachrichten (2007) Deutsche Wirtschaft hat Notfallplan für Bahnstreik, Finanznachrichten.de, 2 Nov 2007, http://www.finanznachrichten.de/nachrichten-2007-11/artikel-9374268.asp

Fokus (2007) Bahnstreik – Lokführer nur punktuell erfolgreich, Fokus online, 8 Nov 2007, http://www.focus.de/finanzen/news/bahnstreik aid 138604.html

Frankfurter Rundschau (2007) Krise wegen Rheinsperrung – Einbußen für Binnenschiffer, Frankfurter Rundschau, 29 Mar 2007, p. 35

Hillmer (2005) Wo sind die Flüsse geblieben? Niedrigwasser – Tiefstand-Rekorde auf dem Rhein, und auf der Elbe geht nichts mehr, Hamburger Abendblatt, 1 Oct 2003, No. 229, p. 33

Huethig, Jehle, Rehm (2007) Fakten zur Rhein-Havarie. http://www.huethig-jehle-rehm.de/hjr/news/count/14223

Koc (2003) Ebbe auf dem Rhein: Binnenschiffer kämpfen mit Niedrigwasser, Deutsche Presse Agentur (dpa) Landesdienste, 19 Aug 2003, No. 819, p. 42

Kölner Stadtanzeiger (2007) Strömung erschwert Container-Bergung, Kölner Stadtanzeiger, 27 Mar 2007

Kurier (2007) Streik stoppt öBB-Güterverkehr, Kurier 7th November 2007. http://www.kurier.at/nachrichten/wirtschaft/119704.php

Kupke (2007) Buhnen und temporäre Staustufen – Experten planen für Niedrigwasser, Deutsche Presse Agentur (dpa) Landesdienste, 7 May 2007, No. 507, p. 10

Main-Rheiner (2007) Rhein, Main-Rheiner vom, 28 Mar 2007, http://www.main-rheiner.de/welt/lexikon/objekt.php3?artikel_id=2766356

Manager Magazin (2007) Bahn Streik – Noch herrscht Ruhe, Manager Magazin, 8 Nov 2007. http://www.manager-magazin.de/unternehmen/artikel/0,2828,516092,00.html

Merck (2003) Der Rhein darf sich nicht an Zuflüssen nähren – Kein Moselabstau, Deutsche Presse Agentur (dpa) Landesdienste, 15 Oct 2003, No. 1017, p. 11

Mohr (2003) Niedrigwasser: Schiffer nehmen's noch gelassen, Westdeutsche Allgemeine Zeitung (WAZ), 6 Aug 2003, p. 0

Morcher, Stinauer (2007) Rhein bleibt für Tage gesperrt, Kölner Stadtanzeiger, 25 Mar 2007. http://www.ksta.de/html/artikel/1174563714372.shtml

N24 (2007) Rhein-Freigabe fraglich: Container verschollen, N24, 29 Mar 2007. http://www.kl-lan.de/news/top-news/rhein-freigabe-fraglich-container-verschollen.html

Neue Züricher Zeitung (2003) Schiffe und Fische in Bedrängnis – Auswirkungen des tiefen Rheinpegels, Neue Züricher Zeitung, 9 Oct 2003, p. 17

N-TV (2007) Rhein-Freigabe fraglich: Container verschollen. http://www.n24.de/news_stories/article.php?articleId=111660

N-TV (2008) Teure Bahn Streiks, N-TV, 30 Mar 2008. http://www.n24.de/941297.html

NZZ-ONLINE (2007) Gefahr für den Rhein gebannt – Bergung der Container von havariertem Frachter geht voran, Neue Zürcher Zeitung (NZZ)-Online 29 Mar 2007. http://www.nzz.ch/2007/03/27 /vm/newzzEZSHUGWL-12.html
Rhein-Zeitung (2006) Wasserstände sinken weiter, Rhein-Zeitung, 21 July 2006, Köln. http://rhein-zeitung .de/on/06/07/20/tt/t/rzo265878.html
Rhein-Zeitung (2007) Nach Havarie: Rhein bleibt gesperrt, Rhein-Zeitung, 26 Mar 2007, Köln. http://rhein-zeitung.de/on/07/03/26/news/t/rzo323930.html
RP (2007) Stehen bei Porsche die Bänder still? Rheinische Post (RP) – online 8 Nov 2007. http://www.rp-online.de/public/article/wirtschaft/news/498627/Stehen-bei-Porsche-die-Baender-still.html
Rudzio, Uken (2007), Der Schaden wird jetzt groß, Die Zeit, 8 Nov 2007, No.46
Schulze (2003) Wir fahren, bis es nimmer geht – Die "Glarus" kommt Schiffen zu Hilfe, die den Rhein aus eigener Kraft nicht schaffen, Frankfurter Allgemeine Sonntagszeitung, 5 Oct 2003, p. 16
Schwarz et al (2007) Bei Blockade im Güter- und Fernverkehr – Industrie befürchtet Stillstand, Süddeutsche Zeitung, 1 Nov 2007. http://www.sueddeutsche.de/wirtschaft/artikel/109/140808
Seidel (2003) Binnenschiffahrt leidet unter Niedrigwasser, Die Welt, 23 July 2007, No. 169, p. 12
Spiegel (2007a) Wirtschaft wappnet sich mit Notfallplänen, Spiegel-Online 7 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,515975,00.html
Spiegel (2007b) Lifeticker: Wo der Streik die Bahn lahm legt, Spiegel-Online 8 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,516139,00.html
Spiegel (2007c) Streik im Überblick – Wo die Wirtschaft mit Schäden rechnet, Spiegel – Online 8 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,516151,00.html
Spiegel (2007d) Duell der Streik-Deuter, Spiegel-Online 9 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,516421,00.html
Spiegel (2007e) Bahn spricht von schlimmstem Streik in ihrer Geschichte, Spiegel-Online 9 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,516515,00.html
Spiegel (2007f) GDL erhöht den Einsatz – Wirtschaft flucht, Spiegel-Online 11 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,517220,00.html
Spiegel (2007g) Diese Bahnhöfe trifft der Streik besonders hart, Spiegel-Online 14 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,517257,00.html
Spiegel (2007h) Hunderttausende Pendler genervt, Millionen vernichtet, Spiegel-Online 15 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,517522,00.html
Spiegel (2007i) Massive Behinderungen im Osten – Streikkasse reicht bis Februar, Spiegel-Online 16 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,517711,00.html
Spiegel (2007j) EU-Kommission befürchtet Schaden für die Wirtschaft in Europa, Spiegel-Online 17 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,517930,00.html
Spiegel (2007k) Lifeticker: Wo der Streik die Bahn lahm legt, Spiegel-Online 8 Nov 2007. http://www.spiegel.de/wirtschaft/0,1518,516139,00.html
Stumm (2007) Bahn holt Lokführer aus Tschechien, Manager Magazin, 9 Nov 2007. http://www.manager-magazin.de/unternehmen/artikel/0,2828,516271,00.html
Stuttgarter Nachrichten (2007) Notfallpläne der Wirtschaft greifen, Stuttgarter Nachrichten, 8 Nov 2007. http://www.stuttgarter-zeitung.de/stn/page/1561312_0_2147_noch-kein-chaos-wegen-bahnstreik-notfallplaene-der-wirtschaft-greifen.html
Sueddeutsche.de (2007) Schiffsunglück – Der Rhein ist wieder frei, Sueddeutsche.de, 30 Mar 2007. http://www.sueddeutsche.de/panorama/artikel/95/107987/
Tagesschau (2007) Bahnstreik gefährdet Produktion – Firmen befürchten Milliardenverluste, Tagesschau.de, 7 Aug 2007. http://www.tagesschau.de/wirtschaft/meldung4982.html
Tagesspiegel (2007) Angst vor Streik im Güterverkehr geht um, Tagesspiegel.de, 31 Oct 2007. http://www.tagesspiegel.de/wirtschaft/bahn/Bahnstreik-GDL-BASF;art15463,2410941
Tagesspiegel (2007b) Der Bahn-Streik wird teuer, Tagesspiegel, 3 Nov 2007
Trimborn (2007), Lokführer wollen Güterverkehr 42 Stunden bestreiken, N24, 7 Nov 2007. http://www.n24.de/print.php?articleId=165226

TVaktuell (2007) Ostbayrische Wirtschaft in Gefahr? – Bahn-Streik bedroht Güterverkehr, TV aktuell Nachrichten, 7 Nov 2007. http://www.tvaktuell.com/print.aspx?ID=1015& showNews=144488
Uken (2007) Wir wären längst lahmgelegt – Dürfen die Lokführer auch im Güterverkehr streiken?, Zeit-Online, 1 Nov 2007. http://www.zeit.de/online/2007/45/bahnfracht
Verkehrs Rundschau (2006) Weniger Güter auf Binnenschiffen, 4 Sept 2006. http://www.verkehrsrundschau.de/weniger-gueter-auf-binnenschiffen-437787.html
WAZ (2003) Tiefe Rinne sichert Schifffahrt, Westdeutsche Allgemeine Zeitung (WAZ), 22 Aug 2003, p. 0
WAZ (2006) Tagesthema: Die ganze Stadt lechzt nach Wasser – Nie war es so wertvoll – Schiffe müssen abladen, Westdeutsche Allgemeine Zeitung (WAZ) Duisburg Mitte, 18 July 2006, p. 16
Wenkel (2007) Bahnstreik auch im Güterverkehr erlaubt, Deutsche Welle, 2 Nov 2007. http://www.dw-world.de/dw/article/0,2144,2861809,00.html

Chapter 18
Financing Adaptation: For Whom, By Whom, and How

Nazmul Huq

Abstract It is now beyond reasonable doubt that climate change is happening. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) concluded that even the most stringent mitigation efforts would not avoid further impacts of climate change in the next few decades. This makes adaptation essential, particularly in addressing near-term impacts. Yet mitigation also remains crucial: to rely on adaptation alone would lead to a level of climate change to which it is no longer possible to effectively adapt, or only at very high social, economic and environmental costs. Successful action on climate change therefore must include both mitigation and adaptation. For the last two decades or even more, the literature on climate change, its science, the role of human society, the physical and socio-economic impact has experienced an explosive growth and surge in research and policy analysis on ways in which technology and finance can support mitigation. Similar studies for adaptation are much more recent, and their results therefore less mature. As adaptation is deemed an urgent need, its financing issue is now at the centre of all discussions related to adaptation. Against this background, the major focus of this paper is the financing of adaptation measures in developing countries. Of course, it should be acknowledged that mere financing represents only a part of what is needed in order to adapt to climate change. But to keep the discourse limited to adaptation financing, this paper is organized into the following sections: describing the nature and scale of the adaptation challenge in developing countries, presenting the range of numbers that have been put on the table to estimate the developing countries' actual need for adaptation funding. Subsequently, the current status of adaptation funding – how much money is currently being channelled through the multilateral adaptation funds as well as potential bottlenecks for post-Kyoto regimes – is particularly discussed in this paper.

Keywords Adaptation · Climate change · Financing

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Introduction

It is now beyond reasonable doubt that climate change is happening (Klein and Persson 2008). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) included observations of the first effects of climate change. The report concludes with the decisive findings that even stringent mitigation efforts would not avoid further impacts of climate change in the next few decades (IPCC 2007). According to the United Nations Human Development Report, mitigation will only start to make a difference from around 2030 onwards, and even under a best-case scenario, temperatures will continue to increase until around 2050 (UNDP 2008).

The impacts of climate change will adversely affect many groups in society across many economic sectors. According to IPCC AR4, impacts will include increased water stress, flood risk, food insecurity, reduced biodiversity and ecosystem services, losses of livelihoods, economic production losses, increased health risks, and other factors (IPCC 2007). There are two principal strategies for managing climate change risks: mitigation and adaptation. Until recently, mitigation and adaptation have been considered separately in both climate change science and policy. Mitigation has been treated as an issue for developed countries, which hold the greatest responsibility for climate change, while adaptation is seen as a priority for the Global South, where mitigation capacity is low and vulnerability is high. This conceptual divide has hindered progress against the achievement of the fundamental sustainable development challenges of climate change (Ayers and Huq 2009).

According to the United Nations Human Development Report (UNDP 2008), mitigation will only start to make a difference from around 2030 onwards, and even under a best-case scenario, temperatures will continue to increase until around 2050 (ibid.). This means that at least until 2050, adaptation is a “no choice” option. Apart from this, all the observations and reports oblige climate-hit regions around the world to intensify adaptation practices as the first option to cope with the changing climate with equal evaluation of mitigation. Realizing the facts of adapting to climate change, the Bali Action Plan (BAP) was adopted at the Conference of the Parties 13 in 2007, which is considered as an important milestone in raising the political status of adaptation and laying the foundation for more details of international adaptation finance (Persson et al. 2009). The BAP attaches equal weight to both mitigation and adaptation (Klein 2008) and prioritized financial mechanisms as the key priority in implementing adaptation and mitigation activities.

Compared to mitigation, adaptation is a much more complex concept due to its local nature. The scale and nature of adaptation varies according to geo-sociological and cultural conditions, whereas mitigation is commonly uniform in nature all over the world. Financing for adaptation is another complex issue for present day negotiations. This paper aims to facilitate discussions on adaptation financing by presenting a summary overview of the current state of knowledge and policy initiatives. In addition, describing the nature and scale of the adaptation challenge in developing countries, presenting the range of numbers that have been put on the table to estimate the developing countries' actual need for adaptation funding will be discussed in this paper. Finally, the recent outcomes of adaptation financing from COP 15 at Copenhagen are highlighted.

Climate Change and Global Impact: Observed

Five years ago, the world was still engaged in debating whether or not climate change was taking place, and whether or not it was human-induced. Climate change scepticism was a flourishing industry. Today, the debate is over and climate scepticism is an increasingly fringe activity. The AR4 review of the IPCC has established an overwhelming scientific consensus that climate change is both real and man-made (UNDP 2008).

The foremost evidence for worldwide climate change has been global warming. For the northern hemisphere, temperatures during the second half of the twentieth century were higher than during any other 50-year period in the last 500 years, and probably in the last 1,300 years. In addition, eleven of the last 12 years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature begun in 1850 (IPCC 2007). Expressed as a global average, surface temperatures have increased by about 0.74°C over the past 100 years (Pender 2008). Surface air temperatures over land have risen by about double the rate of temperatures over the ocean, which means that less warming has occurred in small island states (Mertz et al. 2009).

Drought and tropical cyclone occurrences are now more frequent than ever in history. Droughts have often been linked with prolonged heat waves (UNFCCC 2008). There have been substantial increases in heavy precipitation events in many land regions, even in regions with no change or reductions in total rainfall (Groisman et al. 2005), where droughts might be exacerbated if the reduced rainfall is increasingly falling in heavy precipitation events. Globally, estimates of the potential destructiveness of tropical cyclones have shown a significant upward trend since the mid-1970s, with a trend towards longer lifetimes and greater storm intensity (Emanuel 2005). The largest increases in intense tropical cyclones have been observed in the North Pacific, Indian, and southwest Pacific Oceans (Pender 2008).

There are also emerging findings of climate effects on human systems, although these are often difficult to discern since all sectoral information is not yet well documented. Recent climate variations are beginning to have effects on many other natural and human systems which are yet to be documented. Projected observations give a much more transparent view on impacts. The next section discusses some projected dangerous climate impacts.

Climate Change and Global Impact: Projected

The following discussion is a selection of the key findings regarding projected impacts. The projected impacts are characterized by certainty and uncertainty and depend heavily on various surrounding factors. The impact studies were conducted by renowned scientists, researchers, supreme bodies such as the IPCC and UNDP, but are based on some physical and social assumptions.

The IPCC's AR4 provides a best-estimate set of projections for future climate (UNDP 2008). Latest IPCC predictions from their Fourth Assessment Report reveal that for the next 20 years, warming at a rate of 0.2°C per decade is expected (IPCC 2007). However, if current trends continue, it can be expected that average global temperatures will rise by 1–3°C within the next 50 years or so, and the Earth will be committed to several degrees more warming if greenhouse gas emissions continue to grow (Stern 2006).

According to the IPCC, major losses in agricultural production will lead to increased malnutrition and reduced opportunities for poverty reduction. Overall, climate change will lower incomes and reduce the opportunities of vulnerable populations. By 2080, the number of additional people at risk of hunger could reach 600 million – twice the number of people living in poverty in sub-Saharan Africa today (UNDP 2008; IPCC 2007). Climate change impacts on agriculture will thus have important multiple effects. Agricultural production and employment underpin around 50 developing countries' economies.

Reduced water supplies would place additional stress on people, agriculture, and the environment (Pender 2008). Already some 1.7 billion people, a third of the world population, live in water-stressed countries, a figure expected to rise to 5 billion by 2025 (UNFCCC 2008). Climate change will exacerbate stresses on the water supply caused by pollution and by growing populations and economies. The most vulnerable regions are arid and semi-arid areas, some low-lying coasts, deltas, and small islands (Williams 2002).

Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas. Coastal wetlands, including salt marshes and mangroves, are projected to be negatively affected by sea level rise (IPCC 2007). Currently, more than 200 million people living in coastal floodplains around the world (Stern 2006) are projected to be flooded every year due to sea level rise by 2080 (Stern 2006). UNDP estimates that due to dangerous climatic change (UNDP 2008):

- 344 million are exposed to tropical cyclones
- 521 million are exposed to floods
- 130 million are exposed to droughts

Severe health impact projections are available on the IPCC summary for policy makers (2007) submitted by working group II. Impacts on health has a spiral effect from individual to country level (World Bank 2009) especially for developing countries. Labour and manpower is the core economic driving force for low income countries, and adverse impacts on health may paralyse the national economy to some extent. The major summaries taken from IPCC findings are as follows:

- Projected climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity

- Increases in malnutrition and consequent disorders, with implications for child growth and development
- Increased deaths, disease and injury due to heatwaves, floods, storms, fires, and droughts
- The increased burden of diarrhoeal disease
- The increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change
- The altered spatial distribution of some infectious disease vectors (IPCC 2007)

According to The World Health Organization (WHO), since the 1970s, climate change has already been responsible for over 150,000 deaths each year through increasing incidence of diarrhoea, malaria, and malnutrition (WHO 1993), predominantly in Africa and other developing regions. A more dangerous picture is projected by the Stern Review. He states that an increase in temperature of just 1°C in the Indo-Gangetic plain above pre-industrial levels (it is already 0.5°C higher) could double annual deaths from climate change to at least 300,000 (Stern 2006).

The processes of climate change will interact with wider pressures on ecosystems and biodiversity. Many of the world's great ecosystems are already under threat (UNDP 2008). In 2005, the Millennium Ecosystem Assessment found that 60% of all ecosystem services were either degraded or being used unsustainably (Millennium Ecosystem Assessment 2005). The IPCC findings depict dreadful pictures of ecosystems. In very brief:

- The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change and associated disturbances
- Approximately 20–30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5–2.5°C
- For increases in global average temperature exceeding 1.5–2.5°C and in concomitant atmospheric carbon dioxide concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity, and ecosystem goods and services, e.g. water and food supply (UNFCCC 2008)
- Some 277 medium or large mammals in Africa would be at risk in the event of 3°C warming (Millennium Ecosystem Assessment 2005)

Climate Change Adaptation and Financing

The impacts of climate change therefore pose a massive threat to development. The need for all countries, but developing countries in particular, to adapt to these impacts is increasingly urgent (Ayers and Huq 2009). "Adaptation" has therefore emerged as a key policy response to climate change, describing the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (AfDB et al. 2003; IPCC 2007). From its inception, the international climate policy effort has predominantly been focused on mitigation, i.e. on reducing greenhouse gas emissions to prevent climate change. The concept of *adapting* to climate change has, on the other hand, received less attention. This is partly due to the "local" nature of adaptation, as opposed to the global scope of mitigation efforts (Flåm and Skjærseth 2008) though some argue that adaptation as a "local mantra" is no longer valid (Burton 2008).

The financial implication for adaptation is a great challenge, but one that is unavoidable, and adaptation to climate change will bring additional costs for both the public and the private sector. Of course, it should be acknowledged that mere financing represents only a part of what is needed in order to adapt to climate change. Effective adaptation measures also depend on a series of other factors such as information, institutional capacity, technology, transparency, and political stability (Flåm and Skjærseth 2008). However, assessing the costs and, especially, the benefits of adaptation is considerably more complicated than it is for mitigation. Most importantly, in contrast to mitigation, the performance of adaptation options cannot be measured and expressed in a single measurement, e.g. CO^2 or US dollars. This makes it difficult for decision-makers to compare between alternative adaptation options and to consider potential trade-offs (Klein and Persson 2008). What is needed for developing countries to adapt to climate change? Changes should be at many levels. Communities must build their resilience by adopting appropriate technologies and diversifying their livelihoods to cope with the coming climate stress that lies outside the realm of human experience (Oxfam International 2007).

The Scale of the Adaptation Finance Challenge

The international community has made slow progress in identifying and articulating concrete financial adaptation needs in developing countries. This is perhaps not surprising, considering that the actual need for adaptation is highly dependent on global mitigation efforts. The fewer mitigation efforts, the larger the challenge of adaptation (Flåm and Skjærseth 2008).

In spite of innate complex and uncertain factors, some initial estimates of the potential adaptation costs have been made. The World Bank's 2006 estimate concludes that the costs of adapting to climate change in developing countries are likely to be between US$10–40 billion a year. This figure is based on the estimated proportion of ODA, foreign direct investment (FDI) and domestic investment that is sensitive to climate change. Oxfam International in 2007, taking into account a broader range of costs, estimated the figure to be over US$50 billion a year. Christian Aid goes further and predicts that the annual adaptation costs could be double this figure, reaching US$100 billion. The UNDP's Human Development

Report in 2008 indicated that a total of US$86 billion will be required for adaptation by 2015. The UNFCCC secretariat in 2007 estimated the additional investment and financial flows needed worldwide to be $60–182 billion in 2030, some $28–67 billion of which would be needed in developing countries (Klein and Persson 2008). All the calculations profoundly show the gap between the worst and best case scenario is huge. The discrepancy is partly due to varying methods of calculation and varying cost bases (Parry et al. 2009). In addition, the variation in estimates also reflects the complexity and uncertainty related to the assessment of the exact costs of adaptation. A rigorous assessment of the economics of adaptation is urgently required, equivalent to the detailed analysis that the Stern Review provided on the economics of cutting greenhouse gas emissions (Oxfam International 2007).

Even though the above numbers are now widely cited to demonstrate the need to increase the availability of funds for adaptation in developing countries Agrawala and Fankhauser (2008) expressed concern about the methodology of the studies. They argued that there has been "a premature and very rapid convergence around initial estimates that are quite sensitive to the assumptions made (Agrawala and Fankhauser 2008)". For example, all subsequent studies adopted the World Bank's assumptions that 40% of official development assistance (ODA), 10% of foreign direct investment and 2–10% of gross domestic investment are climate-sensitive, and that the cost of climate-proofing the exposed investments is 10–20% of the financial exposure in each of these cases (Klein and Persson 2008). According to Agrawala and Fankhauser (2008), the "consensus" on global adaptation costs, even in order of magnitude terms, may therefore be premature. In addition, in most cases, the estimates do not have a direct attribution to specific adaptation activities, nor are the benefits of adaptation investments articulated (Agrawala and Fankhauser 2008). There are also issues of double-counting between sectors, and scaling up to global levels from a very limited (and often very local) evidence base. At the same time, many sectors and adaptations have not been included in the estimates (Klein and Persson 2008).

Despite these shortcomings, the message is clear: there is a vast need for adaptation finance in developing countries (OECD 2009; Parry et al. 2009). According to the United Nations Framework Conventions on Climate Change (UNFCCC), developed countries are legally obliged to provide such funding. UNFCCC article 4 states that developed countries are required to assist developing countries that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse affects (Flåm and Skjærseth 2008). How is the international community currently coping with this obligation? What is the status and the "delivery" of the financial mechanisms established under the UNFCCC?

Governance of the Fund

The funding available for adaptation in developing countries flows mainly through two channels. The United Nations Framework Convention on Climate Change (UNFCCC) commits developed countries to helping "particularly vulnerable" countries meet the costs of adaptation, and has instigated several funding mechanisms towards this end (Ayers and Huq 2009). The second available avenue is Official Development Assistance (ODA) type financing or bilateral financing (Flåm and Skjærseth 2008; Ayers and Huq 2009). Four adaptation-related funds have been established at the international level. Three of them are established under the UNFCCC – the Global Environment Facility (GEF) Trust Fund's Strategic Priority on Adaptation (SPA), the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF). The fourth, the Adaptation Fund (AF), has been established under the Kyoto Protocol, meaning that only the countries that are party to the Protocol have access to the fund and potential influence on its governance (Flåm and Skjærseth 2008; Müller 2008).

The first three funds are governed by GEF. Based on the views expressed by the developing countries and previous experiences, the current GEF-managed funds are widely considered to be inadequate and bureaucratic in procedure. Table 18.1 shows a summarized view of current flow of multilateral funds governed by GEF.

Clearly these figures are too small to cover even the most conservative estimates of the adaptation funding needs of developing countries. Mobilizing the required finance for adaptation is now an urgent call that GEF-managed funds fail to respond to with the necessary means. In addition, a series of analyses on GEF-managed funds in terms of their efficiency, fairness, and responsiveness to the needs of developing countries found several shortcomings. It is also revealed that GEF does not fully adhere to guidance on the SPA, the LDCF and the SCCF due to the complex governing system, imperfect design and inconsistent implementation (Parry et al. 2009). Thus new, there is an urgent call for innovative funding and governance to implement climate change adaptation.

The Adaptation Fund (AF) under the Kyoto Protocol aims to finance concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. What really separates the AF from the other funds, however, is its income scheme. In essence, the fund is financed through an international private sector tax. More specifically, its funds come from a two per cent levy on Clean

Table 18.1 The multilateral adaptation funds

Fund	Goal	Pledged ($m)	Received ($m)	Disbursed ($m)
SPA	Funds pilot projects that address local adaptation needs and generate global environmental benefits	50	28	14.8
LDCF	Implementation of most urgent adaptation projects in LDCs, based on NAPAs	163.3	52.1	12
SCCF	Funds activities aimed at adaptation as well as three other purposes: technology transfer, economic diversification, and support in key sectors	70	53.3	6
Total		283.3	133.4	32.2

Source: (Flåm and Skjærseth 2008) (as of April 2008)

Development Mechanism (CDM) transactions. This means that the fund is not contingent upon aid from donors. It also means that the scale of the fund will depend on the volume of the CDM market and on the price of CDM credits. This of course makes it difficult to estimate the fund's potential value. The World Bank and United Nations Development Programme expects well over US$900 million by the year 2012 (Persson et al. 2009). But the success of AF depends on the smooth functioning of CDM processes, whose existence is already being questioned on the ground of fairness, equity, and justice. In reality, the AF is not functioning due to inadequate funds.

In contrast, ODA (0.7% of GNI of OECD countries), the most conventional funding, has shown more success as regards adaptation funding. Most of the multilateral funding bodies focus on infrastructural types of projects which are highly vulnerable to climate change impacts, where 60% of ODA-funded projects have climate adaptive capacity and adaptation in a positive way (Persson et al. 2009). The money flow from ODA is obviously many times higher than multilateral finance. As of 2007, ODA provided through bilateral and multilateral channels for all purposes totalled US$103.7 billion (Persson et al. 2009). ODA is therefore being used to support adaptation initiatives that contribute towards building sustainable development, and climate change is also increasingly being mainstreamed into development investments (Ayers and Huq 2009). However, most adaptation financing by definition should be operated by the internationally agreed bodies specifically dedicated to adaptation support under the jurisdiction of UNFCCC. In doing so, international funds must be disbursed through mechanisms that are effective, efficient and fair, ensuring that resources reach the countries and communities that need them most. In order to make this possible, some of the finance should be available to non-governmental organizations, since they are sometimes best placed to provide early and effective support to vulnerable communities. The finance should be:

- Additional to and distinct from existing aid requirements
- Determined on the basis of what is needed
- Provided reliably from year to year, so that adaptation can be properly integrated into national planning processes
- Raised in ways consistent with cutting greenhouse gas emissions, since these lie at the heart of the problem
- Raised broadly in proportion to each nation's share of responsibility and capability

Generation of Adaptation Funds: A Few Options

There have been many proposals for generating necessary adaptation funds. The funds can be generated either from public money or private endeavour. Regardless of which approach is taken to the setting of a total level of finance, new and additional financial sources would have to be raised in some way (Persson et al. 2009). According to the BAP, they should be raised in an adequate, predictable and sustainable way (ibid.). The role of the private sector is crucial for generating this additional funding, although the term "private sector" needs to be clearly defined. Among others, Reducing Emissions from Deforestation and Degradation (REDD), International Levy on Air Passengers, Global Carbon Tax and International Marine Levy are remarkable.

The recently ended COP-15 at Copenhagen shows some hope for adaptation financing, both in the short and long term, although the summit is generally considered to have failed. It puts forward the promise of short-term funding mainly for adaptation in vulnerable developing countries (US$30 billion over 3 years, from 2010 to 2013) and it puts forward the notion of longer-term funding to the tune of US$100 billion a year from 2020 for mitigation as well as adaptation (UNFCCC 2009). Nevertheless, how this pledged amount would be governed and disbursed remains an issue for the decision-makers, and needs to be resolved as early as possible. In Copenhagen, as regards financing issues, most of the parties showed their disappointment over financing mechanisms and put emphasis on stronger financial mechanisms for adaptation. It therefore is important to handle the amount that has been pleaded in a sustainable way so that effective fighting against climate change is possible. The potential bottlenecks are how this money would be governed, who will govern, and how reportable, measurable, and verifiable (MRV) the process will be. Moreover, what will be the status of ODA finance? There have been two trains of thought (1) climate finance should be additional to ODA and (2) the percentage of ODA should be increased (LDC demands 1.5% as ODA). The Adaptation Fund under the Kyoto Protocol has received a great deal of support, despite its disappointing performance, because of its international legal status, whereas funds operated under GEF have been highly criticized by the Parties. The major challenge is now to rectify the financial mechanisms, transcending all the deadlocks in the shortest possible time. At the same time, all possible mechanisms for mobilizing funds, both for adaptation and mitigation, should be amassed with rigorous attention paid to sustainable financing, keeping the overarching goal of sustainability in focus.

Summary and Conclusion

This paper has (1) mapped the estimated needs for adaptation funding in developing countries, (2) presented the status and "delivery" of the current financing efforts at the multilateral level, and (3) pointed to some of the possible alternative mechanisms that can be implemented in order to generate additional funding.

It has been seen that climate change will, irrespective of stringent mitigation efforts, demand adaptation in most parts of the world. However, the greatest challenge will be for developing countries. These are countries with little historic responsibility for the climate change problem – and with generally fewer resources to adapt. Yet the resources needed are significant, ranging from US$10–100 billion a year. Of course, such wide-ranging numbers are hampered by numerous uncertainties and complexities, as it is difficult to assess the exact cost of adaptation. No matter which figure one chooses to rely on, the picture is clear: the need for funding for adaptation measures in developing countries is significant and quick action is an urgent call, considering the rapid pace of the climate catastrophe.

References

AfDB, ADB, DFID, EU, DGIS, BMZ, et al (2003) Poverty and climate change: reducing the vulnerability of the poor through adaptation. African Development Bank, Abidjan

Agrawala S, Fankhauser S (2008) Economic aspects of adaptation to climate change: costs, benefits and policy instruments – Executive summary. OECD, Paris

Ayers JM, Huq S (2009) Supporting adaptation to climate change: what role for official development assistance? Dev Policy Rev 27:675–692

Boyd E, Grist N, Juhola S, Nelson V (2009) Exploring development futures in a changing climate: frontiers for development policy and practice. Dev Policy Rev 27:659–674

Burton I (2008) Beyond borders: the need for strategic global adaptation. IIED, London

Emanuel K (2005) Increasing destructiveness of tropical cyclones over the past 30 years. Nature 436:686–688

Eriksen S, Kelly P (2007) Developing credible vulnerability indicators for climate adaptation policy assessment. Mitigation Adapt Strateg Glob Change 12:495–524

Flåm KH, Skjærseth JB (2008) Financing climate change adaptation in developing countries: current picture and future possibilities. Norwegian Church Aid, Oslo

Groisman PY, Knight RW, Easterling D, Karl T, Hegerl G, Razuvaev VN (2005) Trends in intense precipitation in the climate record. J Clim 18:1326

IPCC (2007) Summary for policymakers. In: Climate change 2007: impacts, adaptation and vulnerability (contribution of Working Group II to the Fourth Assessment Report). Intergovernmental Panel on Climate Change, Geneva

Klein R (2008) Mainstreaming climate adaptation into development – briefing note for the European parliament temporary committee on climate change. Stockholm Environment Institute, Stockholm

Klein R, Persson A (2008) Financing adaptation to climate change: issues and priorities. SEI Briefing Note for the European Climate Platform. Stockholm Environment Institute, Stockholm

Klein RJ, Eriksen SE, Næss LO, Hammill A, Tanner TM, Robledo C et al (2007) Portfolio screening to support the mainstreaming of adaptation to climate change into development assistance. Clim Change 84:23–44

Mertz O, Halsnæs K, Olesen JE, Rasmussen K (2009) Adaptation to climate change in developing countries. Environ Manage 43:743–752

Millennium Ecosystem Assessment (2005) Ecosystem and human well-being: synthesis. Island, Washington

Müller B (2008) International adaptation finance: the need for an innovative and strategic approach. Oxford Institute for Energy Studies, Oxford

OECD (2009) Integrating climate change adaptation into development co-operation: policy guidance. Organization for Economic Coperation and Development, Paris

Oxfam International (2007, May) Adapting to climate change. What's needed in poor countries, and who should pay. www.oxfam.org.uk: http://www.oxfam.org.uk/resources/policy/climate_change/downloads/bp104_adapting_to_climate_change.pdf. Accessed 22 Feb 2009

Parry M, Arnell N, Berry P, Dodman D, Fankhauser S, Hope C et al (2009) Assessing the costs of adaptation to climate change: a review of the UNFCCC and other recent estimates.

International Institute for Environment and Development and Grantham Institute for Climate Change, London
Pender JS (2008) What is climate change? and how it will effect Bangladesh. Church of Bangladesh Social Development Programme, Dhaka
Persson Å, Klein RJ, Siebert CK, Atteridge A, Müller B, Hoffmaister J et al (2009) Adaptation finance under a Copenhagen agreed outcome. Stockholm Environment Institute, Stockholm
Stern N (2006) Report of the stern review: the economics of climate change. HM Treasury, London, UK
UNDP (2008) Human development report – Fighting climate change: human solidarity in a divided world. United Nations Development Program (UNDP), New York
UNDP (2009) Human development report 2009 – Overcomig barrirs: human mobility and develoment. United Nations Development Programme (UNDP), New York
UNFCCC (2008) Climate change: impacts, vulnerabilities and adaptation in developing countries. Climate Change Secretariat (UNFCCC), Bonn
UNFCCC (2009, Dec) Copenhagen Accord. Opgeroepen op January 7, 2010, www.unfccc.int: http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf
WHO (1993) Guidelines for Cholera Control. World Health Organization, Geneva
Williams M (2002) Climate change information kit. United Nations Environment Programme and Climate Change Secretariat (UNFCCC), Bonn
World Bank (2009) Convenient solutions to an inconvenient truth: ecosystem-based approaches to climate change. The World Bank, Washington

Chapter 19
GIS-Based Flood Risk Management for Thermal Power Plants in Germany

Jeannette Schulz

Abstract Climate projections for the Upper Rhine Region describe a warmer atmosphere and higher evaporation capacity in winter. Therefore, a change to more frequent and more extreme runoff in winter may influence the infrastructure of adjacent power plants as they need to be protected against floods. In Germany, two different regulations exist to specify the flood protection of companies. For coal-fired power plants, the required flood protection level is a 100-year flood. For nuclear power plants, the level is a 10,000-year flood.

Several guidelines deal with risk handling; none of these contains a specific approach how to manage flood risk via Geographical Information Systems (GIS). Therefore, a general concept based on a GIS approach will be set up:

Problem analysis: Sites are supposed to be protected against flooding. Relevant data is implemented into a GIS.

Assessing alternatives: Different water levels are illustrated for the sites with a following comparison accomplished.

Decision-making: Based on the illustrated water levels, an emergency plan is established.

Implementation: Implementation of the site-specific emergency plan. Here, protection measures can be checked and improved.

In a next step, the suitability of embedding the concept into a GIS-based approach will be tested and implemented.

Keywords Flood risk management · GIS-based approach · Thermal power plant

Introduction and Context

For Germany in general, precipitation shifts from summer to winter; especially heavy precipitation will occur more often during the winter half-year (Zebisch et al. 2005). Climate change projections and the influences of climate change on runoff in

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Germany therefore describe a higher risk of occurrence of floods in winter as well as a higher risk of low water events in summer (Zebisch et al. 2005). Heavy precipitation may be one of the reasons for the currently measurable increase in flood events, for example in south-western Germany (Caspary 2004; Grieser and Beck 2002; Schönwiese et al. 2005). Still, an increase in flood events is only detectable in the winter months.

For the Upper Rhine Region, a shift of high runoff from summer to the winter half year respectively to spring has been detected (Middelkoop and Kwadijk 2001; AK KLIWA 2006). This is not only based on heavy precipitation events that occur in form of rain instead of snow but also due to the combination of the nival regime of the Alpine Rhine River and the pluvial regime of the Upper Rhine River (Zebisch et al. 2005; Moser 2006). This change to more frequent and more extreme runoff in winter (Jacob et al. 2008) may influence the infrastructure of adjacent installations and facilities. Studies show that runoff in the Upper Rhine Region in winter will increase by about 10%, in summer it will decrease by about 5% instead (Moser 2006).

Although the design water levels for plant safety, e.g. return periods $HQ_{1,000}$ and $HQ_{10,000}$, are not influenced by this change (AK KLIWA 2006), existing power plants need to be protected against floods. Therefore, the so-called design water level is calculated. A design water level is described as the highest water level to be expected for certain regions and a certain return period of the runoff extreme (DIN 2007). To adapt the design water level, the German research group KLIWA (Climate Change and Consequences for Water Management) established a climate change factor (AK KLIWA 2006). By adding the factor, the design water levels are calculated using the return period as well as an extra amount of runoff which is expected due to increasing precipitation.

Regulations

In Germany, two different regulations exist to specify the flood protection of industrial plants. For coal-fired power plants, the flood protection level required by the Association of German Engineers (VDI 2006) is a 100-year flood. For nuclear power plants, the level required by the Nuclear Safety Standards Commission (KTA) (2004) is a 10,000-year flood. On the one hand, for a nuclear power plant the return period of a $HQ_{10,000}$ should not change due to a shift in climate as described above. On the other hand, coal-fired power plants could be subject to increasing water levels during flood events. Nevertheless, both types of power plants are subject to different further regulations that imply flood protection measures.

Method

Although several guidelines deal with risk handling, none of these contains a specific approach how to manage flood risk via Geographical Information Systems (GIS). Therefore, the project “GIS-based flood risk management for thermal power plants" was established to collect data on climate and hydrology at power plant sites in a GIS and display the risks and the subsequent risk assessment. The advantage of a GIS-based approach is the storage, manipulation, and visualization of all available data of the specific power plant site as well as the legislation and regulations.

Concept

In the following, some guidelines containing risk handling will be described, compared, and adapted to a GIS-based approach. A general concept will be set up according to a scheme by Schmidt-Thomé (in Greiving and Fleischhauer 2006) containing the following steps:

- Problem analysis: In this phase, four major points are analysed. First of all, the problems need to be identified and the goals set. Therefore, a first data collection is initialized and the existing conditions are described. Since sites are supposed to be protected against flooding, relevant site-specific data is collected
- Assessing alternatives: In this second phase, measures are identified and impacts are estimated. Afterwards, the assessment through comparison is accomplished. For a site-specific approach, different water levels are illustrated for the sites
- Decision-making: In the decision phase of the project, first decisions are made on the basis of the previous steps. A plan for the operation of the identified measures is set up. In the site-specific approach, based on the illustrated water levels, an emergency plan is established
- Implementation: During the last phase, the emergency plan gets implemented at the site. Now protection measures can be checked and improved, which leads back to the identification of problems and thus to the first phase of problem analysis

Each of the steps is subject to a circle of plan, do, check, and act, which was set up by the Federal Ministry of the Interior to point out that a management and planning process consists of continuous actualization and further studies (BMI 2008). It is important to notice that the site-related approach starts with the identification of the risk itself ("do") and the GIS approach starts with an initial plan of the general structure, the database, and the background research ("plan").

Problem Analysis

In GIS-based flood risk management, four different analyses are carried out. First of all, a hazard analysis is a description of the characteristics of the hazard. This includes probability of occurrence, magnitude, intensity, place, and influence of geology, as well as meteorological components (Chen et al. 2004; Grünthal et al. 2006). The analysis of exposition includes the identification and mapping of all elements at the site, especially constructions and plant components as well as buildings and other infrastructural constructions, e.g. access routes, communication, supply, and disposal (Chen et al. 2004). The storage and handling of hazardous materials and substances should be implied in the GIS (Gunes and Kovel 2000; Grünthal et al. 2006). The vulnerability analysis is about the detection of the degree of vulnerability of one of the above-mentioned components against flooding (Chen et al. 2004; Grünthal et al. 2006). Here, the differences between variable water levels are of special interest, because not every water level has an impact on the same part of the site. The risk analysis consists of a combination, analysis, and assessment of the three mentioned analyses (Chen et al. 2004; Grünthal et al. 2006). As a result, maps and diagrams are generated that display the impacts of the flood risk on affected parts of the power plant site.

To carry out the complete problem analysis, the modelling needs to be prepared and a first concept should be set up. Within the preparation phase, goals and methods are specified. Technical terms as well as the degree of detail should be defined (Oltmanns et al. 2007). The goal is the protection of the power plant site against the calculated design flood level, e.g. the HQ_{100} or the $HQ_{10,000}$. This does not only include the protection of constructions and buildings against water intrusion but also the maintenance of operation, i.e. access to employees as well as fuel and lubricants. With the help of maps, which contain terrain- as well as site-specific information and the expected water levels, critical phases and places can be detected. To provide constant protection, specified water levels result in preassigned measures. The concept involves the basic duties of the company (Oltmanns et al. 2007). Those duties of coal-fired and nuclear power plants are to provide electricity for base and medium load and need to be protected. Mostly however, the capacity of electricity production is reduced due to high water levels. Such regulations are part of the operating manual.

Assessing Alternatives

For an assessment of alternatives, the actual state as well as the target need to be modelled. The first step is a display of the basic state even before the calculated design water levels are applied to the site. Therefore, the so-called actual state of the industrial site needs to be registered to realize weak points and identify, in a second step, the room for improvement (Oltmanns et al. 2007). Within the process-oriented management, modelling of the actual state encompasses a display of calculated design water levels in the GIS so that the planning of temporary flood protection measures can be carried out. The described room for improvement is implemented within the step of target modelling; every operation in the company will be adapted to the new situation (Oltmanns et al. 2007). For a power plant site, this means an emergency plan needs to be created and afterwards implemented. During the flood event, this emergency plan should be employed. The GIS helps to inform employees and shows still current weaknesses and solutions.

Decision-Making

According to Oltmanns et al., a structural organization for the decision-making process means a rearrangement of the present organization of the company to meet the challenges of a case of emergency (Oltmanns et al. 2007). Therefore, all existing measures are planned which guarantee the operation of the power plant in case of floods and which remove the potential damages as soon as possible. In this step, a GIS is used for orientation and to display the original state of structures and installations. Furthermore, storage places for tools as well as dry places for supply and disposal can be displayed which are classified as safe places that will not be affected by the flood.

Implementation and Continuity

Within this phase all suggestions for improvement as well as the perceptions of the flood event shall be implemented (Oltmanns et al. 2007). This means that in case of a flood of equal dimension, potentially emerging threats are recognized as early as possible and the site can be protected due to the adapted state. In a GIS, the changes (e.g. accumulation of material on the terrain, construction of dams, etc.) are implemented to establish an up-to-date database.

The last step of the planning process leads back to the initial point preparation of modelling as the process-oriented management is a perception cycle. The goals of the company may be rearranged after a flood event and the cycle begins with the preparation of modelling again (Oltmanns et al. 2007).

Exemplified Process of GIS-Based Flood Risk Management

As mentioned before, the GIS-based flood risk management can be described by a circle of plan, do, check, and act (BMI 2008). Whereas the site-related approach starts with the identification of the problem ("do"), the GIS-based approach starts with the planning and structuring of the management process ("plan"). Therefore, the two cycles, that run parallel but nevertheless in a different order, will be exemplified.

Site-Related Approach

Within the site-related approach, the first step is to identify the problem itself ("do"); this identification encompasses the direct and indirect influences of high water levels on power plant structures, listed in Table 19.1. As soon as a company

Table 19.1 Identification of direct and indirect influences of high water levels on power plant structures

Structure	Direct influence	Indirect influence
Buildings (offices, recreation)	Intrusion of water Damages to substance Damages to interior	Contamination due to mud as well as hazardous substances
Access roads	Overflowing	No access to power plant Difficult to evacuate
Cooling tower	Flooding of cooling tower pond to avoid its floating	Contamination due to hazardous substances
Reactor	Intrusion of water	Contamination due to mud as well as hazardous substances
Storage rooms	Intrusion of water	Wet protection measures Wetting of hazardous substances in case of wrong storage
Security places	Intrusion of water	Difficult to evacuate Contamination due to mud as well as hazardous substances
Cooling water intake and discharge structures	Overflowing Damages to structures due to collision with objects	Blockage with objects

has recognized its possible exposure to a hazard, in this case to floods, the initial steps in the planning process should be to take a critical inventory of all existing and missing protection measures and plans. If the identification reveals gaps in the protection, the following step contains research, a comparison of risks, an estimation of risks as well as the evaluation of the perceptions ("check"). Those perceptions are part of the following development of an emergency management as well as the supply of temporary protection measures ("act"). The subsequent step contains the equipments acquisition, the training of staff, and the implementation of the emergency plan ("plan").

GIS-Based Approach

The GIS-based approach starts with the planning of a general structure of the management process, data requests and background research ("plan"). Mostly, the GIS-structure consists of the original data, the tables, the processed data and the output. Within this structure, the layers for a GIS are prepared, the data sources are combined and compared, and afterwards – if needed – the uncertainties are calculated ("do"). Therefore, all available data from the Digital Elevation Model and site-specific data, e.g. the constructions and other buildings, on calculated design water levels is collected. To calculate the actual state and the target, the design water levels are displayed within the GIS first, simply by creating a layer of one polygon with the specified height of the water level over the terrain. Through an overlay of the Digital Elevation Model, site-specific data, and the “water layer”, a simple overview of dry and flooded areas is produced. In a second step, the real water depths can be calculated within the GIS. To complete an analysis, different water levels, which result in measures at the site and are defined in the operation manual, are displayed and analysed with regard to possible consequences and damage to constructions and the operating process (“check”). In case of an incomplete operation manual, steps of about ten centimetres from the lowest to the highest possible water level are a reasonable alternative.

For process-oriented management, plans and manuals need to be clear and easy to understand. Within the GIS, emergency plans that meet these obligations can be prepared and transported to the staff. The output of the comparison can be displayed digitally as well as transferred into an analogue form that is available even in case of a total blackout (“act”).

To combine the advances of the site-related and the GIS-based approaches, the steps are applied in the following order (see Fig. 19.1).

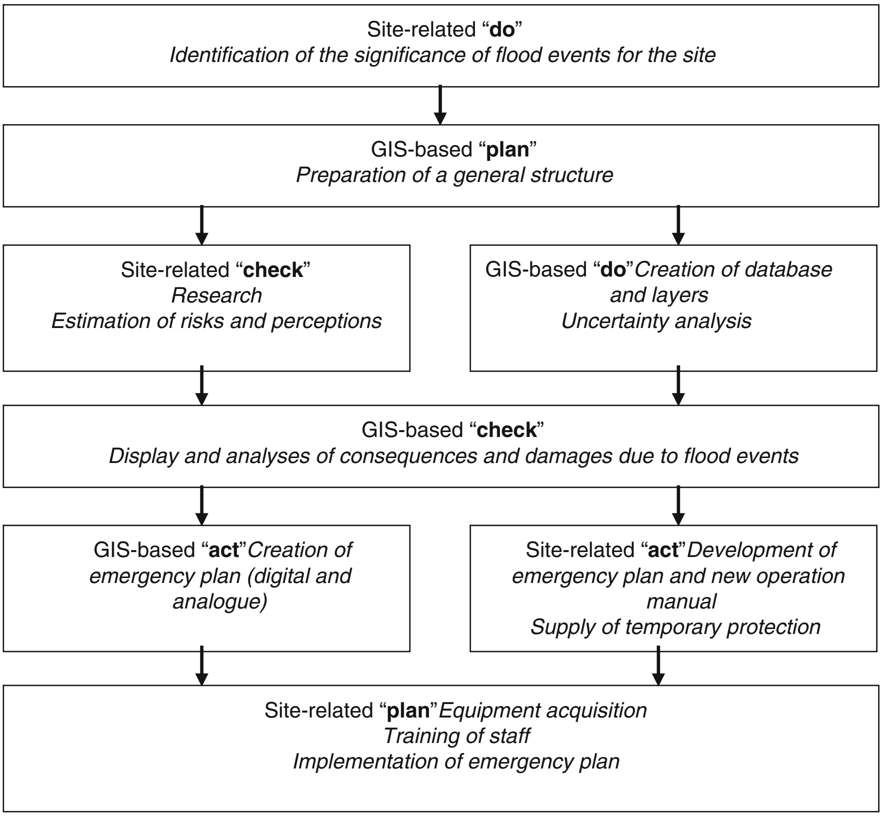

Fig. 19.1 Overview on steps taken within the circle of plan, do, check and act

Conclusions

Due to a changing climate in Germany, higher runoff in the winter half-year is expected, especially for the Upper Rhine Region. This may influence the operation of adjacent thermal power plants that are built near rivers in order to withdraw cooling water. Even though the effect of floods on power plants is well known, no regulations or concepts that specify the required protection level deal with risk handling via a Geographical Information System (GIS). This article therefore described a general concept on how to set up a strategy from the starting point of identification to the implementation of emergency plans with the use of a GIS. Within this method, different water levels may be displayed on the basis of a Digital Elevation Model and site-specific data. An overlay of the data reveals dry and flooded places, and this information can be used to install temporary and stationary protection measures, to transport additional information to the staff and to improve the operation of the power plant during a flood event.

References

Arbeitskreis Klimaveränderung und Konsequenzen für die Wasserwirtschaft (AK KLIWA) (ed) (2006) Regionale Klimaszenarien für Süddeutschland, Abschätzung der Auswirkungen auf den Wasserhaushalt, KLIWA- reports 9, self-published, Karlsruhe

Association of German Engineers (VDI) (2006) Richtlinie 6004-1: Schutz der Technischen Gebäudeausrüstung. Hochwasser. Gebäude, Anlagen, Einrichtungen, Beuth Verlag, Berlin

Caspary HJ (2004) Zunahme “kritischer” Wetterlagen als Ursache für die Entstehung extremer Hochwasser in Südwestdeutschland. KLIWA-Symposium 2004, pp. 170–186

Chen K, McAneney J, Blong R, Leigh R, Hunter L, Magill C (2004) Defining area at risk and its effect in catastrophe loss estimation: a dasymetric mapping approach. Appl Geogr 24:97–117

Deutsches Institut für Normung e.V. (DIN) (2007) DIN 19700-10: Stauanlagen – Gemeinsame Festlegungen, Ausgabe 2007-03. Beuth Verlag, Berlin

Federal Ministry of the Interior (BMI) (2008) Schutz Kritischer Infrastrukturen – Risiko- und Krisenmanagement, Leitfaden für Unternehmen und Behörden. self-published, Berlin

Greiving S, Fleischhauer M (2006) Spatial planning towards natural and technological hazards. In Schmidt-Thomé P (ed) Natural and technological hazards and risks affecting the spatial development of European regions. Geological Survey of Finland, Special Paper 42, pp 109–123

Grieser J, Beck C (2002) Extremniederschläge in Deutschland. Zufall oder Zeichen? Klimastatusbericht, DWD, pp 141–150

Grünthal G, Thieken AH, Schwarz J, Radtke KS, Smolka A, Merz B (2006) Comparative risk assessments for the city of Cologne – storms, floods, earthquakes. Nat Haz 38:21–44

Gunes AE, Kovel JP (2000) Using GIS in emergency management operations. J Urb Plann Dev 126:136–149

Jacob D, Göttel H, Kotlarski S, Lorenz P, Sieck K (2008) Klimaauswirkungen und Anpassung in Deutschland – Phase 1: Erstellung regionaler Klimaszenarien für Deutschland. In Umweltbundesamt Climate Change 11/08, Dessau-Roßlau

Middelkoop H, Kwadijk JCJ (2001) Towards integrated assessment of the implications of global change for water management – The Rhine experience. Phys Chem Earth B Hydrol Oceans Atmos 26(7–8):553–560

Moser H (2006) Einfluss der Klimaveränderungen auf den Wasserhaushalt des Rheins. Presentation, regionale 2010 – Rhine conference 2006. Accessed 14 Nov 2006

Nuclear Safety Standards Commission (KTA) (2004) Sicherheitstechnische Regel KTA 2207. Schutz von Kernkraftwerken gegen Hochwasser, self-published, Salzgitter

Oltmanns S, Kotthoff K, Sommer D, Stiller J, Verstegen C (2007) Managementsysteme in Kernkraftwerken. In: Entwicklung bundeseinheitlicher Kriterien von Sicherheitsmanagementsystemen auf der Grundlage von Sicherheitsindikatoren, Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS), self-published, Cologne

Schönwiese C-D, Staeger T, Trömel S (2005) Klimawandel und Extremereignisse in Deutschland. Klimastatusbericht, DWD, pp 7–17

Zebisch M, Grothmann T, Schröter D, Hasse C, Fritsch U, Cramer W (2005) Klimawandel in Deutschland – Vulnerabilität und Anpassungsstrategien klimasensitiver Systeme. Umweltbundesamt Climate Change 08/05, Dessau

Chapter 20
Release of Carbon Dioxide by Terrestrial Ecosystems Over Indonesia During the 1997–1998 ENSO Warm Event

Pavel Propastin

Abstract El Niño-Southern Oscillation (ENSO) is a global climatic phenomenon causing redistribution of rainfall from Southeast Asia into the Pacific and to the western coast of South America. The climatic conditions during ENSO warm events in insular Southeast Asia are characterized by a decrease in precipitation which is assumed to contribute to a reduction of photosynthetic activity of vegetation during such periods. Against this background, the study analyses the release of carbon dioxide in terrestrial ecosystems over the Indonesian archipelago during the El Niño event of 1997–1998 using satellite-based measurements of net primary production (NPP) and an ENSO proxy. We used 10-day time series of the NPP product derived from Advanced Very High Resolution Radiometer (AVHRR) by the Global Photosynthesis Ecosystem Monitoring (GLOPEM) group and the Multiple ENSO Index (MEI). Respiratory processes were estimated from complex mathematical models incorporating biome-dependent constants and climatic data. Using temporal correlation analysis (TCA), we were able to estimate statistically significant relations between dynamics of carbon dioxide exchange and the MEI variable, both at the scale of vegetation types and at per-pixel scale. The results revealed that the release of carbon dioxide caused by the 1997–1998 El Niño event differs between vegetation types and varies from one locality to another. Natural tropical rainforest experienced the weakest relative loss of carbon dioxide (mean value is 14.26 gC/m^2/month). For cropland, mosaics, and shrubland, the relative loss of carbon dioxide was 18.67 gC/m^2/month, 18.31 gC/m^2/month, and 17.05 gC/m^2/month respectively. These results confirm the hypothesis that, in general, tropical rainforest is better adapted to ENSO droughts than other land use systems. However, because of the largest area covered by the tropical rainforest in Indonesia (1.03 million km^2), the total loss of carbon dioxide for this land cover category was the greatest (17.23 million tonnes). For cropland (0.16 million km^2), mosaics (0.49 million km^2), and shrubland (0.18 million km^2), the total carbon dioxide

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release was 3.33, 13.31 and 7.33 million tonnes, respectively. The results of the study improve our understanding of ENSO impacts on the carbon cycle in tropical regions and demonstrate that the current conversion of tropical rainforest to other land use systems significantly increases the total discharge of carbon dioxide during ENSO warm events.

Keywords ENSO · Indonesia · NEP · NPP · Remote sensing

Introduction

The terrestrial carbon cycle is a highly dynamic system that includes several storage pools and different components of the flux. The total terrestrial carbon cycle can be classified into the following fluxes: gross primary production (GPP), total ecosystem respiration (R_e), and net ecosystem production (NEP). Annual plant growth is the difference between photosynthesis and autotropic respiration (R_a), and is referred to as net primary production (NPP). NPP is the fraction of GPP resulting in plant growth. The total ecosystem respiration (R_e) is the sum of all autotrophic (R_a) and heterotrophic (R_h) respiration over some time period from instantaneous fluxes to annual total. Net ecosystem production (NEP) is the most fundamental carbon flux for a natural ecosystem and is defined as the difference between NPP and heterotrophic respiration (R_h) (Running et al. 2000).

$$\mathrm{NEP} = \mathrm{NPP} + R_h. \tag{20.1}$$

Recent studies proved long-term and short-term temporal variations of the terrestrial carbon cycle. Long-term changes in carbon result from the contemporary global warming of the Earth climate leading to a redistribution of precipitation and temperature patterns on the Earth surface (Schaefer et al. 2002). According to calculations, globally about 44% of interannual variability in NEP resulted from precipitation, about 16% from temperature, and about 12% from soil carbon (Schaefer et al. 2002). In tropical forest ecosystems, variations in solar radiation and, to a lesser extent, temperature and precipitation, explained most interannual variation in GPP (Tian et al. 1998).

Short-term variations are caused by periodical climate fluctuations such as El Niño-Southern Oscillation (ENSO) (Ichii et al. 2005; Bousquet et al. 2000). The periodicity of ENSO events is approximately 2–7 years. It is a coupled atmospheric and oceanic mechanism responsible for changes in the Walker circulation system that in turn affects the global atmospheric circulation and, therefore, the weather and climate in other parts of the world (Hoerling and Kumar 2000). Indonesia belongs to the most affected areas. It is well known that the warm event of ENSO or El Niño results in droughts in Indonesia due to weakening of trade winds. The associated weather extremes affect many economical and societal branches such as agriculture, fisheries, energy consumption, environment and water resources, public health, and epidemiological prospects (Fox 2000). Therefore, there is a great demand for a better understanding of the impact of ENSO events on ecosystems in Indonesia. A number of recent satellite-based studies investigated the response of vegetation to ENSO warm events over the Indonesian archipelago (Gutman et al. 2000; Erasmi et al. 2009). These studies found evidence of the El Niño impact on interannual and intraannual vegetation dynamics over Indonesia during the last two decades. However, effects of ENSO on carbon storage in the Indonesian ecosystems has not yet been investigated.

The goal of the present study was to estimate the loss of carbon dioxide by the ecosystems in Indonesia during the ENSO warm event of 1997–1998. Using satellite-based measurements of net primary production and an ENSO index, we detected and measured areas characterized by the ENSO-caused carbon loss and calculated the total amount of CO_2 released into the atmosphere.

Data Used in the Study

Satellite Data

Net Primary Production

In this study, we used the Global Production Efficiency Model (GLOPEM) NPP product (Prince and Goward 1995). The GLOPEM used the approach first described by Montheith (1977) to calculate biomass by linking the incoming radiation to vegetation production through an empirical biophysical conversion factor – the light use efficiency (LUE). In this approach, gross primary productivity can be calculated as a product of LUE and the amount of photosynthetically active radiation absorbed by plants. The GLOPEM algorithm incorporates separate estimation of gross primary production and autotrophic respiration to account for potential differences in light use efficiency between vegetation types due to differences in respiration costs and climate conditions. These biome- and climate-induced ranges of LUE are taken into account in the GLOPEM by incorporating the optimal biome-specific LUE parameter, derived from an extensive set of observations, and linear ramp functions of minimum temperature and vapour pressure deficit. The lower and upper limits of these functions are biome-specific constants. For details on the most recent version of the GLOPEM model and input data used see Goetz et al. 2000; Cao et al. 2004. The GLOPEM NPP data is freely available from www.glcf.umiacs.umd.edu/data/glopem/. The GLOPEM NPP product has a spatial resolution of 8 km and covers the period 1981–2000. For this study, we extracted the Indonesia archipelago from the global NPP data set and transformed the original 10-day NPP values to monthly NPP sums.

Land Cover Data

The land cover information in this study is based on the GLC2000 global land cover product for the reference year 2000 at 1 km spatial resolution (Stibig et al. 2008). The initial land cover map included 17 land cover classes based on a global land cover classification system. For the purpose of this study, the LCCS classes were thematically aggregated to the five major land cover categories within the area under investigation [evergreen broadleaved forest (EBF), shrubland, grassland, cropland, mosaic of cropland and other natural vegetation]. The abbreviations used for these land cover classes are indicated in Fig. 20.1. For reasons of spatial coherence, the land cover data was resampled to 8 km spatial resolution and co-registered to the NDVI data using a nearest neighbour resampling algorithm.

Climate Data

ENSO Index

In order to describe the state of ENSO system or the intensity of a particular ENSO event, the so-called indices are used which are built e.g. on the basis of anomalies of climatic variables measured over the various parts of the Pacific Ocean. A comprehensive discussion on the ENSO indices can be found at http://www.cpc.ncep.noaa.gov. The ENSO index used for this study is the Multivariate ENSO Index (MEI), which evaluates the six observed atmospheric and maritime parameters to present the air–sea interaction (Wolter and Timlin 1998). These six parameters are: sea level pressure, zonal and meridional components of the surface wind, sea surface temperature, surface air temperature, and total cloudiness fraction of the sky. The MEI has recently been subject to several studies and showed its high suitability for remote sensing-based analyses of ENSO-vegetation relationships in various geographical regions and vegetation zones (Nagai et al. 2007; Propastin 2009). Strong positive values of MEI indicate thresholds for warm El Niño events.

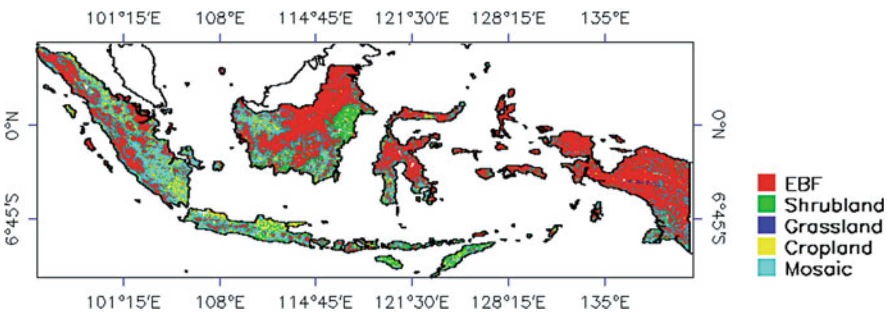

Fig. 20.1 Distribution of land-cover classes in Indonesia based on the GLC2000 global land cover product (Stibig et al. 2008)

We used 1 standard deviation from the mean value of MEI respectively as threshold for identifying ENSO warm events. Months with values of MEI below (above) 1 standard deviation were classified as El Niño months.

Temperature and Precipitation Dataset

Global data sets of air temperature and precipitation were used (New et al. 2000). This grid raster data is interpolated from climate station records and has a spatial resolution of 0.5°. This data is available from the Climatic Research Unit (CRU), School of Environmental Sciences, University of East Anglia (http://www.cru.uea.ac.uk/). For this research, the monthly temperature and precipitation data was resized to 8-km resolution to get a regional vision and to match the 8-km GLOPEM NPP dataset. In order to minimize information distortion and loss during the conversion process, we used the co-kriging technique for the interpolation of the data (Wackernagel 1998). Altitude above sea level was a co-variable in this interpolation process. A tile plot of the GTOPO30 digital terrain model covering the Indonesian archipelago was obtained from http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html. The use of altitude as an additional variable significantly decreased all negative consequences on the resizing of the source 0.5° dataset.

Methodology

The flowchart in Fig. 20.2 shows the processing stream for estimation of carbon dioxide release from Indonesian ecosystems. The parameters inside the parallelograms represent the input data sets used in the model, whereas the parameters inside the boxes are deriving during the execution of the model. Detailed description of

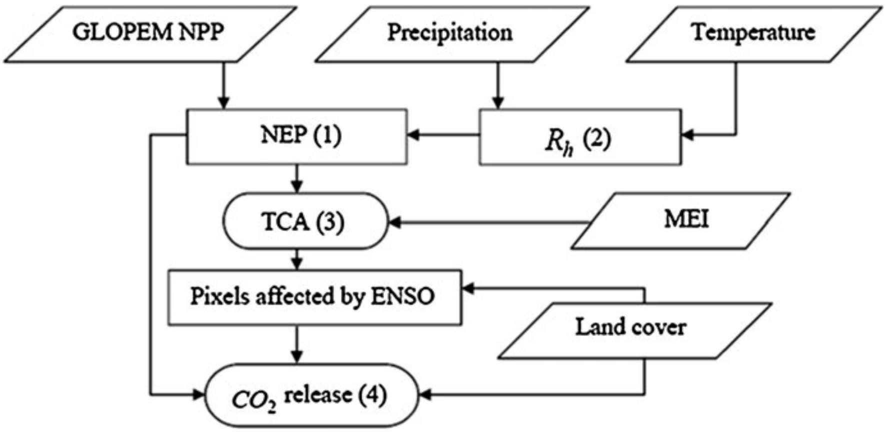

Fig. 20.2 Processing workflow for the estimation of CO_2 release (number of respective equations are in *brackets*)

the individual variables, modelling steps, and equations presented in the flowchart follows in the sections below.

Estimation of NEP

Using (20.1), we estimated carbon budget at the monthly time-scale for the period 1997–1998. In this model, the NPP is represented by the GLOPEM NPP data set, whereas the heterotrophic respiration is calculated from a climate-driven respiration model described in the next section.

Estimation of R_h

Heterotrophic respiration is the sum of respiration by decomposers (animals, bacteria, and fungi feeding on dead tissue or soil organic matter) and is most closely associated with the decomposition of residue and soil organic matter. The relative contributions of autotrophic and heterotrophic respiration to the total are important, whereas heterotrophic respiration includes soil respiration and respiration of dead biomass on the ground surface (litter).

The model of soil respiration by Raich et al. (2002) was developed using a compilation of reports about in situ measurements of soil CO_2 efflux around the world (n = 335). The model calculates the mean monthly soil-CO_2 efflux in gC/m^2/day (R_h) and contains three parameters: F is the base soil respiration rate when the mean monthly temperature is 0°C; Q (°C) defines the rate of change of the soil respiration rate with respect to temperature; and K (mm/ month) is the half-saturation constant for a hyperbolic relationship between soil respiration and rainfall:

$$R_h = F \times \exp(Q \times T_a) \times P/(K + P). \tag{20.2}$$

In this equation, T_a refers to the mean monthly air temperature (°C), and P is the mean monthly precipitation (cm). The experimental values the parameters encompassed in the equation are the following (Raich et al. 2002): F = 1.250; Q = 0.05452; K = 4.259. We used this model to estimate soil respiration for each grid cell of the Indonesian archipelago. As climatic inputs we used monthly temperature and precipitation data described in section “Temperature and Precipitation Dataset”.

Modelling the Relation Between NEP and ENSO

The relationship between NEP and the MEI was investigated using the temporal correlation analysis (TCA). The equation for calculation of the correlation coefficient using TCA is like that for the common correlation analysis but is expanded by implementing temporal lags and varying number of data points (n) that are included in the correlation analysis:

$$r_{in} = \frac{\frac{1}{n}\sum_{j=1}^{n}\left(MEI_j - \overline{MEI}_n\right)\left(NEP_{j+i} - \overline{NEP}_n\right)}{\sigma_{MEI_n}\sigma_{NEP_n}} \qquad (20.3)$$

where r_{in} is the correlation coefficient between NEP and MEI calculated for temporal lag i; n is the amount of month included in the correlation analysis; MEI_j and NEP_{j+i} are values of the dependent and independent variables NEP and MEI with consideration of a temporal lag i; $\overline{MEI}_n$ and $\overline{NEP}_n$ are mean values of MEI and NEP calculated within the n; σ_{MEI_n} and σ_{NEP_n} are corresponding standard deviations for MEI and NEP.

Calculations were done between synchronized time series and by imposing temporal lags from 0 to 6 months into the correlation analysis. Measured on the value of MEI, the ENSO warm event of 1997–1998 lasted 12 months (from June 1997 to June 1998). However, the impact of an ENSO event on tropical ecosystems is characterized by a prolonged response of vegetation. Therefore, it is difficult to estimate the accurate temporal borders of the ecosystem response to ENSO during an event. We tested different numbers of months included in the single TCA (from 18 to 48) in order to find the closest correlation between NEP and MEI.

We repeated this correlation analysis for every pixel in Indonesia. Pixels showing a statistically significant correlation coefficient ($p < 0.05$) were considered to represent areas which carbon budget was affected by the ENSO event of 1997–1998. These areas were mapped and measured. Percentage of these areas was calculated both for the total area and for the individual land cover types.

Calculating the Release of Carbon Dioxide

For pixels with statistically significant correlation to MEI ($p < 0.05$) we calculated the carbon dioxide budget throughout the 1997–1998 ENSO event. Similar calculations were also done for each of the temporal lags (from 0 to 6 months) in order to capture the prolonged effect of ENSO on NEP. For example, when we calculated the carbon budget on the concurrent basis (without implemented temporal lags), we summed NEP for all the months from the beginning (June 1997) to the end (June 1998) of the 1997–1998 ENSO event. When we calculated the carbon budget by imposing 1 lag, we summed NEP throughout July 1997 to July 1998. After that, we re-calculated the results from the per-pixel level to the individual land cover classes and to the whole Indonesian archipelago. The following equation was used for the re-calculations:

$$C(N) = \sum_{i}^{k} C(n) \times A_n \qquad (20.4)$$

where C(N) is the total carbon release for the land cover class *N*; C(n) is the carbon release for a pixel *n*; A_n is the area of one pixel; and *k* is the amount of pixels with statistically significant correlation between NEP and MEI in the land cover class *N*.

Results

Dynamics of NEP and MEI During the ENSO Event of 1997–1998

During the period from 1997 to 1998, Indonesia experienced a strong El-Niño event which lasted 12 months. Figure 20.3 shows 2-year courses of monthly NEP from sample sites taken in different land cover types versus MEI. One can observe a clear relationship between temporal patterns of the ENSO proxy and NEP. According to MEI, the 1997–1998 El-Niño episode began in June 1997. The MEI rapidly increased from about 0 in April to 0.46 in May and to 1.25 in June. During the summer months, the MEI continued to increase and reached local maximum of 2.88 in August, after which the short decrease in autumn–winter was observed, followed finally by a new local maximum in March 1998 (2.76). Thereafter, the MEI gradually declined during the following months until it reached its normal value in July 1998.

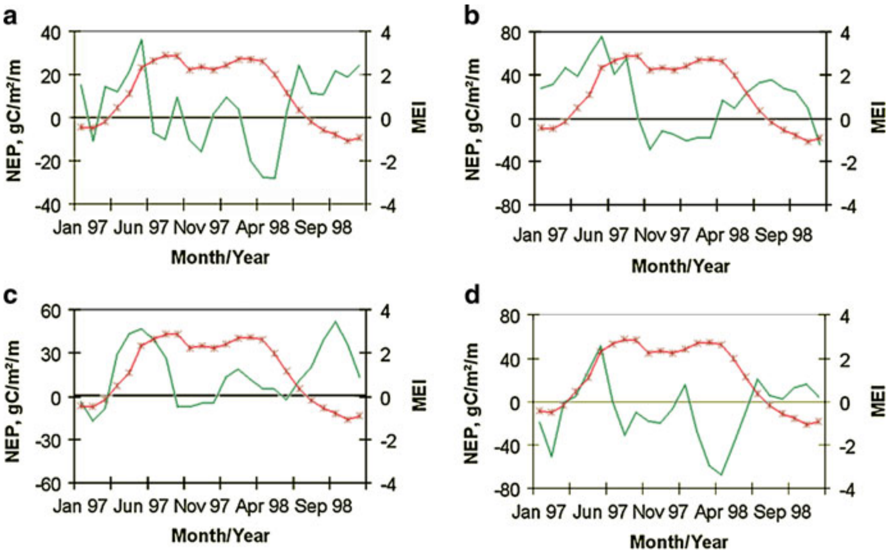

Fig. 20.3 Monthly variations in net ecosystem production (*green line*) and MEI (*red line*) from sample sites taken in (**a**) mosaics (3°20′45.22″S, 103°59′53.57″E), (**b**) cropland (7°2′8.32″S, 111°7′10.49″E), (**c**) tropical rainforest (0°35′48.32″S, 112°55′4.46″E), and (**d**) shrubland (2°15′38.43″S, 115°4′33.22″E) in Indonesia. Positive NEP indicates carbon uptake from atmosphere to biosphere

Intraannual dynamics of NEP from the sample sites in Fig. 20.3 showed high month-to-month variability over the investigated period 1997–1998 with large negative anomalies corresponding with the ENSO months. Previous investigations based on terrestrial ecosystem modelling studies (Ito and Oikawa 2000; Cao et al. 2002) and atmospheric CO_2 inversions studies found similar patterns in the ENSO affected regions throughout the world (e.g. Bousquet et al. 2000). Figure 20.3 also shows that patterns in monthly NEP significantly differ between the land cover types. Thus, shrubland and cropland show a stronger reaction of NEP to MEI than forest and mosaics: the magnitude of NEP anomalies for these sample sites (Fig. 20.3b, d) is much higher than for the sample sites from forest and mosaics (Fig. 20.3a, c). These results correspond with the results of the study by Erasmi et al. (2009) that proved a lower sensitivity of tropical rainforest and other wooded vegetation types in Indonesia to ENSO warm events.

Spatial Patterns of ENSO-Affected Carbon Release

Results of the correlation analysis at the per-pixel scale showed that the relationship between NEP and MEI varies extensively over the vegetated area of the Indonesian archipelago. The strength of the relationship and its direction also changed with changing temporal lag implemented into the correlation analysis. For the purpose of our study, only areas with statistically significant negative correlation between NEP and MEI were interesting. These areas are characterized by the ENSO-driven release of carbon dioxide. We detected, mapped, and measured these areas for different land cover classes.

Over the whole of Indonesia, the results of our calculations show that only 2.04% of all vegetated pixels exhibited negative correlation with MEI on the concurrent basis of the correlation analysis (Table 20.1). The percentage of the ENSO-affected pixels substantially grows with increasing the temporal lag and achieves its maximum by 4 lag (11.55%). The implementing of larger temporal lags (>4) into the correlation analysis did not add to the percentage of the ENSO-affected pixels.

Table 20.1 Percentages of pixels with statistically significant ($p < 0.05$) negative correlation to MEI over the vegetated pixels for different land cover types and different temporal lags

Land-cover type	Temporal lags						
	0	1	2	3	4	5	6
Evergreen broadleaved forest	0.98	2.43	6.70	7.69	9.78	8.17	7.03
Shrubland	1.02	4.37	12.79	19.77	19.21	17.20	14.21
Grassland	3.45	8.34	16.12	12.90	6.45	6.45	3.22
Cropland	0.68	1.29	4.25	9.40	9.01	7.86	5.71
Mosaics	1.09	2.66	6.73	12.36	10.84	9.02	7.40
Total	2.04	2.15	9.32	10.73	11.55	9.59	8.87

The percentage of pixels with statistically significant correlation between NEP and MEI varied substantially by land-cover type. Shrubland and grassland showed substantially larger percentage than the other vegetation types. For shrubland, the percentage of these pixels varied from 1.02% (no lag) to 19.77% (3 lag), while for grassland – from 3.22% (no lag) to 16.12% (2 lag). For the other vegetation classes, the percentage of pixels with significant correlation never exceeds 12%.

The investigated land-cover types are different according to the time of their maximum reaction to the unfavourable climate conditions caused by the 1997–1998 ENSO event. For tropical rainforest, maximum percentage of the ENSO-affected pixels is observed by imposing a temporal lag of 4 months into the correlation analysis. For cropland, mosaics, and shrubland, the highest percentage is observed by a temporal lag of 3 months. For grassland, the time of maximum reaction to ENSO is shorter: the highest percentage is observed by 2 lags. These results support the study by Erasmi et al. (2009) which concluded that forest vegetation shows a long-lasting and weaker reaction to ENSO-caused drought conditions than other vegetation classes.

Pixels with statistically significant correlation between NEP and MEI are densely distributed in the middle part of Kalimantan, west-southern and southern parts of New Guinea, as well as northern part of Sumatra (Fig. 20.4). There are only sparse sporadically distributed ENSO-affected pixels across other regions of the Indonesian archipelago. Previous satellite-based studies found similar spatial patterns of ENSO-affected areas over the Indonesian land (Erasmi et al. 2009; Gutman et al. 2000).

Release of Carbon Dioxide by Indonesian Ecosystems

Table 20.2 summarizes the results of calculating the release of carbon and carbon dioxide by vegetation class and as well as their totals over the entire Indonesian vegetated land. For the whole of Indonesia, the total loss of carbon into atmosphere was 41.25 million tonnes. Recalculating for carbon dioxide resulted in 151.24 millions tonnes of CO_2 escaping into the atmosphere during the 1997–1998 ENSO event. Averaged over the whole of Indonesia, the mean rate of carbon loss was 17.88 gC/m^2 per month or 214.65 gC/m^2 summed throughout the 12 months of the event. The rates of carbon release and the contributions to the total carbon loss were different for the vegetation classes. Despite the fact that the forest's carbon release rate was the lowest among all the vegetation classes, tropical rainforest was the major contributor, responsible for almost 43% of the total carbon loss (17.23 from 41.25 million tonnes), because the area covered by rainforest is the largest among all the vegetation classes in Indonesia.

The land-cover class mosaics were the second major contributor, losing 13.31 million tonnes of carbon during the ENSO months. Even though the area covered by mosaics is 2 times smaller than the area of rainforest in Indonesia (about 0.5 million km^2 versus 1.1 million km^2; cf. Table 20.3), the contribution

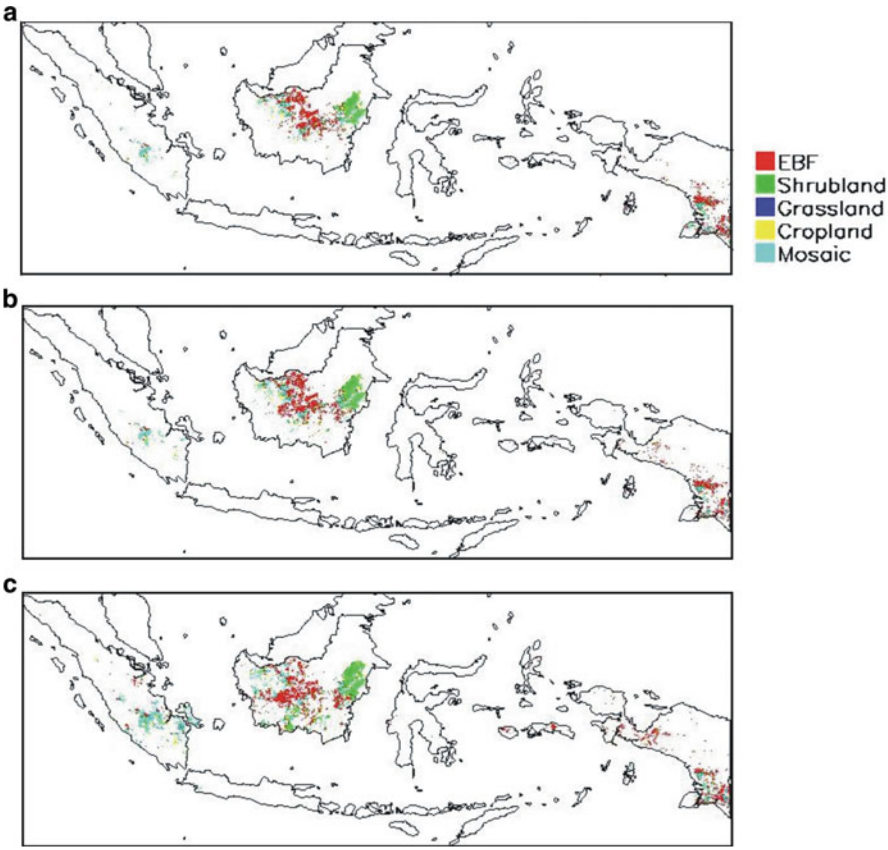

Fig. 20.4 Pixels within the land cover classes that show statistically significant correlation between NEP and MEI by imposing (**a**) 2 lags, (**b**) 3 lags, and (**c**) 4 lags into the correlation analysis

Table 20.2 Amounts of carbon (C) and carbon dioxide (CO_2) released into atmosphere during the 1997–1998 ENSO warm event

Land-cover type	Best temporal lag	Mean NEP (gC/m^2/month)	NEP (gC/m^2)	Total C loss (10^6 tons)	Total CO_2 loss (10^6 tons)
Evergreen broadleaved forest	4	14.26	171.14	17.23	63.21
Shrubland	3	17.05	204.18	7.33	26.87
Grassland	2	21.17	254.11	0.08	0.29
Cropland	3	18.67	224.16	3.32	12.69
Mosaics	3	18.31	219.75	13.31	48.83
Total	4	17.88	214.65	41.25	151.24

of this land-cover type to the total carbon loss is compatible with the contribution of the rainforest. The reason for this is the higher rate of carbon release

Table 20.3 The total number of pixels within each land-cover class, its area, and percentage in Indonesia based on the GLC2000 global land cover product (Stibig et al., 2000)

Land-cover type	Number of pixels	Area, 10^6 km^2	Percentage, %
Evergreen broadleaved forest	16,087	1.0296	55.32
Shrubland	2,837	0.1816	9.75
Grassland	31	0.0019	0.11
Cropland	2,466	0.1578	8.48
Mosaics	7,659	0.4902	26.33
Total	29,080	1.8611	100.00

observed by the mosaics. The contribution of shrubland amounts to 7.33 million tonnes (about 18% of the total carbon loss). Contributions of cropland and grassland (3.33 and 0.08 millions tonnes) are very low at the present stage of land-cover distribution in Indonesia.

Discussion and Conclusions

The study estimated the discharge of carbon and carbon dioxide from Indonesian ecosystems which was driven by the unfavourable climatic conditions caused by the 1997–1998 ENSO warm event. We calculated net ecosystem production (NEP) from time series of the GLOPEM NPP product and total ecosystem respiration estimated from a mathematical model developed by Raich et al. (2002). The modelled NEP values were then analysed in combination with the Multiple ENSO Index (MEI) that served as a proxy of ENSO dynamics. Using correlation analysis, we detected vegetated areas of Indonesian land, which were characterized by statistically significant response to MEI. For these areas, we calculated carbon escape into atmosphere during the ENSO warm event of 1997–1998.

In terms of the extent of the ENSO-affected areas, grasslands and shrublands were found to be the areas mostly impacted by unfavourable climatic conditions during the 1997–1998 El Niño warm event. These land-cover categories are characterized by the highest percentage of ENSO-affected areas, whereas tropical rainforest has the lowest percentage. These results correspond well to the conclusions from previous satellite-based studies by Erasmi et al. (2009) for Indonesian vegetation and by Propastin (2009) for African vegetation, which proved lower sensitivity of forest to ENSO in comparison to other non-forest vegetation classes.

The results revealed that the release of carbon dioxide caused by the 1997–1998 El Niño differs between vegetation types and varies from one locality to another within the vegetation types. In terms of the sensitivity to ENSO expressed in the carbon discharge rate, tropical rainforest is characterized by the lowest sensitivity among all the land cover types. Shrubland, cropland, and mosaics showed significantly higher sensitivity to ENSO than forest but lower sensitivity than grassland. The lower rates of carbon release by forest ecosystems can be explained by the ability of root systems of forest trees to accumulate moisture from wet periods and to use it gradually over time during dry periods.

The total loss of carbon from the Indonesian terrestrial ecosystems was 41.25 million tonnes. This corresponds to 151.24 million tonnes of CO_2. Rainforest has the largest area among all the vegetation classes (55% of the total area of Indonesia) and is the greatest contributor to the total carbon release (42%). Four other vegetation classes – grassland, cropland, mosaics and shrubland – account for the remaining 58% of the total carbon release, even though that they cover only 45% of the total area of Indonesia. The Indonesian land cover is characterized by the undergoing process of intensive deforestation (Erasmi et al. 2007). Therefore, we have to expect that the contributions of mosaics and shrubland to the total ENSO-driven carbon release will be considerably increasing over the next few decades. The analogous suggestion can also be applied to the cropland: a stable increase of its area will certainly make cropland an important contributor to the ENSO-driven carbon release in the near future. Against these conditions, we can conclude that the undergoing deforestation increases the sensitivity of the Indonesian ecosystems to ENSO warm events. Bearing in mind that the deforestation will be in progress in the near future, we have to expect a significant increase in ENSO-driven carbon loss in Indonesia during the next few decades.

References

Bousquet P, Peylin P, Ciais P, Le Quere C, Friedlingsten P, Tans PP (2000) Regional changes in carbon dioxide fluxes of land and ocean since 1980. Science 290:1342–1346

Cao M, Prince SD, Shugart HH (2002) Increasing terrestrial carbon uptake from 1980s to the 1990s with changes in climate and atmospheric CO^2. Global Biogeochemical Cycles 16:1069

Cao M, Prince S, Small J, Goetz SJ (2004) Remote sensing interannual variations and trends in terrestrial net primary productivity 1981–2000. Ecosystems 7:233–242

Erasmi S, Knieper C, Twele A, Kappas M (2007) Monitoring inter-annual land cover dynamics at the rainforest margin in Central Sulawesi, Indonesia. In: Bochenek S (ed) New developments and challenges in remote sensing. Milpress, Rotterdam, pp 297–308

Erasmi S, Propastin P, Kappas M, Panferov O (2009) Spatial patterns of NDVI variation over Indonesia and their relationship to ENSO warm events during the period 1982 – 2006. J Clim (in print)

Fox JJ (2000) The impact of the 1997-98 El-Niño on Indonesia. In: Grove RH, Chappell J (eds) El-Niño: History and crisis. The White Horse Press, Conway, pp 171–190

Goetz SJ, Prince SD, Small J, Gleason A (2000) Interannual variability of global terrestrial primary production: results of a model driven with satellite observations. J Geophys Res Atmos 1005:20077–20091

Gutman G, Csiszar I, Romanov P (2000) Using NOAA/AVHRR products to monitor El Nino impacts: focus on Indonesia in 1997-98. Bull Am Meteorol Soc 81:1188–1205

Hoerling MP, Kumar A (2000) Understanding and predicting extratropical teleconnections related to ENSO. In: Diaz HF, Markgraf V (eds) El Niño and the Southern Oscillation: multi-scale variations and global and regional impacts. Cambridge University Press, Cambridge, pp 57–88

Ichii K, Hashimoto H, Nemani R, White M (2005) Modelling the interannual variability and trends in gross and net primary productivity of tropical forests from 1982 to 1999. Glob Planet Change 48:274–286

Ito A, Oikawa T (2000) A model analysis of the relationship between climate perturbations and carbon budget anomalies in global terrestrial ecosystems: 1970 to 1997. Clim Res 15:161–183

Montheith JL (1977) Climate and the efficiency of crop production in Britain. Philos Trans Roy Soc Lond B 281:277–294

Nagai S, Ichii K, Morimoto H (2007) Inter-annual variations in vegetation activities and climate variability caused by ENSO in tropical rainforest. Int J Remote Sens 28:1285–1297

New M, Hulme M, Jones PD (2000) Global monthly climatology for the twentieth century. Data set, available online http://www.daac.ornl.gov

Propastin PA (2009) Monitoring system for assessment of vegetation sensitivity to El-Nino over Africa. In: Sester M, Bernard L, Paelke V (eds) Advances in GIScience. In: Lecture Notes in Geoinformation and Cartography. Springer, Berlin, pp 329–342

Raich JW, Potter CS, Bhagawati D (2002) Interannual variability in global soil respiration, 1980-94. Glob Change Biol 8:800–812

Running SW, Thornton PE, Nemani R (2000) Global terrestrial gross and net primary productivity from the earth observing system. In: Sala OE, Jackson RB, Mooney HA, Howarth RW (eds) Methods in ecosystem science. Springer, New York, pp 44–57

Schaefer K, Denning AS, Suits N, Kaduk J, Baker I, Los S, Prihodko L (2002) Effect of climate on interannual variability of terrestrial CO^2 fluxes. Global Biogeochem Cycles 16:1102–1110

Stibig H-J, Upik R, Beuchle R, Hildanus, Mubareka S (2008) The land cover map for South East Asia in the Year 2000. In: GLC2000 database, European Commission Joint Research Centre, 2003. Available online at http://www-gem.jrc.it/glc2000

Tian H, Mellilo JM, Kicklighter DW, McGuire AD, Helfrich JVK, Moore B, Vorosmarty CJ (1998) Effect of interannual climate variability on carbon storage in Amazonian ecosystems. Nature 396:664–667

Wackernagel H (1998) Multivariative geostatistics: an introduction with applications. Springer, New York

Wolter K, Timlin MS (1998) Measuring the strength of ENSO – how does 1997/98 rank? Weather 53:315–324

Chapter 21
The Potential of Major Hydro and Wind Energy Projects for Seeking Carbon Credits Under the Clean Development Mechanism and Voluntary Markets

Nitin Chaudhary and Shubhangi Lamba

Abstract Climate change is recognized as one of the greatest environmental threats facing the world today. To tackle this problem, a protocol was adopted in Kyoto in 1997 which establishes legally binding commitments to developed countries to bring down the emissions of six major greenhouse gases by 5.2% compared to the year 1990. Three flexibility mechanisms have been provided to developed countries to achieve the target of emission reduction under this protocol and one of them is the Clean Development Mechanism (CDM), which allows industrialized nations or private entities therein to implement emission reduction projects in developing countries and receive credits in the form of Certified Emission Reduction (CERs), which may be counted against their national reduction targets. The fund channelled through the CDM by developed countries can assist developing countries to achieve objectives contributing to sustainable development and poverty alleviation. Against this background, the paper discusses about the scope of hydroelectric and wind projects in the CDM market in India and also looked at the options available other than the CDM market, namely the Voluntary Carbon Market. It also identifies to what extent the potential of these projects could be harnessed and also presents the key challenges to making full use of these opportunities.

Keywords Carbon credits · CDM · Hydro · Projects

Introduction

Climate change is recognized as one of the greatest environmental threat facing the world today. It threatens to have a major adverse impact on the natural world, as well as on human society. The Inter-Governmental Panel on Climate Change (IPCC),

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representing the vast majority of scientists internationally, predicted in its first assessment report that if no action were taken to limit greenhouse gas (GHG) emissions, temperatures would rise in the range of 1.4–5.8°C by the year 2100. This would be a faster rate of warming than at any time since the end of the last ice age, 10,000 years ago. There is scientific consensus that a doubling of atmospheric carbon dioxide concentrations could have a variety of serious environmental consequences in the days to come. The impacts of climate change may vary in severity across regions and include variations in rainfall pattern, changes in species composition in terrestrial ecosystems, thawing of permafrost, poleward migration of freshwater fish habitats, decrease in sea ice-over, changes in salinity, wave conditions and ocean circulation, sea level rise and accelerated erosion of coastal areas, increase in flood and droughts, retreat of glaciers, variations in the crop growing seasons affecting agriculture – further endangering food security, increasing intensity of natural disasters, species extinction, and the spread of vector-borne diseases (IPCC 2001a).

In 1990, after the IPCC came out with its first assessment report confirming that global climate change was indeed a threat, the international community responded through the United Nations formally launching a framework convention on climate change, the United Nation Convention on Climate Change (UNFCCC). Adopted in 1992 in Rio, the UNFCCC set a framework for action aimed at stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

After that, the first conference of parties to the convention (COP-1) was held in Berlin from March to April 1995. During COP-1, it became clear to the world community that Rio was not enough, and participants pressed for adequacy of commitment by the developed countries for the reduction of greenhouse gas emissions. Accordingly, a protocol to the climate change convention was adopted in Kyoto on 11 Dec 1997, now known as the Kyoto Protocol. The objective of the Kyoto Protocol is to bring down global greenhouse gas emissions by 5.2%. The Kyoto Protocol establishes legally binding commitments for the reduction of six greenhouse gases, namely carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons produced by "Annex I" (industrialized) nations, as well as general commitments for all member countries. As of 2008, 183 parties have ratified the Protocol, which entered into force on 16 Feb 2005. Under its first commitment period from 2008–2012, industrialized countries have agreed to reduce their collective GHG emissions by 5.2% compared to the year 1990.

Flexibility Mechanism Under Kyoto Protocol

Kyoto Protocol defined three "flexible mechanisms": Emissions Trading, Joint Implementation, and the Clean Development Mechanism to allow Annex I economies to meet their greenhouse gas (GHG) emission limitations by purchasing GHG emission reductions credits from elsewhere, through financial exchanges, projects that reduce emissions in non-Annex I economies, from other Annex I countries, or from Annex I countries with excess allowances. In practice, this means that non-Annex I economies have no GHG emission restrictions, but have financial incentives to develop GHG emission reduction projects to receive “carbon credits” that can then be sold to Annex I buyers, encouraging sustainable development. In addition, the flexible mechanisms allow Annex I nations with efficient, low GHG-emitting industries, and high prevailing environmental standards to purchase carbon credits on the world market instead of reducing greenhouse gas emissions domestically. Annex I entities typically want to acquire carbon credits as cheaply as possible, while non-Annex I entities want to maximize the value of carbon credits generated from their domestic greenhouse gas projects.

Clean Development Mechanism

The Clean Development Mechanism (CDM), described in Article 12 of the Kyoto Protocol, allows government or private entities in industrialized (Annex I) nations to implement emission reduction projects in developing (non-Annex I) nations and receive credits in the form of Certified Emission Reductions (CERs), which may be counted against their national reduction targets. The objective of the Protocol is stated in Article 12.2 of the Protocol: “the purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the convention, and to assist Parties included in Annex I in achieving compliance with their qualified emission limitation and reduction commitments under Article 3”.

The fund channelled through the CDM to the developing nations can assist them achieve objectives contributing to sustainable development and poverty alleviation. As these nations, preoccupied with their social and economic needs, commit their existing resources towards fulfilling these, this mechanism may provide an incentive to participate in the climate mitigation process and adopt cleaner technologies, and improve land use. To take part in the CDM project, all the Parties concerned have to fulfil three eligibility criteria: voluntary participation, ratification of the Kyoto Protocol and establishment of designated national authority (DNA) for CDM, whose role is to confirm that the projects contribute towards sustainable development in the country.

The kind of projects eligible under the CDM include: energy efficiency improvement (e.g. cogeneration), renewable energy projects (e.g. hydro, wind, solar), fuel switching, industrial processes (e.g. CO_2 emissions from cement production), agriculture (e.g. reduction of methane emissions), waste management, solvent and other chemical use, forestry projects (only afforestation and reforestation).

As of 5 Nov 2008, 360 projects have been registered by the CDM executive board and 1,426 projects are at or after the validation stage. The numbers of projects registered by the scheme in India are listed below in Tables 21.1 and 21.2, with their

Table 21.1 Basic information (as of 5 Nov 2008)

Project status	No. of projects
CDM projects registered at CDM executive board	360
CDM projects at or after the validation stage	1,426

Source: Country Fact Sheet: India

Table 21.2 Basic data on registered CDM projects (as of 5 Nov 2008)

	No. of projects	Annual emission reduction (tCO_2/year)	Total ERs by 2012 (tCO_2)	Amount of CERs issued (tCO_2)
Biomass	120	4,200,190	29,912,628	4,319,268
Wind power	58	2,163,343	17,868,315	2,120,362
Waste gas/heat utilization	50	4,816,998	31,796,172	6,529,379
Hydropower	43	3,271,569	12,817,102	964,551
Energy efficiency	42	1,005,127	7,529,638	677,261
Cement	17	1,973,310	16,806,437	945,758
Fuel switch	11	4,168,479	21,129,990	794,329
Biogas	9	264,308	1,907,283	292,945
HFC reduction	4	10,174,879	80,751,326	28,814,392
Methane avoidance	3	368,893	1,282,448	0
Methane recovery and utilization	1	64,599	569,990	75,896
Transportation	1	41,160	236,811	0
Other renewable energies	1	562	3,936	0
Total	360	32,513,417	222,612,076	45,534,141

Source: Country Fact Sheet: India

annual emission reduction potential per year, total emission reduction by 2012, and amount of CERs to be issued:

Voluntary Markets for Carbon Projects

As international trade in greenhouse gas reductions is now becoming a large and rapidly growing market, there is another window developing for the carbon mitigation projects for companies, institutions, and individuals who voluntarily want to reduce their carbon footprints. They can purchase emission reduction units from this newly formed market. The voluntary market has been very small compared to the regulatory market, but has been growing quickly according to many reports. The voluntary market generally applies to companies, individuals, and other entities and activities not subject to mandatory limitations that wish to offset GHG emissions. An ICF Consulting report suggests the voluntary market could expand from 10 million to 25 million tonnes (Mt) of CO_2e in 2005 to a mid-range estimate of 400 $MtCO_2e$ by 2010. Michael Molitor of Climate Wedge estimates that demand in

Table 21.3 Carbon market programmes

Carbon market	System	Notes
Clean development mechanism	Regulatory	Certified Emission Reductions can be used for compliance with Kyoto Commitments
Voluntary offsets markets	Voluntary	Companies, individuals, and events buy emission reductions to reduce their carbon footprints

Table 21.4 Carbon trading prices

Carbon market programme	Approx. US $/tonne CO_{2e} (March 2007)
Clean development mechanism	6–16
Voluntary offsets markets	5–20+

the voluntary market could grow to over 500 Mt in the next 3 years. The buyers under voluntary markets include companies that buy offsets for their own operations, companies that buy offsets on behalf of their customers (e.g. airlines and travel agents, automobile and petroleum companies), events (e.g. the G8 Summit, the World Cup), and individuals. The sellers include retailers and wholesalers who buy and resell offsets, and project developers who develop GHG-abating activities and sometimes sell direct. The brokers acting as market intermediaries connects project developers and resellers with institutional ER buyers and consultants who help clients select ER suppliers and prepare offsets portfolios (Tables 21.3 and 21.4).

Scope of Hydro Projects Under CDM

The production of electricity through the use of the gravitational force of falling or flowing water is known as hydropower. It is the most widely used form of renewable energy. Once a hydropower complex is created, the project generates minimal or no waste, and has a considerably different output level of greenhouse gases (mainly CO_2) than fossil fuel-powered energy plants. Worldwide, hydroelectricity supplied an estimated 715,000 MWe in 2005.[1] This was approximately 19% of the world's electricity (up from 16% in 2003), and accounted for over 63% of electricity from renewable sources.

India has one of the largest programmes in renewable energy, including small hydro, wind, solar, biomass, etc. Out of these programmes, power generation from hydro has emerged as one of the most rapidly growing renewable technologies in the country. India has immense economically exploitable hydropower potential of over 84,000 MW at 60% load factor (148,700 MW installed capacity), with

[1] http://ga.water.usgs.gov/edu/wuhy.html.

Table 21.5 List of hydro electric stations with capacity above 3 MW

Region	No. of stations	No. of units	Capacity in MW
Northern	78	234	11,070.30
Western	45	117	6,588.80
Southern	92	286	11,004.35
Eastern	26	82	2,424.10
North Eastern	15	42	1,094.70
Total	256	761	32,182.25

Source: Fact Sheets, Press Information Bureau Government of India

Brahmaputra, Indus and Ganges basins contributing about 80% of it. In addition to this, small, mini, and micro hydropower schemes (with capacity of less than 3 MW) have been assessed to have 6,781.81 MW of installed capacity. Of this enormous hydro potential, India has harnessed only about 15% so far, with another 7% under various stages of development. The remaining 78% remains un-harnessed due to many issues and barriers to the large-scale development of Hydropower in the subcontinent (Table 21.5).

There is a wide scope for the hydro project under Clean Development Mechanism activities. The CDM allows hydropower projects with less than 25 MW capacity to claim carbon credits. In India, there is an estimated potential of 6,781.81 MW from small hydropower projects. Of this, about 2,000 MW has been tapped so far under CDM. This shows that there is a significant potential for taking up CDM projects in this segment. India, which accounts for 29.76% of the world's CDM projects, has a huge opportunity for small hydropower projects to get carbon credits or Certified Emission Reductions (CERs).[2] Till now, India has had more than 70 small hydroprojects in the pipeline to get CDM status. Of these, 43 have already been registered, while others are at the validation stage. The small-scale CDM projects have several benefits compared to the large scale CDM projects, including easy approval by the CDM Executive Board (normally for large-scale CDM projects, it is a tedious process and higher chances for review during registration or issuance of CERs), lower registration fees and lower registration time (4 weeks instead of 8 weeks as a requisite for large-scale CDM projects) and the same DOE can be continued from validation till verification and certification.

Large hydropower plants can also take advantage of the CDM mechanism, subject to the conditions stipulated in the methodologies of CDM. Noting the scientific uncertainties concerning greenhouse gas emissions from reservoirs and that these uncertainties are not expected to be resolved in the short term, a simple and transparent criterion, based on thresholds in terms of power density (W/m^2), is used to determine the eligibility of large hydroelectric power plants for CDM project activities. The thresholds are as follows:

[2]http://unfccc.int/2860.php.

- Hydroelectric power plants with power densities less than or equal to 4 W/m^2 cannot use current methodologies
- Hydroelectric power plants with power densities greater than 4 W/m^2 but less than or equal to 10 W/m^2 can use the currently approved methodologies, with an emission factor of 90 gCO_2eq/kWh for project reservoir emissions
- Hydroelectric power plants with power densities greater than 10 W/m^2 can use current approved methodologies and the project emissions from the reservoir may be neglected

Scope of Hydro Project Established by Narmada Hydroelectric Development Corporation Under CDM

Narmada Hydroelectric Development Corporation (NHDC) has been entrusted with the construction of the Indira Sagar and Omkareshwar projects with an installed capacity of 1,000 MW and 520 MW respectively. Besides these large hydropower projects, there are a number of small, micro, and canal head hydropower projects installed by NHDC. As outlined in section "Flexibility Mechanism Under Kyoto Protocol" above, all these large, small and micro hydropower projects have scope for gaining carbon credits under the Clean Development Mechanism (CDM) for the mitigation done by them to the climate change process.

If found feasible for CDM, large hydropower projects such as the Indira Sagar project with an installed capacity of 1,000 MW would have reduction potential of about 3,465,000 metric tonnes CO_2 equivalent per annum, which can generate revenue to the tune of Rs. 156 crore per annum at $10[3]/tonne$CO_2$e. Similarly, the Omkareshwar project has the potential of generating revenue of Rs. 80 crore per annum at $10/tonne CO_2e. In the case of small hydro projects with installed capacity up to 25 MW, they would have reduction potential of about 53,000 metric tonnes CO_2 equivalent per annum, which can generate revenue to the tune of Rs. 2.3 crore per annum at $10/tonne$CO_2$e.

Scope of Wind Projects Under CDM

Power generation from wind has emerged as one of the most rapidly growing renewable technologies in the country. India is ranked fourth amongst the wind energy-producing countries of the world after Germany, Spain, and the USA. The estimated power generation capacity in India through wind is about 45,000 MW assuming 1% of land availability for wind farms requiring 12 ha/MW in sites having wind power density in excess of 200 W/m^2 at 50 m hub-height. However,

[3] $1 = INR 45.

the installed capacity is about 1,870 MW, which is about 4% of the total estimated potential. This sector has been growing at a rate of over 35% for the last few years.

Although the coastal states of the country are ideally suited for promoting power generation from wind energy, the most actives states in harnessing wind energy are Gujarat, Rajasthan, Maharashtra, Karnataka, and Tamil Nadu. Also, now the states of West Bengal, Madhya Pradesh and Andhra Pradesh are starting to catch up, taking annual capacity addition to 2,200 MW in the coming years.

The Ministry of New and Renewable Energy has been promoting the development of wind energy technologies in the country through its Centre for Wind Energy Technology (CWET). There are over 598 stations spread in 27 states in the country with 1,050 wind monitoring and wind mapping stations being set up. Nine states have installed wind farms and seven states have over 95% of installed capacity belonging to private sector. Wind turbine manufacturers are producing wind electric generators (WEGs) of 225–2,100 kW and a large number of agencies have come up to supply components/spares/accessories and to provide services such as erection, O&M, civil and electrical construction, consultancy, etc. The country also boasts a large number of installed water pumping windmills and small aero-generators, as well as wind–solar and wind–diesel hybrid systems.

There is a wide scope for wind projects under Clean Development Mechanism activities. The main objectives of CDM are to provide the high mitigation cost industrialized nations with access to low mitigation cost projects in developing nations and in turn benefiting both in terms of CERs for industrialized nations and sustainable development for developing countries. Wind power projects could be of interest under the CDM because they directly displace greenhouse gas emissions while contributing to sustainable rural development. The annual potential Certified Emissions Reductions (CERs) of wind power projects in India was theoretically estimated to be around 86 million in case of lax additionality. In India, there are five regional grids – the Northern, Western, Southern, Eastern and North-Eastern; therefore, the CO_2 emissions mitigation potential through wind power projects in

Table 21.6 Annual gross and technical CO_2 emissions mitigation potential through wind power projects in India

State	Baseline	Annual electricity generation		Annual CO_2 emissions mitigation potential	
		Gross	Technical	Gross	Technical
Andhra Pradesh	0.86	18.1	3.8	15.6	3.3
Gujarat	0.89	21.2	3.9	19.0	3.5
Karnataka	0.86	14.5	2.5	12.5	2.1
Kerala	0.86	1.9	1.3	1.6	1.1
Madhya Pradesh	0.89	12.0	1.8	10.8	1.6
Maharashtra	0.89	8.0	6.6	7.2	5.9
Orissa	1.04	3.7	1.5	3.9	1.5
Rajasthan	0.75	11.8	2.0	8.9	1.5
Tamilnadu	0.86	6.7	3.8	5.8	3.3
West Bengal	1.04	1.0	1.0	1.0	1.0
All India		99.0	28.2	86.2	24.9

Source: CEA

India is estimated based on the emission factors calculated by the Central Electricity Authority (CEA) of the Government of India in 2006 (Table 21.6).

Based on the technical potential of wind power projects in India, the CDM potential has been estimated at 25 million tonnes. Among all the states in India, Gujarat has the largest CO_2 emissions mitigation potential through wind power (19 million tonnes) followed by Andhra Pradesh (15.6 million tonnes), Madhya Pradesh (10.8 million tonnes), Karnataka (12.5 million tonnes), and Rajasthan (8.9 million tonnes). With a 25% PLF of wind power projects, the annual gross electricity generation potential has been estimated at 99 TWh, whereas the annual technical electricity generation potential has been estimated at 28 TWh.

Conclusion

Many countries have agreed that climate change is a major threat to our planet. The Kyoto Protocol is a mechanism through which these countries came together on the same platform, to address this pressing issue, irrespective of their economic status. Under it, the Clean Development Mechanism provides a way by which developing countries can participate in carbon mitigation, requiring them to assess and prioritize areas for potential carbon mitigation. India has considerable scope for mitigating carbon emission, such as hydroelectric power and wind energy. As of now, out of the 6,781.81 MW potential from small hydropower projects, only around 2,000 MW has been captured under CDM. Similarly, the potential of wind power projects has been estimated at around 25 million tonnes in India, with Gujarat having the highest potential capacity of 19 million tonnes. This clearly indicates that these energy supply segments have significant potential for taking up more CDM projects. If we in India capture this market efficiently, our dependence on fossil fuels in the long run will be minimized, which in turn helps to reduce our net carbon emissions and diversify the current energy portfolio of the country.

References

Achanta AN (1993) The climate change agenda: an Indian perspective. TERI, New Delhi

Core Writing Team, Pachauri RK, Reisinger A (eds) (2007) Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. IPCC, Geneva, Switzerland

Fact Sheets, Press Information Bureau Government of India, Central and Ministry of Renewable Energy of India, New Delhi

Faure M (2002) Climate change & the Kyoto Protocol: the role of institutions to control global change. Earthscan, London

Gates DM (1993) Climate change and its biological consequences. Sinaver Associates, Sunderland

Gillenwater M, Broekhoff D, Trexler M, Hyman J, Fowler R (2007) Policing the voluntary carbon market. Nat Rep Clim Change Nov:85–87

Gonsalves JB (2006) An assessment of projects on the clean development mechanism (CDM) in India. In: United Nations Conference on Trade and Development
Hamilton K, Bayon R, Turner G, Higgins D (2007) State of the voluntary carbon markets 2007: picking up steam. Ecosystem Market Place and New Carbon Finance
Hardy JT (2003) Climate change: causes, effects and solutions. Wiley, New Jersey
Houghton JT et al (1992) Climate change: the supplementary report to the IPCC scientific assessment. Cambridge University Press, Cambridge
Ichihara J, Nozomi O (2009) CDM country fact sheet: India. IGES market mechanism Project/Climate Change Area
Jager J (1983) Climate and energy system: a review of their interactions. Wiley, Chichester
Kates RW, Ausubel JH, Berberi M (1985) Climate impact assessment studies of the interaction of climate & society. Wiley, New York
Kenber M (2007) Raising the bar – On voluntary carbon standards. Environmental Finance
Long D (2004) Global warming. Cambridge University Press, Cambridge
Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (eds) (2007) Climate change 2007: Mitigation of climate change-contribution of working group III to the fourth assessment report of the intergovernmental panel on climate change, 2007. Cambridge University Press, Cambridge, United Kingdom and New York
Purohit P, Michaelowa A (2007) Potential of wind power projects under the clean development mechanism in India. Carbon Balance Manage 2:8
Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) (2007) Climate change 2007: the physical science basis-contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom and New York
TERI (2004) CDM in India, Kyoto Mechanisms: Information Platform for CDM. TERI, New Delhi (Report No. 2003RT54)
A, Kristen H (2002) Climate change and sustainable development. Earthscan, London

Part III
Political Aspects of Climate Change

Chapter 22
An Assessment of Adaptation Strategies in the Baltic Sea Region: A Two-Country Analysis

Hye R. Yoon, Fernanda Rivas, and Walter Leal Filho

Abstract The Baltic Sea is located in northeastern Europe and is the largest brackish sea surrounded by nine countries: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden. Due to its fragile ecosystem, the Baltic Sea's vulnerability in climate change has been studied by several international organizations by multidisciplinary groups. With the release of the recommendation from the white paper by the European Union in April of 2009, the need for adaptation strategies is reaffirmed in the area and today consensus on the need for national adaptation policy has been built among Baltic Sea countries. This paper offers an overall assessment of adaptation strategies in the Baltic Sea Region and outlines the results of a comparative analysis of two countries, namely Latvia and Sweden. The two countries' advancements in terms of releasing official climate change adaptation strategies are presented, as well as the areas each of their policies or suggested policies cover. Finally, both countries are placed into context with Baltic Sea neighbours with similar socioeconomical characteristics to offer a more rounded view of the general situation in the region.

Keywords Baltic · Climate · Latvia · Policies · Sweden

Introduction

The Baltic Sea is a semi-closed brackish inland sea located in northeastern Europe. It is surrounded by nine countries: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden. In addition, five other countries that do not border the Baltic Sea have influence upon it, since water caught in their territories drains towards it; these are Belarus, Czech Republic, Norway, Slovakia, and Ukraine. Figure 22.1 illustrates the geography of the Baltic Sea along with the political boundaries of the sea-limiting countries.

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The Baltic Sea is the largest brackish sea in terms of surface area covering a total of 415,000 km^2. The catchment zone in the fourteen countries comprises an area of 1.74 million km^2 with most of it in Sweden (25.3%), Russia (19.0%), Poland (17.8%), and Finland (17.4%) (HELCOM 2007). Its location, from approximately 50–70° North latitude, makes it seasonally freeze on a large part of its surface, on average some 218,000 km^2 or approximately 52%. The Baltic catchment area contains about 80 lakes with a combined area larger than 100 km^2 and nearly 10,000 lakes larger than 1 km^2, of which many are located in Sweden and in Finland. Forests cover about 54% of the catchment area, agricultural land 26%, wetlands 20%, and built-up areas 4%. The ten largest rivers (in descending order of size of drainage area: Neva, Vistula, Oder, Neman, Daugava, Narva, Kemi, Göta, Torne, and Kymi) account for 59% of the total drainage area of the Baltic. There are around 200,000 islands in the Baltic Sea (HELCOM 2007).

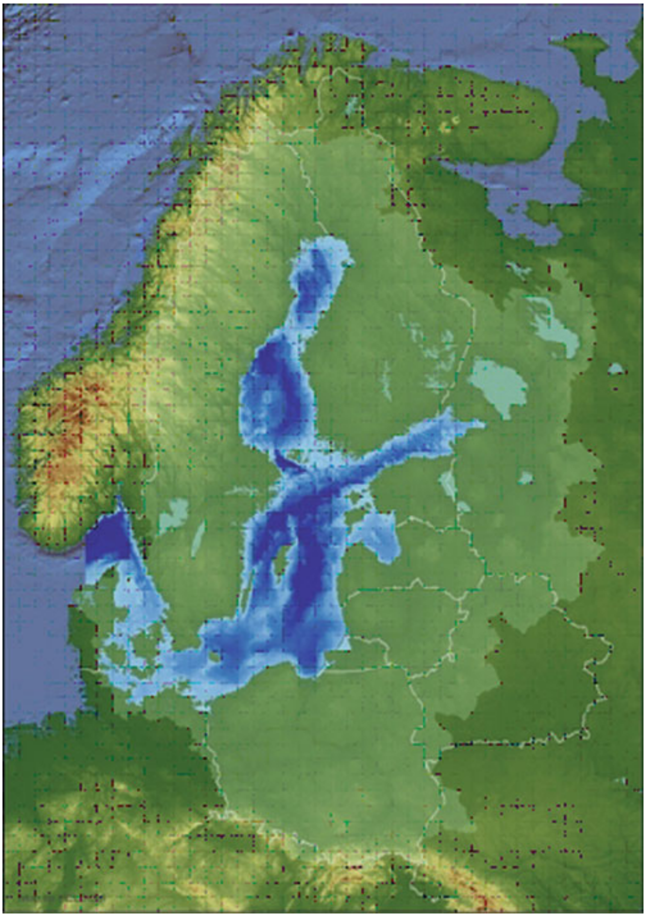


Fig. 22.1 Baltic Sea and bordering countries.
Source: HELCOM

There are several international organizations that aim to jointly manage the Sea and its inland drainage basin across a multidisciplinary spectrum. Some of these groups arise from treaties and projects that regional governments participate in. In environmental terms, the most important of these accords is the Helsinki Convention, a treaty that aims to assure the ecological restoration of the Baltic Sea, ensuring the possibility of self-regeneration of the marine environment and preservation of its ecological balance. The nine bordering countries are signatories to the Helsinki Convention, which was first signed in 1974 and re-drafted in 1992, entering into force in January 2000.

Another international association for the management of the region is the Council of the Baltic Sea States (CBBS), which is formed by the nine bordering countries plus Norway, Iceland, and the European Commission. Regarding programmes, BaltCICA is a project partly financed by the European Union whose objective is the improvement of the management of climate change's adaptation measures. In this project, which will run from February 2009 to January 2010, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, and Sweden will participate. BaltCICA will work with the results from two past projects dealing with adaptation strategies and climate change, ASTRA and SEAREG, both of which were carried out by the same countries (IPCC 2007a, b).

An Introduction to Climate Change

What exactly is climate change? Climate change is a phenomenon whereby due to the chemo-physical alteration of the composition of the atmosphere, partially caused by human activity, "usual" meteorological patterns are altered. Climate change is a broader concept than global warming, as it not only implies the rise in the mean temperature of the planet, but it includes altered rainfall patterns, extreme weather events, changes in humidity, and changed oceanic currents.

According to the Intergovernmental Panel on Climate Change (IPCC), this phenomenon is currently observed and measured in the following ways: a undeniable warming of atmosphere and ocean; global melting of snow and ice; rising global average sea level; increased precipitation in eastern North and South America, northern Europe, and north and central Asia; decreased rainfall in the Sahel, Mediterranean, southern Africa, and parts of south Asia; and increased intense tropical cyclone activity in the north Atlantic (and suspicions of increased activity in other parts of the world) (IPCC 2007a, b).

Effects of climate change on polar ecosystems are easily evidenced due to their fragility and strong dependence on air and water temperatures. Both the Arctic and the Antarctic are considered extremely vulnerable to climate change, and ironically, as the areas with the greatest potential to alter the global climate. More specifically, HELCOM has identified the following impacts specifically targeting the Baltic Sea area: decrease in the number of very cold days during winter, decrease in the duration of the ice cover and its thickness in many rivers and lakes, longer frost-free season, general increase in precipitation mostly in winter, altered mean annual river flows, projected decrease of salinity, and possible increases in storm surges and floods. It is to be noted, however, that the Baltic Sea presents regional differences on usual climate and more recent trends.

With regard to meteorological changes observed, temperatures in the Baltic Sea basin were more pronounced in northern parts, particularly in the winter. Warming was first observed approximately in 1980 in Sweden, whereas Denmark and Estonia began registering it in 1990. The eastern Baltic (south and east from Tallin and St Petersburg) registered the highest warming in the 1980s and 1990s. Regarding precipitation, the tendencies are unclear (HELCOM 2007). Snow and ice cover and thickness has been found to decrease in practically all the sea-bordering countries.

The future effects of climate change in the region have been estimated through the coupling of climate models and emissions scenarios based on assumed human behaviours (Fig. 22.2).

Climate Change Adaptation Strategies

A well-described definition from the third IPCC assessment report (IPCC 2001) suggests that adaptation is the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or

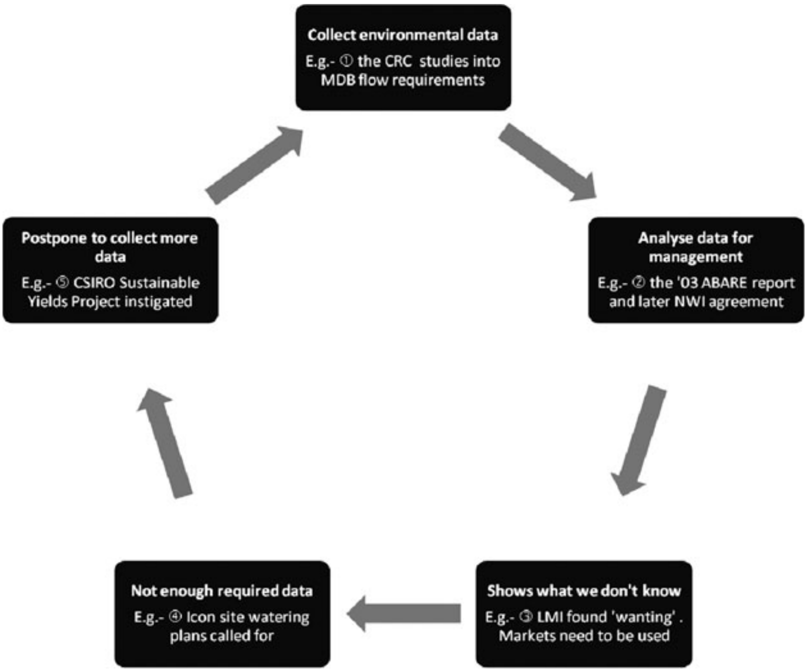


Fig. 22.2 The cycle of deferment

exploits beneficial opportunities". The concept of adaptation is closely linked to the vulnerability of a region or a society to damage from climate changes; the more vulnerable, the more severe consequences are expected. Adaptation plans are designed to decrease the vulnerability of a region by preparing in advance for an expected future state of affairs. Adaptation measures must acknowledge both the expected impacts of climate change and the degree of vulnerability of the region and society which will suffer those impacts in order to be an effective measure.

When recognizing the susceptibility of a system, it is important to assess the degree of vulnerability, to know "who is vulnerable, to what, in what way and where" (Lim and Spanger-Siefried 2005). As these questions are answered, adaptation plans can be developed at national, regional and local levels. Furthermore, an additional notion to take into account when thinking of adaptation strategies is the concept of mitigation. Mitigation in this case refers to the reduction of the effects of climate change by reducing greenhouse gas emissions as the trigger of this change. Adaptation and mitigation strategies should be complementary. The success of both plans of action will lower the risks for society due to climate change (Hilpert et al. 2007). Figure 22.3 represents the links between adaptation and mitigation strategies regarding climate change.

The Need for Adaptation Strategies in Europe and the Baltic Sea Region

On 29 June 2007, the European Union released a Green Paper on options for adaptation to climate change for EU countries (European Commission 2007). The paper maintains that the aim of adaptation is to reduce the risk and damage from

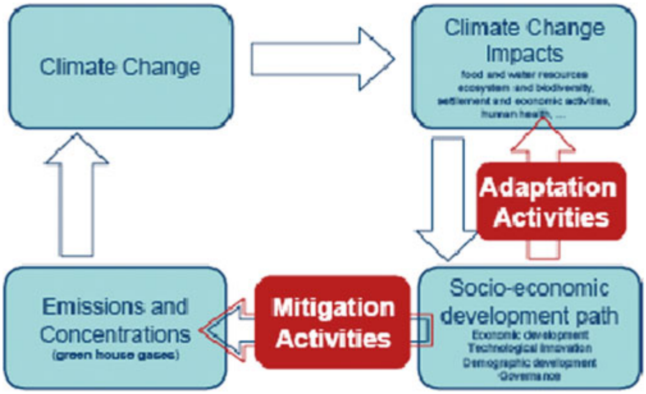


Fig. 22.3 Mitigation and adaptation as complementary approaches in climate change policy (adapted from IPCC 2001:3)

harmful impacts and exploit potential benefits, meaning that adaptation should be anticipatory and planned. Under the IPCC definition, anticipatory adaptation or proactive adaptation takes place before the impacts of climate change are observed. Planned adaptation is completed by policy makers based on the awareness of climate change's impacts in the future, and it aims to maintain or achieve a desired state.

Within six selections of vulnerable areas in Europe described by this Green Paper, below are the areas that Baltic region can fall within:

- Coastal zones due to sea level rise combined with increased risks of storms
- Densely populated floodplains due to increased risks of storms, intense rainfall, and flash floods, leading to widespread damages to built-up areas and infrastructure
- Scandinavia, where much more precipitation is expected and a larger part in the form of rain instead of snow

On 1 April 2009, the European Union released a White Paper, "Adapting to climate change: towards a European framework for action". In this paper, the EU again advocates and reaffirms the principles of the Green Paper (European Commission 2009). The main message from the EU papers is that early action is necessary. As previously supported in the Stern Review (Stern 2006), an adaptation plan will not only benefit the general wellbeing of human society but will be of great help in saving future costs. The EU suggests that adaptation plans should be mainstreamed into existing sectoral policies. Each member state should have a national adaptation strategy. Still, however, lots of uncertainties remain over the impact and measure of climate change; therefore, there is still a need for proactive research and education.

The Need for Research

There is a perceived need for research and comparative analyses on the level of preparedness of climate change adaptation strategies within the Baltic Sea Region (Leal Filho and Mannke 2009a, b). Based on this, this paper has chosen to focus on two completely different countries, namely Sweden and Latvia, to assess the disparities that exist in the region. The countries were chosen only according to the criteria of the common perception or reputation of the countries. Sweden was chosen as an example of a developed Scandinavian country and Latvia as the representative of a weaker economy in transition and with a smaller influence in the region. No previous research into the level of policy making regarding climate change for the Baltic Sea countries was done, and this parameter did not influence the selection of countries.

As several documents offer a wider comparison on the level of climate change policy making in Europe in general, the purpose of this study was to deepen the knowledge on the differences that exist amongst the region. Furthermore, recent developments, such as 2008–2009s economic crisis, the change of European Union presidency, and other factors, are commented upon for their relationship with the development of adaptation strategies at a national level.

Country Profiles

Sweden

Sweden is located in northwestern Europe, at approximately 62° N latitude and 15° E longitude. It borders on the north and northeast with Norway; to the northwest with Finland; and to the west, south, and southeast with the Baltic Sea. It has a generally flat topography with some mountainous areas. Swedish climate is divided roughly in two, sub-arctic in the north and temperate in the south with cold cloudy winters and cool partly cloudy summers.

Sweden's natural resources mainly comprise metals, some minerals, timber, and hydropower. It has a small production of oil which is greatly surpassed by its demand. No natural gas consumption or reserves are present (CIA 2009).

Sweden produces approximately 44% of its electricity through hydroelectric power plants. Another important source of energy in the country is nuclear power, accounting for 46% of the total.

Sweden has a GDP per capita of US$38,500. According to the CIA World Factbook: "Until 2008, Sweden was in the midst of a sustained economic upswing, boosted by increased domestic demand and strong exports. Despite strong finances and underlying fundamentals, the Swedish economy slid into recession in the third quarter of 2008 and growth continued downward in the fourth as deteriorating global conditions reduced export demand and consumption. On 3 Feb 2009, the Swedish Government announced a $6 billion rescue package for the banking sector" (CIA 2009) (Fig. 22.4).

Latvia

The Republic of Latvia meets the border of Estonia in the north and Lithuania in the south. Sweden is located across the Baltic Sea to the west. Latvia has a humid, continental, and temperate climate due to the maritime influence of the Baltic Sea. Spring, summer, and autumn are fairly mild; however, winter can be extreme due to its northern location and cold winds from the interior of Russia. Precipitation is common throughout the year, with heavy rainfall in August and severe snowfalls during the winter period.

It has natural resources of peat, limestone, dolomite, amber, hydropower, wood, and arable land. According to statistics in 2005, arable land consists of 28.19% of total land use. Due to Latvia's humid climate, land in Latvia often needs drainage.

Fig. 22.4 Map of Sweden
Source: European Commission 2004

Approximately 16,000 km^2 or 80% of agricultural land has been improved by drainage. GDP per capita in 2008 is est. $17,800, slightly less than 2007s $18,100. Due to the worldwide financial crisis, −3.2% industrial production growth was recorded in 2008. (CIA 2009) (Fig. 22.5).

Riga, the capital city of Latvia has the major role as economic development centre, but it is very vulnerable to the impacts of climate change due to the vicinity of the Gulf Riga and the mouth of three rivers: Daugava, Gauja, and Lielupe. Damages such as flooding, storm, groundwater level rise, hydropower plant dam safety, and heat waves are all major threats to the security of the city (Astra).

Fig. 22.5 Map of Latvia
Source: European Commission 2004

Adaptation Strategies per Country

Sweden

At the time of writing, Sweden did not have an approved and authoritative national policy regulating or enforcing strategies for adaptation to climate change. However, on 11 Mar 2009, a document touching upon the subject and with the status of recommendation for policy was presented to the Swedish parliament under the name “Swedish Climate Bill”. This bill sets up target levels for greenhouse gas emissions and an overall action plan on how to achieve this objective plus the transition towards a fossil fuel free country by 2050.

The UNFCC has identified ten key areas in which adaptation strategies world-wide should focus:

1. Coastal zone management
2. Landscape management (including soil erosion, floods, and fires)
3. Water management (including quantity and quality)
4. Extreme temperature (including heat waves and cold)
5. Energy, security of supply of energy
6. Biodiversity management
7. Financial management (insurance and financial markets)
8. Health and disease management

9. Agriculture and food security
10. Development cooperation

A large section of the Swedish Climate Bill talks about adaptation to climate change focusing on 14 areas (Government of Sweden 2009), which correspond to 9 of the UNFCCC aims. Development and cooperation is not included in the Bill. Figure 22.6 shows the adaptation areas Sweden has addressed according to Massey and Bergsma (2008).

The Swedish Climate Bill strongly states the need for clear adaptation strategies, as can be seen from the following statement: "The scientific results indicate that Sweden will be strongly affected by climate change. Inquiry determines that the security of this conclusion is sufficient to initiate far-reaching measures for the adaptation of the Swedish society" (Government of Sweden 2009, p. 161).

Concerning the government's role in the implementation of strategies, the Swedish government proposes that the national coordination should be allocated to several authorities with a strongly regionalist approach. It also suggests that several sectoral authorities (such as drinking water, telecommunications, disaster prevention and protection, agriculture, etc.) should have a clear responsibility for the adaptation to climate change of their respective areas of influence, and the overall monitoring and reporting should be undertaken by the Swedish environmental protection agency (Government of Sweden 2009, pp. 161–162).

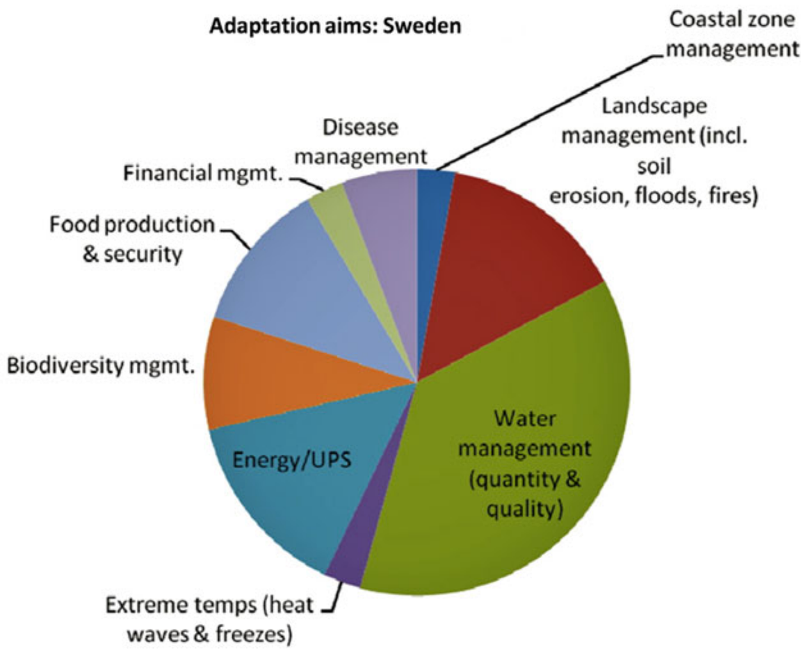


Fig. 22.6 Adaptation aims: Sweden (Massey and Bergsma 2008)

In addition to the government plans, several research programmes led by independent institutions have worked or are working towards the creation of a national adaptation strategy document. Most notably, the work by the Foundation for Strategic Environmental Research (MISTRA) has led to important information being included in the government plans. The project SWECLIM (Swedish Regional Climate Modelling Programme), supported by MISTRA, aimed at providing information on climate change at a regional level according to different scenarios and ran from 1996 to 2003. A second project financed by MISTRA is the Swedish Research Programme on Climate, Impacts and Adaptation (SWECIA). SWECIA is expected to focus its research on adaptation in and around Stockholm and to deal with the energy sector. One shortcoming of this project is that its scope is global although it focuses more on the Nordic region; thus, it does not directly concern Swedish policy. SWECIA is a project commenced in 2008 and expected to be finished by 2011.

Other agencies involved in the development of climate change adaptation strategies are:

1. The Commission on Climate Change and Development. (CCCD). A Swedish government-appointed commission integrated by 13 international experts and chaired by the Swedish minister for international development cooperation. This commission focused on global adaptation issues regarding climate change and development and presented its final report to the United Nations for 14 May 2009.
2. The Swedish Commission on Climate and Vulnerability. Swedish ministry of the environment commission appointed in June 2005 that worked in the early stages of the development of the Climate Bill. It rendered its final report on 21 Dec 2007. The report concluded that adaptation measures should be undertaken as soon as possible and suggested strong roles for municipalities and counties.

Latvia

Currently, Latvia does not have a National Adaptation Strategy (NAS) but is beginning to prepare one. The Latvian government-driven adaptation plan is being developed by the Ministry of Environment at the head of an official government task force which includes experts from other major ministries (agriculture, defence, internal affairs, external affairs, health, regional development, economy, and transport) (Massey 2009, p. 9).

Latvia's experience of increasing temperatures, an increasing risk for coastal erosion and changes in hydrological processes, brought concern to policy discussion on climate change. Furthermore, along with scientific research that proves that adaptation will be economically beneficial, they act as drivers for the creation of a national adaptation policy (Swart et al. 2009, p. 228).

The Latvian government's effort toward combating climate change began with a focus on mitigation which resulted in a document titled "Climate Change Mitigation Programme for 2005–2010". It was in 2008 that the Latvian government started to establish a national movement on adaptation. An advisory report on adaptation needs and preliminary suggestions for further policy development (Ministry of Environment 2008) was accepted by the government in August 2008. This report serves as a basis to bring about a NAS by the end of 2009 under the coordination of the Climate and Renewable Energy Department within the Latvian ministry of environment. Two working groups functioning with two different goals were formed and are in charge of developing NAS. One is an inter-governmental expert group and the other is a group of scientists, specialists from different agencies, and representatives from companies and the insurance sector. These working groups are expected to promote and elaborate (Swart et al. 2009). Table 22.1 describes the groups.

According to Massey (2009), Latvia is the one of the rare countries to have inter-ministerial cooperation for adaptation planning in central and eastern Europe. (This paper discusses Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Hungary, and Slovenia). Latvia, however, is lacking plans in many of the sectors in society and the existing plan proposal is limited to specific areas. According to Massey and Bergsma (2008), the Latvian adaptation plan focuses on four out of ten aims drawn mainly from UNFCCC (with proportions given):

- 33% landscape management (including soil erosion, floods and fires)
- 25% water management (quantity and quality)
- 25% coastal zone management
- 17% biodiversity management

These goals and the magnitude of Latvian involvement in each are presented in Fig. 22.7.

On the other hand, Latvia shows good progress in establishing a NAS, compared to measures by other developing eastern European countries with similar GDP such as Estonia and Lithuania; their adaptation aims have been more diversified but they have not come up with a significant NAS proposal (Estonia has proposed a NAS but it has been delayed and Lithuania has not proposed an adaptation plan).

Table 22.2 shows the list of actions by the Latvian government including those that are currently under progress (Massey 2009).

Table 22.1 Design of working groups in Latvia

	Inter-governmental expert group	Expert working group
Members	Inter ministerial Agriculture, Defence, Internal Affairs, External Affairs, Health, Regional Development, Economy and Transport	Scientists, specialists from different agencies and representatives of companies and the insurance sector
Jobs	Revision of policy planning documents and legislation	Studying and developing further research needs on existing knowledge on impacts and adaptation

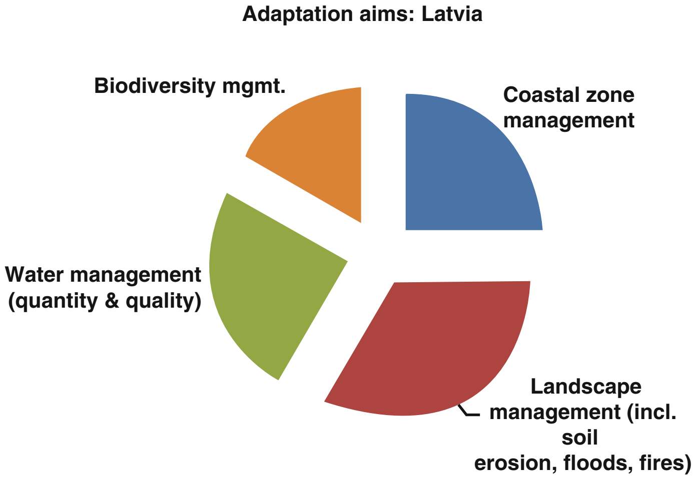


Fig. 22.7 Adaptation aims: Latvia (Massey and Bergsma 2008)

Table 22.2 Adaptation actions by the Latvian government

National policy planning	Sectoral policy planning
Latvian report on adaptation to climate change (CC) until the end of 2009	Conception on Risk Management Policy in Agriculture (2007)
National Research Programme KALME “Climate change impact on the waters of Latvia” (2006–2009)	Latvian Rural Development National Strategy Plan for 2007–2013 (2006)
Latvian Sustainable Development Strategy up to 2030 (under preparation)	National programme for EU financing planning period 2007–2013
National Development Plan for 2007–2013	National programme for EU financing planning period 2007–2013
National Security Conception (2008)	Forest Branches Development Programme (2006)
Civil Protection Plan (2007), Civil Protection Law (2006), Law on State Material Reserves (2007)	Law on Protected Belts (1997)
National Flood Risk Assessment and Management Programme for 2008–2015 (2007)	Individual nature protection and usage rules for particular protected territories (e.g. flood-grasslands, coastal nature parks, other types of coastal zones)
National Lisbon Programme for 2005–2008	Law on territory planning (2002)
	Spatial Planning Law (2002)
	State Forest Monitoring Programme
	National Programme for Environmental Monitoring for 2009–2012

Discussion

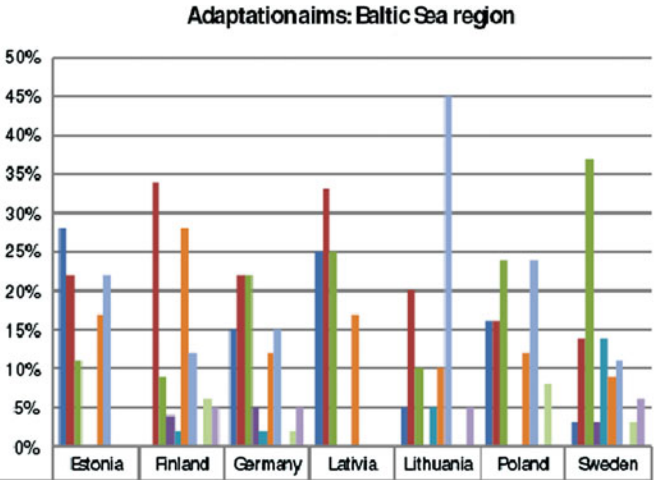
The Swedish and Latvian governments both started with adaptation strategy in a similar period. (Mitigation plans were not considered for this paper.) After 2005, when the Kyoto Protocol entered into force, both governments were motivated to propose climate change policy. Both have government-driven adaptation strategies but are engaged in independent national and international research groups that feed the government proposals.

Latvia and Sweden were compared in four general areas:

- NAS adaptation aims
- Drivers for the creation of these NAS
- Level of completion
- Description of the efforts in general

The result overview is presented in Table 22.2. It can be seen that in general terms, the Scandinavian country is more advanced in its progress towards the establishment of a NAS, as a government bill has been issued and it is in a state of revision.

Another important characteristic is the diversity of the topics covered by these national or independent proposals. As can be seen from Fig. 22.8 (taken from



	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Sweden
Coastal zone management	28%	0%	15%	25%	5%	16%	3%
Landscape management (incl. soil erosion, floods, fires)	22%	34%	22%	33%	20%	16%	14%
Water management (quantity & quality)	11%	9%	22%	25%	10%	24%	37%
Extreme temps (heat waves & freezes)	0%	4%	5%	0%	0%	0%	3%
Energy/UPS	0%	2%	2%	0%	5%	0%	14%
Biodiversity mgmt.	17%	28%	12%	17%	10%	12%	9%
Food production & security	22%	12%	15%	0%	45%	24%	11%
Development co-op	0%	0%	0%	0%	0%	0%	0%
Financial mgmt.	0%	6%	2%	0%	0%	8%	3%
Disease management	0%	5%	5%	0%	5%	0%	6%

Fig. 22.8 Adaptation aims of different countries of the Baltic Sea region (Massey and Bergsma 2008)

Massey and Bergsma 2008), Sweden's efforts touch upon nine topics, while Latvia dwells in only four.

Nevertheless, the measure on the number of topics developed by each country cannot be taken as a measure of quality for the adaptation strategy. For example, in the case of Latvia, it engages in only four topics, while its neighbours Estonia and Lithuania include five and seven topics respectively; however, Latvia is far advanced over its neighbours in the completion of its NAS. On the other hand, Finland, by far the country with the most and most diverse recommendations, does not have yet any legally binding NAS, which Sweden is already in the process of establishing (Table 22.3).

According to a UNFCCC comparison table, Latvia seems to care more about funding compared to Sweden. Latvia was hit hard by the recession in 2008, so its GDP growth was −5%, whereas in 2006 and 2007, it had grown by 10%. It is questionable to ask if economic measures will have an impact on adaptation policy, as the focus of the government will turn towards economic concerns rather than climate change adaptation strategies.

On 1 July 2009, Sweden assumed the EU presidency until the end of the year. Since the UNFCCC Copenhagen meeting will take place under its regime, Sweden has been trying to pose itself as an international leader in climate change policy development. Several press articles taken from the EU presidency and Swedish government websites touch upon this leading role of Sweden in the international arena. In this way, the drive of the country to stand out internationally differs greatly from that of the Latvian and other Baltic Sea countries, which are focusing more on strengthening national plans.

Conclusions

Both from a social and economical point of view, the Baltic Sea is a diversified region, where countries at different stages of development share a common water body and common concerns on the impacts that climate change will have in the region (Leal Filho et al. 2009). Baltic Sea countries have often excelled with examples of successful international cooperation in sustainable development issues, as they have actively participated in common projects such as ASTRA, BaltCICA, HELCOM, SEAREG, and others.

At present, climate change is one of the most concerning issues in the region and numerous international organizations are urging all countries to develop mitigation and adaptation strategies in order to reduce the vulnerability at the local, regional, national and international levels.

Latvia and Sweden were selected as examples of two different Baltic Sea countries which are developing a National Adaptation Strategy (NAS) under the European Union framework. They were selected because of their perception as a "developed" economy and "transitional" economy respectively. Comparisons were

Table 22.3 Comparing Latvia and Sweden's adaptation strategy efforts

Country	Focus areas (Massey and Bergsma 2008)	Stakeholders	NAS progress	Description
Latvia	Landscape (33%)	Government	Preparation phase	Integrating adaptation into health, agriculture, and national security conceptions, at all government levels including local (mainstreaming)
	Water (25%)			
	Independent international research groups		Latvian report on	adaptation to climate change is expected to propose firm systematic adaptation by the end of 2009
	Coastal zone (25%)	Independent national research groups		
	Biodiversity (17%)			
Sweden	Landscape (14%)	Government	Revision phase	Creation of commissions to develop regional climate change scenarios and adaptation measures
	Water (37%)	Independent international research groups		Backed up an international commission to review climate change adaptation strategies with a global focus. This reported to the UN
	Coastal zone (3%)	Independent national research groups		The government issued a proposal on climate change in March 2009 to be reviewed by the parliament. This includes adaptation measures
	Biodiversity (9%)			
	Extreme temperatures (3%)			
	Energy (14%)			
	Food production and security (11%)			
	Financial (3%)			
	Disease (6%)			

made mainly in four areas: NAS adaptation aims, drivers for the creation of these NAS, the level of completion, and their efforts in general.

It can be concluded that both countries have a similar driver, namely, government policy, backed up by national and international research groups. The adaptation strategies in Sweden touch upon more subjects than in Latvia, although this alone cannot be taken as a measure of quality of the NAS. Sweden is also more advanced in the implementation of their NAS since a government bill has already been issued and is under consideration by the Swedish Parliament, whereas Latvia has just started to implement measures agreed upon in late 2009.

When these two countries are compared against other Baltic Sea countries, it is worth mentioning that Latvia has outdone its neighbours with similar social and economic backgrounds, namely Estonia and Lithuania. Latvia has developed an inter-ministerial taskforce to develop the NAS, while the other two countries have approached the subject in a linear single-ministry manner. Estonia and Lithuania have both made some effort towards a NAS that includes a more diverse range of issues than Latvia; however, a formal document is, in the best case, delayed (Estonia) or, in the worst case, not planned at all (Lithuania). On the other hand, Sweden has proved to be slower than similar neighbours, (Finland, Norway, and Denmark), who had worked on adaptation strategies earlier. Sweden has also focused more on the international arena to become a leader in climate change negotiations rather than in establishing national legislation on mitigation and adaptation strategies.

Further research needs to be done in this field. Do the adaptation strategies have the same hope of success in both countries or is there an ingrained inequality? Do the links between countries positively or negatively affect their policy development? How does the economic crisis affect a NAS? How does foreign aid impact the focus of the National Adaptation Strategies in countries that require this funding? It is hoped that future research projects will address these and many other questions which are still open.

References

Astra (2009) Towards climate change adaptation in the Baltic Sea region, results from the case studies. Astra http://www.gsf.fi/projects/astra/sites/download/ASTRA_results_booklet_web.pdf. Accessed May 2009

CIA (2009, May 14), World Factbook: Sweden & Latvia. From CIA World Factbook https://www.cia.gov/library/publications/the-world-factbook/geos/sw.htm, https://www.cia.gov/library/publications/the-world-factbook/geos/lg.htm. Accessed 27 May 2009

European Commission (2009) White Paper, Adapting to climate change: Towards a European framework for action. Europa, Brussels

European Commission (2007) Green Paper, Adapting to climate change in Europe – options for EU action. Europa, Brussels

Government of Sweden (2009, Mar 11) A coherent climate and energy policy: Government proposal 2008/09:162. From National Adaptation Strategies http://www.eea.europa.eu/themes/climate/national-adaptation-strategies. Accessed 27 July 2009

HELCOM (2007) Climate Change in the Baltic Sea Area. HELCOM Thematic Assessment in 2007. Baltic Sea Environment Proceedings No.111. HELCOM, Helsinki. http://www.helcom.fi/publications/en_GB/publications/. Accessed 21 May 2009

HELCOM (2008a) Interactive map of the Baltic Sea. HELCOM, Helsinki. http://www.baltic.vtt.fi/demo/baltmap.htm. Accessed 19 May 2009

HELCOM (2008b, Nov) The Helsinki Convention. Helsinki Commission, Baltic Marine Environment Protection Commission. http://www.helcom.fi/stc/files/Convention/Conv1108.pdf. Accessed 21 May 2009

Hilpert K, Mannke F, Schmidt-Thomé P (2007) Towards climate change adaptation strategies in the Baltic Sea Reagion. Geological Survey of Finland, Espoo

IPCC (2001) Climate change 2001: impacts, adaptations and vulnerability. Cambridge University Press, Cambridge

IPCC (2007a) Climate change 2007: Synthesis report. Intergovernmental Panel on Climate Change, 12–17 Nov 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf. Accessed 21 May 2009

IPCC (2007b) Working Group II Report: impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-intro.pdf. Accessed 24 May 2009

Leal Filho W, Mannke F (eds) (2009a) Interdisciplinary aspects of climate change. Peter Lang Scientific, Frankfurt

Leal Filho W, Mannke F (2009b) Towards policies and adaptation strategies to climate change in the Baltic Sea region – outputs of the ASTRA project. Boreal Environ Res 14:250–254

Leal Filho W, Babir J, Spiric J (2009) An appraisal of measures to cope with climate change in the Baltic Sea. Manage Environ Qual 20(1):82–91

Lim B, Spanger-Siefried E (2005) Adaptation policy frameworks for climate change: developing strategies in policies and measures. Cambridge University Press, Cambridge

Massey EE (2009) Adaptation policy and procedures in Central & Eastern Europe. Working Paper. Institute for Environmental Studies, Vrije Universiteit, Amsterdam

Massey E, Bergsma E (2008) Assessing adaptation in 29 European countries. Working Paper. Institute for Environmental Studies, Vrije Universiteit, Amsterdam

Ministry of Environment, Latvia (2008) http://www.vidm.gov.lv/eng/. Accessed 2009 May

Stern N (2006) Stern Review executive summary. Cabinet Office, HM Treasury, Great Britain, p 12. http://www.hm-treasury.gov.uk/d/Executive_Summary.pdf

Swart R, Biesbroek R, Binnerup S, Carter TR, Cowan C, Henrichs T et al (2009) Europe adapts to climate change: comparing national adaptation strategies. PEER, Helsinki, p 228

Chapter 23
Climate Change and Protected Areas in Bolivia

Dirk Hoffmann and Imke Oetting

Abstract Climate change is probably the main challenge humanity is facing in the twenty-first century, and even though Bolivia belongs to the nations least responsible for global greenhouse gas output, the impacts of climate change and global warming (glacier retreat in the Cordillera mountain range; droughts in the Altiplano, the inner Andean dry valleys, and the Chaco region; inundations in the Beni lowlands) are affecting an ever increasing number of people. Thus, to tackle the impacts of climate change in Bolivia is not only a task for political authorities at national, departmental, municipal, or communal level, but also one that has to be taken up by the management practitioners of the country's protected areas. Nonetheless, the impacts of climate change are not yet a central issue in the management of the Bolivian National Protected Area System.

This article shows how protected areas are "victims" of climate change, since their biodiversity is being affected by rising temperatures and changes in the hydrological regime; we also analyse in what ways Bolivia's protected areas are a fundamental element in the drafting of mitigation and adaptation strategies, considering the importance they have in maintaining ecosystem resilience and the provision of environmental services.

Keywords Adaptation · Andes · Bolivia · Climate change · Global warming · Mitigation · Protected areas

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Introduction

Climate change and global warming, with the subsequent melting of Andean glaciers and an increase in the frequency of droughts and inundations, are already a reality that is being felt in Bolivia ever more strongly year after year (Francou et al. 2005; PNCC 2007a; Ulloa and Yager 2007). Nonetheless, studies on the impacts of climate change on biodiversity are very scarce, and those taking a closer look at protected areas as key instruments for biodiversity conservation, even scarcer.

The guiding questions are the following:

- What is the impact of climate change on biodiversity in Bolivia?
- What is the role of the country's protected areas for biodiversity conservation?
- In what way can protected areas assist mitigation and adaptation strategies to climate change?

Climate Change and Biodiversity in Bolivia

Human-induced climate change is a reality recognized by the international scientific community (IPCC 2007a, b; Vuille et al. 2003). What is still under debate is the share of human influence and the magnitude of the impact ongoing climate change will have in the future (Schliep et al. 2008). Climate change has different dimensions to it; first and foremost, it means an increase in global temperature, but also changes in precipitation patterns and humidity, as well as an increase in the frequency and severity of extreme weather events (IPCC 2007a; Richardsen et al. 2009).

A second element, which has to be mentioned, is the fact that Bolivia as one of the Andean countries suffers the direct consequences of the El Niño-Southern Oscillation (ENSO) phenomenon, a natural phenomenon of multi-annual recurrence (Arnaud et al. 2001; Francou et al. 2003). There is evidence to assume that the main impact of global warming in Bolivia will not be directly due to temperature rises, but will be on the hydrological cycle, e.g. inundations in Beni lowland savannas and melting glaciers with direct and indirect impact on different protected areas (Sajama, Cotapata, Apolobamba, Madidi), as well as on water availability for the La Paz-El Alto metropolitan area (Hoffmann 2007b, 2008; Ramírez 2007).

Global warming is not uniform, since it depends on a number of different local and regional variables. For the Andean region, as for other high mountain regions of the world, it is important to consider that temperature rise is greater in higher altitudes (Bradley et al. 2006; IPCC 2007a), as is illustrated by the Fig. 23.1.

Climate change impacts on biodiversity are still not studied adequately. Due to the heterogeneity of the Bolivian territory, ranging from the Amazon lowlands at around 200–400 masl up to the highest peaks of the Andean *Cordilleras* measuring more than 6,000 masl, and the large number of different ecosystems it hosts, the

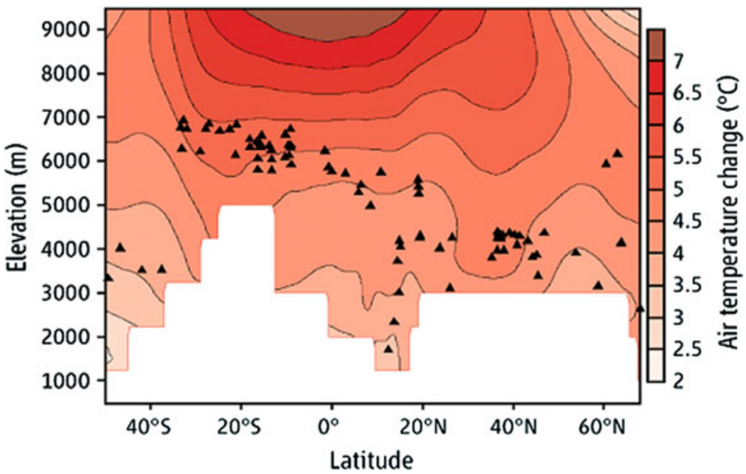

Fig. 23.1 Global warming and the American Cordillera
Source: Bradley et al. (2006)

consequences and impacts of climate change will be delivered in a variety of ways. One of the difficulties in trying to draft biodiversity scenarios for the future – which would be a key element for protected areas – is the lack of climate models with sound resolution; the existing climate models are still very coarse. Even though different pioneering initiatives are underway to develop regional climate models (for example by FAN in Santa Cruz), we are still some way from having the country's territory covered at an acceptable scale. One of the obstacles to advance with more precise climate models is the lack of reliable long-term meteorological data due to the lack of meteorological stations, especially in mountain regions (CAN 2007). Up to now, data gained from glacier measurements and ice cores constitutes the main source of information for the estimate of future climate trends in Bolivia (PNCC 2007a), leaving the greater part of the territory without precise data.

Potential Impacts of Climate Change on Biodiversity

Climate change not only presents a new and complex reality for protected areas, but also brings uncertainty in relation to the magnitude and character of its impact on biodiversity. This can be explained, among other elements, by the lack of national or sub-national climate scenarios with a sound resolution, which would allow for modelling changes in the Andean region, but also by insufficient information on the evolution of biodiversity under these conditions; a third element being the fact that existing studies on biodiversity are mainly short term. Finally, the existing climate models are still contradictory, particularly in relation to precipitation and climate impacts in the higher elevations of the *Cordilleras* (it is important to take note that in most of the climate models, the topographies used give only limited representation to the mountainous regions of the Andes).

A number of authors warn of the consequences of accelerated climate change, one of which is the geographic relocation of species and ecosystems (Dudley 2003; Hannah et al. 2007; Hansen et al. 2003; PNCC 2007b). It is important to note that the migration of species in altitudinal and latitudinal gradients may be negatively affected or restricted by agricultural and urban areas.

Some authors expect that by the end of this century the impacts of climate change will be the main direct driver of biodiversity loss and changes in ecosystem services globally (Mooney and Larigauderie 2009). Very likely the resilience of many ecosystems will be exceeded during this century, due to an unprecedented combination of climate change and associated disturbances (e.g. inundations, droughts, fire, insects, ocean acidification) in combination with other factors such as land use change, contamination, and over-exploitation of resources (IPCC 2007b; Stolton et al. 2008).

There will not only be a movement of species from and to protected areas (desired and undesired, e.g. invasive species). As Hoffmann (2007a) points out, changes in the management of natural resources by local communities in response to climate change can also be observed: higher temperatures allow for the cultivation of resources in mountain regions traditionally reserved for camelid livestock, e.g. in the Apolobamba and Tuni areas. These phenomena are indirect impacts of climate change, which cannot be ignored.

The first systematic efforts to get a view of the impact of climate change through the eyes of local rural populations have been realized in close relation to the GLORIA high mountain biodiversity observation sites in Sajama and Apolobamba protected areas (Pauli et al. 2003; Ulloa and Yager 2007). The objectives of the GLORIA project – Global Observation Research Initiative in Alpine Environments – are to establish a research and monitoring network on the impacts of climate change on high mountain biodiversity (www.gloria.ac.at). It is unique insofar as it integrates climate change and biodiversity at a regional and even global scale (Photo 23.1).

Protected Areas as an Instrument for Biodiversity Conservation

Protected areas must be considered the principle instrument for biodiversity conservation, at international, national, and local levels (Sandwith 2008). With approximately 12% of the earth's terrestrial surface legally protected against anthropogenic transformation of land cover, protected areas are a crucial element for the conservation of biodiversity and ecosystems (Lee and Jetz 2008; Sandwith 2008). This has been recognized explicitly by the Convention on Biological Diversity of the United Nations (CBD), which in its Seventh Conference of the Parties in Kuala Lumpur in 2004 created a Programme of Work on Protected

Photo 23.1 Field work at a GLORIA site, Sajama National Park (Photo by D. Hoffmann)

Areas. This includes the commitment of the Parties of the CBD to establish national systems of protected areas. Nonetheless, today's natural reserves may not be effective enough to resist the impacts of climate change on biodiversity, as climate and habitat types change over space and time (Lee and Jetz 2008).

Bolivia has 22 national protected areas, covering approximately 15% of the country's territory. The rapid expansion of the territory covered by national protected areas in Bolivia dates from the mid-1990s of the last century (see Fig. 23.2) and stands in direct relation to the Rio Summit of 1992 (UN World Conference on Environment and Development). The National System of Protected Areas of Bolivia (SNAP) as a whole integrates 240 protected areas, adding national, departmental, and municipal areas, thus covering about 20% of the territory (SERNAP 2007; personal communication Omar Rocha, Director of Biodiversity and

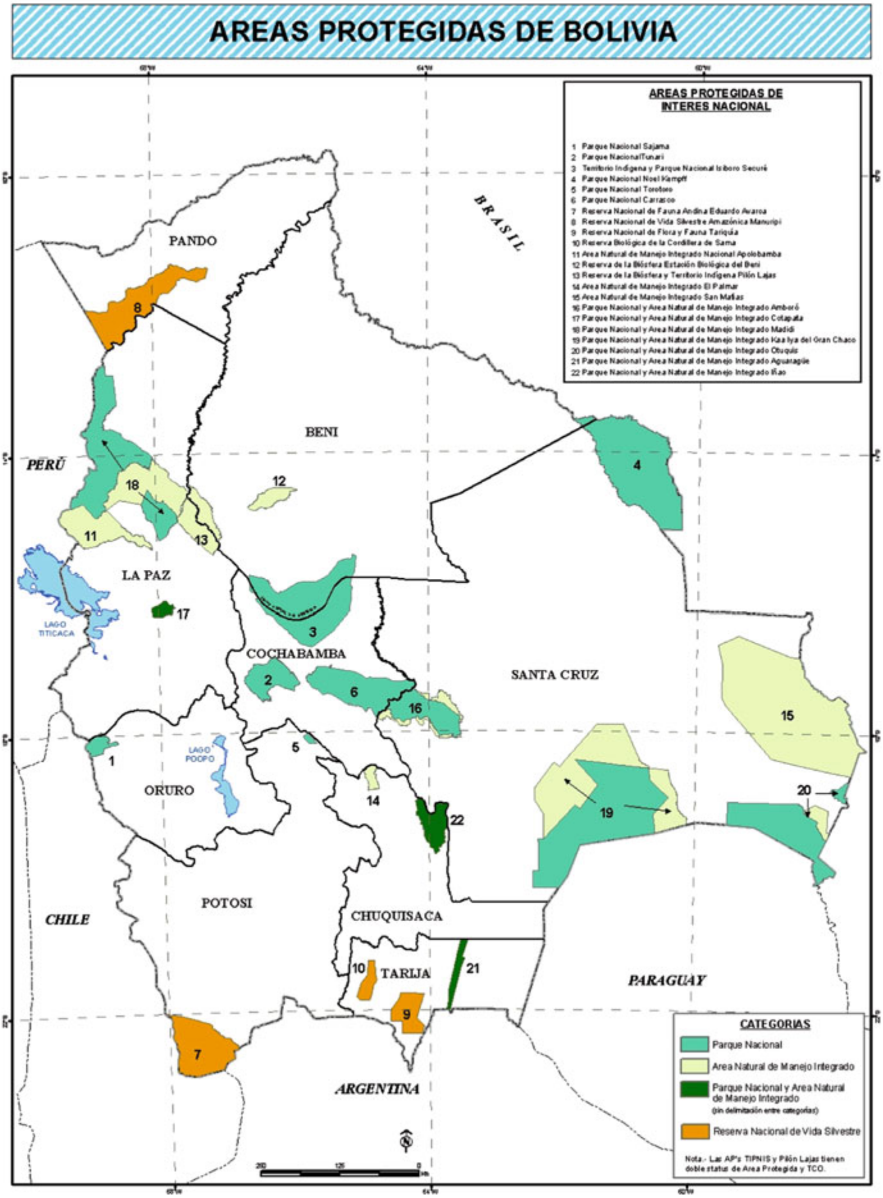

Fig. 23.2 Map of the National Protected Areas of Bolivia
Source: SERNAP – National Service of Protected Areas (2007)

Protected Areas at the Vice Ministry of the Environment, Biodiversity and Climate Change 2009). Among the main environmental characteristics of the SNAP are that of the 16 ecoregions and 199 ecosystems existing in Bolivia, 14 ecoregions and 170

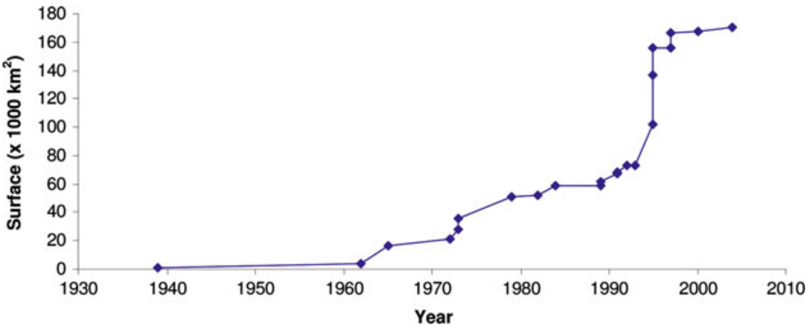

Fig. 23.3 Surface of national protected areas by year
Source:: SERNAP – National Service of Protected Areas (2007)

ecosystems are presently represented in the National System, which means coverage of about 80%. In the same way, it is estimated that 68% of the total of 14,000 native plant species are included in protected areas; for vertebrates, the percentage estimated is even higher (80%; SERNAP 2007). Thus we can assume that to date and under present climate conditions, approximately 70–80% of all species are being included in protected areas in the country.

The increase in the surface of nationally important protected areas in Bolivia has been exponential, having doubled the legally protected surface in a period of only 3 years (1995–1997) (see Fig. 23.3).

Methodological Aspects

How do we measure the impact of climate change on biodiversity in protected areas? Difficulties result, on the one hand, from the fact that in many cases, climate change can only be diagnosed in the long term, and on the other hand, there are a number of other factors that impact on the biodiversity of protected areas, such as the frequency of fire incidents, land use change, etc.

Our approach is based on our own observations, personal communications, technical and strategic documents of the National Service of Protected Areas (SERNAP), the few existing publications (e.g. Ibisch and Mérida 2003) and references from the international discussion.

To assess the importance attributed to climate change, in a first step we considered the most relevant documents on biodiversity and protected areas in Bolivia:

- National Biodiversity Conservation Strategy (MDSP 2001)
- The book *Biodiversity* by Ibisch and Mérida (2003)
- Gap analysis of representativeness of the National System of Protected Areas (FAN et al. 2005)

- Strategic Institutional Plan “Nueva Agenda para el Cambio del SERNAP” (SERNAP 2006)
- National Report of SERNAP to the Latin American Parks Congress in Bariloche, Argentina (SERNAP 2007)
- The book *Áreas Protegidas de Bolivia* by Arnold and Barroso (2008)

Our findings show that – with the exception of the scientific work of Ibisch and Mérida – the documents cited have no focus on the subject of climate change in protected areas. The SERNAP documents, when listing the “main threats” to protected areas, do not cite climate change among them, nor is climate change mentioned among the “challenges for the future” of the protected area system (SERNAP 2007, 2006). Our intention is to raise the awareness of the importance of integrating climate change into protected area planning as it is a current and future threat to protected area biodiversity and sustainability.

Protected Areas as “Victims” of Climate Change

As already stated by Halpin (1997), the potential for fast climate change and its effects on vulnerable ecosystems due to greenhouse gas emissions is putting protected areas and other natural landscapes under strong pressure. The magnitude and temporality of the anticipated climate change could lead to a situation where species and ecosystems as conservation objectives within protected areas are lost, disappear, or migrate to new sectors. Over the past 10 years, the conservation community has become more aware of the potential impacts of climate change on protected area systems and their management, particularly in terms of species representation and abundance, smaller protected areas being the ones to be most affected by environmental change (Araújo et al. 2004; Coenen et al. 2008; Hannah et al. 2002, 2007, 2008; Hewson et al. 2008; Hole et al. 2009; Ibisch and Mérida 2003; Lee and Jetz 2008; Sandwith 2008; Welch 2008).

More recently, the local academic community has been incorporating the impacts of climate change on protected areas into their agendas for research and analysis. As a strong example, we can mention the “Gap Analysis in Representativeness of Protected Areas of the National System of Protected Areas of Bolivia” (FAN et al. 2005), one of the first exercises in integrating possible impacts of climate change into conservation planning. The analysis focuses on the identification of important ecosystems, including ecosystems whose conservation would assist the migration of species under pressure from climate change, as well as areas that are particularly vulnerable to climate change and thus require mitigation and adaptation measures in order to deal with human activities that highlight the effects of climate change. As a result, altitudinal corridors and riverside forest corridors can be mentioned as priority ecosystems and areas in order to guarantee ecosystem connectivity (FAN et al. 2005).

The complementary analysis on “Anticipations of climate change” offers a qualitative identification of ecosystems whose future existence might be in danger

Photo 23.2 High altitude landscape below glacier-capped Sajama Mountain, Sajama National Park (Photo by D. Hoffmann)

due to climate change, as well as an identification of areas that could be possible routes of escape for animals and plants (Mueller 2005).

Except for this example, however, a review of relevant documents shows that in Bolivia conservation strategies only poorly consider climate change. There is (almost) no analysis that adequately and convincingly reflects the risks of climate change for the representativeness of species and ecosystems in the National System of Protected Areas. With this paper we seek to raise attention to related needs for information and research, on the one hand, and focused conservation action, on the other (Photo 23.2).

The Reaction of Protected Area Managers Towards Climate Change

Also in Bolivia the most important tool for conservation are protected areas, which is why the most important mechanism for adaptation to climate change is through the identification of priority sites for conservation, which then translate into protected area proposals. A crucial issue to be addressed is the identification of criteria and methodologies for determining priority areas, as well as the evaluation of management plans structured for each of the protected areas.

Important progress has been made in the identification of priority sectors for protected area creation and implementation. At a national scale, the Gap Analysis in Representativeness of Protected Areas of the National System of Protected Areas of Bolivia can be mentioned (FAN et al. 2005), through which departmental and municipal level complementary gap analyses are underway in different parts of the country. For example, by the end of 2009, an assessment of potential sites for municipal level protected area conservation will be concluded for the inner Andean dry forests in Bolivia (FAN et al. 2005; Ibisch and Mérida 2003; SERNAP 2007). Still, due to information gaps and methodological weaknesses, these initiatives do not adequately reflect issues of climate changes and its impacts.

Since 2000, protected area management plans in Bolivia have begun to reflect considerations on climate change and its impacts on the protected areas of Madidi (SERNAP and WCS 2005), Pilón Lajas (SERNAP and CRTM 2007), Apolobamba (SERNAP and Apolobamba 2006), San Matías (SERNAP and San Matías 2008), where the impacts of climate change have been identified as a “threat” (Madidi) or as an issue to be responded to through research and monitoring programmes (Pilón Lajas and Apolobamba). Only in the case of San Matías does the protected area assessment show an analysis of possible trends that the protected area could be suffering from climate change in terms of a gradual decrease in precipitation levels in the future. All the management plans highlighted here still show a weakness in the orientation of clear management measures that address climate change, as well as in mechanisms for the analysis, monitoring, adaptation, and mitigation of its impacts. In this sense, the issue of climate change has not yet received the attention and importance required in the integral planning and management of protected areas in Bolivia. This can be explained in part because from the point of view of protected area managers, there are more urgent needs than climate change to be addressed, for example, the agricultural frontier, human settlements and migration, regional development projects and infrastructure, hydrocarbon exploration and exploitation, mining, coca production, and others (Greenwood 2005; Schliep et al. 2008), and in part because of the poor availability of scientific information that could sustain decision-making based on dynamics of climate change. In response to the aspects considered in some of the more recent research documents (Ibisch et al. 2007; GLORIA Project), the design and implementation of more effective conservation strategies inside and around protected areas is prior.

Protected Areas as Key Elements in Mitigation and Adaptation Strategies

Following Hole et al. (2009), protected area networks are still the most important tool in biodiversity conservation at the global level. There is also an increasing acknowledgement of the role of protected areas in carbon sequestration and retention, and thus, in the mitigation of the impacts of climate change (Sandwith 2008; Dudley 2008). In this sense, in the Andean region and also specifically in Bolivia, a series of proposals are under way seeking to contribute to the avoidance of deforestation and degradation of forests in the area of influence of protected areas (REDD) and within protected areas (REDD+). Nevertheless, the viability and relevance of these initiatives are still under debate in the framework of the negotiations towards a post-Kyoto agreement. In Bolivia, different initiatives are reviewing methodologies for assessments of biomass, historic deforestation rates, and modelling of future deforestation. In order to strengthen these proposals, it is crucial to foment research on the role of terrestrial ecosystems in the emission and/or capture of greenhouse gases, as well as the decrease in deforestation rates as a governmental policy (PNCC 2007b) (Photo 23.3).

On the other hand, there is evidence that adequately managed protected area systems can offer opportunities for the design and implementation of adaptation strategies based on key ecosystem services, beyond mitigating the negative impacts of climate change (Dudley 2008; Dudley and Stolton 2003; Sandwith 2008). Abundant research is available that evaluates best practice in adaptation to climate change in the higher Andean area; nevertheless, only a few documents show reference to protected areas. In order for protected areas to accomplish their key role in adaptation to climate change, a change in paradigm is necessary to conceive and define conservation strategies and action that adequately respond to challenges and guarantee that conservation objects of protected areas transcend in time and continue accomplishing a key role in the provision of environmental services. In this sense, it is important that the National Climate Change Strategy includes strategic objectives that directly relate to protected areas, strengthening diverse mechanisms of adaptation to the anticipated change by the surrounding population. In this context, protected areas can also play a role in maintaining strategic natural habitats as a measure of risk management in the case of natural disasters that will become more accentuated through climate change.

An innovative aspect that contributes to the strengthening of adaptive capacities within protected areas is the analysis of intersections between ecological and social systems, analysing and revisiting the CDB ecosystem approach, reaching out for resilience of socioecological systems, systems of social and institutional learning (Berkes 2000, 2003; Buitrón s/d; Shepherd 2006). This interaction can be observed

Photo 23.3 Amboró National Park (Photo by D. Hoffmann)

in mechanisms of social participation in protected area management, such as protected area management committees in Bolivia, or mechanisms of shared management that involve social stakeholders in diverse manners in the integrated planning and management of protected areas, where capacity building towards adaptation to climate change should be one of the main foci of work (Berkes 2000, 2003; Holling 1973; Schliep et al. 2008). According to Stolton et al. (2008), protected area functions in mitigation and adaptation to climate change should receive more acknowledgement and be integrated into effective protected area management and their funding strategies.

The creation of protected areas that permit the preservation of the still glacierized water resources (in the *Cordillera Real*) is an initiative to be discussed further. At present, we can highlight the following examples: on the one hand, the declaration of Tuni Condoriri as a national level protected area in 1942 without ever initiating management of this area. Tuni Condoriri includes the area of Chacaltaya, Huayna Potosí, and the Tuni Lake, providing water to the cities of La Paz and El Alto. On the other hand, the municipal government of La Paz is in the process of declaring the regions of Hampaturi and Zongo, where important hydroelectric activity is underway, as municipal level protected areas (Hoffmann 2007b).

Above, we analysed to what extent protected areas can be considered in mitigation and adaptation strategies to manage the impacts of climate change, considering their importance in maintaining the resilience of ecosystems and in providing environmental services. In this context, it is necessary to properly reflect upon the importance of sub-national protected areas, in terms of the biodiversity and ecosystems they include, as well as in terms of the stakeholders involved in their management. Over the last few years, Bolivia has created a considerable number of municipal and departmental level protected areas which are important keystones in in situ conservation strategies and, in the framework of the National System of Protected Areas, importantly contribute to the conservation of biodiversity, water and forest resources, as well as to sustaining environmental services (Grupo Biodiversidad 2008; Hoffmann 2007a; PROMETA 2008).

Conclusions

Protected areas as a conservation strategy in Bolivia have seen a large expansion over the last 20 years (see Fig. 23.2), and are still in a phase of consolidation. In most cases, these areas have been set up to guarantee species and ecosystem representation. These efforts however, are becoming threatened by global warming and climate change.

Assessing the dimension of this threat is one of the most pressing needs in order to adapt management strategies. One of the main difficulties biodiversity researchers and conservation practitioners are faced with is a lack of climate data and regional models on climate change. The development of regional climate models and downscaling of existing ones are as important as it is to start long-term research on the impacts of climate change on biodiversity and ecosystems. Mountain regions and dry zones will most likely be the most affected by climate change.

Research from other regions indicates that protected areas have already become victims of climate change, while on the part of protected area managers in Bolivia, the issue of climate change is not being perceived as a priority (yet). One first step would be to deepen analysis of gaps in the representativeness of protected areas, with focus on climate change and related risk assessment (Ibisch and Mérida 2003) and to assess present conservation efforts and management approaches and their feasibility in the future (e.g. the establishment of protected areas in elevation gradients).

Then, it is important to consider that whilst protected areas suffer the impacts of changing climate, they are also under threat by the impacts of changes in land use patterns (e.g. deforestation, advance of agricultural frontier, settlements, as well as road and energy infrastructure projects), whose specific relation with the impacts of climate change (in time and in space) will still have to be established. Most authors concur that for the coming decades, these impacts on biodiversity and ecosystems in general will still be greater than those of climate change.

On a wider scope, it is important on the one hand to strengthen coordination between researchers and protected area managers in order to integrate research findings into protected area management measures and decision-making, while on the other, stronger alliances between protected area managers, researchers, and decision-makers at the political level are required in order to include climate change in a more integral way into conservation planning.

Finally, and in the light of limited possibilities for species to adapt to strong climate change, we agree with Stafford Smith and Leadley (2009) that one of the highest conservation priorities is strong international action to limit greenhouse gas emissions.

Acknowledgments We thank Carlos Alberto Arnillas, Roberto Ulloa, and two anonymous reviewers for their very helpful advice and comments.

Appendix: National Protected Areas of Bolivia

Protected Area	Extention (ha)	Department	Year of declaration	Year management established	Main ecosystems included
Parque Nacional Sajama	100,230	Oruro	1939	1995	Puna Desértica con Pisos Nivales y Subnivales de la Cordillera Occidental
Parque Nacional Tunari	300,000	Cochabamba	1962	s/d	Puna Semihúmeda, Yungas
Parque Nacional y Territorio Indígena Isiboro-Sécure	1,236,296	Cochabamba/Beni	1965	1995	Bosques Amazónicos Pre- y Subandinos, Sabanas Inundables de los Llanos de Moxos
Área Natural de Manejo Integrado Nacional Apolobamba	483,743	La Paz	1972	1977	Yungas, Vegetación Altoandina de la Cordillera Oriental con Pisos Nivales y Subnivales
Reserva Nacional de Fauna Andina Eduardo Avaroa	714,745	Potosí	1973	1994	Puna Desértica con Pisos Nivales y Subnivales de la Cordillera Occidental
Reserva Nacional de Vida Silvestre Amazónica Manuripi	747,000	Pando	1973	1999	Bosques Amazónicos de Pando y de Inundación
Parque Nacional Noel Kempff Mercado	1,523,446	Santa Cruz	1979	1992	Bosques Amazónicos del Beni y Santa Cruz, Cerrado Chiquitano, Bosques Amazónicos de Inundación
Reserva de la Biosfera Estación Biológica del Beni	135,000	Beni	1982	1985	Bosques Amazónicos Preandinos, Sabanas Inundables de los Llanos de Moxos
Parque Nacional y Área Natural de Manejo Integrado Amboró	637,600	Santa Cruz	1984	1989	Yungas, Bosques Amazónicos Subandinos, Bosque Tucumano – Boliviano
Parque Nacional Torotoro	16,570	Potosí	1989	1997	Bosques Secos Interandinos
Reserva Nacional de Flora y Fauna Tariquía	246,870	Tarija	1989	1995	Bosque Tucumano – Boliviano, Chaco Serrano
Parque Nacional Carrasco	622,600	Cochabamba	1991	1992	Yungas, Bosques Amazónicos Subandinos y otros
Reserva Biológica de la Cordillera de Sama	108,500	Tarija	1991	1997	Puna Semihúmeda, Bosque Tucumano – Boliviano

Protected Area	Extention (ha)	Department	Year of declaration	Year management established	Main ecosystems included
Reserva de la Biosfera y Territorio Indígena Pilón Lajas	400,000	La Paz/Beni	1992	1992	Bosques Amazónicos Subandinos, Yungas
Parque Nacional y Área Natural de Manejo Integrado Cotapata	40,000	La Paz	1993	1993	Yungas, Vegetación Altoandina de la Cordillera Oriental con pisos Nivales y Subnivales
Área Natural de Manejo Integrado San Matías	2,918,500	Santa Cruz	1995	1999	Bosque Seco Chiquitano, Sabanas Inundables del Pantanal, Cerrado Chiquitano
Parque Nacional y Área Natural de manejo Integrado Kaa-Iya del Gran Chaco	3,441,115	Santa Cruz	1995	1995	Gran Chaco (Cerrado Chaqueño)
Parque Nacional y Área Natural de Manejo Integrado Madidi	1,895,750	La Paz	1995	1995	Yungas, Bosques Amazónicos Sub- y Preandinos, Bosques Secos Interandinos y otros
Área Natural de Manejo Integrado El Palmar	59,484	Chuquisaca	1997	2002	Bosques Secos Interandinos, Chaco Serrano
Parque Nacional y Área Natural de Manejo Integrado Otuquis	1,005,950	Santa Cruz	1997	2002	Sabanas Inundables del Pantanal, Cerrado Chaqueño, Bosque Seco Chiquitano
Parque Nacional y Área Natural de Manejo Integrado Serranía del Aguaragüe	108,307	Tarija	2000	2007	Bosque Tucumano – Boliviano, Chaco Serrano, Gran Chaco
Parque Nacional y Área Natural de Manejo Integrado Serranía del Iñao	263,090	Chuquisaca	2004	2007	Bosque Tucumano – Boliviano, Chaco Serrano
Total (has)	17,004,796				

Source: Ibisch and Mérida 2003; SERNAP 2007
s/d: No data

References

Araújo MB, Cabezas M, Thuiller W, Hannah L, Williams PH (2004) Would climate change drive species out of reserves? An assessment of existing reserve-selection methods. Global Change Biol 10:1618–1626

Arnaud Y, Muller F, Vuille M, Ribstein P (2001) El Niño-Southern Oscillation (ENSO) influence on a Sajama volcano glacier (Bolivia) from 1963 to 1998 as seen from Landsat data and aerial photography. J Geophys Res 106(D16):17773–17784

Arnold I, Barroso P (2008) Áreas Protegidas de Bolivia. Situación y Perspectivas de Gestión. Nativa-Avina, Tarija, Bolivia

Berkes F (2000) Cross-scale institutional linkages: perspectives from the bottom up. IASCP 2000 Conference, Indiana University

Berkes F (2003) Can cross-scale linkages increase the resilience of social-ecological systems? Draft Paper, RCSD International Conference, Politics of the Commons, Chiang Mai

Bradley RS, Vuille M, Diaz HF, Vergara W (2006) Climate change: threats to water supplies in the tropical Andes. Science 312:1755–1756

Buitrón X (w/d) El enfoque esosistémico en la práctica. UICN Sur, Quito, Ecuador

Coenen D, Porzecanski I, Crisman TL (2008) Future directions in conservation and development: Incorporating the reality of climate change. Biodivers Clim Change (Spl Issue Biodiversity) 9 (3–4):106–113

CAN – Comunidad Andina de Naciones (2007) This climate is serious business: an overview of climate change in the Andean community. Lima, Peru, pp 58

Dudley N (2003) No place to hide. Effects of climate change on protected areas. WWF Climate Change Program, USA

Dudley N (2008) The use of protected areas as tools to apply REDD carbon offset schemes. In: IUCN Commission on environmental, economic and social policy, 2008, Climate change, energy change and conservation. Policy Matters 16:99–107

Dudley N, Stolton S (2003) Ecological and socio-economic benefits of protected areas in dealing with climate change. In: Hansen et al. (eds) Buying time: a user's manual for building resistance and resilience to climate change in natural systems WWF. Gland, Switzerland

FAN-TROPICO-CEP-NORDECO (2005) Análisis de Vacíos de Representatividad del Sistema Nacional de Áreas Protegidas. Santa Cruz, Bolivia

Francou B, Vuille M, Wagnon P, Mendoza J, Sicart J-E (2003) Tropical climate change recorded by a glacier in the central Andes during the last decades of the twentieth century: Chacaltaya, Bolivia, 16 S. J Geophys Res 108(DS):4154 (doi:10.1029/2002JD002959)

Francou B, Ribstein P, Wagnon P, Ramírez E, Pouyaud B (2005) Glaciers of the tropical Andes. Indicator of global climate variability. In Huber UM, Bugman HKM, Reasoner M (eds) Global change in mountain regions. Springer, Berlin, pp 197–204

Greenwood GB (2005) What are the important global change themes and issues in mountain biosphere reserves? In: UNESCO-MAB (eds) Global change impact in mountain biosphere reserves. UNESCO-MAB, Paris, pp 179–194

GTZ – Grupo Biodiversidad (2008) Áreas de Conservación Municipal. Una oportunidad para la conservación de la biodiversidad y el desarrollo local. Reflexiones desde América Latina y el Caribe

Halpin PN (1997) Global climate change and natural-area protection: management responses and research directions. Ecol Appl 7(3):828–843

Hannah L, Midgley G, Millar D (2002) Climate change-integrated conservation strategies. Global Ecol Biogeogr 11:485–495

Hannah L, Midgley G, Andelman S, Araujo MB, Hughes G, Martinez-Meyer E, Pearson RG, Williams P (2007). Protected area needs in a changing climate. Front Ecol Environ 5:131–138

Hannah L, Dave R, Lowry PP II, Andelman S et al. (2008) Climate change adaptation for conservation in Madagascar. Biol Lett 4:590–594

Hewson J, Ashkenazi E, Andelman S, Steininger M (2008) Projected impacts of climate change on protected areas. Biodivers Clim Change(Spl Issue Biodiversity) 9(3–4):100–105

Hoffmann D (2007a) El rol de las Áreas Protegidas Municipales en el Sistema Nacional de Áreas Protegidas (SNAP) de Bolivia. Technical document, Servicio Nacional de Áreas Protegidas de Bolivia (SERNAP). La Paz, Bolivia

Hoffmann D (2007b) Introducción sobre el impacto del retroceso de los glaciares y los recursos hídricos – presentación de las conclusiones de la conferencia regional de Quito. In: BMI (ed) Memoria del foro-debate “Retroceso de los Glaciares y Recursos Hídricos en Bolivia – De la Investigación a la Acción”. La Paz, Bolivia, pp 3–11

Hoffmann D (2008) Consecuencias del retroceso glaciar en la Cordillera boliviana. Pirineos 163:77–84

Hoffmann D, Oetting I, Arnillas CA, Ulloa R (2010) Cambio climático y áreas protegidas. In: SCOPE Book, Project An assessment of research and institutional needs to cope with the effects of climate change in the Andean biodiversity. IAI, Sao José dos Campos, Brazil (in print)

Hole DG, Willis SG, Pain DJ, Fishpool LD, Butchart SHM, Collingham YC, Rahbek C, Huntley B (2009) Projected impacts of climate change on a continentwide protected area network. Ecol Lett 12:420–431

Holling CS (1973) Resilience and Stability of ecological systems. Annu Rev Ecol Syst 4:1–23

Ibisch PL, Mérida G (eds) (2003) Biodiversidad: La riqueza de Bolivia. Estado de su conocimiento y conservación. Ministerio de Desarrollo Sostenible, Editorial FAN, Santa Cruz de la Sierra, Bolivia

Ibisch PL, Araújo N, Nowicki C (2007) Visión de Conservación de la Biodiversidad del Corredor Amboró – Madidi. Santa Cruz de la Sierra, Bolivia

IPCC (2007a) Climate change 2007: The physical science basis. IPCC – Intergovernmental Panel on Climate Change, Geneva

IPCC (2007b) Fourth assessment report. Climate change 2007: synthesis report. IPCC – Intergovernmental Panel on Climate Change, Geneva

Lee TM, Jetz W (2008) Future battlegrounds for conservation under global change. Proc Roy Soc Lond B 275:1261–1270

Mooney H, Larigauderie A (2009) Biodiversity and climate change: findings of the millenium ecosystem assessment, Box 6. In Richardsen et al. (eds) Synthesis Report. Climate Change Conference on Global Risks, Challenges & Decisions, Copenhagen, 10–12 Mar 2009, p 15

Mueller R (2005) In: FAN et al. (eds) Proyecciones futuras de cambio climático

Pauli H, Gottfried M, Hohenwallner D, Reiter K, Grabherr G (eds) (2003) Manual para el trabajo de campo del proyecto GLORIA. Aproximación al estudio de las cimas. www.gloria.ac.at/downloads/GLORIA_MS4_Web_espanol.pdf. Accessed June 2009

MDSP – Ministerio de Desarrollo Sostenible y Planificación (2001) Estrategia Nacional para la Conservación de la Biodiversidad de Bolivia (ENCB). La Paz, Bolivia

PNCC (2007a) Vulnerabilidad y Adaptación al Cambio Climático en Bolivia. PNCC – Programa Nacional de Cambios Climáticos, La Paz, Bolivia, pp. 141

PNCC (2007b) Mecanismo Nacional de Adaptación al Cambio Climático. PNCC – Programa Nacional de Cambios Climáticos, La Paz, Bolivia, pp. 75

Protección del Medio Ambiente Tarija – PROMETA (2008) Áreas protegidas municipales y departamentales facilitan las acciones contra el cambio climático. Revista Hábitat (Bolivia) 74:4

Ramírez E (2007) Impacto del Cambio Climático sobre la Disponibilidad de Recursos Hídricos. In: BMI (ed) Memoria del foro-debate “Retroceso de los Glaciares y Recursos Hídricos en Bolivia – De la Investigación a la Acción”. La Paz, Bolivia, pp 19–30

Richardsen K, Steffen W, Schellnhuber H-J, Alcamo J, Barker T, Kammen DM, Leemans R, Liverman D, Munasinghe M, Osman-Elasha B, Stern N, Waever O (2009) Synthesis report. In: Climate change conference on global risks, challenges and decisions, Copenhagen, 10–12 Mar 2009, pp 39

Sandwith T (2008) Protected areas and climate turnaround strategy (PACT) – an insurance policy for the world's greatest risk. In: IUCN commission on environmental, economic and social policy, climate change, energy change and conservation. Policy Matters 16:119–126

Schliep R, Bertzky M, Hirschnitz M, Stoll-Kleemann S (2008) Changing climate in protected areas? Risk perception of climate change by biosphere reserve managers. GAIA 17 (S1):116–124

SERNAP – Servicio Nacional de Áreas Protegidas (2006) Nuestra Agenda para el Cambio. La Paz, Bolivia

SERNAP (2007) Bolivia. Informe sobre el Sistema Nacional de Áreas Protegidas. SERNAP – Servicio Nacional de Áreas Protegidas, La Paz, Bolivia

SERNAP and CRTM (2007) Plan de Manejo y Plan de Vida de la Reserva de la Biosfera y Tierra Comunitaria de Origen Pilón Lajas. WCS, CI, USAID. Rurrenabaque, La Paz

SERNAP and CG ANMIN Apolobamba (2006) Plan de Manejo del ANMIN Apolobamba. CI, ITTO. La Paz, Bolivia

SERNAP and CG ANMI San Matías (2008) Plan de Manejo del ANMI San Matías. Santa Cruz de la Sierra, Bolivia

SERNAP and WCS (2005) Plan de Manejo del PM – ANMI Madidi, WCS, CAE, CARE. Unión Europea, La Paz, Bolivia

Shepherd G (2006) El Enfoque Ecosistémico: Cinco Pasos para su Implementación. UICN, Gland, Switzerland and Cambridge, UK

Stafford Smith M, Leadley P (2009) Biodiversity: enhancement of resilience or facilitating transformation? Sub-theme 31, Theme 4: Preparing for impacts: adapting to the inevitable. In: Climate change conference on global risks, challenges & decisions, Copenhagen, 10–12 Mar 2009

Stolton S, Randall J, Dudley N (2008) Protected areas climate change and disaster mitigation. In: IUCN commission on environmental, economic and social policy, climate change, energy change and conservation. Policy Matters 16:82–91

Ulloa D, Yager K (2007) Memorias del taller "Cambio Climático: Percepción local y Adaptaciones en el Parque Nacional Sajama", Sajama, 19–22 Sept 2007, Conservation International, Bolivia, pp. 42

Vuille M, Bradley RS, Werner M, Keimig F (2003) 20th century climate change in the tropical Andes: observations and model results. Clim Change 59:75–99

Welch D (2008) What should protected area managers do to preserve biodiversity in the face of climate change? Biodivers Clim Change (Spl Issue Biodiversity) 9(3–4):84–88

Chapter 24
Climate Change Policies and Issues: A Tool for Increased Wood Production in Developing Countries

Abiodun Oluwafemi Oluwadare

Abstract Climate change is a reality and forest trees are a major mitigating factor since they can sequester carbon dioxide and store carbon. Current climate change policy frameworks should address increased wood production in developing countries. The Kyoto Protocol (Article 3.3) should emphasize afforestation and reforestation while promoting increased use of wood products via wood recycling and good forest management. Sustainable forest management in Nigeria arising from global concern for climate change has led to increased afforestation programmes with the intensive taungya system and private establishment of many hectares of teak plantation in Nigeria. Ethiopia, Turkey, Kenya, and Mexico have planted 100–700 million trees under the UNEP tree planting programme initiative from 2006 to 2008. Legislation on Kyoto Protocol implementation may have to place emphasis on higher prices for trees that are to be given off (carbon trading) instead of being cut. A carbon tax incentive for tree planters will increase wood production and possible environmental protection. Those who contributed least to the atmospheric build-up of greenhouse gases are the least equipped to deal with the negative impacts; therefore, policies and issues in climate change should promote increased wood production in developing nations. The need to make policy issues in climate change to address increased wood production in developing nations is addressed in this paper.

Keywords Carbon trading · Climate change · Developing nations · Policy making · Wood production

Introduction

The climate is changing, the entire globe is warming up, and global concern seems to be reaching a consensus stage where every nation may have to come to accept climate change as a reality (Adger et al. 2005). The world mostly agrees that

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something needs to be done about the climatic "conjoined twins" – global warming and climate change. The establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1998 to assess the scientific bases of climate change perhaps paves the way for various other bodies that are concerned with issues on climate change today. Twenty years later, the IPCC stated that the impacts of climate change are quite enormous and the world may be engulfed in them if left unabated (Alao 2008).

The Kyoto Protocol, negotiated by 160 countries of the world, is yet to be fully signed and implemented. The United States, Russia, and a few other countries are against climate change treaties. While it is good for these countries to cut their emissions to save the globe, the issues raised in the Kyoto Protocol should strongly emphasize the need for developing countries to plant or establish more forest plantations. Forest trees have been singled out as an important factor in climate change mitigation (Muhamad 1997; CEI-Bois 2006, 2008; Zerbe 1990). It also pertinent that developing countries be aided or have more incentives for trees planted. This can be done through legislation on carbon trading/tax. Most developing nations may not have the scientific and human resources to cope with climate change monitoring but increased wood production may go a long way in combating global warming, as trees can sink and store carbon: two important functions trees can perform that no other material can do.

Issues in Climate Change

Global climate change is a major concern. Human activities are increasing daily, resulting in large quantities of greenhouse gases (GHG) being produced (Congregational Budget Office, Orszag 2007). The most devastating of these gases is carbon dioxide, CO_2. One of the issues is how industrialized countries can reduce their emissions of these gases that are causing the world to be at great risk. According to Orszag (2007), reducing GHG emissions would be beneficial in limiting the degree of damage associated with climate change. The irony of this is that it has a direct impact on the economy of the nations concerned. This perhaps is responsible for the refusal of the United States to ratify the Kyoto Protocol till now. This action has implications for the developing world, as they may not be able to financially support mitigating measures necessary to combat global warming. Their economies are poor, poverty and disease prevailing, hunger and food insecurity everywhere, while environmental degradation and war are ravaging most countries.

Orszag (2007) suggested that employing incentives-based policies to reduce CO_2 emissions would be much more cost effective than using more restrictive measures. Two forms of incentives have been proposed (a) those that limit the overall level of emissions, and (b) those that reduce emissions raising their price. Whichever incentives seem appropriate, policy issues such as vulnerability to tsunamis and flooding of coastal areas, desertification, loss of biodiversity (floral and faunal), health, and a host of others should be well addressed in developing countries such as Nigeria and other sub-Saharan countries (Okali 2004). This is necessary because these developing countries that contribute the least to causes of climate change are the most vulnerable to its impacts. In Nigeria in 2008, a Caribbean mahogany tree that had lived for over 45 years died as a result of continued inundation of its environment. Okali (2004) argued that developing countries are likely to suffer the heaviest casualty from climate change because they are least equipped or endowed with resources to combat the problem.

The Kyoto Protocol

The Kyoto Protocol is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC). The treaty aims to bring together countries, especially industrialized countries, to agree on reducing their GHG emissions. Article 3 of the Convention sets out principles to guide all the Parties to the Convention in their actions in achieving the objectives of the UNFCCC, as stated in Article 2. The fact that the climate system is to be protected for present and the future generations brings to heart the need for the emitters to give consideration to the developing countries that are most vulnerable to the impacts of climate change. Their considerations should place more emphasis on afforestation, reforestation, and sustainable management. By 2008, some developing countries had planted (Table 24.1) 1.45 billion trees (UNEP 2008). According to UNEP (2009), over 4 billion trees have been planted in over 166 countries; a growing concern from developing countries and many non-governmental organizations is the need for public participation in global warming issues.

Emissions Trading

In Article 12 of the Kyoto Protocol, the Clean Development Mechanism (CDM) was moved. The CDM allows developed countries with GHG emissions to invest in GHG reduction actions. According to Akande (2009), such investment, often

Table 24.1 Countries participating in tree planting programme initiatives of UNEP (2008)

Country	Total no. of trees planted (millions)
Ethiopia	700
Kenya	100
Mexico	250
Turkey	400
Total	1,450

termed carbon trading, should be geared towards plantation establishment. In the forestry sector, the investment of Annex 1 countries should be redefined in the Kyoto Protocol to include heavy financing of forest plantations in the developing countries, since only the forests can mop up the excess CO_2 in the air, thereby stabilizing the climate. It has been noted that young forest plantations will absorb more CO_2 compared to old growth. Therefore, the idea of the destruction of old growth forests to make way for young ones should not be held in such absolute terms as the fact that such action does not tackle the root causes of climate change effectively. The fact remains that sustainable forestry development holds the key to mitigating climate change and that developing countries will be helped towards the development of their forest lands so that areas under forest cover would be increased. It is believed that ozone layer weakness will result from global warming, and in order to cool the globe that is warming up gradually, more trees must be planted.

Role of Forests and Carbon Sequestration of Forest Plantations

The current concern over climate change is a good thing, however; there must be contentious efforts towards the role of forests in carbon sequestration. This is important because of the role forests play as carbon sinks. Zerbe (1990) opined that forests can serve as a remedy to the problem of climate change if appropriate measures are taken. Forests can reduce the amount of atmospheric CO_2 in four major ways:

1. Forests are a natural carbon sink and can absorb CO_2 from the atmosphere
2. Utilization of forests for wood products can sequester carbon for long periods
3. Use of timber in lieu of steel, concrete, aluminium, plastics, and other intensive materials can reduce energy requirements and CO_2 production
4. Forests can also store carbon for a very long period until needed

The use of wood as wood fuel in mitigating climate change is controversial, as energy use will produce carbon again. However, if the wood used can be replaced through reforestation, the carbon is continually being recycled. Since forest carbon sinks were included in the Kyoto Protocol as a mechanism to mitigate climate change, there would be the need to plant more trees. Pohjola (2010) reported that land management activities that reduce the amount of CO_2 in the atmosphere, known as land use, land use change, and forestry, are dealt with in Article 3.3 and Article 3.4 in the Kyoto Protocol. Article 3.3 covers afforestation, reforestation, and deforestation, while Article 3.4 covers forest management, cropland management, grazing land management, and revegetation. All these point to the invaluable contributions of forest plantations as a mitigating factor in climate change. Mitigating carbon emissions through forestry in tropical countries such as Nigeria will provide a promising avenue for reducing CO_2. Forests have the potential to significantly impact atmospheric levels of CO_2: trees absorb the most CO_2 when young and growing vigorously; though after 80–120 years the rate tapers off, depending on the species and site. However, if the forest is not well managed and allowed to decay, the stored carbon is released back into the atmosphere (CANFOR 2009). Godinho et al. (2003) reported that tropical forest ecosystems in Asia contain a substantial reservoir/amount of carbon (see Table 24.2).

Activities that disrupt the forest ecosystem balance (see Table 24.3), such as logging, slash-and-burn, and deforestation, could reduce carbon stocks by 33–75% according to Godinho et al. (2003). In another work, Greig (2009) reported between 80 and 244 million tonnes of carbon in United Kingdom forests (Table 24.4).

Current carbon sequestration is put at 4.0 million tonnes per annum while current removal is put at 2.0 million tonnes. Current UK GHG emissions amount to 151 million tonnes carbon equivalent per annum (554 million tonnes CO_2 equivalent). According to Macqueen et al. (2004), one of the quickest and lowest-cost options for reducing CO_2 emissions is to replace non-renewable fuels such as coal or oil with renewable fuels such as biomass wastes and residues. For long life-cycle

Table 24.2 Carbon density in vegetation and soils of forest ecosystems in tropical Asia

Carbon pool	Tropical moist forest	Tropical seasonal forest	Tropical dry forest
Vegetation (Mg/ha)			
High biomass	250	150	60
Low biomass	135	90	40
Soils (Mg/ha)	120	80	50

Source: Godinho et al. (2003), citing Palm et al. (1986)

Table 24.3 Above-ground carbon density after logging of Asian and Indonesian forests

Forest type and country	Biomass C density (Mg/ha)		Percentage of original carbon
	Undisturbed	Logged	
Closed broadleaf/Asia	98.2[a]	46.6	47
Closed conifer/Asia	72.5[a]	56.3	78
Open forest/Asia	39.5[a]	13.2	33
Indonesia	390	148.2	38
Indonesia	254	150	59
Indonesia	325	245	75

[a]Calculated from biomass data by assuming 50% C content
Source: Godinho et al. (2003), citing Lasco (2002)

Table 24.4 United Kingdom forestry and carbon amount (Mt)

Location of carbon storage	Quantity
Forest trees	150
Forest soils	244
Wood products	80
Current carbon sequestration in forests	4.0/annum
Current carbon removal in harvested wood products	2.0/annum

Source: Adapted from Greig (2009)

construction materials, substituting a cubic metre of wood for materials such as concrete, blocks, or bricks results in an average of 0.8 tonnes of CO_2 savings (Macqueen et al. 2004); see Table 24.5. The net emission of sawn timber ($-1,500$ gCO_2e) compared with the rest of the available building material (e.g. rock wool, 1,635 gCO_2e) will produce far less CO_2.

Choosing wood saves CO_2 as there are different manufacturing processes for different building/construction materials. In Table 24.6, the amount of CO_2 that can be saved by substituting a cubic metre of wood is given. In a French study (see Table 24.7), it was shown that the amount of CO_2 that was saved using wood was

Table 24.5 Net emissions from building material life cycles in gCO_2e per kg material

Building materials	Net emission (gCO_2e/kg)
Standard concrete	135
Heavy concrete	540
Light concrete	375
Calcite sand brick	540
Red brick	675
Chipboard	−1,000
Sawn timber	−1,500
Rock wool	1,635
Glass fibre wool	1,000
Cellulose wool	−1,250

Source: Adapted from Macqueen et al. (2004)

Table 24.6 Amount of carbon dioxide saved using wood as substitute material

Material	Saving (tonnes CO_2)
Light concrete blocks	0.725
Heavy concrete blocks	1,010
Red brick	0.922

Source: From CEI-Bois, citing RTS Building Information Foundation, Finland Environmental Reporting for Building Materials, 1998–2001, and IIED – Using Wood Products to Mitigate Climate Change (2004)

Table 24.7 Comparison of CO2 emissions of beams made of different materials

Building materials	CO_2 absorption in kg
Aluminium	330
Concrete	100
Steel	80
Wood	−150

Source: Indufor, CEI Bois Roadmap 2010 (2004)

Table 24.8 Comparison of different pillars of 3 m length designed for the same load of 20 kN

Material	Weight (kg)	Energy used (kWh)	Weight exerted (kg)	Ratio of wood to other materials
Wood	60	60	15	1
Steel	78	561	136	9.1
Concrete	300	221	54	3.6
Brick	420	108	26	1.7

Source: Adapted from Kursten (2008)

negative. Wood can absorb 150 kg CO_2 per tonne, while aluminium emits 330 kg per tonne.

In the manufacturing processes, the embodied energy is far lower in wood compared to other materials. CO_2 emissions resulting from the production of different pillars of 3 m length designed for the same load of 20 kN based on the energy consumption for their manufacture is given in Table 24.8, from which it is clear that the advantages of wood are overwhelming. The energy needed to produce a pillar that carries the same load is nine times higher for steel than for wood. It is evident, therefore, that forests and wood products are important factors in mitigating climate change and carbon sequestration (Kursten 2008).

In summary, this can be achieved by conservation of existing carbon stocks, expansion of carbon stocks, and substitution of wood products for fossil fuels-based products. Apart from established forest plantations, sparse forests and upland agroforestry areas could provide additional areas for carbon sequestration, thereby increasing carbon stocks.

Sustainable Forest Management in Nigeria

The dynamics of forest growth under different silvicultural practices has shown that sustainably managed forest establishment can sequester more carbon over time than unmanaged forests. Sustainable management practices keep the forest growing at a higher rate over time, providing net sequestration benefits that are additional to those of unmanaged forests. Managed forests provide climate change mitigation benefits over time through the delay of wood decay and CO_2 emissions from harvested wood products, as compared with the decomposition or thermal degradation of wood in unmanaged forests. Harvested wood products that have long life cycles after production can store carbon for decades into the future (Ruddell et al. 2007). Sustainable forest management provides a method of balancing diverging priorities of sustainable economics and social development on the one hand, and ecologically sustainability on the other. A well managed forest will ensure forest regeneration, health, and vitality (Patosaari 2007). Sustainable forest management contributes in no small measure to mitigation of harmful effects of GHG. In stabilizing CO_2 concentrations, five action plan strategies have been suggested by Patosaari (2007):

- Managing forests with high carbon uptake potential
- Expanding such forests through reforestation and afforestation
- Reducing deforestation and reversing the loss of forest cover
- Providing an enabling environment for investments and market access to sustainable forest-based products
- Increasing the use of forest-based products such as bioenergy and durable wood products, and substituting these for less eco-efficient materials

Forest-related activities that have mitigation measures can be designed to support national development and poverty alleviation programmes, as multiple benefits could be derived from such actions. Developing countries such as Nigeria should be vigorously aided to sustainably manage their forests. Globally, forestry makes valuable contributions to sustainable development. There has been increased participation in forest/plantation establishment in Nigeria, though it may not be compared to the rate of global participation. An estimate of about one million cubic metres of timber could be produced each year from the forest on sustainable basis. Akande (2009) opined that between 3 and 4 million hectares of young plantations could be established for carbon sequestration. However, the current national plantation is less than 25% of this estimate. To increase the areas under forest cover, establishing greenbelts across the country has been advocated. The greenbelt arrangement would assist in advancing carbon credits, water resources conservation, biodiversity conservation and management, and restoring degraded land. It should be noted that such projects require huge financial outlay. It is here that the Annex 1 countries, through incentives such as carbon trading/carbon tax, can help to finance sustainable forest management in developing countries. Dominant species planted in Africa (especially in Nigeria) and Asia include Tectona and Eucalypts. By the 2008 planting season, a total of 1,620 ha. of Tectona were planted in five southwest states of Nigeria, while over 5,000 ha have been planted with more than three indigenous species (Tables 24.9 and 24.10). Opportunities still abound for more hectares of land to be planted, bearing in mind the good news of UNEP (2009) that over 4 billion trees have been planted. The area under forest cover in Nigeria is about 0.03% of the world's total, while according to Jimoh and Bada (2001), less than 5% of Nigeria land is under forest.

Table 24.9 Distribution of plantation areas by species in five southwest states

Species	Plantation (Ha)					
	Ekiti	Ogun	Ondo	Osun	Oyo	Total
Teak	493	324	368	279	156	1,620
Gmelina	92	N.A.	N.A.	50	31	173
Terminalia	25	N.A.	N.A.	N.A.	N.A.	25
Khaya	5	2[a]	N.A.	N.A.	N.A.	7
Mansonia	2	5[a]	N.A.	N.A.	N.A.	7
Total of all species	617	331	368	329	187	1,832

[a]Estimate
N.A. Not available

Table 24.10 Distribution of hardwood species plantation areas by participating agencies in Nigeria

Agencies	Teak	Gmelina	Khaya	Mansonia
Federal	78.6	10	–	–
State	1,620	173	7[a]	N.A.
Private	5,500	1,100	10[a]	N.A.
Community	N.A.	N.A.	N.A.	N.A.

[a]Estimate
N.A. Not available

This is a clear indication that developing countries like Nigeria need more areas under forest cover to be able to cope with climate change. Already there is widespread interest from private individuals, NGOs, schools, and communities to plant more trees due to gradual awareness of climate change. The understanding is that "if you plant trees you can get dollars from America". This is our local understanding of carbon credits in Nigeria. This is further corroborated by the European Union (2009): "the exclusion of tropical forests from the world's largest carbon market could soon be reversed as European policy makers consider amendments to the current rules". I believe such amendments will include greater incentives to protect the tropical forests while more forest plantations are being established. Thus, the financing of such plantation establishment should be an issue of interest in the Kyoto Protocol. In Malaysia, according to an EC-FAO (2003) report, a database of private sector forest plantations has been established. Similar trends should be extended to other developing countries.

Conclusion

There are many ways climate change can be mitigated and at the same time established forests can be sustainably managed. There is an understanding that forests and wood products act as carbon stores and thus help mitigate climate change. Moreover, more carbon can significantly be stored when wood products replace other construction and packaging materials.

Forests have tremendous potential to serve as a tool in combating climate change, protecting people, and improving livelihoods. Sustainable forest management provides the framework for international and national level planning and participation on how best to deal with the issue of climate change that has confronted us. Therefore, two key policy issues must be addressed (1) plant more forest trees and allow them to be in forests and (2) sequester more carbon through sustainable forest management.

Issues relating to carbon trading should be carefully considered to encourage investments in forest management. For this to occur, the rules and issues relating to carbon trading must be carefully weighed up in order to know how carbon stocks are measured, monitored, evaluated, verified, and computed. These must be defined clearly so that costs of carbon trading are not exaggerated.

There is the need to rediscover the use of wood and its climate change mitigation potential in order to foster greater establishment of forest plantations. This should be the primer for developing countries, as they are more vulnerable to the impacts of climate change.

The advocacy of support from the Annex 1 countries for developing countries to establish more forest plantation should be given greater consideration. Incentives for financing the establishment of such projects ought to be supported by the emitters of greenhouse gases. This is highly imperative if developing countries such as Nigeria are to be able to cope with the future consequences of climate change while mitigating its present impacts.

References

Adger WN, Arnell NW, Tompkins EL (2005) Successful adaptation to climate change across scales. Global Environ Change 15:77–86

Akande JA (2009) Environmental advocacy for green collar, green belt and green certification. A paper presented at the annual public lecture of Tree Club, University of Ibadan, Nigeria, May 2009, p 14

Alao JS (2008) Issues and policies on climate change. In: Popoola L (ed) Climate change and sustainable renewable natural resources management. Proceedings of the 32nd Annual Conference of the Forestry Association of Nigeria, Umuahia, Nigeria, pp 352–358

CANFOR (2009) Wood and green building: the role of life cycle assessment. http://www.canfor.com/_resources/products/wood_Green_building.pdf. Accessed 28 Sept 2009

CEI-Bois (2006) Tackle climate change: use wood. In: CEI-Bois Roadmap 2010. CEI-Bois, Europe, p 58

CEI-Bois (2008) Wood products help slow global warming. http://www.cei-bois.org/prowood

EC-FAO (2003) Private sector forest plantation development in peninsular Malaysia. FAO, Rome

European Union (2009) EU carbon trading: tropical forests poised to win credits. Climate Change Corp. http://www.climatechangecorp.com/content.asp

Godinho L, Nacuray E, Cardinoza MM, Lasco D (2003) Climate change mitigation through carbon sequestration: the forest ecosystems of Timor Leste. In: Proceedings from the 1st national workshop on climate change, Dili, 19 Nov 2003, pp 36–46

Greig S (2009) Forests, carbon and climate change mitigation. http://www.forestry.gov.uk/pdf/nee.climate-conf-greig.pdf/SFILE/nee.climate. Accessed on 17 Aug 2009

Jimoh SO, Bada SO (2001) Private participation in forest plantation development in Nigeria. J Trop For Res 17(2):65–72

Kursten E (2008) How forest industries may contribute to environmental protection. Wood News 17(6):8–15

Macqueen D, Mayers J, Reid H (2004) Could wood combat climate change? International Institute for Environment and Development, The Edinburg Centre for Carbon Management, Edinburg

Muhamad A (1997) Global warming and typical forest ecophysiology. In: Appanah SS, Yusmah MY, Astinah WJ, Khoo KCL (eds) Conference on forestry and forest products research. Proceedings for the Fourth Conference. Forest Research Institute of Malaysia, Kuala Lumpur, pp 13–32

Okali D (2004) Climate change and Nigeria: a guide for policy makers. Nigerian Environmental Study/Action Team, Nigeria, p 20

Orszag PR (2007) Issues in climate. In: Paper presented at congressional budget office director's conference on climate change, 16 Nov 2007, p 16

Patosaari P (2007) Forests and climate change: mitigation and adaptation through sustainable forest management. Remarks presented to the 60th annual DPI/NGO conference, Climate change: How it impacts us all. UN, New York, 6 Sept 2007, p 46

Pohjola J (2010) How sinks in wood products affect the cost of climate convention and world trade of forest products. Results from global economy wide model

Ruddell S, Sampson R, Smith M, Giffen R, Cathcart J, Hagan J, Sosland D, Godbee J, Heissenbuttel J, Lovett S, Helms J, Price W, Simpson R (2007) The role for sustainably managed forests in climate change. J For (Sept):314–319

UNEP (2008) Billion tree campaign to grow into seven billion tree campaign. http://www.unep.org/Document

United Nations (2009) UN tree planting campaign reaches 4 billion mark. UN news Centre. http://climate-l.org/2009/06/05/unep-tree-planting-campaign-passes-four-billion-mark/

Zerbe JI (1990) Biomass energy and global warming. World Resour Rev 2(1):66–82

Chapter 25
Climate Policy Integration in the EU

Claire Dupont

Abstract Climate change is an issue that cuts across several policy domains, from the environment to transport, industry, agriculture, and health, among others. It follows that responses to climate change need to cut across the various policy fields also. The phenomenon of incorporating or mainstreaming climate policy into other policy fields is often termed "climate policy integration", and it is a policy requirement that has not yet been extensively explored, especially at EU level. With the agreement on the EU's integrated climate and energy package in December 2008, it is clear that climate policy integration is considered important for the Union's strategy to combat climate change. Can it be said that climate policy integration is already in place in the EU? How can we identify climate policy integration? How can we ensure that climate policy integration is effective? The aim of this paper is to examine the extensive research already carried out on environmental policy integration (EPI) in order to draw out lessons that could help, firstly, to conceptualize climate policy integration, and, secondly, to identify a framework for analysis or a set of criteria that could aid the analysis of climate policy integration at EU level. EPI is an area of literature that rarely deals with climate policy in particular. However, its focus on policy processes, administrative structures and communication channels, for example, can provide lessons for the study and implementation of climate policy integration. This paper contributes to the development of an analytical framework for assessing and studying climate policy integration at EU level, and concludes by highlighting some areas for further research.

Keywords Climate change · Climate policy integration · Environmental policy integration · European Union climate policies

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Introduction

Climate change is one of the greatest threats facing humanity today – environmentally, socially, and economically. The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) highlighted that humanity holds great responsibility for the changes evident in the climate system and the related effects on all aspects of the environment (IPCC 2007). As well as highlighting this evidence, the IPCC outlined scenarios on how climate change could affect human society in terms of food supply, health, coastal and other settlements, industry, and water supply. Such scientific warnings about the impacts of climate change for humanity have resulted in calls for urgent action to mitigate the causes of climate change and adapt to its effects, and have highlighted the need to integrate climate change concerns into other policy areas.

Climate change is now an issue that can be found high on the political agendas at all levels – locally, nationally, internationally, and, of course, at the level of the European Union (EU). In 2007 and 2008, climate change featured on the agendas of the United Nations General Assembly, the United Nations Security Council, and the G8 and G20 summits (Ott et al. 2008). However, despite such high-level political discussions and political commitments at all levels to reduce emissions of greenhouse gases, progress towards combating climate change has been limited, with remarkably slow progress being made in reducing emissions (Compston and Bailey 2008).

The EU, however, considers itself an international leader on climate change issues (Gupta and Grubb 2000; see also European Council conclusions, especially from 2007 onwards). Since the beginning of the 1990s, the EU has been developing its domestic policies on climate change, along with its international stance on committing to stringent climate policy measures, to the extent that it can justifiably claim such a leadership role (Oberthür and Roche Kelly 2008, p. 47). Ensuring that its domestic policy measures live up to its international commitments and negotiating stance is crucial for the EU if it wishes to retain its leadership status. With the EU possessing competence in several crucial policy areas (e.g. agriculture) affecting, or affected by, climate change, the EU itself must act to ensure "win-win" situations across these policy areas.

One way for the EU to ensure its climate policies are successful is to promote the integration of climate policy aims into other policy areas. Since the impacts and concerns of climate change tend to go beyond the environmental sector (as outlined in the IPCC 2007 assessment report – see above), there is much overlap into other environmental and non-environmental policy areas (such as energy, biodiversity, agriculture, transport, industry, etc.). It is crucial, therefore, that policy responses also cut across the various policy fields. Combating climate change cannot successfully take place within the narrow remit of environmental policy makers – it must be a "whole-of-government" affair (Ahmed 2009, p. 2). Within the EU, this means that climate change must be taken into account across the different Directorate-Generals of the European Commission, across the various formations of the

Council of Ministers and in the deliberations of the Parliament (with the political backing and political impetus of the European Council of heads of state and government).

Despite the cross-cutting nature of the problem, and the necessity for cross-cutting policy responses, and despite the role played by the EU in formulating climate policy, climate policy integration at the level of the EU has not yet received much attention. However, there is much research on the topic of environmental policy integration. The historical development of EPI in the EU is also well researched, especially since the Single European Act (1987) introduced the requirement of ensuring that environmental protection objectives become a "component" of other EU policies (Single European Act 1987, Article 130r[2]). EPI became an even more developed concept within the EU after the Amsterdam Treaty (1997) outlined sustainable development as an overall objective of the EU. Article 6 even commits the EU by stating that "environmental protection requirements must be integrated into the definition and implementation of the Community policies", which further heightened research on EPI. Besides the many studies on environmental policy integration (Jordan and Lenschow 2008a; Lafferty and Hovden 2003; Lenschow 2002a; Nilsson and Eckerberg 2007; Persson 2007), there has very recently been an interest in climate policy integration at national level (Mickwitz et al. 2009; Van Bommel and Kuindersma 2008), with some research being carried out in this area. The concepts and analytical frameworks in environmental policy integration and national-level climate policy integration research provide a good basis for expanding the research on climate policy integration to EU level.

The aim of this paper is to, firstly, conceptualize climate policy integration in general, and, secondly, to operationalize the concept at EU level. To this end, the paper is structured in the following manner. Below is a brief introduction to the climate policies of the EU. The next section outlines a broad and flexible definition of climate policy integration. This definition is derived from literature on policy integration in general, and on environmental policy integration in particular. However, a broad definition is only useful for operational purposes if it is accompanied by a set of identifying and evaluating criteria. The following section, therefore, draws on studies of climate policy integration at national level and environmental policy integration at EU level in order to identify a set of criteria to operationalize the concept of climate policy integration. The next section then expands on the set of criteria to discuss how the concept and the criteria can be applied to the study of climate policy at EU level. In this section, reference will be made to the climate and energy package of measures agreed upon in the EU in December 2008, with some brief reference to other sectoral policies where possible. However, without an in-depth analysis of various policy areas (a task that is beyond the scope of this paper), the criteria will only be discussed briefly. Finally, the paper will conclude with some recommendations for further research and development of the concept and its operationalization.

Climate Policy in the European Union

The Council of Ministers and the European Parliament agreed on the integrated climate and energy package of policies of the European Union in December 2008, which was the final step in a policy development process that began with Commission proposals for limiting global climate change to 2°C in January 2007 (European Commission 2007a). The heads of state and government at the European Council in March 2007 endorsed this vision. At this European Council summit, the member states committed the EU to cutting its greenhouse gas emissions independently by 20% compared to 1990 levels by 2020. It further agreed to increase this commitment to a 30% cut, if other developed countries made similar commitments, and if developing countries made "adequate" commitments to reduce emissions (European Council conclusions, March 2007). The EU also committed to increase the share of renewable sources of energy in total energy consumption to 20%, and to increase the share of biofuels used in transport fuel to 10% by 2020.

The relative speed with which the climate and energy package was adopted is all the more remarkable in contrast to the slow development of climate policies in the EU from 1990 until 2006. Indeed, the EU has attempted to provide international leadership on climate change since the beginning of the negotiations on the United Nations Framework Convention on Climate Change (UNFCCC) in 1991, but this leadership was hardly credible with the lack of progress in domestic policies (see Oberthür and Roche Kelly 2008). Much of the difficulty in developing EU climate policies was as a result of a prolonged discussion during much of the 1990s on the suitability of applying a combined European CO_2/energy tax – a proposal that ultimately failed (Wettestad 2000). Accordingly, any reductions in greenhouse gas emissions in the EU during the 1990s were more a result of unrelated political developments than effective domestic climate policies (i.e. German reunification and the UK's move from coal to gas) (Oberthür and Roche Kelly 2008, p. 40). There was, however, a significant increase in the pace of climate policy development after the agreement of the Kyoto Protocol in 1997 and the Marrakech Accords in 2001 – highlighted by agreement on the 2003 EU emissions trading directive (among others), representing the flagship climate policy tool of the EU (see Skjærseth and Wettestad 2008). This period also saw the beginning of the narrowing of the credibility gap between the EU's international leadership claims and its domestic climate policies – a narrowing that accelerated after the commitments made by the EU in 2007 (above).

With the increasing alignment between the EU's international leadership claims and its actions at the domestic level, can the EU now be considered a credible leader in climate change policies? One important aspect of being a leader on climate change is ensuring continued and increasing efficacy in domestic climate policies. Enabling a high level of climate policy integration across all policy areas in the EU is one strategy for increasing efficacy and efficiency in domestic climate policies.

Conceptualizing Climate Policy Integration

At present, academic research on climate policy integration is only in its infancy. Some studies have been carried out at national level, yet little has been done to explore the concept at EU level. As such, this paper contributes to filling this gap, by proposing a working conceptualization of climate policy integration derived from policy integration and EPI literature, and an analytical framework for studying the concept at EU level. This section begins by developing the concept of climate policy integration.

Policy Integration and Policy Coordination

Underdal defined policy integration as requiring three elements: comprehensiveness, aggregation and consistency (1980, quoted in Persson 2004, pp. 10–11). From this perspective, a policy that is integrated is one where "all significant consequences of policy decisions are recognized as decision premises, where policy options are evaluated on the basis of their effects on some aggregate measure of utility, and where the different policy elements are in accord with each other" (Underdal, 1980, p. 162, quoted in Persson 2004, p. 11).

Key concepts within the policy integration discussion include policy coherence and policy coordination. Policy coherence refers to the synergy between different policy areas (Van Bommel and Kuindersma 2008, p. 15), while policy coordination has been described as an "administrative Holy Grail" (Peters 1998, p. 295) where "policies and programmes of government are characterized by minimal redundancy, incoherence and lacunae" (Peters 1998, p. 296). In other words, policy coherence is interested in ensuring synergistic policy outcomes, while policy coordination is concerned more with policy processes. For many, however, policy coordination and coherence are regarded as synonyms (Mickwitz et al. 2009, p. 24). Both these concepts play a role in helping to establish an ideal end state of policy integration – i.e. where an integrated and coordinated policy results in synergy.

The policy integration and policy coordination literature form a useful starting point for environmental policy integration (EPI), as we will see below, and climate policy integration. Underdal's definition goes beyond general descriptions to provide for three basic criteria to establish if a policy is truly integrated, and so combines both description and elements of an analytical framework. However, neither Underdal nor the literature on policy coordination place an environmental or climate focus in their definitions. The EPI literature aims to go beyond these conceptualizations by applying a specific environmental twist to the policy integration discussion, as outlined below.

Environmental Policy Integration

Environmental policy integration (EPI) can be examined and defined from several different perspectives and levels. EPI can be regarded as a policy principle; a process or a set of measures; and/or as an output or outcome (Persson 2004, p. 19). It emerged and developed as a concept because of the perceived failure and inability of traditional sectoral environmental policy to respond to the pressures placed on the environment by the actions of a wider society. It can be considered a broad concept that is value-laden and political, and therefore results in several interpretations (Persson 2007, p. 44). For these reasons, there is much debate on the meaning of the term "environmental policy integration", how it can be defined, recognized, implemented, measured, evaluated, and improved upon. In fact, the European Environment Agency (EEA) describes how the lack of agreement on the meaning of EPI has helped to make it "more acceptable to policy-makers" (EEA 2005, p. 12).

Firstly, EPI as a policy principle highlights the strong normative dimension of the concept. As a principle of policy making, it is held up as what ought to happen in the interactions between the environment, society, and the economy (see Nilsson and Eckerberg 2007). Thus, EPI aims to establish a relative value for the environment (Jordan and Lenschow 2008a). From this normative or rational perspective, EPI requires a higher priority for environmental needs in policy making – i.e. giving the environment "principled priority", as outlined by Lafferty and Hovden (2003). The idea of having a principled priority for the environment is justified by two factors (1) because "environmental policy for too long has been treated as a peripheral concern for policy-makers in general"; and (2) because there is "increasing recognition and acceptance of the fact that we are facing potentially irreversible damage to life-support systems" and therefore "as far as some environmental objectives are concerned, these cannot simply be 'balanced' with the objectives of other sectors" (Lafferty and Hovden 2003, p. 10).

Secondly, when studying EPI as a process or as an output, it is important to note that these two aspects are not mutually exclusive. In much of the literature, EPI is analysed from the perspective of process, including issues of policy coordination between agencies (Peters 1998); communication channels and processes for issue mainstreaming; and inter-sector relations, for example (Nilsson and Persson 2003; Jordan 2002). Analysis of EPI from the policy output perspective involves examining the policy document or programme in place. Taking both perspectives together allows EPI to be regarded as a broader scheme for overall policy change (Persson 2007) and a continual process during all policy-making phases (EEA 2005, p.13).

Thirdly, looking at EPI as a policy outcome, then, is concerned with whether or not evidence of EPI within the policy-making process has actually resulted in an improvement for the environment. However, it is methodologically difficult to establish evidence of EPI throughout the policy-making process and in the policy outputs and outcomes, as no concrete and agreed definitions or sets of criteria for evaluations of this kind exist (Jordan and Lenschow 2008b, p. 18). Understanding

EPI as an overarching principle can help avoid such conceptual difficulties (Persson 2004, p. 23).

In later EPI literature, the definition provided by Lafferty and Hovden (2003) is commonly accepted as an encompassing understanding of EPI. Their two-tiered definition of EPI is as follows (2003, p. 9):

- The incorporation of environmental objectives into all stages of policy-making in non-environmental policy sectors, with a specific recognition of this goal as a guiding principle for the planning and execution of policy
- Accompanied by an attempt to aggregate presumed environmental consequences into an overall evaluation of policy, and a commitment to minimize contradictions between environmental and sectoral policies by giving principled priority to the former over the latter

This definition goes beyond the definition of Underdal by describing the heart of the EPI issue, namely the importance of sectoral and/or of environmental objectives in the integration process (Persson 2004, p. 18).

The many perspectives and definitions of EPI, coupled with literature on policy integration and coordination, provide a good foundation for any general conceptualization of climate policy integration.

Climate Policy Integration

Although climate policy is traditionally a sub-environmental policy area, it has not been extensively considered under environmental policy integration processes – a gap that requires the development of climate policy integration. Taking Lafferty and Hovden's (2003) definition of environmental policy integration (above) and replacing "environment" with "climate" can result in a reasonable workable definition of climate policy integration (Ahmed 2009, p. 11). However, it is necessary to understand that climate policy is, in general, still considered a sub-environmental policy, and therefore establishing a principled priority of climate policy over all other policy areas, including other environmental policies and sustainable development policies, would likely cause more harm than good for the general environment, as well as the climate. This normative issue can be resolved by distinguishing between climate policy integration into *environmental* areas and into *non-environmental* areas. For this reason, I take the stance that climate policy integration into other *environmental* policies should aim to ensure synergistic processes and outputs between the areas. When climate policy aims are being integrated into other *non-environmental* policy areas, climate policy aims should then be given "principled priority", as outlined by Lafferty and Hovden above.

While keeping such a two-tiered understanding of the priority climate policy aims in mind, a broad working definition of climate policy integration will aid its operationalization and analysis. Such a broad definition of climate policy integration can be outlined, based on Underdal's definition of policy integration, and definitions of EPI, as follows: "the incorporation of the aims of climate change adaptation and mitigation into all stages of policy-making in other policy sectors" (Van Bommel and Kuindersma 2008, p. 9). This definition can be further developed by adding that such an incorporation of climate policy aims should be "complemented by an attempt to aggregate expected consequences for climate change mitigation and adaptation into an overall evaluation policy, and a commitment to minimize contradictions between climate policies and other policies" (Mickwitz et al. 2009, p. 19). As such, the definition covers climate policy integration, both in terms of a process (the "incorporation...") and also in terms of policy output ("minimize contradictions...").

Coupled with the understanding of the principled priority of climate policy objectives in non-environmental policy areas in case of conflict, the above definition provides a first step for the study of climate policy integration at EU level. In order to operationalize the concept, however, and attempt to apply the concept to the EU level, it is necessary to devise a set of criteria to accompany the definition. The next section deals with how to establish such a set of criteria in order to operationalize the concept of climate policy integration.

Operationalizing Climate Policy Integration

Now that climate policy integration has been defined in general terms as the incorporation of climate policy aims into other policy sectors and attempting to minimize any potential contradictions between these policies (while ensuring climate policy aims receive priority in non-environmental policy areas), it is necessary to establish a set of criteria to help operationalize this concept. Such criteria are necessary to ensure that climate policy integration does not remain a broad general principle without operational value, as such criteria can "allow for a regular review of progress towards achieving a policy target and setting sectoral benchmarks" (Lenschow 2002c, p. 227).

In this section, I again look to the well-established EPI literature in order to outline some criteria that can be applicable to climate policy integration. Furthermore, I examine some country-level studies of climate policy integration, in order to establish if the criteria used at national level can also be applicable for operationalizing climate policy integration at EU level.

Within EPI literature, both the Organization for Economic Cooperation and Development (OECD 2002) and the EEA (2005) have outlined sets of criteria for identifying, evaluating, and improving the levels of EPI (Table 25.1). The criteria outlined by the OECD are aimed specifically at enhancing policy coherence and integration in order to improve sustainable development, as EPI has long been conceptually linked to the aim of sustainable development. This linkage of EPI to sustainable development, by promoting EPI as one tool for achieving sustainable development, has helped the concept gain acceptance politically. The EEA's criteria, however, are aimed even more specifically at improving environmental policy integration in the EU. Again, within the EU, EPI is closely linked to

Table 25.1 Checklist on improving policy coherence and integration for sustainable development (OECD 2002) and EEA's (2005) checklist of criteria for evaluating EPI

OECD Checklist	EEA Checklist
1. Is there a common understanding of sustainable development?	1. Trends in drivers, pressure, changes in state of the environment, impacts
2. Is there clear commitment and leadership?	2. Political commitment and strategic vision
3. Are conditions in place to steer sustainable development integration?	3. Administrative culture and practices
4. Is stakeholder involvement in decision-making encouraged?	4. Assessments and consultations to underpin policy design and decisions
5. Is the diversity of knowledge and the scientific input to problems adequately managed?	5. Use of policy instruments to deliver EPI
	6. Monitoring and learning from experience

sustainable development (a link Lenschow argues has not helped with adapting the EPI concept to "the operational level" [Lenschow 2002b, p. 4]). However, the conceptual link between EPI and sustainable development means that the criteria set out by the OECD and the EEA are rather similar.

As can be seen from the criteria listed by the OECD and the EEA, several factors are considered important for the successful integration of environmental concerns into other policies. These factors listed above include: political commitment and leadership, administrative practices, scientific and other knowledge input into the policy-making process, stakeholder involvement, and monitoring and learning. With regard to climate policy integration at EU level, some of these criteria can also be applied.

A combination of some of the criteria outlined above and criteria used for assessing climate policy integration at national level can be useful to assess levels and effectiveness of climate policy integration at EU level. As the policy-development process at national level is different to that at EU level (with the co-decision procedure, for example), and since the implementation of policy happens at member state level, there will be some differences between the criteria for assessing climate policy integration at national and EU levels. However, criteria similar to those outlined by the OECD and EEA above have already been applied in studies of climate policy integration at national level.

Recent country-level studies have listed five criteria necessary for identifying and analysing the process of climate policy integration at national level. These criteria include: the inclusion of climate policy aims; consistency between policy aims; relative weighting of climate aims; reporting procedures; and resources allocated (Mickwitz et al. 2009, p. 23; Van Bommel and Kuindersma 2008, pp. 11–12). Mickwitz et al. (2009) and Van Bommel and Kuindersma (2008) elaborate on these criteria as follows. The level of inclusion of climate concerns involves assessing to what extent climate change issues have been included in various action programmes as well as in different policy sectors. The factor for measuring consistency looks at whether the contradictions between the policy sector aims and climate policy aims have been assessed and minimized. This involves ensuring as many win-win outcomes as possible, while understanding that where conflicts arise, strategies ought to be implemented to minimize these conflicts as much as possible. Weighting of climate policies in other policy sectors seeks to establish whether the relative priorities of climate impacts compared to other policy aims have been decided upon. It is also important to find out if procedures are in place to determine these relative priorities. As with EPI, reporting procedures are considered very important for the development, evaluation, and improvement of climate policy integration. It is necessary to identify whether there are clearly defined requirements for evaluating and reporting on climate change issues within a policy sector. Finally, Mickwitz et al. (2009) and Van Bommel and Kuindersma (2008) cite the allocation of resources as an important factor for improved climate policy integration. This refers specifically to budgetary, human, and knowledge resources – is know-how about climate change mitigation and adaptation available, applied and used in other policy sectors? Are resources allocated to ensure this happens?

Drawing from EPI and climate policy integration criteria, Table 25.2, below, outlines a sample framework for analysing climate policy integration at EU level. As well as the five criteria outlined in the reports by Mickwitz et al. and Van Bommel and Kuindersma, a sixth criterion has been added. The criterion of "political commitment" assesses the levels of leadership on climate policy integration. It is included here as it was identified in EPI literature as a particularly important element at EU level for the integration of environmental considerations into other policy areas.

The next section will briefly examine each of these criteria in turn, in the context of the EU.

Table 25.2 Criteria for assessing climate policy integration at EU level

Criteria	Key points
Political commitment	High-level promotion of climate change integration? Strategic long-term vision and political leadership?
Inclusion	Extent to which direct as well as indirect climate change impacts covered in policy? Cooperation mechanisms between policy sectors in place? Mix of policy tools used? Degree of institutionalization of climate change concerns?
Consistency	Possible contradictions and conflicts between climate policy aims and other policy aims assessed? Efforts to minimize contradictions and promote "win-win" solutions?
Weighting	Are relative priorities of climate aims compared to other policy aims determined? Does the policy address how conflicts with climate aims can be minimized?
Reporting	Clearly stated evaluation, monitoring and reporting requirements? Mechanisms for exchanging good practice?
Resources	Stakeholder involvement? Know-how on climate impacts available and used? Resources allocated?

Operationalizing Climate Policy Integration in the EU

Now that a set of criteria has been added to the conceptualization of climate policy integration, it remains to discuss these criteria in the context of EU policies. This section begins with a brief introduction to the climate policies and commitments of the European Union. Next, each of the criteria outlined above will be discussed in the EU context. In some cases, some tentative conclusions can already be drawn, but for the majority of the criteria, an in-depth case study analysis of a particular policy sector will be required. Throughout the discussion below, some references are made to the integrated climate and energy package of the EU adopted in 2009, as well as to various other policy sectors. This exercise helps establish the utility of the analytical framework outlined above, and also gives some first indications of the extent of climate policy integration at the EU level.

For the analysis below it is important to outline what is meant by “climate policy objectives”. As climate policies include both climate mitigation and climate adaptation objectives, both of these objectives are encompassed in the term “climate policy objectives” or aims. The EU has as its climate mitigation objective the reduction of the emission of greenhouse gases to ensure that global mean temperature increase does not exceed 2°C (compared to pre-industrial levels). As its climate adaptation aims, the EU outlines that it means dealing with the unavoidable impacts of climate change, by taking timely and effective adaptation measures, “ensuring coherency across different sectors and levels of governance” (European Commission 2009b, p. 3).

Political commitment: The European Council is the highest political gathering in the EU, bringing together the heads of state and government of the member states. As such, the European Council provides the political impetus for the directions the Union will take (Treaty on European Union, Article 4). As opposed to the different policy-specific formations of the Councils of Ministers, the European Council works on all policy issues at its summits. While the various rotating Presidencies of the EU, as well as the College of Commissioners may also play a role in leadership on and/or political commitment to climate policy integration, I will focus here on the leadership and commitment of the European Council. To assess the level of political commitment to climate change issues, and the integration of climate aims into other policies areas in the European Council, it is necessary to look to the Conclusions of the regular summits of the European Council for indications of commitment and leadership.

When examining the conclusions of the European Council over the past two decades, it is clear that political leadership and commitment on climate change is a relatively new phenomenon. In the 1990s, the European Council rarely dealt with climate change issues in particular, and when it did so, it corresponded with developments on the international stage (e.g. discussions on climate change in the European Council took place in 1990 in preparation for negotiations on the UNFCCC; again in 1997 in preparation for the negotiations leading to the Kyoto Protocol; and also in 1999 and 2000 prior to the agreement on the Marrakech

Accords in 2001). However, no clear and consistent political commitment from the European Council can really be seen in their discussions during this time.

From 2006 onwards, however, climate change and the necessity to take action on the issue, feature regularly in the conclusions of the European Council. From this time, the European leaders also emphasize the links between climate change and other policy areas, but energy policy most particularly. In December 2006, the European Council outlined its recognition of "a strong link between the EU's climate policy and its energy policy as well as its jobs and growth and sustainable development strategies, and that all of these policies can and should be mutually reinforcing". In March 2007, the European Council announced the need to tackle climate change "effectively and urgently" in order to limit "the global average temperature increase to not more than 2°C above pre-industrial levels". To help achieve this aim, the European Council backed the importance of opting for an "integrated approach to climate and energy policy" and that "integration should be achieved in a mutually supportive way". Again, in June 2007, the European Council reiterated that "with its decisions on an integrated climate and energy policy the European Council in Spring 2007 underlined the synergies between these two key areas and paved the way for improved climate protection and dealing responsibly with energy".

Such heightened political commitment, both to climate change issues, and the importance of integrating climate change with other policies, albeit particularly energy policy, continued throughout 2008 and 2009. In March 2008, the European Council highlighted the integration challenge by stating that "a key challenge will be to ensure that this transition to a safe and sustainable low-carbon economy is handled in a way that is consistent with EU sustainable development, competitiveness, security of supply, food security, sound and sustainable public finance and economic and social cohesion". The European Council also broadened its climate policy integration ambitions further at this time by outlining the necessity to "achieve greater synergies between climate change and biodiversity policies as a way of securing co-benefits". And furthermore, in June 2008, the European Council highlighted "the need for coherent policies and instruments exploiting the synergies relating to Energy and Climate Change, in all economic sectors concerned, i.e. the transport sector".

This commitment is even more remarkable since, in the latter half of 2008, the EU was also struck with financial and economic crises. These crises did not prevent the European Council promoting the adoption of the energy and climate package, however. In fact, measures to combat climate change and improve energy efficiency were presented as going hand-in-hand with the plans for economic recovery. Indeed, in December 2008, the European Council announced, "it is imperative to intensify action to improve energy efficiency of buildings and energy infrastructure, to promote green products and to support the automotive industry's efforts to produce more eco-friendly vehicles". A general trend can be seen at the political level to promote measures to combat climate change as a method of economical modernization. In June 2009, in the midst of the worst global economic recession since the Second World War (European Council, June 2009), the European Council even felt confident to state that:

> The time has now come for the international community to make the commitments needed to limit global warming to under 2°C. A coherent response to the challenges posed by both climate change and economic and financial crises will open up new opportunities and make it possible to move to a safe and sustainable low-carbon economy capable of generating growth and creating new jobs.

In sum, political commitment, firstly, to combating climate change, and, secondly, to doing so by enhancing synergies, minimizing contradictions and integrating climate policy aims with other policy areas has taken root in the EU in recent times. Although serious political commitment can only be traced to 2006/2007 with the high level commitments of the EU to independently reduce its emissions by 20% by 2020, such commitment has been sustained since then. This commitment has recently been tested with the financial and economic crises, yet the reformulation of climate change measures as an opportunity for economic recovery proves that, on the political level at least, the commitment to climate change policies and climate policy integration exists.

Inclusion: Once the high-level political commitment exists to act on climate change issues and to promote the incorporation of climate policy aims into other policy areas, climate policy aims ought to be found in general and in sector policies. This means that the political commitment will need to be translated into lower-level decision-making and behaviour. We will, therefore, need to find some degree of institutionalization of climate policy integration within policy sectors, along with systematic inclusion of climate concerns into policy decisions and policy tools. With the high profile of climate change on the political agenda at EU level, along with the public support for taking action and high media coverage of the issue, we would indeed expect to find evidence that climate policy aims are deliberately considered and included in other EU policies and programmes.

To examine how this particular criterion can be applied to studies of climate policy integration at EU level, I here highlight some examples of inclusion in programmes and policies as varied as the economic recovery plan, maritime policy, biodiversity, industry, and transport. Firstly, with regard to boosting the economy and combating economic recession, the EU plans to accelerate the move to a low-carbon economy and promote innovation and so-called "green jobs" (European Commission 2009a; European Council, June 2009). Secondly, in promoting an integrated maritime policy, the European Commission outlined an action plan listing the inclusion of two climate objectives in the maritime policy. They identified the necessity of putting in place a "strategy to mitigate the effects of climate change on coastal regions", and they also identified the "reduction of CO_2 emissions and pollution by shipping" as an objective of the maritime policy (European Commission 2007b, p. 3). Thirdly, the strong links between biodiversity and climate change are also recognized and included in the EU's biodiversity policy. Protection of ecosystems is a strategy both for protecting biodiversity and for combating climate change. Climate change aims are thus included in the biodiversity policies of the EU, with one of the objectives of the biodiversity action plan stating the need to "support biodiversity adaptation to climate change" (European Commission 2006). Fourthly, for industrial policy, there are ongoing developments for a “sustainable industrial policy” to take account of environmental and climate policy objectives. The Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy details various actions to be taken, including improving energy and environmental labelling, and supporting eco-innovation (European Commission 2008c). Finally, looking to transport policy, the package of policies for “greening transport” put forward by the Commission in July 2008 included combating climate change as one of its objectives. Indeed, the climate and energy package agreed in December 2008 provided measures for reducing CO_2 emissions from passenger cars, and paved the way for the inclusion of aviation emissions in the European Emissions Trading Scheme in the future. In addition, in the “greening transport” package, the Commission proposes to go further by legislating on emissions of nitrogen oxides from aviation, and on CO_2 emissions from vans (European Commission 2008d).

As can be seen from this brief look at several different EU policies, both sub-environmental (such as biodiversity) and non-environmental (such as industry), there seems to be a certain level of awareness and inclusion of climate policy objectives. Evidently, such a brief overview cannot result in concrete conclusions. Generally, however, since climate change is such a high-profile issue within the EU, the various programmes and policy sectors seem to be responding by attempting to include climate policy objectives into their policies if possible.

Consistency: Measuring consistency between policies means assessing whether potential contradictions and conflicts between policy aims are minimized, and whether efforts are made to promote “win-win” solutions. The issue of consistency between policies at EU level is beginning to enter discussion, especially with the relatively recent reorientation of measures to combat climate change representing an opportunity for modernization and economical development, rather than simply an economic cost to bear (see European Council conclusions mentioned above, for example; Mickwitz et al. 2009, p. 8). This new orientation can provide some more opportunities for reducing policy conflicts.

However, promoting consistency between policies is not yet well developed and conflicts can still be found in relation to certain policy areas. Such conflicts are also likely to arise again in future. Prominent conflicts with regard to land use, for example, have already arisen at EU level. The EU objective of ensuring a 10% share of biofuels for transport by 2020 created concerns over the sustainability of such biofuels – forestry, biodiversity objectives, and food production or agriculture policies could be impacted by such an objective. Sustainability criteria for choosing biofuels were outlined to help alleviate negative impacts on other policy objectives. More assessment of trade-offs and possible policy contradictions or inconsistencies with other policy objectives in the policy-development phase seems to be necessary to limit contradictions as much as possible. Strong communication channels and links between the various policy makers is a necessity for ensuring consistency between policies, as also found in EPI research (for example through “interdepartmental coordination committees”, see Jacob et al. 2008, pp. 33–34). At present, in the EU, the main strategy for limiting inconsistencies between climate objectives and other policies seems to be a rebranding of climate policy measures as opportunities for advancing other policy aims in a sustainable way.

Weighting: This criterion aims to establish the relative weight given to the aims of climate policies in other policy areas – necessary especially in policy areas where conflicts are possible. This criterion is also a measure of the reality of the political commitment to climate measures, and to climate policy integration.

Hints that climate objectives are given weight in another policy area include the existence of plans for the implementation of any included climate objectives, budgetary resources assigned, and high political-level involvement (Mickwitz et al. 2009). Within the EU, the political commitment to climate change is expressed mainly in the conclusions of the European Council, as outlined above. Within the general budget of the EU, climate issues can be considered under Title 06 on Energy and Transport, and under Title 07 on Environment. Under the resources set aside for research, climate change is considered under environmental research, with the main objectives being to promote "sustainable management of the natural and human environment and its resources by advancing our knowledge of the interactions between the biosphere, ecosystems and human activities, and developing new technologies, tools and services, in order to address in an integrated way global environmental issues" (OJ 13.3.2009 II/401). Resources allocated to this area or research for the 2009 budget lie within the lower- to mid-range of allocations at €219,203,000 (compared to 681,120,000 for health or 71,878,000 for socio-economic sciences and the humanities, for example) (OJ 13.3.2009 II/381-2). Finally, when it comes to assessing the weight given to climate policies by looking at implementation plans, for example, a more in-depth case study of the policy sectors of the EU will be required – an exercise that is beyond the scope of the present paper. Since the implementation of EU policies is within the remit of each of the member states, it is likely that examining implementation will mean looking to any procedures taken by the Commission against a member state for non-implementation.

Even with a brief overview of the weighting of climate objectives in the EU, it can be said that some positive weighting can be seen through the evident political commitment and the inclusion of climate objectives in the general budget. However, it is impossible to draw any conclusions without further in-depth policy sector analysis. It is clear that the "weighting" criterion will prove useful for such an analysis and for assessing climate policy integration into EU policies, and for assessing how "strong" such climate policy integration is (see below).

Reporting: To ensure the efficacy of a policy, effective reporting mechanisms must be in place in order to evaluate and learn from practice. The EEA highlighted the necessity of reporting, monitoring, and evaluation for learning from experience and putting in place mechanisms to promote best practice (EEA 2005). In this way, accountability is also improved.

At EU level, the EEA itself is an agent charged with the task of providing up-to-date information on the state of the environment, and assessing whether EU policies (such as the Environmental Action Plans) are impacting positively. As well as this, the EEA regularly reports on the levels of greenhouse gas emissions in the

European Union, assessing whether they are decreasing in line with the targets of the EU. All this information is made available to the public and to policy makers, and ought to inform future decision-making.

In addition, each member state is charged with reporting on its own implementation of EU policies. On the basis of these reports, the Commission checks for member state compliance. However, beyond the fact that reporting on the state of the environment takes place and non-compliance procedures can begin, it is important to be able to assess whether the information from the reports is taken into account in the development of future policies. This means assessing whether the reports on achieving climate policy objectives impact the decision-making in policy sectors as varied as transport, agriculture, tourism, water management, etc. It will be necessary to establish whether reporting mechanisms under these sectors also evaluate the climate impacts of their policy measures. Especially if climate objectives are integrated with the aims of the particular policy area, it is necessary that reporting and evaluation in that policy area account for the climate objectives also. Again, a more in-depth case study analysis will be most useful for establishing more detailed analysis here.

In general, it is already important to note that reporting and evaluation mechanisms exist in the European Union, and in the member states, but that the extent to which experience on combating climate change feeds into the development of other policy sectors requires more in-depth analysis. At national level, analysis shows that many countries "still struggle with the issue of how to combine monitoring, policy evaluation and policy learning" (Mickwitz et al. 2009, p. 45). If member states were having such difficulties, it would be interesting to assess whether these struggles are translated to the EU level. At present, experience and information is just being built up, which should provide further impact on policies in future. Reporting, together with evaluation and feedback, therefore, can play a useful role in assessing climate policy integration.

Resources: Two aspects are of interest when exploring the issue of resources: firstly whether scientific knowledge and stakeholder know-how provide input into the policy development; and secondly, whether adequate resources (human and financial) are allocated to ensure the integration of climate policy aims in the particular policy area (an aspect that can also be considered part of the inclusion and institutionalization of climate policy integration).

It can certainly be said that EU climate policies have taken scientific evidence into account (especially from the Assessment Reports of the IPCC). Indeed, the EU target of limiting the increase in global temperature to 2°C is a direct endorsement of recommendations from the IPCC (IPCC 2007). This scientific evidence, and the target subsequently set by the EU, is often cited in other EU policy sectors for their consideration (e.g. transport policy). In the evolution of the EU's climate and energy package, stakeholder input was encouraged, and reported upon, as with the development of other EU policies also. However, the actual impact of stakeholder involvement on the development of policies in the EU generally is difficult to assess on a general level, without analysis per policy sector.

In terms of assessing both human and financial resources allocated to achieve climate policy objectives in various sectors, further policy-level analysis is required. At present, climate objectives are pursued within the Environment Directorate General (DG) of the European Commission. However, in an attempt to integrate climate and energy policies further, proposals abound on creating a new Energy and Climate DG. Although such a step at first glance seems to be a way of promoting climate policy integration even further, especially into energy policy, and allocating the human resources to do so, there are fears that such a move could, in fact, reduce the access climate policy civil servants have to other policy DGs (see for example ENDS Europe 2009). Others question whether such a move would really benefit further integration, especially when considering sustainable development objectives (Adelle et al. 2009). Whether such a proposal becomes a reality or not, it will still be necessary to assess the resources allocated to achieving climate objectives in other policy sectors to help identify the extent of climate policy integration. Again, such an analysis will require in-depth case study research into a particular policy sector.

Summary

As seen above, the six criteria, and their sub-questions, can provide the basis of an analytical framework for the study of climate policy integration at EU level. Through a more in-depth policy sector case study analysis, the framework can be further tested and elaborated. It is already envisioned that certain factors will prove more difficult to assess than others.

As with EPI research, simply establishing whether climate policy integration exists or does not exist within a policy sector is unlikely to provide any valuable added information. A scale of climate policy integration from “weak”, perhaps where climate concerns are simply “taken into account”, to “strong” integration, where climate concerns take “principled priority” over other policy objectives (see Lafferty and Hovden 2003; Jordan and Schout 2006) will likely need to be established to aid in further assessment. Such a scale can be further developed through future case study analysis.

Conclusions

Climate policy integration helps to ensure the effectiveness of climate policies, since the impacts of climate change cut across many aspects of society and many policy domains. Climate policy integration is a concept and policy tool that has not yet been extensively explored and assessed at EU level. This paper aimed to conceptualize climate policy integration and to outline a set of criteria to operationalize the concept for analysis at EU level. The paper began with a review of literature on policy integration and coordination and EPI, in order to aid the conceptualization and operationalization of climate policy integration.

Once climate policy integration was defined, above, as the incorporation of climate policy aims into other policy sectors while minimizing potential contradictions between policies, a set of criteria was needed to help identify, measure, and assess climate policy integration at EU level. The set of criteria outlined in this paper (political commitment, inclusion, consistency, weighting, reporting, and resources) drew on studies on EPI and climate policy integration at national level. It was shown that each of the criteria could indeed help in assessing climate policy integration at EU level, but that more policy sector analysis is required for in-depth study and analysis.

In general, this paper contributes to the development of climate policy integration research at EU level, but calls for more in-depth case study analysis to supplement it. Further case study analysis at EU level will help to elaborate better the realities of climate policy integration and provide, not only a more developed framework for analysis, but also recommendations on how to improve policy integration and minimize contradictions between policy aims. Such case studies ought to include analyses of both other environmental as well as non-environmental policy sectors. Through the case study research, it is envisioned that a scale indicating the level of climate policy integration (from “weak” to “strong”, for example) can be developed to aid analysis. Such an analysis could help highlight the policy areas needing further improvement with regard to climate policy integration.

With the urgency of dealing with climate change issues, it is certainly important that effective climate policies are in place. Since the EU is continuing to promote its leadership role on climate change, it is also necessary that its climate policies are effective and well integrated – thereby reducing any credibility gap that may exist between its international stance and domestic actions.

References

Adelle C, Pallemaerts M, Chiavari J (2009) Climate change and energy security in europe: policy integration and its limits. SIEPS Report No. 4, Swedish Institute for European Policy Studies, Stockholm

Ahmed IH (2009) Climate policy integration: towards operationalization. DESA Working Paper no. 73, ST/ESA/DWP/73, UN/DESA, New York

Collier U (2002) European Union energy policy in a changing climate. In: Lenshow A (ed) Environmental policy integration: greening sectoral policies in Europe. Earthscan, London, pp 175–192

Compston H, Bailey I (eds) (2008) Turning down the heat: the politics of climate policy in affluent democracies. Palgrave MacMillan, Hampshire

ENDS Europe (2009) MEPs alarmed by plans for a new DG energy and climate. http://www.endseurope.com/21318. Accessed 18 May 2009

European Commission (2006) Annexes to the Communication from the Commission: halting the loss of biodiversity by 2010 – and beyond: sustaining ecosystem services for human well-being, SEC (2006) 621, Commission of the European Communities, Brussels, 22 May 2006

European Commission (2007a) Communication from the Commission: progress towards achieving the Kyoto objectives, COM (2007) 757 final, Commission of the European Communities, 27 Nov 2007, Brussels

European Commission (2007b) Communication from the Commission: an integrated maritime policy for the European Union, COM (2007) 575 final, Commission of the European Communities, 10 Oct 2007, Brussels

European Commission (2008a) Impact assessment: document accompanying the package of implementation measures for the EU's objectives on climate change and renewable energy for 2020, SEC (2008) 85/3, Commission Staff Working Document, Commission of the European Communities, 23 Jan 2008, Brussels

European Commission (2008b) 2020 by 2020: Europe's climate change opportunity, COM (2008) 30 final, Commission of the European Communities, 23 Jan 2008, Brussels

European Commission (2008c) Communication from the Commission: on the sustainable consumption and production and sustainable industrial policy action plan, COM (2008) 397/3. Commission of the European Communities, Brussels

European Commission (2008d) Communication from the commission: greening transport, COM (2008) 433 final, Commission of the European Communities, 8 July 2008, Brussels

European Commission (2009a) Communication from the commission: a shared commitment for employment, COM (2009) 257 final, Commission of the European Communities, 03 June 2009, Brussels

European Commission (2009b) White Paper. Adapting to climate change: towards a European framework for action, COM (2009) 147 final, Commission of the European Communities, 01 Apr 2009, Brussels

European Environment Agency (EEA) (2005) Environmental policy integration in Europe: state of play and evaluation framework, EEA Report no. 2/2005, EEA, Copenhagen

Gerger Swartling Å, Nilsson M, Engström R, Hagberg L (2007) Theory and methodology for EPI analysis. In: Nilsson M, Eckerberg K (eds) Environmental policy integration in practice: shaping institutions for learning. Earthscan, London, pp 49–66

Gupta J, Grubb M (eds) (2000) Climate change and European leadership. Kluwer, Dordrecht

Intergovernmental Panel on Climate Change (IPCC) (2007) Climate change 2007. Fourth assessment report: synthesis report. IPCC, Geneva. www.ipcc.ch

Jacob K, Volkery A, Lenschow A (2008) Instruments for environmental policy integration in 30 OECD countries. In: Jordan AJ, Lenschow A (eds) Innovation in environmental policy? Integrating the environment for sustainability. Edward Elgar, Cheltenham, pp 24–45

Jordan AJ (2002) Efficient hardware and light green software? Environmental policy integration in the UK. In: Lenschow A (ed) Environmental policy integration: greening sectoral policies in Europe. Earthscan, London, pp 35–56

Jordan AJ, Lenschow A (eds) (2008a) Innovation in environmental policy? Integrating the environment for sustainability. Edward Elgar, Cheltenham

Jordan AJ, Lenschow A (2008b) Integrating the environment for sustainable development: an introduction. In: Jordan AJ, Lenschow A (eds) Innovation in environmental policy? Integrating the environment for sustainability. Edward Elgar, Cheltenham, pp 3–23

Jordan AJ, Lenschow A (2008c) Environmental policy integration: an innovation in environmental policy? In Jordan AJ, Lenschow A (eds) Innovation in environmental policy? integrating the environment for sustainability. Edward Elgar, Cheltenham, pp 313–341

Jordan AJ, Schout A (2006) The coordination of the European Union: exploring the capacities of networked governance. Oxford University Press, Oxford

Jordan AJ, Schout A, Unfried M (2008) The European Union. In: Jordan AJ, Lenschow A (eds) Innovation in environmental policy? Integrating the environment for sustainability. Edward Elgar, Cheltenham, pp 159–179

Lafferty WM, Hovden E (2003) Environmental policy integration: towards an analytical framework. Environ Polit 12(5):1–22

Lafferty WM, Knudsen J (2007) The issue of ‘balance’ and trade-offs in environmental policy integration: how will we know EPI when we see it? EPIGOV paper no. 11, Ecologic – Institute for International and European Environmental Policy, Berlin
Lenschow A (ed) (2002a) Environmental policy integration: greening sectoral policies in Europe. Earthscan, London
Lenschow A (2002b) Greening the European Union: an introduction. In: Lenschow A (ed) Environmental policy integration: greening sectoral policies in Europe. Earthscan, London, pp 3–21
Lenschow A (2002c) Conclusion: what are the bottlenecks and where are the opportunities for greening the European Union? In: Lenshow A (ed) Environmental policy integration: greening sectoral policies in Europe. Earthscan, London, pp 219–233
Mickwitz P, Aix F, Beck S, Carss D, Ferrand N, Görg C, Jensen A, Kivimaa P, Kuhlicke C, Kuindersma W, Máñez M, Melanen M, Monni S, Branth Pedersen A, Reinert H, van Bommel S (2009) Climate policy integration, coherence and governance. In: PEER Report No. 2. Partnership for European Environmental Research, Helsinki
Nilsson M (2007) Shaping institutions for learning. In: Nilsson M, Eckerberg K (eds) Environmental policy integration in practice: shaping institutions for learning. Earthscan, London, pp 163–168
Nilsson M, Eckerberg K (eds) (2007) Environmental policy integration in practice: shaping institutions for learning. Earthscan, London
Nilsson M, Persson A (2003) Framework for analysing environmental policy integration. J Environ Policy Plann 5(4):333–359
Nilsson M, Eckerberg K, Persson Å (2007) Introduction: EPI agendas and policy responses. In: Nilsson M, Eckerberg K (eds) Environmental policy integration in practice: shaping institutions for learning. London, Earthscan, pp 1–24
Oberthür S (2007) The European Union in international climate policy: the prospect for leadership. Intereconomics Rev Eur Econ Policy 42(2):77–83
Oberthür S, Roche Kelly C (2008) EU leadership in international climate policy: achievements and challenges. Int Spect 43(3):35–50
Official Journal of the European Union (2009) L69 52, 13 Mar 2009
Organisation for Economic Co-operation and Development (OECD) (2002) Improving policy coherence and integration for sustainable development: a checklist. OECD, Paris
Ott HE, Sterk W, Watanabe R (2008) The Bali roadmap: new horizons for global climate change? Clim Policy 8(1):91–95
Persson Å (2004) Environmental policy integration: an introduction, PINTS – Policy Integration for Sustainability, background paper. Stockholm Environment Institute, Stockholm
Persson Å (2007) Different perspectives on EPI. In: Nilsson M, Eckerberg K (eds) Environmental policy integration in practice: shaping institutions for learning. Earthscan, London, pp 25–48
Peters BG (1998) Managing horizontal government: the politics of co-ordination. Public Adm 76(2):295–311
Skjærseth JB, Wettestad J (2008) EU emissions trading: initiation, decision-making and implementation. Aldershot, Ashgate
Van Bommel S, Kuindersma W (2008) Policy integration, coherence and governance in dutch climate policy: a multi-level analysis of mitigation and adaptation policy, Alterra-rapport 1799. Wageningen, Alterra
Wettestad J (2000) The complicated development of EU climate policy. In: Gupta J, Grubb M (eds) Climate change and European leadership: a sustainable role for Europe? Kluwer, Dordrecht, pp 25–45

Chapter 26
Exploring Economic and Political Drivers for the Introduction of Innovative Mitigation Policies

Valentino Piana

Abstract Politicians and high-level officials from all over the world will meet in Copenhagen in December 2009 to reach a global agreement on climate. Mitigation policies aiming at radical cuts in emissions, starting now, deepening over time, and widening their geopolitical coverage, will require domestic and international consensus, if they are to be agreed and implemented in the months and years to come.

The paper explores the drivers for adoption of mitigation policies, with a special emphasis on those arising from the International Symposium on Innovative Economic Policies for Climate Change Mitigation, held in July 2009 at the Subiaco Monastery of St Scholastica (Italy).

Instead of framing climate change mitigation as a burden, these policies are meant to generate a conducive environment for innovation, profits, employment, wages, and improvement of real quality of life.

An exploration of their economic and environmental effectiveness is conducted, together with a limited analysis of possible political factors influencing the decision to adopt them. In the conclusions, the need to reframe the discourse on climate change is put forth for the success of climate negotiations.

Keywords Co-benefits · COP15 · Copenhagen agreement · Democracy · Economic policy · Mitigation

Introduction

Driven by the strong and unequivocal words of the International Panel on Climate Change (IPCC 1997), the basic texts for the negotiations (hopefully) leading to the COP15 Copenhagen agreement recognize the crucial importance of mitigation,

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i.e. drastic reduction of greenhouse gas emissions by developed and developing countries over the next few decades (UNFCCC 2009). Developed countries have a particularly strong responsibility for past and current contributions to climate change and need to take the lead in effective, deep, prolonged policies to cut emissions, whereas developing countries need to put in place a systemic approach to conjugate poverty eradication, energy efficiency, sustainable development, and emission growth curbing.

But resistances are already appearing and have plagued these issues for years: the world is late in responding to what in the 1980s was already called "global warming" (leading to the establishment of the IPCC in 1988) and received international official recognition as a rising threat to humankind at the 1992 UN Conference on Environment and Development in Rio de Janeiro. Since then, only relatively few countries have indeed reduced emissions and for many of them, that was more the unintended side effect of deep economic crisis than the outcome of explicit policy making. Carbon taxes envisaged at the time did not spread beyond the early adopters and even there they were largely marginalized in total state revenue (see e.g. EU Commission 2009). Cap-and-trade has had some diffusion, notably in the European Union, but only now does it seem to be getting the impetus necessary to become much more important.

"The short history of climate policy in Britain and elsewhere is already littered with good ideas that, due to lack of support from the public, industry and special interests – as well as obstacles within governments, legislatures, departments and political parties – had to be abandoned or diluted to the point where they lost most of their impact" (Compston and Bailey 2009). This lack of political will has been rooted in the subjective judgement that mitigation policies would entail large costs, both for powerful lobbies and for the widest populace, to the effect that either because of the action of pressure groups or out of democratic rejection, governments have been wary of bold targets and consequential action.

A new generation of policies framing mitigation as an opportunity for innovation, profits, employment, and a better quality of life is being elaborated (Piana et al. 2009), based mainly – but not exclusively – on a growing body of literature of evolutionary approaches to climate change (e.g. Andersen 1999, 2002, 2006, 2008a, b; Geels 2001; Kemp et al. 2001; Maréchal and Lazaric 2009; Oltra 2008; Smith 2009; De Laurentis and Cooke 2008) as well as on other contributions (e.g. Barker 2008; Jochem and Madlener 2003; Markowitz and Doppelt 2009; Taylor and Allen 2008; Cohen and Vandenbergh 2008; Stern 2008; OECD 2009; DeCanio 2003; Carrillo-Hermosilla et al. 2009; Waltz and Schleich 2009) to complement more conventional approaches, like cap-and-trade, direct regulations, standards, etc. (e.g. Owen and Hanley 2004; Stern 2006; Nordhaus 2007; IEA 2008).

This paper presents these policies and explores a few drivers conducive to their introduction. A short comparison with policies framing mitigation as a cost will be provided. Finally, some remarks about reaching an agreement in Copenhagen will be set forth. The entire discussion will be kept on a fairly discursive tone because of the relative novelty of the policies under investigation. In particularly, no empirical examples or statistics will be used. Conversely, we shall use quite pragmatically the general models of democracy (e.g. Buchanan and Tullock 1962; Lijpart 1999; Acemeglu and Robinson 2006), since they usually focus on selected determinants in a very structured way, whereas we simply try to enlist a number of key factors relevant in mixed proportions for the case at hand.

Innovative Economic Policies for Climate Change Mitigation: An Overview

The transition towards a low-emission economy, capable of guaranteeing the full satisfaction of basic needs to the whole of humankind, with a large array of non-basic consumption activities available to a growing number of citizens will require vast and deep changes in how firms, markets, banks, governments, and a number of other economic and non-economic agents act and interact.

It will be the result of both spontaneous and policy-driven changes in three broad areas, partially overlapping and systematically linked:

- Market structures and behaviour of firms
- Consumer lifestyles and purchasing rules
- Government policy making

For instance, to the extent that vested interests of incumbent firms hinder the spread of clean technologies, it is important that new entrants bring disruptive innovation to the existing market structure, first nurtured in a niche, then recognized with eco-labels and awards, and gain a sale boost by getting free airwaves in TV advertising, so that fashion-sensitive consumers first adopt and then push others to adopt their products. At a later stage, a specific policy of "sectoral euthanasia" might be needed to painlessly suppress "dirty" producers with full recompensation for owners, managers, workers, and suppliers, especially in sub-national regions and towns where they represent the backbone of local economy.

Throughout this industry lifecycle, green jobs are growing, people are being retrained, and absorption of structural unemployment is managed with the involvement of the business community, trade unions, and appropriate public agencies. A green innovation system is put in place to strengthen positive market outcomes at home and abroad.

By replicating these industrial dynamics in a multi-sectoral economy, thanks to a country-wide push of an interactive government, capable of leadership, commitment, communication, and reputation, a structured list of nationally appropriate mitigation actions (NAMAs) can be outlined both in developed and developing countries.

These policies have been devised by scholars from such diverse countries as Kenya, Mauritius, Azerbaijan, India, Singapore, the UK, the Netherlands, Denmark, Hungary, and Italy to the effect that national policies have been commented on and several changes proposed so as to adapt to the largely different situations in the world.

Meanwhile, a zoom to sub-national regions and cities has sharpened the focus on specific agents that will play a crucial role in implementing the Copenhagen agreement. In the book, some suggestions have been also put forth for the international negotiations as such.

This is not the place for a detailed descriptions of all these 20+ policies, to which Piana et al. (2009) devotes a chapter each. Some of them will be briefly outlined later on, when we shall explore the drivers of political support they might get. We only note here that their common trait is an emphasis on the advantages of mitigation for at least some agents, magnified by the policies, to induce organic paths of change over time, in a non-equilibrated environment of new technologies, learning processes, bounded rationality, and organizational balances.

Evaluating the Drivers for the Introduction of an Innovative Policy: The Example of PRODINT

Before covering a larger set in the next chapter, we would like now to concentrate on one specific policy, advocated first at the Copenhagen Conference on Climate Change: Risks, Challenges and Decisions, then included in Piana et al. (2009): the Pro-Diffusion-of-Innovation Tax (PRODINT).

By repetitively levying a small tax on non-adopters to finance adopters, a responsive mechanism of stimulation is put in place to "foster an efficient level of [. . .] diffusion of greenhouse gas emissions-reducing technologies" (Duval 2008). Indeed, the dominant diffusion of clean technologies, substituting the "brown" ones, is key to sizeable reductions in aggregate emissions.

The policy takes into account the physiology of diffusion and the heterogeneity of consumers. The standard theory of diffusion of technological and behaviour innovations (e.g. Rogers, 1962, revised Rogers 2003) has been enlarged by new strands of models and insights (e.g. Nelson and Winter 1982; Mansfield 1995; Andersen 1999) but it is still confirmed that diffusion follows more or less an S-shaped curve of successive adoptions by:

1. A very small group of pioneers (who have a special preference for the technology often beyond direct economic benefit, e.g. they have a "green" culture)
2. A small group of "early adopters" (who scrutinize the pioneers and are rewarded by the social consideration of being "opinion makers")
3. A group of "early majority" (who are attracted by economic benefits – "carrot")
4. The "late majority" (who should be motivated by the negative effects of non-adopting – "stick")
5. The "laggards" (who adopt only if there is a compelling mandate by law, because they have a stubbornness out of cultural reasons, e.g. anti-environmentalist attitude)

Other patterns can be due to intensive advertising before launch of the innovation on the market (with an early peak of sales), erratic paths around a low average due to products having both strong minuses and pluses, constant low sales because of forced repurchasing by the same categories of users, diffusion failure (with fast aborted trajectories). Cyclical fashions might exhibit irregular sinusoidal dynamics. However, the large majority of successful innovation in normal conditions appeals to different user categories as described.

Policies targeted to fast and wide diffusion of innovation should take into account the heterogeneity of potential buyers. In particular:

1. "Pioneers" should be free, with a liberalization of laws, regulations and social conventions
2. "Early adopters" should be praised in moral and social terms across mass media and communication networks, e.g. with eco-labels and awards
3. The "early majority" should receive positive material incentives
4. The "late majority" should suffer from negative material disincentives if they do not adopt
5. The "laggards" should face a mandate by law to adopt before a certain temporal deadline

In so doing, the policy maker would impact the different motivational triggering factors of the population of consumers or firms, taking advantage of asymmetries such as those between positive and negative incentives, as underlined by prospect theory (Kahneman and Tversky 1979; Brekke and Johansson-Stenman 2008).

Early majority potential buyers are particularly sensitive to positive incentives, whereas late majority should feel the cost of not adopting. Since together they account for the largest part of the population, a wide adoption requires their mobilization. The perspective of a final deadline for adoption is effective also on laggards; it is especially credible, with no past experience of deadlines missed and postponed.

In this perspective, medium- and long-term quantity restrictions on emissions and mandatory standards of efficiency can be supplemented by a tax scheme that anticipate benefits to adopters and give a first "bite" to polluters to stimulate their transition before the deadlines.

The Proposed PRODINT Scheme

Let us concentrate on a situation in which innovation is embodied in a durable good characterized by a good environmental performance; thus, adoption means just to purchase it by paying a given price P. Let us further assume that the use of the good does not generate any additional flow of money, neither positive nor negative. Adoption thus has a sunk cost (P) but no fixed or variable cost (see Piana 2009 for the removal of all these hypotheses).

Although in general the cost C of adopting the good includes not only P but also monetary and non-monetary components due to the difficulty of using the new good, any cultural resistances to adopt, and possibly the cost of overwhelming the very unawareness of its existence, in this simplest case the adoption cost might be reduced to P.

The tax on non-adopters will be a lump sum whose value is a fraction f of C. The tax revenue will be distributed in equal shares to recent adopters, defined as the agents that at a certain date can demonstrate having adopted the innovation after a previous date. To the extent that environmental performance is measurable, the tax can be levied on the group of agents that does not meet a minimum threshold and the tax revenue given to those exceed a sufficiency threshold.

The two thresholds can converge in one or be separated by a neutral zone, where no payment is made in either direction. If performance, e.g. energy efficiency, is presently distributed according to a bell curve, the situation can be depicted in the following way (Fig. 26.1).

People and firms using technology whose energy efficiency is below EE1 will pay the tax, whose revenue is transferred to those whose energy efficiency is higher than EE2. Because of the fact that the blue taxed are more numerous than the red receivers, the tax can be small and tolerable, while the incentive will be strong.

The thresholds can be established to change over time, e.g. an increase of 2% per year, so as to create a clear, stable, and pro-diffusion environment for all the agents. Were the tax levied just once, it would be a mere payment from non-adopters to users. However, we assume that it is levied several times, thus turning out to be:

- The first time: a payment to the entire population of adopters, but
- Further times: a payment just to who adopted meanwhile, i.e. between two application dates

Each adopter can get the payment just once.

The revenue of a lump-sum tax of a fraction f of the cost C of adopting a new clean technology, levied on non-adopters, is distributed to recent adopters. The entire burden of adopting is brought by non-adopters. Not only do they pay the tax,

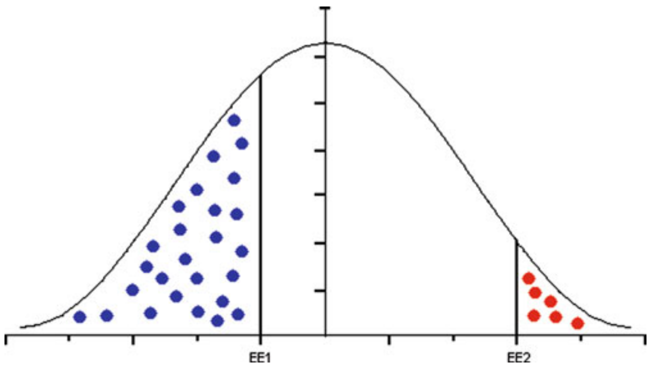

Fig. 26.1 Distribution of energy efficiency and its effect on who pays PRODINT and on who receives a share of PRODINT revenue. Key: EE1 = low-efficiency threshold under which the "blue" agents pay; EE2 = high-efficiency threshold over which the "red" agents receive

but also they do not share the tax revenue and they do not have the advantages of using the innovation (e.g. alternative fuel cars and distribution stations, gas-free refrigeration platforms, eco-buildings, etc.).

If the tax is levied at the beginning of the diffusion curve, when only a very small number of pioneers has adopted, then the tax revenue will be extremely high, even if the fraction f is small, because almost everybody is a non-adopter. The adopters will receive more than C, making a large profit, which will have a strong media coverage, prompting imitation.

In the next round, non-adopters again have to pay f. In order to avoid paying, some (not all) will adopt; their strategy clearly pays off: they receive a larger sum than C because non-adopters are still a large majority.

If the tax is levied frequently enough, the recipients will be less numerous than the payers, with a ratio of f needed to cover the adoption cost.

As far as the diffusion process proceeds and non-adopters become a minority ("latecomers"), there might be a change: the tax revenue could be distributed as a loan to those who promise to adopt in this new period. If they adopt, the loan is written off; if not, they have to pay it back. Since a minority of them will promise to adopt, they will be awarded with a loan fairly near to the entire C (although possibly not covering it in whole).

In another vein, as the number of non-adopters goes down, one might increase the percentage of tax. This will raise a larger revenue even at this stage and will encourage everyone to "get on board" early.

If non-adopters are a very small minority, they can be left in peace with the tax scrapped (if it is tolerable that somebody does not adopt), or the loan structure can be in place indefinitely.

In this simplest form, the tax does not generate revenue for the state, it is a mere redistribution within an industry or a population; some receive what others pay.

The Main Advantages of PRODINT

In synthesis, the main advantages of this tax system are the following:

1. Totally relying on spontaneous decision, leaving people free to adopt or not
2. No tax burden for the population as a whole
3. During the process, a large number of people are better off with the scheme than without; of course, non-adopters would have preferred the absence of the scheme but they become a minority over time; if the wide diffusion triggers the diffusion of a complementary technology (as with the case of cars after the stations) even the "forced" adopters are happy having done this
4. The tax levied can be really small in absolute terms
5. Administrative costs of PRODINT are minimal. By leveraging existing technology, one can imagine a bank account where people pay the tax, while signalling by email that they adopted the good so as to receive to their bank accounts the share of tax revenue. No bureaucracy has to be added

6. Monitoring costs can be brought down to very low levels through widespread power of control. For instance, any citizen could be entitled to signal non-adoption and this message is compared with official declaration of the adopter/non-adopter; in case of discrepancy (or a number of signalled discrepancies), a mission to verify is sent; if indeed there is a violation, then a high fine is issued; the citizen(s) having signalled receive(s) a part of the fine

Additionally, the reaction of the sellers of the good is much better than in the presence of a state incentive: they do not change their prices because they do not know how much the adopters might receive from the tax. On the contrary, lump-sum or percentage state-paid incentives to customers are often transferred to extra profits of the sellers who increase prices by that amount with no net benefit for the purchaser.

In the sector producing the innovation, this scheme generates a diffusion dynamic that matches reasonable production timetables, with increasing production over time and a relatively long tail, whereas deadlines – which mandate everybody adopting – generate a skyrocketing production before deadlines and zero afterwards, with the necessity of having a large production capacity which ends up being useless. Capital is piled up, labour is selected in a rush, has no time to learn the job, and then is fired because employment falls to zero.

In turn, the smoother dynamic fostered by PRODINT allows incremental improvements of the innovation itself, as with solar panels getting more efficient over time, because the profits from early production can be channelled to R&D.

In the supplier sector, many firms compete and the consumer has the time to compare the many different versions offered, whereas with deadlines, the suppliers are sure to sell and do not care about additional features.

The Economic and Environmental Effectiveness of the Policy

To verify its effectiveness in quantitative terms, the policy has been tested in an agent-based model of an artificial economy with two competing technologies, product differentiation, heterogeneous consumers, R&D, advertising, and finance, based on Piana (2003). The results are very encouraging for a broad range of parameters.

In particular, by fixing certain starting conditions and dynamic features, a number of simulations have been carried out to contrast the presence with the absence of PRODINT. In all cases, consumers are modelled as heterogeneous, since they are imposed to differ in income, green orientation, attitude to non-energy performance (e.g. aesthetical design), rules of choice, intensity of good use, subjective rate of discount for future stream of costs and revenues, and expectations about the value of the PRODINT subsidy.

PRODINT is structured as a tax levied in each period at the same small level (2% of the difference in initial prices between the two goods) on owners of "dirty

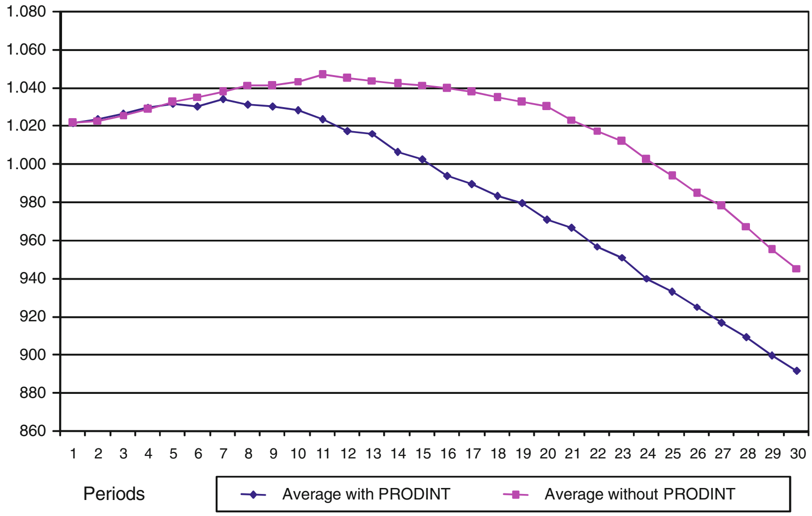

Fig. 26.2 Greenhouse gas (GHG) emissions over time with and without PRODINT (average over ten simulations). Key: Numbers on Y axis are free-scale and conventional, embedded on simulation parameters

technology", defined as a product emitting more than a certain threshold. PRODINT revenue is redistributed in equal share to all recent adopters of "clean" technologies. The two technologies evolve over time because of R&D, funded by current and past profits, capital, and loans.

Averages of ten simulations (of 30 periods each) show that – with PRODINT – GHG emissions peak earlier, and fall steeper and deeper (Fig. 26.2).

This favourable dynamic is due to the fact that clean technologies reach a faster and wider diffusion with PRODINT than without it (Figs. 26.3 and 26.4).

Profits of the producer of clean technologies are higher – on average – by 126% with PRODINT than in its absence. Thus, they should be very interested in introducing PRODINT in national legislation and to spend money in lobbying for that.

In turn, PRODINT make the clean technology more affordable, with a positive impact on the cost of living of the middle class, as demonstrated by the fall in the average income of the clean technology adopter by an average of 5% with respect to the situation without PRODINT.

Exploring the Political Drivers for the Adoption of PRODINT

Compston and Bailey (2009) in Anthony Giddens' book Building a Low-carbon Future: The Politics of Climate Change try to answer the key question "How can we build political support for action on climate change in western democracies?"

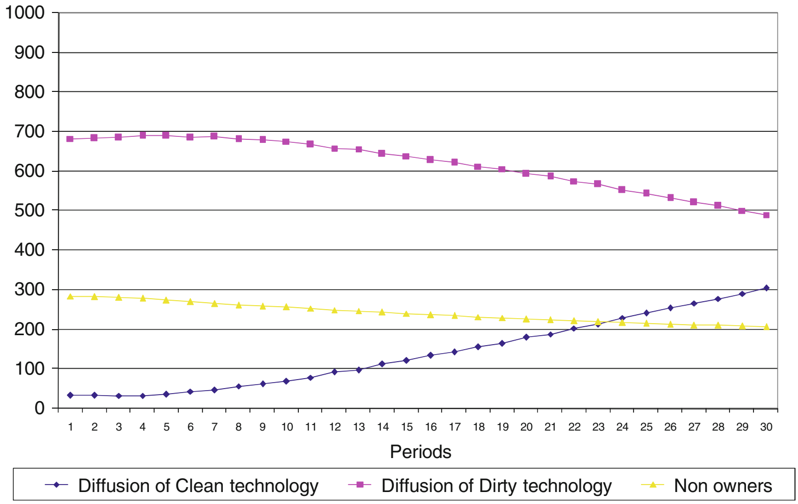

Fig. 26.3 Diffusion over time with PRODINT – Number of consumers owning clean, dirty or no technology (average over ten simulations) Explanations: The total number of simulated consumers is 1,000. Each can own either the clean or the dirty technology but can also not own any (thus their emissions will be zero)

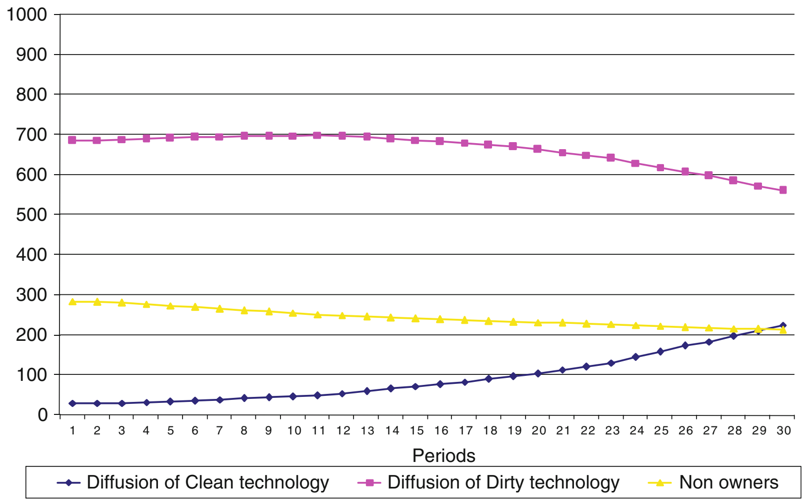

Fig. 26.4 Diffusion over time without PRODINT – Number of consumers owning clean, dirty or no technology. (average over ten simulations) Explanations: The total number of simulated consumers is 1,000. Each can own either the clean or the dirty technology but can also not own any (thus their emissions will be zero)

and state that “political strategies for strengthening climate policies can be divided into four broad categories: playing it safe, improving communications, changing the rules of the game, and venturing beyond consensus” (p. 54), thus offering 17 guidelines:

Playing it safe

1. Stick to consensus policies
2. Small steps on many fronts
3. Take advantage of windows of opportunity
4. Continue to push for international agreements
5. Improve policy design
6. Offer trade-offs
7. Introduce spillover policies

Improving communications

8. Reports and targets
9. Emphasize co-benefits
10. Keep the message simple, clear and tailored to the audience
11. Stress the moral dimension
12. Be positive
13. Get the framing right

Changing the rules

14. Alter the organization of government
15. Change the distribution of power resources

Beyond consensus

16. Spend political capital
17. Selective imposition of more radical policies

PRODINT can be seen as leveraging:

- On guideline 5, because it offers a fair distribution of efforts (by creatively applying the “polluter pays” principle)
- On guideline 6, because the actual composition of the two groups hinges on individual decisions: everybody can decide to get the subsidy, simply by purchasing the clean good. So in a way, this is a voluntary tax: you pay it only if you do not improve your emissions by getting a better good. Thus, a person might charge him/herself in being taxed and accept this individual consequence of a “noble” collective goal
- On guideline 15, as it reduces the typical attrition between the Minister of Environment and the Minister of Finance (as the policy is meant to be fiscally neutral, whereas most traditional environmental policies require public expenditure or hurt an entire industry)

More generally, one could expect the adoption of PRODINT being the uncertain outcome of political bargaining, influenced – but not determined – by internal dynamics of politicians' power, by voters' attitudes (as revealed by opinion polls or other methods) and by lobby pressures, within a much broader political process and discourse.

Internal dynamics of politicians' power cannot be easily foreseen and generalized. In turn, voters' opinion on PRODINT, if any, might in principle be influenced, among other elements, by:

- How they become informed about, understand, and frame the proposed PRODINT scheme
- How they perceive the proposed PRODINT scheme as a gain or a loss for themselves
- How they empathically identify with other people touched by PRODINT
- How they evaluate the environmental benefit promised by PRODINT
- The alternatives to PRODINT active in their mental list (the reference point for comparison)
- How waves of opinions are transferred from one person to another through social networks
- How sub-national regions are hit or favoured by the measures

Business lobbying might in general be influenced, among other elements, by:

- Which sectors will be covered by the scheme, their relative importance in the national economy and in trade associations
- How they become informed about, understand, and frame the proposed PRODINT scheme, both within firms and at trade associations
- How much money they feel there would be in business with and without PRODINT
- The present level of profits that can be directed to lobbying
- How companies are organized in trade associations and the relative power of their members on their collective decisions (e.g. big or small, by region, by sector, etc.)

In costly electoral campaigns, concentrated money from large donors might be particularly relevant for a certain party or candidate, who might be prone to lobbying efforts. In other cases, the candidate might leverage small amounts of money from a very large population, possibly being less sensitive to lobbying.

Trade unions usually operate less through money and more through the pressure of their (large or narrow) base and activists to engage in votes and other broad-range activities, to some extent imitated by NGOs and other organizations, which, however, can also mix elements from business lobbying and have their own specific ways of exerting pressure.

In all this, it is highly likely that a proposal like PRODINT would be part of a larger package of measures and that a number of unforeseeable conditions would influence the wording of the proposal, both in legislative and in communicational terms, to the effect that a careful analysis would require a number of further details.

However, for the sake of simplicity, let us take the assumption that there is indeed some political debate on climate change and at least one relevant political player is seriously taking into consideration the possibility of putting forth a proposal and is interested in understanding whether PRODINT might be viewed positively by voters.

As mentioned above, the population may have a number of different interconnected ways to judge such a proposal, many of which are deeply linked with values and the ongoing public discourse, with its agenda-setting issues, framing and reframing, ordering, rhetoric, arguing, bargaining, advocacy coalition framework, networks, etc. (see for instance Fischer et al. 2007; Moran et al. 2006).

However in many reform processes, there is a moment in which people begin to ask: "What's in it for me?" In this, narrow, respect, PRODINT could receive a positive judgement by a democratic majority (Fig. 26.5).

A minority (Group 1) pays the tax, a smaller minority (Group 2) gets the subsidy, and the people excluded from the scheme (Group 3) have a net gain (the environmental benefit) at no cost. Thus we might have three situations:

(a) If people look only at what happens to them, PRODINT would pass the test, because Group 1 would be against, Group 2 would be for, and the majority for PRODINT is reached thanks to Group 3
(b) If people have a positive opinion of the adopters of the clean technology and can imaginatively identify with them, a wider majority would arise
(c) If, by contrast, the people are not only selfish but also unimpressed by the environmental benefit, PRODINT would be rejected (since by construction the payers are more than the receivers)

All this is under the general provision of fiscal neutrality to the budget. In fact PRODINT is designed as fiscally neutral, so that it can be adopted by governments of any political orientation and in any phase of the business cycle.

If, by contrast, the government would like to counter-cyclically inject money into the system during a recession, the subsidy might be higher than tax revenue,

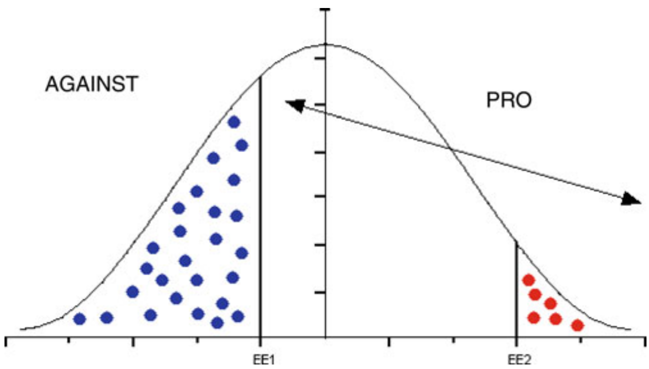

Fig. 26.5 Distribution of opinions over PRODINT
Key: EE1 = low-efficiency threshold under which the "blue" agents pay; EE2 = high-efficiency threshold over which the "red" agents receive a share of the PRODINT revenues

and both large and targeted exemptions (e.g. people with income lower than a certain threshold) might be conceded, widening Group 3.

Conversely, if a large fiscal deficit is considered as a problem, or the core principle of the government hinges on fiscal responsibility, PRODINT can be parametrized so as to produce a positive inflow to the budget. If this is the case, again the government can use these amounts for a number of purposes and justify the scheme in this way.

In any case, the design is such that the payers are hit only with a small amount and the recipients get a larger subsidy. It is true that with Thaler (1991) we know that people react more intensively to losses than to gains, but the dispersion of small losses across a number of people makes it more difficult for them to mobilize, whereas the larger expected benefit might lead certain people to publicly express themselves in favour of the measure and generate a positive buzz.

Still, one should be particularly careful in applying an economic point of view to voters' behaviour, since "By demonstrating that rational abstention is the best solution for citizens who base their decision to vote on narrowly defined self-interest, Downs (1957) showed us that widespread participation is best understood as a manifestation of an activity that is valued intrinsically. [. . .] much of the progress in political behavior research during the past 40 years, beginning with Simon's (1957) work, has come in response to the political economist's challenge – the challenge to rediscover the role of purposeful citizens in the workings of democratic politics" (Goodin and Klingemann 1996, pp. 227–228).

Together with voters and inner political dynamics, a third driver in the decision to adopt policy is lobbying. In this respect, PRODINT greatly increases the profits of the producer of clean technology, so it can prospectively fund a pro-environmental business lobby. Their current weaknesses in their profits, however, might reduce the ability to mobilize. In that case, the decision of which market to involve under a PRODINT scheme might lead to a wider number, including some where large firms would have competitive green products to boost. Business trade organizations, having among their members both winners and losers from this tax, might in principle reduce or annihilate their lobbying activities against it, to avoid the risk of an exit of the clean producers from it.

Although very reasonable, since it cumulates the carrot of subsidy with the stick of taxes, PRODINT is relatively new in its direct linkage of the amounts between the two. Accordingly, to accompany a rising political consensus for it, it would need to be well communicated with proper examples for the specific country.

Some Drivers for a Few Further Innovative Economic Policies for Mitigation

PRODINT is just one out of more than 20 innovative mitigation policies proposed in Piana et al. (2009), aimed at transforming market structures and firm behaviours, consumers' purchasing rules and lifestyles, and policy making itself. They can be applied at national and international levels, zooming into the sub-national and the city level.

The decision to adopt them will depend on a large number of interrelated drivers, some favourable and others unfavourable, deeply embedded in political dynamics, as tentatively indicated in the previous chapter. In order to explore a specific subset of all the possible drivers to adoption, one might take the following features into consideration:

- The number of voters gaining from the measure
- Whether the gain assured is high or low
- The number of voters hurt
- The pain inflicted
- Whether voters can change side from punished to rewarded

The same scheme can be replicated for businesses, as a preliminary proxy for their lobbying motivation.

Out of the many policies proposed in the book, the following ones will be shortly described and then characterized according to the above-mentioned features (Table 26.1).

These few lines do not do justice to the contents articulated in the book chapters, but serve as a minimal introduction to them. Meanwhile, a preliminary judgement of the capability for those policies to get political consensus can be articulated by considering Table 26.2.

These policies present a widely differentiated potential, with some having large favourable constituencies and others being more focused. Most of them do not have real enemies, because they do not "hurt" voters or firms. Others would require a proper handling of opposition, be it on the business side or in the democratic constituencies. In particular, the neutral strip of people and businesses not concerned directly with the changes can turn out to be quite relevant.

It should be noted that these policies are capable of assuring high gains (thus potential lobbying power) to a certain range of firms, mainly eco-innovators, but also ailing sectors taking advantage e.g. of EUTANSECTOR.

Proper dynamic framing of those policies would help boost their acceptability in political terms, anchored in the very real benefit that those policies imply and the relative novelty they introduce in the current discourse on environment. Indeed, both carbon tax and cap-and-trade tend to focus more on stick than on carrot, the advantage of the latter being a relatively straightforward linkage to quantity limitation arising from international commitments. Necessary as they are to contain emissions, they risk, in certain countries or constituencies, politically backfiring, i.e. raising fierce opposition, engaging large flows of lobbying money, prompting keen attention towards visible signs of "pain", leading in the end to policy watering down, marginalization or even reversal. It is important, when deciding to push them into legislation, to frame them properly and accompany them with complementary measures to assure their effectiveness and political acceptance.

Table 26.1 Seven mitigation economic policies

Policy acronym	Policy name	Description	Author(s)
GRINS	Green Innovation System	A comprehensive dynamic policy for wiring up the national system for eco-innovation. This policy aims to mould the market and create a selection environment that favours eco-innovation.	Maj Munch Andersen
SNM	Strategic Niche Management	The creation of socio-technical experiments in which various stakeholders are encouraged to collaborate and exchange expectations, information, knowledge and experience, thus embarking on an interactive learning process that will facilitate the incubation of the new technology. This occurs in a protected space called a niche, a specific application domain for the innovation, nurtured through a number of stages of development.	Marjolein Caniëls and Henny Romijn
CSDR	Corporate Sustainable-Developmental Responsibility	An evolution of CSR (Corporate Social Responsibility) outlining and implementing a gradual – but steady – improvement over time of internal routines in firms and organizations, by following steps, indicators, and organizational activation, accompanied by external facilitators	Kua Harn Wei
ECO-LABEL	Eco-labels and Awards	Schemes designed to help consumers to easily identify environmentally friendly goods, boosted by large awareness campaigns, leading to monitored and effective changes in behaviours, complemented by environmental awards	Zsofia Wagner
FREEADV	Free TV Advertising for Clean Products	Free airtime slots in public and private TV channels attributed to the advertising of clean products and habits. Boosting awareness – on a massive scale – of the existence, material advantages and immaterial emotional values of eco-labelled products, this policy provides a tangible result for producers, inducing a rise in sales, employment, and profits.	Valentino Piana
PRODINT	Pro-Diffusion-of-Innovation Tax	A repetitive tax scheme on owners of "polluting" goods, whose revenue is distributed among recent adopters of clean goods.	Valentino Piana
EUTANSECTOR	Sectoral Euthanasia	By identifying regions where polluting industries are pivotal to the whole economy, the policy aims at a painless foreclosure over an agreed time horizon, by a mix of support to local entrepreneurship in other sectors, new localizations, and complementary measures, to fully and timely compensate owners, managers, workers, suppliers, accompanied in their difficult phase.	Valentino Piana

Table 26.2 Comparison of a few adoption drivers for seven mitigation economic policies

Policy	GRINS	SNM	CSDR	ECO-LABEL	FREEADV	PRODINT	EUTAN SECTOR
Voters							
Number of voters gaining	Large	Small	Medium	Medium	Large	Medium	Medium–large
Voters' gain assured	Medium–high	High	Medium–low	Medium	Medium–low	High	High
Number of voters hurt	Small/none	None	None	None	None	Large	Medium–large
Pain inflicted	Low/none	None	None	None	None	Low	Low
Voters can change side	Yes	No	Yes	Yes	Yes	Yes	Yes
Firms							
Number of firms gaining	Medium	Small	Medium–Large	Small–Medium	Small–Medium	Medium	Medium
Firms' gain assured	High	High	High	High	High	High	High
Number of firms hurt	Medium–Small	Small	None	Small	Small	Small	Medium
Pain inflicted	Low	High	None	Low	Low	Low–medium	Low
Firms can change side	Yes	No	Yes	Yes	Yes	Yes	No

Conclusions

Domestic policies and international negotiations are strictly interlinked. Vast and complex as they are, the international negotiations over a climate change agreement need to combine requests, fears, and hopes of a large array of agents rooted in largely divergent national experiences. They concern the far future, but also the very real present, and they are under the burden and the lessons of the past, in terms of credibility of commitments, actions, and effects.

If mitigation is mainly seen as a cost, then the issue shifts back and forth from "keeping the cost low" by unambitious goals to "who has to pay these costs" and how to verify that "you really paid". The fact that the costs of inaction are much higher than mitigation is crucial, but too often overlooked.

Large transfers of funds and technologies across nations, especially from developed to developing countries, will be conducive to an effective agreement. Adequate room to the problem of good governance and capacity building will need to be found.

At the same time, connecting mitigation with the large benefits of low-emission economy for innovative sectors, for green jobs, quality of life, and a host of domestic constituencies will be valuable to rate radical cuts in emissions not only as feasible but highly desirable.

Probably in the same text of the agreement, there will be little place for specific policies, but it would be important that key players know that implementing bold policies is not only economically feasible but also politically rewarding.[1]

References

Acemeglu D, Robinson JA (2006) Economic origins of dictatorship and democracy. Cambridge University Press, Cambridge

Andersen MM (1999) Trajectory change through interorganisational learning. On the economic organisation of the greening of industry. PhD Series, Copenhagen Business School, Copenhagen

[1]In the book, two policies relate directly to international agreements:

MOSAIC, which declines the "common but differentiated responsibilities" in a new setting, based on a five-step procedure (1) To highlight a shared vision of the future for the world (the "mosaic"); (2) To identify a good number of "roles" (the "plugs"); (3) For each role, to specify a list of quantitative commitments (the "colours"); (4) Each country would freely choose one role – at least – for itself; (5) The international community would support the efforts of each country in a gradual and appropriate way; BENCHCLUB, proposing the voluntary creation of Clubs of Nations where to "benchmark" the methods, the efforts, and the achievements of mitigation policies as well as of an history of good results in decoupling GDP and emissions. Benchmark is a proven business strategy aimed at establishing areas of comparison across a selected number of organizations, where qualitative and quantitative performance is assessed. Intelligent imitation, adaptation, and appropriate experimentation of followers can give them a path forward to the performance of the leaders. Such clubs might be supported by international funding.

Andersen MM (2002) Organising interfirm learning – as the market begins to turn green. In: de Bruijn TJNM, Tukker A (eds) Partnership and leadership – building alliances for a sustainable future. Kluwer, Dordrecht, pp 103–119

Andersen MM (2006) Eco-innovation indicators. European Environment Agency, Copenhagen

Andersen MM (2008a) Policies for climate change in the long run: wiring up the innovation system for eco-innovation. DIME Workshop, University of London, 17–18 Jan 2008

Andersen MM (2008b) Eco-innovation – towards a taxonomy and a theory, Chapter for the DRUID conference. DRUID Conference, Copenhagen, 18–20 June 2008

Barker T (2008) The economics of avoiding dangerous climate change. Tyndall Centre for Climate Change Research Working Paper, Norwich

Brekke KA, Johansson-Stenman O (2008) The behavioural economics of climate change. Working Papers in Economics. University of Gothenburg, Gothenburg

Buchanan JM, Tullock G (1962) The calculus of consent – logical foundations of constitutional democracy. University of Michigan Press, Ann Arbor

Carrillo-Hermosilla J, del Rio Gonzalez P, Konnola T (2009) Eco-innovation: when sustainability and competitiveness shake hands. Palgrave Macmillan, Hampshire

Cohen MA, Vandenbergh MP (2008) Consumption, happiness and climate change. Discussion Paper 08-39. Resources for the Future, Washington

Compston H, Bailey I (2009) How can we build political support for action on climate change in western democracies. In: Giddens A, Latham S, Liddle R (eds) Building a low-carbon future – the politics of climate change. Policy Network, London

De Laurentis C, Cooke P (2008) Green innovation and policy: a co-evolutionary approach. DIME Workshop, University of London, 17–18 Jan 2008

DeCanio SJ (2003) Economic models of climate change: a critique. Palmgrave Macmillan, Hampshire

Downs A (1957) An economic theory of democracy. Harper, New York

Duval R (2008) A taxonomy of instruments to reduce greenhouse gas emissions and their interactions. OECD, Paris

European Commission (2009) Taxation trends in the European Union – Data for the EU Member States and Norway. Eurostat, Brussels

Fischer F, Miller GJ, Sidney MS (2007) Handbook of public policy analysis – theory, politics, and methods. CRC, Boca Raton

Geels FW (2001) Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. DRUID Nelson and Winter Conference, Copenhagen, June 2001

Goodin RE, Klingemann H-D (1996) A new handbook of political science. Oxford University Press, Oxford

International Energy Agency (2008) Price caps and price floors in climate policy – a quantitative assessment. IEA Information Paper. IEA, Paris

International Panel on Climate Change (1997) Fourth Assessment Report. Cambridge University Press, Cambridge

Jochem E, Madlener R (2003) The forgotten benefits of climate change mitigation: innovation, technological leapfrogging, employment, and sustainable development. In: OECD workshop on the benefits of climate policy: improving information for policy makers. OECD, Paris

Kahneman D, Tversky A (1979) Prospect theory: an analysis of decision under risk. Econometrica 47:263–291

Kemp R, Andersen MM (2004) Strategies for eco-efficiency innovation. Strategy chapter for the Informal Environmental Council Meeting, Maastricht, VROM, Den Haag, 16–18 July 2004

Kemp R, Mulder P, Reschke CH (2001) Evolutionary theorising on technological change and sustainable development. In: OCFEB Research Memorandum 9912, Environmental Policy, Economic Reform and Endogenous Technology, Working Paper Series 2. OCFEB, Netherlands

Lijpart A (1999) Patterns of democracy – Government forms and performances in thirty-six countries. Yale University Press, New Haven and London

Mansfield E (1995) Innovation, technology and the economy. Edward Elgar, Cheltenham, UK
Maréchal K, Lazaric N (2009) What evolutionary economics has to say about climate policy, Working Paper
Markowitz EM, Doppelt B (2009) Reducing greenhouse gas emissions through behavioral change. Climate Leadership Initiative Working Paper
Moran M, Rein M, Goodin RE (2006) The Oxford handbook of public policy. Oxford University Press, Oxford
Moser SC, Dilling L (2007) Creating a climate for change – communicating climate change and facilitating social change. Cambridge University Press, Cambridge
Nelson R, Winter S (1982) An evolutionary theory of economic change. Belknap, Harvard
Nordhaus WD (2007) To tax or not to tax: alternative approaches to slowing global warming. Rev Environ Econ Policy 1(1):26–44
OECD (2009) The economics of climate change mitigation: how to build the necessary global action in a cost-effective manner. Working Paper. OECD, Paris
Oltra V (2008) Environmental innovation and industrial dynamics: the contributions of evolutionary economics. DIME Workshop, University of London, 17–18 Jan 2008
Owen AD, Hanley N (2004) The economics of climate change. Routledge, New York
Piana V (2003) Dynamic competition with bi-directional product differentiation, bounded rational consumers, innovation, advertising, and finance. Essays Series. Economics Web Institute, Rome
Piana V (2009) Adoption paid by non-adopters: an innovative techno-economic policy to spread clean technologies. In: Copenhagen Conference on Climate Change: Risks, Challenges and Decisions, 10–12 Mar 2009
Piana V, Aliyev S, Andersen MM, Banaszak I, Beim M, Bullywon L, Caniëls M, Doon H, Gaurav J, Ghafary M, Karbasi A, Komalirani Y, Kua HW, Hussey K, Lee J, Masinde J, Matczak P, Mathew PM, Mahdie Z, Mossannan M, Rafieirad S, Romijn H, Oltra V, Schram A, Malik VS, Stewart G, Wagner Z, Weiler R (2009) Innovative economic policies for climate change mitigation. Economics Web Institute, Rome. http://www.economicswebinstitute.org/innopolicymitigation.htm,
Rogers EM (2003) Diffusion of innovations. Simon and Schuster, New York
Simon HA (1957) Models of man. Wileym, New York
Smith K (2009) Climate change and radical energy innovation: the policy issues. TIK Working Papers on Innovation Studies. OECD, Paris
Stern N (2006) The stern review on the economics of climate change. Cambridge University Press, Cambridge
Stern N (2008) Key elements of a global deal on climate change. London School of Economics and Political Science, London
Taylor RE, Allen W (2008) Changing household behaviours: learning for urban sustainability. Public Sector Innov J 13(2), article 5
Thaler RH (1991) Quasi rational economics. Russell Sage Foundation, New York
United Nations Framework Convention on Climate Change (2009) All updated texts for COP15 negotiations. http://unfccc.int
Waltz R, Schleich J (2009) The economics of climate change policies – macroeconomic effects, structural adjustments and technological change. Physica, Heidelberg

Chapter 27
How to Achieve Global-Scale Climate Change Mitigation? An Integrative Global Policy Framework Beyond Kyoto

Vicente Rappaccioli-Navas

Abstract If climate change mitigation is a right of humanity and planet Earth, "Global Risk", as an index – the combined world political, economic, social and warfare risk that is rapidly resulting from the unparalleled planetary ecological degradation with strategic natural-resource scarcity, over pollution and contamination, drastic climate change, ozone layer depletion, excessive biodiversity loss, as well as nuclear weapons and waste build-up – needs to be thinned down as a political and economic priority of the world to mitigate both climate change and economic recession.

It proposes a politically viable and integrative policy framework for a new climate treaty beyond Kyoto to unite all nations in a financially feasible way to achieve global scale climate change mitigation; that is, a fundamental shift in policy and tools, of moving out of a cost approach towards a profit-seeking one for the gradual build-up of the "Green Capitalist Economy", through vital enhancements of the Kyoto Protocol, including capital market instruments such as the "Ecological" stock in the climate change mitigation process within the short term, so that there will be no reason to wait until after 2012 to start profiting within the climate change mitigation process.

Keywords "Ecological" stock · Climate change · Economic incentive · Feasibility · Financial · Framework · Global policy · Global-risk · Global-scale · Innovation · Instrument · Integrative · Market · Mitigation · Policy · Profit · Security-risk · Tools · Treaty

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Introduction

During the United Nations 62nd General Assembly meeting held in September 2007, the international community reached the consensus that climate change is a political priority, a global threat that needs to be resolved urgently. The political and economic question remains as to how this will be accomplished and financed. This paper proposes a new climate change mitigation treaty under an integrative global policy framework to unite all nations in a financially feasible way that could be implemented in the first quarter of 2009; that is, without having to wait until 2012, the end of Kyoto Protocol. It first reviews the current world scenario, and, based upon this, proposes innovative policies and tools for global scale climate change mitigation.

Global Risk

"Global Risk" (GR) is the combined world political, economic, social, and warfare risk that is rapidly resulting from the unparalleled planetary ecological degradation with strategic natural-resource scarcity, over pollution and contamination, drastic climate change, ozone layer depletion, excessive biodiversity loss, as well as nuclear weapons and waste. This indicator involves the appraisal of 25 variables by country, region and the world.[1]

The assessment of GR links climate change and ecological degradation with the performance of the world economy; that is, GR increments are directly associated with the rising economic losses produced by climate change. Its measurement is, thus, required in order to have a true appraisal of the state of the world as well as a prudent forecast of the global economic risk. Hence, there is a real need to control

[1]Global Risk. Variable composition of the indicator in terms of rate, percentage, or monetary value (1) Deforestation; (2) Water scarcity and contamination (i.e. rivers, lakes and underground water sources); (3) Soil erosion and contamination; (4) Desertification; (5) Biodiversity loss; (6) Concentration of GHGs in the atmosphere; (7) Primary and secondary forest land per capita (i.e. forest land/total population). This variable determines the forest ecosystem capacity to support the world economic system and the population; (8) Agricultural sustainability; (9) Ocean ecosystem degradation; (10) Ozone layer depletion; (11) Climate change intensity and variability; (12) Food security; (13) Environmental emigrants. This variable measures the number of people leaving their native land because of environmental problems, climate change and consequential agricultural losses; (14) Nuclear waste; (15) Poverty; (16) Unemployment; (17) General Price Index; (18) Environmental law effectiveness; (19) Environmental education; (20) R&D on renewable energy technology as a percentage of GDP; (21) Disease propagation. (i.e. over pollution and contamination with high temperatures and virus and bacteria natural mutation facilitates the propagation of old and new diseases into epidemics); (22) Sustainable development as a percentage of GDP; (23) Political risk; (24) Political, economic and nuclear confrontation probability for the dwindling strategic natural resources; (25) Global security risk; includes current and potential global conflicts.

and reduce GR through united international actions, if the consequences of extreme climate change are to be avoided.

Economic studies of climate change have the general objective of stimulating economic and financial risk awareness to encourage climate change mitigation actions by means of national and international policies and tools. It is relevant to mention the estimate of the Stern Review that the cost of inaction could be 20% of world Gross Domestic Product (GDP), whereas the cost could be around 1% of GDP if urgent actions are taken without further delay.

In addition, as stated by The United Nations Environment Programme and the International Energy Agency in the report Analysing Our Energy Future 2007 (UNEP-IAE 2007), a summary of the World Energy Outlook 2006, "While the benefits of taking corrective action toward a sustainable energy path would for the most part accrue in the future, the costs would be felt today, which limits their appeal to policy-makers. Yet the costs of inaction outweigh those of implementing the needed policies, so there is clearly a need for improved dialogue between government, industry and consumers to develop effective, long-term policies".

Oil Prices, Budget Deficits, and Surpluses

In 1973 the price of oil was approximately $2.00/barrel and in 1974 increased to nearly $12.00/barrel. Economic studies have shown the negative impact of the oil price shocks of the 1970s in national budgets and the world economy, mainly the appearance of budget deficits with a consequent decrease in general investments and a slowdown in economic activity. "Much higher oil prices acted like a tax on oil consumers. For the world economy as a whole, the impact was demand depressing and cost inflationary – a particularly unpleasant combination" (Marris 1987).

A study by the International Energy Agency in May 2004, "Analysis of the Impact of High Oil Prices on the Global Economy", concluded that "Higher oil prices lead to inflation, increased input costs, reduced non-oil demand and lower investment in net oil-importing countries". In other words, the price trend of oil *can adversely affect the capacity of the world economy to make the critical new capital investments in climate change mitigation*. For instance, R&D investments are essential for economic development, especially in the area of technology. This type of investment declines when a nation is running with budget deficits or corporations are experiencing financial losses; funds become increasingly scarce and are utilized mostly to cover operational expenses. As mentioned by the IPCC in its Fourth Assessment Report – Climate Change 2007, government funding for most energy research programmes has been flat or declining for nearly 20 years (IPCC 2007). Furthermore, high oil prices have a wider economic impact in developing and poor nations than in industrialized nations: "First, rising oil and gas demand, if unchecked, will accentuate consuming countries' vulnerability to supply disruptions and price shocks. Poorer countries will be especially at risk: the loss of real income and the adverse impacts on the budget deficits and current account balances of importing countries are proportionally greater for them. Second, the energy sector is the main contributor of emissions of greenhouse gases" (UNEP-IAE 2007). Therefore, economies of poor and developing nations operating with budget deficits have a very low capacity to make new capital investments in climate change mitigation because their limited funds hardly cover basic expenditures such as welfare programmes, oil imports, health, natural disasters, infrastructure maintenance and reconstruction, and crop losses from floods or droughts.

Last but not least, international monetary policy does not contemplate the climate change mitigation responsibility of countries with large budgets or current account surpluses generated by excessive oil prices, notably OPEC nations. In the same way, the probability of any nation of falling into recession or bankruptcy (i.e. incapacity to pay foreign debt and basic national expenditures) due to climate change-generated costs is not considered. Moreover, in order to have a better depiction of current world cashflows and how urgently they ought to be reviewed, the above scenario needs to include the long-term investment plans of the entire energy sector, essentially the fossil fuel industry of the world economy: "Future energy infrastructure investment decisions, expected to total over 20 trillion US$ between now and 2030, will have long term impacts on GHG emissions, because of the long life-times of energy plants and other infrastructure capital stock. The widespread diffusion of low-carbon technologies may take many decades, even if early investments in these technologies are made attractive" (IPCC 2007). Based upon the above investment plan of the energy marketplace, the projected emissions for the world economy shown in Fig. 27.1 below would only be curved down with a massive capital investment shift into renewable energy technology development and commercialization that would rapidly substitute the fossil fuel industry in an economically feasible way through innovative new financial instruments and business opportunities.

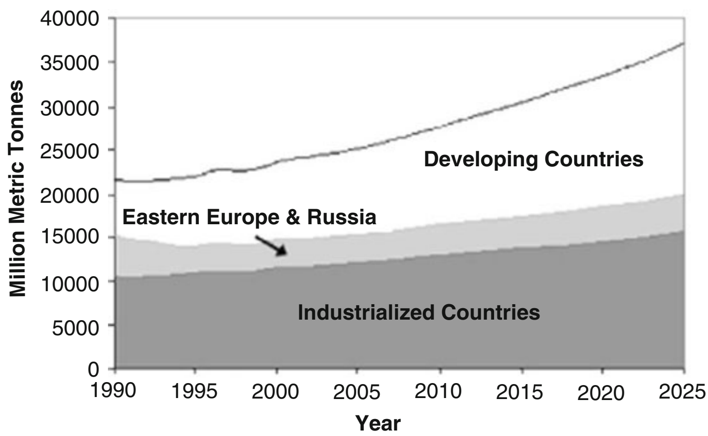

Fig. 27.1 Projected carbon dioxide emissions through 2025, by region Source: US Department of Energy, 2004

The question of how climate change mitigation is to be financed is, then, an international monetary policy challenge that needs to be addressed urgently under a new global climate treaty. Otherwise, the world may well face excessive costs in mitigation in the near future: “Delayed emission reductions lead to investments that lock in more emission intensive infrastructure and development pathways” (IPCC 2007).

Current Policies and Tools (P&Ts)

Two main climate policies are predominant: emissions reductions and renewable energy technology development; commercialization and transfer. Tools under energy include R&D, renewable portfolio standards, tax and non-tax incentives and subsidies. The Kyoto Protocol, as an international agreement for emissions reductions, offers the tools of emissions trading with the Joint Implementation and the Clean Development Mechanism flexible modalities. At the regional and national level, tools vary with mixed policy objectives, notably carbon taxes, emissions trading schemes (i.e. EU ETS; UK ETS; Norway ETS), product or process GHG standards, carbon capture and storage, energy conservation and efficiency, and urban planning. In the area of natural sinks, forestry and reforestation projects are principally located in developing and poor nations. A tool that combines carbon taxes with emissions and environmental services trading is the Payment for Environmental Services (PES), one that has proven to be successful in a few countries of Latin America.

What is most important to consider about the current P&Ts is their effectiveness in climate change mitigation. Tax and non-tax incentives, as well as subsidies, represent different costs and market disequilibrium to the economy, although they reduce tax payments in corporations. Cost savings that may be realized through energy efficiency or conservation can have a favourable impact in a business activity. In relation to the carbon tax, it must be added to the already existing tax burden affecting businesses. Moreover, there *could* be costs and benefits arising from carbon taxes that must be weighted by each national economy: “Taxes and charges can set a price for carbon, but cannot guarantee a particular level of emissions. Literature identifies taxes as an efficient way of internalizing costs of GHG emissions” (IPCC 2007).

In emissions trading, those that sell allowances have to pay for the cost of lowering emissions and the sales proceeds do not necessarily cover the cost. On the other hand, the firms that cannot curb their emissions through changes in the production system must purchase the corresponding carbon allowances or face penalty costs. If a firm experiences cost increments, the new marginal cost either reduces profits or is passed on to the price of the product. That is, “Since the EU power producers passed along some of the cost of their free emissions allowances, their major customers – the other large final emitters – have raised a protest (Sijm et al. 2005; World Bank and IETA 2006). Governments (such as the United

Kingdom and Denmark) considered a retrospective tax on these windfall profits. Already the energy chain is reacting to increased power costs following the placing of most of the burden of emission reduction on the power producers" (Labatt and White 2007). "Improving and expanding the scope of market mechanisms (such as emission trading, Joint Implementation and CDM) *could* reduce overall mitigation costs" (IPCC 2007).

However, the financial impact of most of the current P&Ts is a disbursement in the operational budget of economic units, largely corporations, unfavourably affecting company profits. In the medium term, the cumulative effect of cost inflationary P&Ts can be adverse for capital investments, and, as a result, for the mitigation policy objectives. Therefore, there could well be further effects on economic performance and growth. A concrete overview is:

> The effectiveness of any cap-and-trade scheme, however, depends on the size of the cap. For example, The European Union appeared to have successfully implemented such a program in 2005, only to find that its cap was too high, meaning it didn't save very much in total emissions. The European Commission reported in May 2006 that the EU's original fifteen members would cut emissions by 2010 by only 0.6% compared with 1990 levels. The Kyoto Protocol target is 8% by 2012. When that fact emerged, the price of permits fell by two-thirds. The system inconvenienced very few.
>
> There is no effective way to meaningfully reduce emissions without negatively impacting a large part of an economy. Net, it is a tax. If the cap is low enough to make a meaningful inroad into CO_2 emissions, permits will become expensive and large number of companies will experience cost increases that make them less competitive. Jobs will be lost and real income of workers constrained. Cap-and-trade systems or carbon taxes are likely to be popular only until real people lose real jobs as their consequence. A carbon tax might not be job-destroying if it were uniform across the globe, but I am skeptical that such uniformity is even remotely feasible. Unless we find technologies that delink emissions from output, emissions can be suppressed only through lower production and employment (Greenspan 2007).

Additionally, their implementation has been surrounded with conditions of uncertainty created by the absence of clear and integrated long term global climate policies. To be precise, "The long life of a good deal of energy infrastructure means that the system changes only very slowly. This heightens the need for governments to establish a clear, long-term policy framework – one that, while favoring sustainable investments, allows industry to plan for the future" (UNEP-IAE 2007). Other factors affecting the current scenario are a relatively weak world economic growth increasingly disturbed by natural disasters, exploding oil prices and stiff competition in international trade.

Moreover, the effectiveness of the current P&Ts can be assessed under the recent findings of the British Antarctic Survey (2007): since 2000, atmospheric CO_2 has risen 35% faster than forecasted because of inefficient use of fossil fuels increments with contributions of 17% and forests and oceans CO_2 sink efficiency decline with 18%. Also, the simple fact that not even the emission reduction targets of the Kyoto Protocol have been met by industrialized nations means that it can be inferred that global GHG reduction has been very small relative to the magnitude of the risk facing the world economy and humanity. The above leads to the conclusion that the accomplishments of most of the current P&Ts have fallen short of the general expectations, seemingly because of their cost inflationary factor affecting business, together with the need of the world economy to have feasible economic incentives in the mitigation process under clear long-term global policies.

Beyond the Current World Scenario

How urgent is a new climate treaty?. To answer this question, the risk factor for the world must first be examined. A high Global Risk condition translates itself into security risk. The latter one is clearly described by the German Advisory Council on Global Change in a report released in June 2007, "World in Transition – Climate Change as a Security Risk": "Without resolute counteraction, climate change will overstretch many societies' adaptive capacities within the coming decades. This could result in destabilization and violence, jeopardizing national and international security to a new degree. However, climate change could also unite the international community, provided that it recognizes climate change as a threat to humankind and soon sets the course for the avoidance of dangerous anthropogenic climate change by adopting a dynamic and globally coordinated climate policy". Based upon this statement, as well as the conclusion of most economic studies conducted up to now, a new treaty is extremely urgent, one that can provide a feasible action course acceptable to all parties involved. This leads to the necessity of defining the basic policy guidelines, primarily concerning the economic and financial elements.

With all of the above in mind, in order for the world to effectively address Global Risk and thereby be successful in mitigation, policies and tools of the new treaty must:

(a) Be integrative for industrialized and developing nations as well as for all industries and environmental sectors (i.e. reforestation, afforestation, natural sinks (forests, land and oceans), water sources, soil, biodiversity, nuclear waste, etc.).
(b) Facilitate medium-term (3–5 years) technological transition towards renewable energy technology. This policy guideline is in agreement with the IEA's most recent findings: with current fossil fuels demand trends unhindered, global carbon emissions would soar 57% in the 2005–2030 period, giving a global temperature increase of 5–6°C with climate change unmitigated. "The challenge for all countries is to put in motion a transition to a more secure, lower-carbon energy system, without undermining economic and social development. Vigorous, immediate and collective policy action by all governments is essential to move the world onto a more sustainable energy path. The emergence of China and India as major players in global energy markets makes it all the more important that all countries take decisive and urgent action to curb runaway energy demand" (IEA 2007).
(c) Be based on a dynamic modality that would provide greater flexibility for a continuous improvement of policies and tools as well as revision of goals on a yearly basis. Under this approach, emissions reductions targets could be not only economically and politically ambitious but would be open to upward adjustments, subject to biannual overall progress assessments.

(d) Be supported by a comprehensive financial and business development programme. It will include the development of business investment opportunities and financial incentives in the whole mitigation process for the world economy. "Integrating climate policies in broader development policies makes implementation and overcoming barriers easier" (IPCC 2007).

(e) Motivate participation of the global society under a tripartite body consisting of government, private sector and societal representatives for a thorough implementation of the new treaty and its financial programme.

(f) Eradicate poverty in the medium term.

(g) Effectively overcome the barriers identified by the IPCC at a global level: "Barriers to the implementation of mitigation options are manifold and vary by country and sector. They can be related to financial, technological, institutional, informational and behavioral aspects" (IPCC 2007).

(h) Adapt the policy-making process for all economic, political, and social endeavours, whereby sustainable development would be the main foundation.

(i) Gradually expand the new treaty into a global plan to reform the world economy under the approach of Sustainable Development Intelligent Design described in the Climate Change and Economic Transformation chapter of the annexed "Ecological" stock paper; that is, the imperative need to build the Green Capitalist Economy with the elimination of pollution (Figs. 27.1 and 27.2 below) and waste in the production process designed to fully eliminate Global Risk (urgent need for a transformation of the global economy through "an integrated approach based on the concept of sustainable development" (World Economic and Social Survey 2009)).

(j) Transform traditional agriculture into vertical organic farming with bio-agriculture (pricing linked to the nutritional value and health enhancement

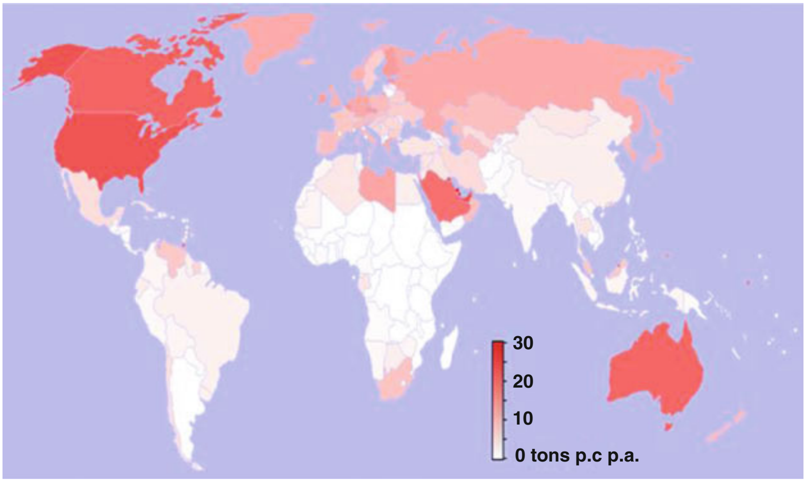

Fig. 27.2 Countries by CO_2 emissions per capita 1990–2004. Source: US Department of Energy's Carbon Dioxide Information Analysis Center (CDIAC) for the United Nations Statistics Division

attributes of foods) to achieve food security, improve human health and free land for reforestation–afforestation to meet the goal of restoring the forests of the planet to at least 70% of their original capacity to help re-establish climate equilibrium under a Global Reforestation–Afforestation Programme (Annex I Empirical Research Findings in the annexed "Ecological" stock paper, including carbon reduction global policy).

(k) Fully include the Montreal Protocol under the new treaty in view of carbon and other GHGs market efficiency as well as economies of scale factor considerations as well as provide incentives for the disposal of ozone-depleting substances (ODS) in an environmentally responsible way in the carbon market.
(l) Account accomplishments of the voluntary market by country to become applicable to the regulated market, including the United States of America, to motivate eventual ratification of the new treaty within its profitability approach for any economy in the new business-oriented mitigation process.
(m) Provide financial incentives for budget-line redistribution from nuclear and conventional weapons to R&D in renewable energy technology and market development.
(n) Enhance the Kyoto Protocol to include the above points.

Moreover, it must allow open emission reductions, as under point (c), beyond a minimum proposed target of 60%, to be negotiated for the first commitment period of the new treaty, expected to be 2010–2012. Nations that surpass the minimum target would receive well-rounded economic incentives and economic reforms support for sustainable development. Countries under the Kyoto Protocol with difficulties in meeting their emission reduction targets would be permitted to move into the new treaty without penalties.

Financial Programme Policy Framework

The need for a financial programme is consistent with one of the main conclusions of the report Analysing Our Energy Future 2007: "the major challenges facing the global energy system today are interlinked – both financially, through global energy and capital systems, and politically, in future agreements under the United Nations Framework Convention on Climate Change. Dealing with these challenges requires both a comprehensive approach and coordinated action". Thus, the policies and tools of this programme would need to resolve the question of how climate change mitigation will be financed; that is:

(a) *Development of an international climate change budget to encompass all financial needs for long-term global scale mitigation and sustainable development*; (1) define allocation of funds based on a nation's net contribution to climate change less a verifiable annual progress – net climate investments and effectiveness of policies and tools; (2) address the international monetary policy challenges of national budget surpluses of oil-producing nations, notably OPEC members, generated by excessive oil prices, as well as their financial responsibility in climate change mitigation. Facilitating financially attractive investment opportunities in mitigation for these nations would probably be the most practical political route. Also, national budget deficits generated by excessively high prices of fossil fuel imports as well as of rising climate change-generated costs. Since these issues fall within the purview of international monetary policy, they would need to be dealt with at a special international treasury summit, to take place hopefully in the short term.

(b) *Development of financial tools to stimulate long term investments***.** The role of profit in the world economy is a key matter for the development of financial tools: "profit influences both the level of resource utilization and the allocation of resources among alternative uses. Entrepreneurs seek profit and shun losses" (McConnnell 1981). A mandatory accord must provide a large diversity of feasible financial incentives in order to promote continuous capital investments to maintain economic stability and growth. If in harmony with the free enterprise, the right tool, then, is one that can contribute to business profits or national budget surpluses. The tools that meet these criteria fall under the category of capital market instruments. This market is formed of long-term instruments such as corporate stocks, bonds and mortgages (Van Horne 1984). Stocks or equity capital has the advantage, unlike debt, of not creating financial risk for the firm. Also, it gives shareholders the permanent rights to the profits of the business (Van Horne 1986). Nevertheless, R&D has been needed to develop the financial tools that will serve in global climate change mitigation. However, one promising proposal, the result of a 10-year international financial R&D, was presented at the 2007 Chemrawn-XVII and ICCDU-IX Conference on Greenhouse Gases – Mitigation and Utilization. Named the "Ecological" stock*,* it is a certifiable and tradable innovative instrument that incorporates features of a corporate stock, a commodity, a derivative and a perpetuity. *It is, therefore, a hybrid new financial product* that aims at developing a global financial market for emissions and environmental services trading in the following areas:

1. Forest conservation and reforestation
2. Renewable energy
3. Long-term CDM projects
4. Foreign debt swaps for poor and developing countries

Similar to corporate stock, it is a transferable unit of ownership with profit rights through price appreciation as well as dividends. Thus, the added special functionality consists in its *hybrid and augmented financial features beyond a traditional corporate stock*. Additionally, its market price encompasses the *combined* market value of the main certifiable underlying assets of a given carbon project. Each share, in turn, will be accompanied by a corresponding Mitigation and Neutralization Certificate (MNC), which includes the certified emission reductions *plus the project's overall ecosystem environmental products*, integrating the complete financial and climate change factor assessment of the given project.

To assure financial integrity, the issue of stocks of specific carbon projects would be done not only through the traditional means (i.e. investment banks and certification firms), but complementarily utilizing a speciality type of corporation, the main mission and business activity of which must be the mitigation of climate change as a fixed binding condition. Moreover, one of its goals is turning the CDM model of the Kyoto Protocol into a new global financial industry under a voluntary scheme as well as under the Protocol through the exchanges.

This new financial innovation would most likely stimulate the level of investment in new carbon projects, which would help in meeting new emission reduction targets without the use of current cost inflationary policies and tools, adverse repercussions in government's national budget, or disruptions in the price system because it would motivate participation, mainly from the private sector, through equity capital and profitability. That is, it would offer the opportunity to all economic units and countries, including the global citizens, to mitigate climate change by investing in the exchanges, which would translate into an economic democratization of a process until now limited to a few (i.e. large multinational firms, investment banks, development banks, governments of industrialized nations, and venture capital). Furthermore, externalities would be gradually absorbed by the economy through the capital market without inflationary effects, the price of carbon would be set by the free market forces, global carbon neutrality would be simpler to achieve, economies of scale could be attained in the mitigation process, and structural changes of the world economy towards a sustainable development path (e.g. building the Green Capitalist Economy with the elimination of pollution (Fig. 27.2 below) and waste in the production process) would be financially induced, fostering sustained employment and economic growth.

The above represents *a fundamental shift in policy and tools (P&Ts), of moving out of cost approach P&Ts to profit-seeking ones*, consistent with the spirit of the free market economy that predominates throughout the world today. Through this *profit development approach*, the wealth of nations could continue to add not only to GDP/capita but also in natural capital (i.e. environmental wealth), surpassing the present economic system's structural boundaries, yet in harmony with Adam Smith's economic philosophy: "Adam Smith's Enlightenment ideas of individual initiative and the power of markets came back from near eclipse in the 1930s to their current dominance of the global economy" (Greenspan 2007).

Carbon funds, investment, development banks, as well as corporations could initiate the pilot trading in the international exchanges. That is, "The primary scarcity facing the planet is not of natural resources nor money, but time" (IEA 2007).

Conclusions

Some key barriers in the implementation of current climate change mitigation alternatives has been the lack of feasible financial incentives for governments and corporations, the existence of budget deficits among some industrialized and developing nations and the use of cost inflationary policies and tools, all combined with global climate policy uncertainty.

The economic risk arising from drastic climate change is increasing at a rate that is difficult to assess in terms of the extent to which it poses a threat to world security. Thus, the reduction of "Global Risk" needs to be the main objective of future climate policies and tools as well as an integral part of a new global climate treaty. A new global treaty is, therefore, urgent; one that would need to integrate all nations, industrialized and developing ones, as well as all economic and environmental sectors, the implementation of which ought to be supported by a comprehensive financial and development programme with business incentives and a profit-seeking orientation. Furthermore, in the short term, the Kyoto Protocol could be enhanced to adopt *innovative policies and tools* as well as *an ambitious global emissions reduction target* so as to avoid further delay in globally coordinated actions, including penalty costs from incompliance.

In brief, besides the economic necessity, *through financial and business policy innovation*, *it is possible to transform the climate change threat into a profitable new industry*, one that would promote world sustainable development for the general wellbeing of all nations and our planet. In this manner, the political, economic, and social systems would be in an action course towards global scale mitigation within the spirit of a free market economy.

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References

British Antarctic Survey, 10 (2007) A joint research of the Global Carbon Project, the University of East Anglia (UEA) and the British Antarctic Survey

Cline WR (1992) The economics of global warming. Institute for International Economics, Washington DC, 399 pp

Ethier WJ (1983) Modern international economics. W. W. Norton, New York, 588 pp

Eiteman DK, Stonehill AI, University of California, Los Angeles and Oregon State University (1989) Multinational business finance, 5th edn. Addison-Wesley, MA, USA, 679 pp

Greenspan A (2007) The age of turbulence. Adventures in a new world. Penguin, New York, 531 pp

German Advisory Council on Global Change (June 2007) World in Transition – Climate Change as a Security Risk. German Advisory Council on Global Change, Germany, 258 pp

Gandhi VP (1998) The IMF and the environment. IMF Survey Magazine. External Relations Department, Publication Services, IMF, Washington, DC

IPCC (2007) Fourth Assessment Report on Climate change: mitigation of climate change. Summary for Policymakers. IPCC, Switzerland

International Energy Agency (2004) Analysis of the impact of high oil prices on the global economy. IEA, Paris

International Energy Agency (2007) World energy outlook 2007 – Executive summary. IEA, Paris

Labatt S, White RR (2002) Environmental finance: a guide to environmental risk assessment and financial products. Wiley, New Jersey, 366 pp

Labatt S, White RR (2007) Carbon finance: the financial implications of climate change. Wiley, New Jersey, 268 pp

Marris S (1987) Deficits and the Dollar: The world economy at risk. In: Policy analysis in international economics. Institute for International Economics, Washington DC, 343 p

McConnnell CR, University of Nebraska-Lincoln (1981) Economics: principles, problems and policies, 8th edn. McGraw-Hill, New York, 911 p

Neuhoffi K (May 2007) Investment decisions under climate policy uncertainty. Round Table of Climate Strategies on Investment Uncertainty, Cambridge

Organization of Petroleum Exporting Countries (OPEC), Official site for the intergovernmental organization dedicated to the stability and prosperity of the petroleum market. Available at www.opec.org

The “Ecological” stock, annexed paper. All chapters with special emphasis in the following: “Climate Change & Economic Transformation” (p. 26) and Annex I – Empirical Research Findings (p. 29)

The Stern Review: the Economics of Climate Change (2006), Executive Summary

The Kyoto Protocol

UNEP-IAE, United Nations Environment Programme and International Energy Agency (2007) Analysing our energy future: some pointers for policy-makers. a summary of the world energy outlook 2006. UNEP-IAE, Kenya

Van Horne JC (1984) Financial market rates and flows. Prentice-Hall, New Jersey, 311 p

Van Horne JC (1986) Financial management and policy, 7th edn. Prentice-Hall, New Jersey, 858 p

World Economic and Social Survey (2009) Available at http://www.un.org/esa/policy/index.html

Chapter 28
ITU: Moving Towards a Global Policy Framework on ICTs and Climate Change

Catherine Candano

Abstract Voluntary initiatives undertaken across private and public sectors have enabled innovative national and regional ICT practices, however fragmented and localized in scope these collaborations are. Policy proposals for an enabling environment have emerged from the voluntary actors, highlighting the need for a framework to spur adoption of carbon-friendly ICT practices. By exploring the links between ICT and climate change, this paper intends to highlight the policy gaps that exist to enable a wider use of ICT for climate change solutions. The study explores the potentials of climate change mainstreaming into global ICT policy platforms at the ITU, as it moves towards a framework regarding ICTs and climate change. A combination of supply and demand side policy analysis identified the forces that present both risk and opportunity for ITU to become a more meaningful player in this context. It was identified that ITU can enable greater coherence and catalysis among stakeholders and policy areas given the potentials across climate change mitigation, monitoring, and adaptation.

Keywords Adaptation · Climate change · Global policy · ICT · ITU · Mitigation · Monitoring

Introduction

Two years ago, United Nations Secretary-General Ban Ki-moon called climate change "the defining challenge of our time" in an address at the UN Climate Conference in Bali (UN 2007). Attention on policy solutions has been mainly focused on the global climate change agreement, the United Nations Framework

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Convention on Climate Change (UNFCCC)'s Kyoto Protocol, adopted in 1997 to address global warming. Policy tools prescribed within it focus on the greatest contributors to global greenhouse gas emissions, mainly deforestation, transport-based emissions, and unsustainable energy sources such as fossil fuels: emissions cap-and-trade, the Clean Development Mechanism as well as Joint Implementation programmes (UNFCCC 2007). Forest management and funds for climate-vulnerable developing countries become additional policy tools (UNFCCC 2008).

A promising area not directly addressed within the Kyoto Protocol framework is the linkage with ICTs. As ICTs inherently use energy to make and use, the sector in itself constitutes an industry which emits greenhouse gases – covering technology products from PCs to mobile phones, and associated infrastructure. The ICT sector's contribution to global greenhouse gas emissions is the same industry-level emission estimate for the global airline transport industry (Gartner 2007). Considering the ICT sector produces between 2% and 3% global greenhouse gases emissions annually, it is usually an overlooked sector as a driver for climate security within policy debates. The breakdown of industry-level emissions consists of the use of computing technologies and telecommunications, which contribute approximately 75% of industry emissions (Fig. 28.1). Fixed-line, mobile, and LAN/office telecommunications contribute to a third of industry emissions while personal computing contributes to 40%.

In addition to a sector-specific perspective is a cross-sector consideration of ICT and climate change. ICT applications are pervasive in the economy as enabling technologies, having impact on society and development consequences. This viewpoint links ICT and climate change in a more integrated manner, proposing greater potential contributions to address the issue. Reports indicate opportunities exist for climate change mitigation when ICT is applied to reduce emissions in other higher-emitting industry sectors (energy, transportation and buildings). Estimates indicate

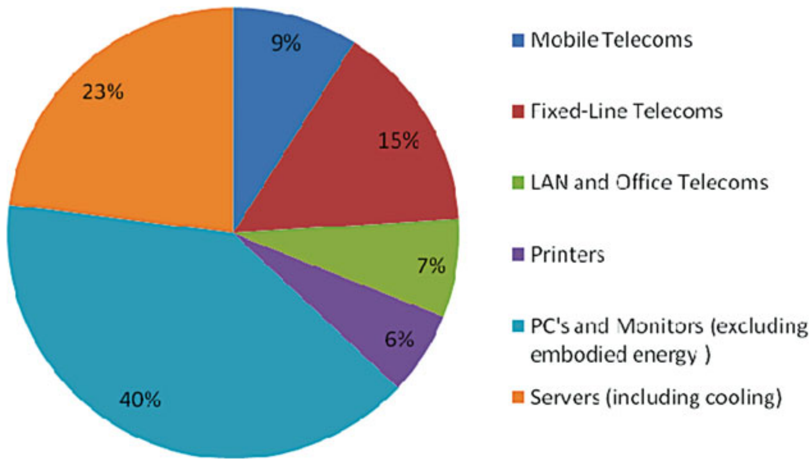

Fig 28.1 ICT contributions to climate change emissions (ITU 2008a, b, c)

such ICT use could reduce global emissions by 15–40% depending on estimation methods (The Climate Group et al. 2008). Potential to reduce emissions, and drive energy-related cost savings, have driven voluntary efforts in the literature among private sector actors within ICT. These voluntary efforts in developed countries such as in Europe, North America, or Japan were undertaken often in relation to sustainability financial reporting and have garnered attention in terms of cases' quantifiable impact. Policy proposals for an enabling environment have emerged from the voluntary actors, highlighting the need for macro-level guidance and governance to spur adoption of carbon-friendly ICT practices.

The International Telecommunications Union (ITU) is the only global platform that brings together state and industry actors on ICT issues of common concern, in a domain where often public efforts to regulate ICT venture on a different roadmap from the private sector. Its recommendations on standards for competing technologies often guide national regulators and industry players on compatibility; it has a high rate of participation among its member countries covering both developed and developed countries among other historical strengths. In 2007, when ITU was tasked by the United Nations Secretary General to lead ICT for climate change efforts within the UN system, ITU was expected to respond and galvanize its organization accordingly. This implied that no longer did climate change lie mainly within the area of the United Nations Framework Convention on Climate Change (UNFCCC), the UN body founded by the two specialized agencies the United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO), to facilitate a global treaty on climate change. Rather, climate change was a responsibility of every UN agency under a unified platform, in line with the current One UN reform programme (UN Acting on Climate Change 2008). As such, this paper intended to explore the role of the International Telecommunications Union (ITU), the main UN agency focused on ICTs, as it moves towards efforts on a global policy towards ICTs and climate change. The policy gaps in the proliferation of ICT for climate change solutions are identified herein as the need for coherence among actors and catalysis among policy areas.

ICT's Potential to Address the Issue of Climate Change

The literature considers the interplay between ICTs and climate change mainly in the context of impacts. ICTs create both positive and negative impacts on environment when applied within ICT fields and across other sectors (Houghton 2008). Potentially positive impacts can come from: the dematerialization and online delivery of physical goods; the reduction in the need for travel upon applying digital office technologies; the use of energy modelling, monitoring, and management applications for energy efficiency in production and use. On the other hand, potentially negative impacts can come from: the production and distribution of ICT equipment; energy consumption in use (directly through application and indirectly for the cooling) of machines; the short product life-cycles (planned obsolescence) of ICT, among others.

Beyond the cost–benefit analysis of ICTs on climate change in terms of only its positive and negative impacts, it is helpful to consider a more nuanced view of ICT impacts, to ascertain its implications for action and policy. The literature identifies three distinctive views of ICTs in terms of its scope and pervasiveness of application and inherent properties of the technology (Fig. 28.2).

The three levels of ICT impacts relate to the creation and use of ICTs across different sectors in society, and both the positive and negative consequences of its applications to the natural environment. These views of ICT impacts move from industry-specific impacts (namely the direct effect or first order impact), to its presence outside the ICT industry (namely the indirect effect or second order impact), and to its wider and broader impacts when present across more sectors in society (namely the systemic effect or third order impact).

First order or direct effects of ICT on climate change are impacts and opportunities created by the physical existence and application of ICT and the manufacturing processes involved, such as pollution, energy to manufacture them, disposal, etc. This includes the direct use of ICT by the industry sector itself. Second order or indirect effects cover impacts and opportunities created by the ongoing use and application of ICT outside of the ICT manufacturing sector (other industries, government, academia, society). One may consider this impact in terms of ICT power-use and savings in these sectors. One recent report estimated that indirect effects might account for 80% of ICT-generated GHG emissions. Third order or systemic effects of ICT are those impacts created by aggregated effects of mass ICT-use and application over the medium and long term, therefore enabling changes in social behaviours to be felt through scaled-up adoption of such technologies. An example of such scaled-adoption would be in the case of a general acceptance emerging, regarding telecommunications substitution effects for physical travel by organizations. The larger-scale impact of a hypothetical widespread preference for telecommuting across sectors may therefore lead to a marked decline in the use of transportation systems (and the carbon emissions implied by transport use)**.** Large-scale choices made about how to use ICTs to change structures and behaviours may play a role towards a global response to the challenge of climate change (IPTS 2007).

Three Distinct ICT Effects on Climate Change		
First Order	Direct Effect	Within ICT Sector
Second Order	Indirect Effect	Outside ICT sector (enabled by ICT)
Third Order	Systemic Effect	Across society-at-large

Fig. 28.2 Three distinct ICT effects on climate change (Adapted from IPTS 2007)

ICT intervention to address climate change is mainly related to three focus areas associated in climate change solutions: climate change mitigation, monitoring, and adaptation. Mitigating climate change refers to areas of action through the mitigation of the cause of climate change, the carbon emissions, by various sectors in society. Monitoring climate change refers to areas of action undertaken in order to understand the extent of the issue and its related impacts on the physical environment and human development. Finally, adaptation to climate change refers to areas of action aimed at reducing human vulnerabilities to climate change effects. The three levels of ICT impacts are dispersed across the three climate change policy areas. Richard Heeks (2009) summarized the literature describing the intermediary effects of ICTs on the climate change causes and effects adapted in the succeeding framework (Fig. 28.3).

Mitigation of climate change through ICT applications in consumption and production processes would include examples such as dematerialization (replacing atoms with bits) and flexible work arrangements via telecommuting. Some case results include: ITU Recommendations Online has saved 105 tonnes of CO_2 annually compared with distribution of paper copies; Telstra held 7,500 video conferences, saving 4,200 tonnes of CO_2; video-conferencing to reduce business travel in Europe by 1% would save 1 m tonnes of CO_2 annually (Climate Risk report for Telstra 2007; ETNO/WWF report, Toyota, ITU 2008a, b, c). The use of smart grids and smart building designs could manage energy efficiencies remotely and in an automated manner, also enabling mitigation of climate change through ICT applications on energy generation, distribution, and usage in buildings, transport, and equipment.

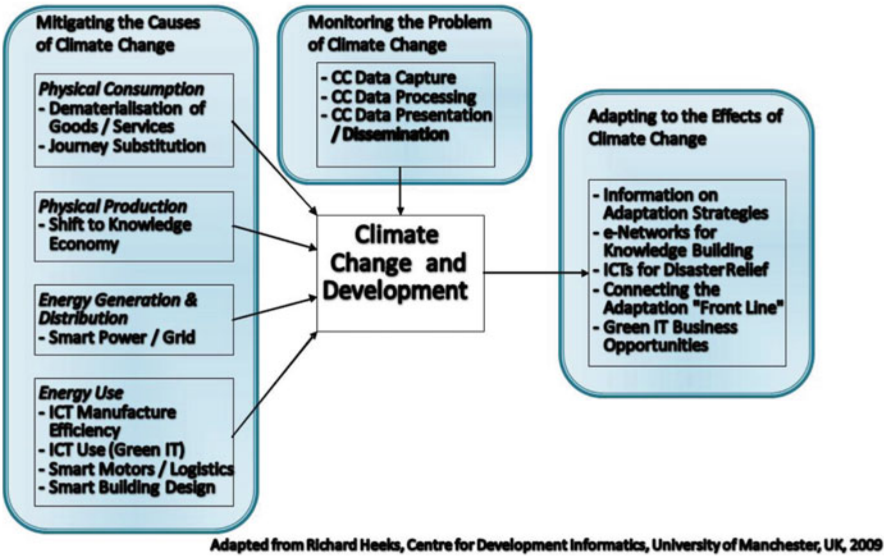

Fig. 28.3 Framework demonstrating ICT's potential applications in climate change

Monitoring climate change through ICT is another way of assessing the extent of the problem and its impacts. Several agencies and programmes in place combine atmospheric and environmental monitoring with early warning systems to manage disaster and risk associated with climate change. In collaboration with the World Meteorological Organization (WMO), the partnership for World Weather Watch incorporates telecom, data processing systems, as well remote sensing and environmental monitoring. An example is the post-tsunami's early warning system and climate forecasting models to predict future warming (ITU 2008a, b, c).

Adaptation to climate change effects focuses on capacity building to manage risks proactively for vulnerable communities. An example is the offline digitization of maps to build adaptive capacity for disaster management begun by the Hunger Project in southeast India after the tsunami. Knowledge management via online platforms on adaptive strategies such as the Asia-Pacific Regional Climate Change Adaptation Knowledge Platform (RCCAKP) are another example (UNEP 2008).

ITU Policy Areas Under the UN Climate Change Strategy

Greater coordination as part of UN response to climate change has been highlighted, particularly under a collaborative effort to deliver specific strategy areas across the UN agencies. As the first UN Secretary-General to visit ITU, Ban Ki-moon identified the ITU as an important climate change stakeholder (ITU 2007). Implicit in this stakeholder role is the focus on ICT governance and technical expertise of ITU, as the main global platform on ICT governance within the UN System, comprising 191 member states and non-governmental members.

ITU's overall objectives include:

> [promoting] the development of telecommunication networks and access telecommunication services by fostering cooperation among governments and a range of non-governmental actors that includes network operators, service providers, equipment manufacturers, scientific and technical organisations, financial organisations and development organisations (ITU 2008a, b, c).

It spearheads the World Summit on Information Society (WSIS), a global multi-stakeholder consultation and policy-making effort. More concretely, its technical recommendations are taken as guidelines for national ICT policy and private sector standards. Related activities include "standardising telecommunications technologies, services and operations, including tariffs and numbering plans; allocating radio frequency bands to different services and coordinating and registering frequency assignments and satellite orbital positions so as to avoid harmful interference; promoting the development of telecommunications infrastructure and services, regulatory institutions, and human resources in developing countries; providing information on global telecommunications trends and developments" (MacLean et al. 2007).

ITU is expected to contribute to, alongside other UN agencies covering climate change mitigation, monitoring, and adaptation, the three ICT impact areas as adapted from Heeks's framework (UN Climate Change Strategy 2008). Climate change mitigation areas cover: capacity building to implement new standards in mitigation (particularly in technology needs assessments for developing countries) and impact methodology of ICT for climate change (particularly in energy use). Climate change monitoring areas cover: observation of global climate change system to link climate data to early warming and action networks (especially in terms of policy options), as well as monitoring climate vulnerabilities and impacts in developing countries. Climate impacts adaptation covers: capacity building for mainstreaming climate change into development strategies; building an institutional framework and assisting LDCs on effective disaster risk reduction; and building on Global E-Sustainability (GeSI) efforts within the ICT sector.

Towards a Framework on ICTs and Climate Change

ITU holds the potential as a harbinger of coherence for stakeholders involved and as a catalyst across related policy fields, within a system of fragmented efforts to bridge the gap between ICTs and climate change. Within these potentials lies the foundation for a global policy framework in the field that addresses some gaps in both practice and policy.

Potential for Coherence

ITU's potential to provide coherence within this emerging field is noteworthy due to its complexity. Where a nuanced trade-off between levels of ICT impacts across cross-sectoral efforts may be needed, technical expertise may enable navigation. It is not surprising that various groups from IOs, IGOs, academia, governments, and business organizations with such expertise have positioned themselves, staking their claim, on some aspect of the debate particularly on standardization (Appendix). It is not until the past 2 years that ITU began to be involved in environment and ICT issues within the UN system itself. Previously, the issue was largely in the realm of the UNEP, under its work on sustainable production and consumption wherein ICT enabled products and processes were included.

Many voluntary players implied various policy stances, methodologies, codes of conduct, and even technical expertise in the community. Currently, overall leadership or management in terms of a comprehensive programme to address various aspects of ICT and climate change links remains to be seen. As such, actors may overlap work across various groups or those which fail to build on core competencies to contribute innovations. Within such competing and fragmented efforts, some coherence is needed. This is not to suggest that ITU position itself as a foremost policy authority to encompass all aspects of the issue. Rather it would be helpful for ITU to consider how it has the best position to enable consensus towards the more urgent areas of focus. For example, ITU already has previously collaborated in energy efficiency standardization for equipment and telecommunication networks (Appendix). It would be good to consider which areas ITU could link or provide a general map of sub-roles given its stature in the global ICT community.

Potential for Catalysis

A number of reports have been published in recent years examining the relationship among ICTs and environmental action nationally and regionally. Little attention has been paid to how policy efforts which can enable innovation may contribute to address the issue. The annual sustainability reports developed by UNEP, UNDP, and OECD barely discuss the link between ICT policy and environmental sustainability, particularly its link to climate-related issues. Historically minimal inter-agency coordination with the ITU, housing the ICT technical expertise within the UN, may be the source of such omission. The catalytic role of ITU to champion ICT-related solutions can potentially bridge this gap that exists across environmental assessment exercises and policy proposals.

Another context of ITU's catalytic potential is in the nature of the ICT solutions needed – the technological resources would need to be drawn from an innovative private sector. Despite documented solutions ICT providers can use (Heeks 2009), localized innovations across industries and the public sector on a macro-level will be valued to enable relevant emissions impact with ICT applications. For systemic level ICT impact, the supra-level actor on transboundary considerations in ICT such as the ITU can play such a role across private–public partnerships. This supports the UN Climate Change Strategy as it specifically highlights the potential of harnessing existing ITU public–private partnership platforms on environmental ICT supply chains, GeSi.

Subsumed within the catalytic role would be an integrative and balanced approach to understanding climate change and ICT potentials, primarily between the different needs across developing countries and developed countries. From Heeks's framework, ITU's centralization allows it to contribute across three levels of climate change response – from end-of-pipe mitigation towards preventive, proactive adaptation. However, most of the areas identified by the UN strategy for ITU collaboration with other agencies relate to assisting developing countries to put together strategies to climate-proof their development paths. The identified areas emphasized in the UN Climate Change Strategy document include technological assessments, climate impact monitoring and disaster risk management. The focus seemed to bulk up vulnerable countries' needs related to state commitments to undertake national communications and assessment reporting cycles under the UNFCCC. Considering that historical responsibility for emissions lies with the developed countries, it would be a more balanced direction to seek deliverables which also address the issue of developed countries' energy-dependent economies and lifestyles. Only two specific tasks were relevant across both developed and developing countries: impact methodology assessments of ICTs and related energy use, as well as the mobilizing of the existing GeSI public–private partnership. The ITU in cooperation with the UNEP set up the Global e-Sustainability Initiative (GeSI), as an environmental management supply chain initiative of ICT service providers and suppliers in the early 2000s (ITU 2008a, b, c).

ITU's Prospects on the Road

During the early days of the Kyoto Protocol in the late 1990s, very little interest in addressing the link between ICT and climate change resulted in policies that were primarily focused on macro-level state intervention via carbon credit and offset partnership schemes across states. As ITU moves to support the UN Climate Change Strategy, there is likelihood that potentials for catalysis and coherence can be acted upon. However, it is noted that prospects and gaps have arisen in ITU's ongoing programme of work internally within the organization. Opportunities in policy areas outside of its immediate next steps, external to the organization, are considered to chart the potentials under a macro-level perspective.

Micro-Level/Internal Forces

From an internal perspective, ITU has played on its strengths, but at the same time inherent weaknesses of their atypical modes of practice exist also. Concretely, the past 2 years has seen the ITU mobilize its existing platforms on ICT governance to the task of mainstreaming climate change. Currently under the WSIS system, ITU has developed a "Dynamic Coalition on Internet and Climate Change (DCICC)", an umbrella organization intended to catalyse multi-sectoral action on the issue. The DCICC was initiated at the second Internet Governance Forum (IGF) in 2007 and subsequently held its first physical meeting at the third IGF in December 2008. The coalition partners covered IGOs, NGOs, academic institutions, industry players and national ICT regulatory bodies: ITU, GeSI, OECD, Japan's Ministry of Internal Affairs and Communication (MIC), International Institute for Sustainable Development (IISD); and industry partners British Telecom (BT), Deutsche Telekom, Daisy Consortium, CAST (China Association for Science and Technology), Nepal Wireless, Tama University Japan, CSDMS (Center for Science, Development and Media Studies), Wipro Technologies, and CTO (Commonwealth Telecommunication Organization) (IGF 2008).

Internal limitations from this arrangement can be seen in terms of ITU's structure, policy environment and timeframe it faces, its scope of influence, and its potential to stimulate innovation. Structurally, the location of this coalition within the context of the IGF – with its discussions on internet access, equity, security – may dilute urgency of mobilization. This position may achieve the potential for catalysis in two ways that could indicate whether or not action will be swift: either through optimization of current multi-issue partnerships towards a separate priority track with a climate change focus in IGF, or through a mainstreaming of climate change impact considerations in the context of overriding IGF issues. The dynamism and responsiveness of the DICC therefore remains to be seen.

Although urgent action is needed as directed by UN climate strategy, the catalytic role of ITU has only begun to build up in the middle of 2008 up until the present with the working group derived from the DCICC. So far, two meetings of this sub-working group from the DCICC have taken place in Japan and UK, with the next one to happen in mid-2009 in Ecuador – however, the preliminary deliverables of the working group may limit a significant contribution when the 2009 UNFCCC Conference of Parties (COP) meet in Copenhagen to address the new policy regime needed to replace the Kyoto Protocol. In terms of DCICC's scope of influence, the exclusion of broadcast technologies and search engine companies not included in current public–private partnerships due to the converged definitions of information industries, implies that the massive computing technologies of these sectors may be left unconsidered in DICC-led ICT climate impact strategies. These two considerations may affect the potential of ITU to serve as a force for coherence within the cacophony of various voices within the UN system, across the IGOs, and in terms of the technological proposals related to climate mitigation and adaptation that are expected to be more contentious. It is expected that, given the lack of consensus from states in the previous Poznan COP, the various actors will likely be highlighting their own respective remedy to the post-Kyoto climate policy regime at the Copenhagen COP in December 2009 for agreement at the plenary.

Macro-Level/External Forces

Outside of its current programme of work, ITU has the opportunity to respond to such potential through addressing ICT policy gaps on climate change in terms of knowledge management, cleaner technology road-mapping and promotion of low carbon tech lifestyles. The first potential area is in its knowledge management role, the ITU being the logical choice as a global clearing house of best practice, highlighting potentials for catalysis and coherence. Ensuring adequate information-sharing schemes and models to enable documentation of practice is critical, so as to provide gentle guidance towards coherence across voluntary actors, than standardization. Also, ITU's current roster of robust and diverse partnerships can be catalyzed towards this innovative storehouse of practice. ITU's ad hoc publications and minimal website content provide promise for an endeavour such as this, particularly as this is an expression of focus on dematerialization in commitment to become a carbon-neutral ITU in 3 years (ITU 2008a, b, c).

The second potential policy area for ITU is the standardization of internet access technology (across both infrastructure and equipment) which plays on its existing work in the area of energy-efficiency standardization for network infrastructure and computing equipment (Appendix). However, the potential for coherence herein lies in its ability to provide what industry organizations have identified earlier: a road-map of clean internet technologies, which belies ITU's historical expertise as the standardization catalyst (Willard and Michael 2003). The proposals for DCICC to examine a life-cycle approach to technologies may isolate the production and consumption of such. In terms of real life application of ICTs, it is unlikely that people will use ICTs in phases. In fact, ICT usage is often in parallel to substitutes, especially when considering various types of internet access technologies. The use of infrastructure to support a growing industry of internet-related businesses, particularly search engines, proposes growing server needs, each of which need to be powered by energy or need energy to be cooled. In this regard, the potential for coherence stems from the integrated viewpoint that ITU may take across internet service provision and consumer access, which in turn may have catalytic effects across the specific production and life-cycle studies of the technology towards standardization.

The third potential policy area of the ITU is the promotion of lower carbon technology lifestyles, which is something that has not been undertaken by various UN agencies in a holistic manner, integrating understanding of technology use and climate impacts. Such would be the ultimate expression of the potentials for catalysis and coherence – not only from a supply side perspective, but also from a demand side perspective to viewing ICT impacts on climate change. ITU's strong technical expertise may be the necessary link between technology impact and consumer use. This may make a difference between largely technology-deterministic solutions currently on the table. Although attempts to link growing innovation in energy-efficient technology and relations to technology-user behaviour is tangentially addressed by recommendations from the DCICC 2008 panel's recommendation, there is a concern that this may be too simplistic if viewed without considering integrated effects and balance between supply and demand side prescriptions.

In general, the supply-side focused, technologically-deterministic approach of the proposals is in providing methods to be aware of and educate users about the emission potential of ICTs. Specifically, the DCICC proposals include the development of industry and consumer tools to assess the impact of ICT use on climate change; ways ICTs can reduce GHG emissions in other sectors; life-cycle analysis in relation between ICTs and climate change, and awareness-raising among consumers (IGF 2008). However, the positive impacts of digitization, dematerialization and substitution of physical goods and services may be offset with large-scale ICT use if touted as a magic bullet. Consider a policy that encourages travel substitution through video conferencing; if excessively adopted, it may not necessarily create the expected net reductions of GHG emissions due to interactive effects. Or consider a public–private partnership labelling effort to brand green consumer ICTs, which in the end may encourage excessive use of electronics by the consumer (i.e. being left running even when not in use, due to complacency about inherent energy efficiency). This leads to the concept of "rebound effects", where initial carbon emission or energy savings may in fact contribute to exponentially greater adoption of technologies, therefore not only possibly negating but exceeding the incremental emission savings (IPTS 2007).

Conclusion

The study explored the potentials of climate change mainstreaming into global ICT policy platforms at the ITU, as the main agency within the United Nations to address ICT issues. With the new directive in recent years for the organization to move towards a framework regarding ICTs and climate change, there has been groundwork particularly under the UN-wide push to strategically consolidate climate change activities across all agencies. However, the literature indicated calls for such interdisciplinary policy explorations of ICT and climate change were ongoing prior to the issuance of the directive from UN Headquarters. Various voices from the market, the business sector, and non-governmental fields had already been generating policy recommendations on what type of enabling environment could hasten the efforts and galvanize the benefits of climate-friendly ICTs.

A combination of supply and demand-side analysis of the forces internal and external to the ecosystem of the ITU provided an indication of the potentials ITU could contribute given its unique technical expertise and institutional memory. The paper identified that ITU can enable greater coherence and catalysis among stakeholders and policy areas from both demand and supply-driven perspectives. In general, ongoing efforts have capitalized on the institutional strengths of the organization, but not inasmuch as maximizing a potential role as harbinger of coherence for productive collaborations among the multi-stakeholders in ICTs and climate change. Furthermore, there is potential in the ITU to become a catalyst across policy areas, especially based on the needs of various developmental states across climate responses of mitigation, adaptation, and monitoring.

At a critical juncture of the UNFCCC COP 15 in Copenhagen 2009, the threats and challenges to such potentials are compounded by a rapidly changing ecosystem of players in state, IO, IGO, market, and civil society in the climate change arena. With each player striving for greater relevance in an increasingly overcrowded climate change forum, the monopoly of policy intervention is no longer in the hands of the few traditionally known players, nor in the hands of the well-capacitated technologists. With both foresight from the hill and a close ear to the ground, a more nimble ITU could better position a policy contribution to be more meaningful. The rosy picture touted from the supply side of ICT as a magic bullet to limit GHG emissions is not entirely true if taken in a vacuum, without a demand-sideperspective. For example, with ICTs, end users' own agency to creatively appropriate applications, the context of ICT application, scale, substitution, and rebound effects is not solely in the hands of policy regulators who must contend with these compounding effects for any climate change ICT intervention. Therefore, a more dynamic and flexible context needs to be considered by the ITU as it moves on the road towards a global policy framework on ICTs and climate change.

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Appendix: Table of Multi-sectoral Players in ICT and Climate Change Standardization Work (ITU Working Group on ICT and Climate Change)

Overview of standardization work

Area	Organization	
	International	Others
Policies	UNEP and World Bank, International Energy Agency	European Commission, OECD
Indicators and statistics	WMO	OECD
Data collection	ISO TC 211	IEEE SCC 40, European Commission JRC
Environmental management	ISO TC 207	–
Corporate reporting	ISO JTC1/SC7	Greenpeace, GHG Protocol Initiative
Energy efficiency of equipment	IEC, ISO, ITU-T	ATIS, CENELEC, Energy Star, ETSI, Energy Efficiency Inter-Operator Collaboration Group, European Commission JRC
Energy efficiency of networks	ITU-T	Ethernet Alliance, Energy Efficiency Inter-Operator Collaboration Group, FTTH Council, IEEE P802.3az, TIA, European Commission JRC
Energy efficiency of data centres	–	Efficient Servers, Green Grid, TIA, European Commission JRC
Electronic waste	–	Basel Convention (MPPI and PACE), European Commission, TTA
Equipment labelling	–	Collaborative Labelling and Appliance Standards Programme, CEN/CENELEC, Energy Star, TCO, Electronic Product Environmental Assessment Tool (EPEAT)

References

Erdmann L et al (2004) The future impact of ICTs on environmental sustainability. European Commission Joint Research Centre, Institute for Prospective Technological Studies (IPTS), Sevilla, Aug 2004. http://ftp.jrc.es/eur21384en.pdf. Accessed Mar 2009

Ericsson (2008) Telecommunication contributes to a carbon-lean economy. http://www.climateactionprogramme.org/books/2008/ca/p122-123.pdf. Accessed Mar 2009

European Information Technology Observatory (2002) The impact of ICT on sustainable development. In: EITO 2002, European Economic Interest Grouping, Frankfurt am Main, pp 250–283, http://www.digitaleu.org/uploadstore/eito_forum_2002.pdf. Accessed Mar 2009

Gartner Inc (2007) Gartner estimates ICT industry accounts for 2 percent of global CO_2 emissions. In: Gartner Symposium/ITxpo 2007 emerging trends, Stamford, Apr 2007. http://www.gartner.com/it/page.jsp?id=503867. Accessed Mar 2009

Gartner Inc. and World Wildlife Fund (2008) Gartner and WWF assess low carbon and environmental leadership among global ICT companies. In: Gartner Symposium/ITxpo 2008, Cannes, Nov 2008. http://www.gartner.com/it/page.jsp?id=792412. Accessed Mar 2009

Global Action Plan (2007) An inefficient truth. Global Action Plan, London, Dec 2007. http://www.globalactionplan.org.uk/upload/resource/Full-report.pdf. Accessed Mar 2009

Hanson A (2007) Global governance for environment and sustainable development. IISD, Winnipeg, 2007, p 20. http://www.iisd.org/pdf/2007/igsd_global_gov.pdf. Accessed Mar 2009

Heeks R (2009) ICTs climate change and development overview model. Centre for Development Informatics¸ University of Manchester, Manchester

Hilty L et al (2006) The relevance of information and communication technologies for environmental sustainability – a prospective simulation study. Environ Modell Softw 2:1618–1629

Houghton J (2008) ICT impacts presentation. Centre for Strategic Economic Studies, Victoria University, Melbourne

Institute for Prospective Technological Studies (2007) The future impact of ICTs on environmental sustainability powerpoint. In: Proceedings of OECD Conference on ICTs and Environment

International Telecommunication Union (2007) ICTs and climate change. ITU Background Report, ITU Symposia on ICTs and Climate Change. http://www.itu.int/ITU-T/worksem/climatechange/. Accessed Mar 2009

International Telecommunications Union (2008) ICT and climate change: the ITU perspective. http://www.climateactionprogramme.org/books/2008/ca/p116-121.pdf). Accessed Mar 2009

International Telecommunications Union (2008a) ITU for e-environment: guidelines for developing countries, with a focus on climate change report. http://www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf. Accessed Mar 2009

International Telecommunications Union (2008b) Leaders address climate change and cybersecurity at the high-level segment of the council 2008. ITU News, Dec 2008. http://www.itu.int/itunews/manager/display.asp?lang=en&year=2008&issue=10&ipage=09&ext=html. Accessed Mar 2009

Internet Governance Forum (2008) ICTs and an environmentally sustainable internet: another challenge of connecting the next billion internet users. In: Proceedings from the Internet governance forum workshop, Hyderabad, 5 Dec 2008

IPCC – Intergovernmental Panel on Climate Change (2007) Climate change: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf. Accessed Feb 2009

MacLean D et al (2007) Internet governance and sustainable development; Towards a common agenda. IISD, Winnipeg. http://www.iisd.org/pdf/2007/igsd_common_agenda.pdf. Accessed Mar 2009

Madden P, Weissbrod I (2008) Connected: ICT and sustainable development. Forum for the Future, London, Apr 2008. http://www.forumforthefuture.org.uk/files/Connected.pdf. Accessed Apr 2009

Mallon Karl et al (2007) Towards a high-bandwidth, low-carbon future: telecommunications-based opportunities to reduce greenhouse gas emissions. Climate Risk Pty, Australia. http://

www.climaterisk.com.au/wpcontent/uploads/2007/CR_Telstra_ClimateReport.pdf17. Accessed Feb 2009

Neves L (2008) Climate change: ICTs to the rescue? In: ITU/MIC symposium on ICTs and climate change, Kyoto, 15–16 Apr 2008. http://www.itu.int/dms_pub/itut/oth/06/0F/T060F0060080003PDFE.pdf. Accessed Mar 2009

OECD (2007a), Innovation and growth: rationale for an innovation strategy. OECD – Organisation for Economic Co-operation and Development, Paris. http://www.oecd.org/dataoecd/2/31/39374789.pdf. Accessed Mar 2009

OECD (2007b) ICTs and environmental challenges: scoping outline. OECD Directorate for Science, Technology and Industry (DTI), Committee for Information, Computer and Communications Policy (ICCP), Working Party on the Information Economy (WPIE), Paris

OECD (2008) Environmental outlook to 2030: Summary in English OECD. OECD, Paris. http://www.oecd.org/dataoecd/29/33/40200582.pdf. Accessed Mar 2009

Pamlin D (ed) (2002) Sustainability@the speed of light. WWF Sweden. http://assets.panda.org/downloads/wwf_ic_1.pdf. Accessed Mar 2009

Pamlin D, Szomolányi K (2007) Saving the climate @ the speed of light: First roadmap for reduced CO2 emissions in the EU and beyond. Report by the World Wildlife Fund and Magyar Telekom, European Telecommunications Network Operators (ETNO). http://www.etno.be/Portals/34/ETNO%20Documents/Sustainability/Climate%20Change%20Road%20Map.pdf. Accessed Mar 2009

Standage T (2009) More silicon, less carbon. In: The Economist: the world in 2009. Print edition, 19 Nov 2008. http://www.economist.com/theworldin/displayStory.cfm?story_id=12494618&d=2009. Accessed Feb 2009

Telstra Australia (2007) Towards a high-bandwidth, low-carbon future: telecommunications-based opportunities to reduce greenhouse gas emissions. http://www.telstra.com.au/abouttelstra/csr/reports.cfm#climate. Accessed Mar 2009

The Climate Group and the Global e-Sustainability Initiative (GeSI) (2008) SMART 2020: enabling the low carbon economy in the information age. GeSI, Vancouver

UN (2007) Secretary-General's appeal at the UN climate change conference, Bali, Indonesia, 15 Dec 2007 – Statement attributable to the Spokesperson for the Secretary-General at the adoption of the decision of the 13th Conference of Parties of the UNFCCC. http://www.un.org/apps/sg/sgstats.asp?nid=2914. Accessed Apr 2009

UN (2008) Acting on climate change: delivering as one. United Nations Climate Change Strategy, United Nations, New York. http://www.un.org/climatechange/pdfs/Acting%20on%20Climate%20Change.pdf. Accessed Apr 2009

UNDP (2007) Fighting climate change: human solidarity in a divided world. In: Human Development Report 2007/08. Palgrave Macmillan, Basingstoke. http://hdr.undp.org/en/media/hdr_20072008_en_complete.pdf. Accessed Mar 2009

UNEP (2007) GEO-4: environment and development. In: Global environment outlook. http://www.unep.org/geo/geo4/report/GEO4_Report_Full_en.pdf. Accessed Mar 2009

UNEP (2008) Regional climate adaptation knowledge platform for Asia. http://www.weadapt.org/initiative/8. Accessed Oct 2009

UNFCCC (2007) Mechanism of the Kyoto protocol. http://unfccc.int/kyoto_protocol/mechanisms/items/1673.php. Accessed Mar 2009

UNFCCC (2008) Report of the conference of the parties serving as the meeting of the parties to the Kyoto Protocol on its fourth session, Poznan, 1–12 Dec 2008. Part One: Proceedings. http://unfccc.int/resource/docs/2008/cmp4/eng/11.pdf. Available Mar 2009

Von Geibler J et al (2005) Governing new technologies towards sustainability: international organisations and social indicators. Paper prepared for the 2005 Berlin Conference on the Human Dimensions of Global Environmental Change – International Organisation and Global Environmental Governance, Berlin, Germany, 2–3 Dec 2005

Willard T, Michael H (2003) The information society and sustainable development: exploring the linkages. IISD, Winnipeg. http://www.iisd.org/pdf/2003/networks_sd_exploring_linkages.pdf. Accessed Mar 2009

Chapter 29
Managing the Ecological and Social Ambivalences of Bioenergy: Sustainability Criteria Versus Extended Carbon Markets

Felix Ekardt and Hartwig von Bredow

Abstract The use of bioenergy for the generation of electricity and heat, as well as for the production of biofuels, is growing at an impressive pace. While some ecological advantages of the use of biomass are well-known, critics stress the negative ecological and social impacts of intensive use of biomass. Existing legal regulations, whether on a European or national level, do not seem to solve these problems. The role sustainability criteria play in overcoming the ambivalences of global bioenergy use naturally is a limited one, as these criteria are not suited to accurately reflecting the complexity of the matter. Also, sustainability criteria may not avoid effects of shifting or indirect land-use, i.e. the production of e.g. meat or non-regulated biomass instead of regulated biomass in areas that do not match sustainability criteria. Finally, some of the most important aspects, as for example the world's nourishment problems, are not representable at all in sustainability criteria – and especially not in the current EU criteria. Instead, a radical policy shift to energy efficiency and strict greenhouse gas caps would prove a lot more effective in overcoming these ambivalences in the use of bioenergy. A far-reaching policy of energy efficiency and strict caps would reduce global energy consumption and thus lead the way to a future zero carbon economy run exclusively on renewable energies. The text analyses the ambivalences of the use of bioenergy and at the same time provides a short overview of the law of bioenergy in the EU (also including some aspects of WTO law).

Keywords Ambivalences of bioenergy (ecological/social) · Bioenergy · Biomass · Carbon markets · Emission trading · Environmental law · European law · International law · Land use · Law · Renewable energies · Sustainability criteria

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Introduction: Climate Policy, Renewable Energies, and Bioenergy

Despite manifold public and political debates on climate change, global climate gas emissions have increased by 40% since 1990. The Kyoto Protocol, however, does not even impose any obligation to reduce greenhouse gas emissions. And leaving aside the de-industrialization caused by economic collapse that hit eastern Europe in 1990, even the emissions in the OECD counties have increased by 10% since 1990. Wicke et al. (2006, p. 62 ff.) demonstrate that there are diverging numbers (on the general problems of climate policy cf. Ekardt 2009c, 2010). The actual reduction in Germany, for instance, amounts to only 7% since 1990, while the rest of the commitment to reduce greenhouse gas emissions by 21% (which is the German commitment under the Kyoto Protocol) has already been "accomplished" by the collapse of industrial production in the former GDR. Whether the 7% will be accomplished is not clear; in 2008, Germany's climate gas emissions have been on the increase again. Although German politics often refer to Germany's climate policy as being in the lead globally, and despite a large number of European and German legal instruments, the average German still emits about three times more greenhouse gases than the average Chinese – and many times more than someone from Africa (cf. Baumert et al. 2005, p. 22), At the same time, according to the IPCC, western countries will need to establish zero carbon economies, i.e. economies that basically do not emit any greenhouse gases (or compensate their emissions), by 2050. In Europe, many people speak of "80% less greenhouse gases in Europe (!) by 2050 compared to 1990". The IPCC, however, speaks of reducing greenhouse gases worldwide (!) by 46–79% by 2050, if we accept a maximum global warming of 2–2.4°C. Due to "feedback effects", the IPCC even characterizes this prognosis as possibly too conservative (IPCC 2007, p. 15, chart SPM.5). With a continuously growing world population, the necessary greenhouse gas reduction would mean CO_2 emissions of as little as 1.3–0.4 tonnes per capita worldwide (without deforestation) – compared to the current 4.6 tonnes. For the industrialized nations, this amounts to reducing greenhouse gases by about 87–96%. And the situation becomes even more dramatic considering (1) the "feedback effects" and (2) the fact that even a warming of 2–2.4°C could have dramatic consequences. Furthermore, due to research done by NASA, the IPCC has recently begun to realize that (3) climate change is happening at an even faster pace than predicted. Considering that climate policy (4) so far still clings to steady economic growth and thus to steadily increasing consumption of resources, it begins to show that the IPCC stipulates the goal of a zero emissions economy until 2050 (cf. on the NASA research Hansen 2007). Apparently, a zero carbon economy would be technically feasible and would at the same time help to lower our dependency on energy imports, to minimize the risk of armed conflicts over resources and to create new jobs and other first move advantages. Taking into account questions of global justice, one also has to consider (a) that western countries still bear per capita emissions many times higher than the per capita emissions of most southern countries and (b) that western countries' efforts may even have to go beyond just levelling out the global emissions between all countries, since western countries' historic emissions since the nineteenth century are still fuelling climate change today (Ekardt and von Hövel 2009).

Being the world's largest market, the European Union recently claimed to try to break with the interconnection of economic growth and energy consumption (European Commission 2006c, p. 11). However, the European Commission's road-map envisions only very small steps that will not yet lead the way to a zero carbon economy. One of these steps is the controversial attempt to promote the use of bioenergy in the electricity, heat, and transport sectors (cf. European Commission. 2006c; European Commission 2006a; Wissenschaftlicher Beirat Agrarpolitik 2007; KBU 2008; Schlegel et al. 2005; The German Council of Environmental Advisors CEA and Umweltfragen 2007; BUND 2006; Ekardt 2007; from the dawn of the debate (although not yet including the clear ambivalences) Bachofen et al. 1981). This contribution deals with the ambivalences of bioenergy and with legal conceptions to solve this problem.

Bioenergy and Its Environmental, Social, and Economic Ambivalences

Biomass has different meanings. It either refers to any energy carrier that derives from raw materials of animal or vegetal origin, such as animal fat, rapeseed, sugarcane, potatoes, sunflowers, and different types of wood, such as forest waste woods, including all secondary and waste products and all residues.[1] Art. 2e of the European Directive on Renewable Energies (Directive 2009/28/EC) also includes the biodegradable fraction of industrial and municipal waste. The same wording can be found in Art. 2b of the Directive 2003/30/EC. The use of organic waste is, however, not yet very common (cf. European Commission 2005). Many different techniques are used to produce bioenergy (for more on the different techniques cf. The German Council of Environmental Advisors CEA and Umweltfragen 2007, p. 5 f.; Kaltschmitt et al. 2007, p. 511 ff.). Biofuels,[2] including fuels for heating purposes, include bio-diesel und bio-ethanol (cf. Duffield et al. 2005, p. 231 f.), biogas, biomass-to-liquid-fuels (BtL), bio-butanol, and bio-hydrogen. A distinction is drawn between different generations of biofuels. First-generation biofuels (plant oil, bio-ethanol, bio-diesel) are produced from sugar, oil, and starch of energy crops. Second-generation biofuels (biogas, BtL, and bio-ethanol from lignocellulose) can

[1]Other forms of wood usage for energy production include waste from sawmills, e.g. bark, and plantation wood, including wood from short rotation plantations. The thermochemical gasification of wood from short rotation plantations is also very promising.

[2]Primary biomass products originate directly from green plants' photosynthesis, whereas secondary biomass products derive from the degradation of other organisms; cf. Reshöft 2009, § 8 ref. 7, 8. The chemical basis is carbon and cellulose; cf. Reitter and Reichert (1984), p. 5.

be produced from any sort of biomass, including waste products. Techniques for the generation of biogas include anaerobic fermentation and the less common thermo-chemical gasification (cf. Institut für Energetik und Umwelt 2007, p. 41).[3]

Considering its environmental, economic, and social impacts, the prevailing boom of bioenergy in Europe – and also worldwide – brings along both assets and drawbacks (cf. OECD 2008). Alongside wind power, biomass is the most intensively debated renewable energy source (more on wind power, among others: Hornmann 2007; Oschmann and Sösemann 2007; Ekardt 2009b). Generally speaking, the use of renewable energies proves advantageous, for instance with regard to security of energy supply: Fossil fuels will not last forever and may increasingly lead to military clashes. Also, in the ideal case, the use of biomass for energy production emits only the amount of climate gases the biomass uses to grow. Fossil fuels, on the other hand, have extracted the carbon dioxides we are about to set free in a few hundred years over the course of millions of years. Thus, biomass is superior in terms of climate policies to e.g. coal, oil, or natural gas. However, energy production from biomass is not yet very energy efficient, as second-generation crops and second-generation biofuels have not yet reached marketability. Similar to biogas from anaerobic fermentation, second-generation energy crops and biofuels make use of the whole plant (not only the seeds) and are more energy efficient that way. Due to the energy intensity of biomass production and refinement, the overall climate balance of bioenergy (and especially biofuels) is often little better then the climate balance of fossil fuels. As the production of biomass is cost-efficient especially in tropical regions, biomass – for instance, palm oil from Indonesia or Malaysia – often comes from plantations that comprise clearance of rainforests and have therefore emitted large amounts of greenhouse gases. Also, some other forms of biomass use, e.g. the collection of small pieces of wood scattered out in the forests, does not necessarily make sense from a climate protection perspective. Lastly, the production of nitrogen fertilizers used in the cultivation of biomass is very energy consuming (cf. for instance Gellings and Parmenter 2004; Haberl and Erb 2006, p. 180) and the fertilization itself, as well as the operation of bioenergy facilities, apparently sets free large amounts of nitrogen oxides. Nitrogen oxides are highly effective greenhouse gases and have their share in climate change.

In order to produce more efficiently, biomass is generally produced by means of *conventional agriculture*, thus aggravating its negative effects on the environment. This especially applies to dangerous long-term negative effects on water bodies and on the soil, such as erosion, eutrophication, overfertilization, and contamination from pesticides. Even expert groups very often ignore the fact that the quality and usability of European soil is endangered. The German government's commission on soil conservation (Kommission Bodenschutz der Bundesregierung, KBU) organized a symposium at the end of 2008. According to the symposium, these

[3] Interestingly, several surveys are based on different facts concerning e.g. the input materials (solid biomass, bio oils, biogas) for biomass plants; see the comparison in Wuppertal Institut and Rheinisch-Westfälisches Institut für Wirtschaftsforschung 2008, and Zimmer et al. 2008.

problems may occur even more often in the context of energy crops than with food crops, simply because energy crops are not meant to be eaten, potentially resulting in even less public sensitivity. In either case, increasing cultivation of energy crops intensifies the economic pressure on areas of unspoiled nature such as tropical forests and on near-to-nature management areas: a number of calculations on the availability of areas for energy crop cultivation do not take into account that the cultivation of energy crops contravenes many other political aims, e.g. nature conservation, the promotion of less efficient eco-farming[4] and the conservation of *biodiversity*. The latter was the subject matter of a world conference in 2008 (COP 9, Conference of the Parties to the Convention on Biological Diversity, Bonn, 19–30 May 2008). The cultivation of energy crops can be very harmful in this respect, as it often relies on monocultures, intensive use of pesticides and fertilizers, and the up-ploughing of grasslands.

There is one further aspect to be mentioned. Since genetic engineering may ostensibly bring about, among others, yield increase and less need for pesticides, the cultivation of energy crops may accelerate the spreading of *genetic engineering* for agriculture, despite the reluctance Europeans show in this matter (cf. European Parliament Committee on Agriculture and Rural Development 2006). In this respect, it is important to know that, contrary to the assertions of the law of genetic engineering, the co-existence of genetically engineered and conventional agriculture will not last very long: as the cultivation of genetically modified energy crops does not encounter the same reluctance, it is only a matter of time until this supposedly less hazardous form of genetic engineering will spread out and, by way of pollen flight and jumping genes, will affect 100% of the food crops as well (unless we consequently cultivate non-hybrid crops only). That is why it is time for a democratic decision based on sufficient public debate of the risks and possible consequences of biotechnology – instead of a subtle, bioenergy-fuelled establishment of green genetic engineering.

There are also a number of ambivalences in context of the *economical and social effects* of bioenergy. While biomass undisputedly is an important alternative to oil, natural gas, and coal, it will certainly not bring the same benefits to European security of energy supply as wind and solar radiation power (even considering that solar radiation power is still very expensive – we must wait and see if solar energy will be utilized in a decentralized manner or if large-scale installations in deserts and suchlike will dominate in the long run), as biomass can be produced only to a limited extent within the European Union. On the other hand, the increase in biomass use may strengthen the European agricultural sector and revitalize underdeveloped rural regions in Europe. This ambivalent balance can be continued on an international level: *on the one hand*, the global food situation might be further worsened if we start feeding the enormous energy needs of western countries by

[4]While e.g. Wuppertal Institut and Rheinisch-Westfälisches Institut für Wirtschaftsforschung 2008, passim, recognize the basic competition of different forms of land use, their paper ignores the problem of eco-farming.

importing biomass from developing countries. This might very well be the strongest single objection to bioenergy. The cultivation of energy crops for western countries will increase dramatically and eventually displace the economically less attractive cultivation of food crops for the local population. Although the main reason for the rise in global food prices can be seen in the change of alimentation patterns in China and other emerging countries, biomass growing has its share in these developments. Additionally, the rise of bioenergy in western countries concurs with southern countries' traditional forms of biomass usage. In many developing countries, especially those with insufficient grid access, biomass is traditionally used for heating and cooking etc. (often causing serious health problems due to indoor air pollution). *On the other hand*, biomass may yield economic and social development and reduce poverty in southern countries, e.g. by building up refinery industries (especially since bioenergy may be more profitable than exporting food). However, the economical advantages of bioenergy may, as usual, benefit the upper middle class, while the short-term food shortage would hurt the poorest. This does not exclude some positive counter-examples of small-scale economic development that benefits the local population.

Nevertheless, contrary to large-scale coal- or nuclear-based power generation, biomass favours a decentralized energy sector, whether in the north or the south, and thus tends to support the set-up of an *innovation-friendly market economy* shaped by a multitude of small competitors. An energy sector structured in such a way could be of utmost importance for the economies of southern countries; concerning western countries, this could also imply democratic advantages as it weakens the oligopoly in energy markets. Not to mention nuclear power's finite nature and the problems of final disposal as well as the risk of terrorist attacks and accidents. Moreover, the heat from nuclear power plants cannot easily be used, as nuclear power plants are generally not located close to residential areas. Nuclear power is not even cheap, if you take into account the large-scale subsidies for research and development and the risk of liability irregularly shifted to the public (or to the public authorities). Additionally, biomass is – as are coal, natural gas, nuclear energy, and geothermal power – base-load capable and does not depend very heavily on storage technology or on a heavily upgraded electricity grid. In this respect, biomass is preferable to other renewable energies such as wind and solar radiation power, and may very well substitute fossil energies. It is important to notice in this context that the fuels for transport and heating will become less important in the long run, as we expect a shift to electric cars and low-energy housing.

As fossil fuels show quite a few ambivalences, too, one might be tempted to demand sufficient environmental and social standards for production processes in oil, coal, and uranium, before going about criticizing bioenergy. However, this line of argumentation does not seem very convincing. First, we should rather focus on reducing fossil fuels in the short term and on *abolishing* fossil fuels altogether in the long term, e.g. by setting up efficiency standards (we will come back to these in a minute). Second, an equally controversial discussion of the production processes of coal and oil would of course be very welcome, especially in view of the fact that e.g. oil exploitation will become increasingly harmful to the environment once e.g. oil sands are exploited. We could answer along this line to the note that meat consumption in western countries is just as problematic as bioenergy, since meat production emits large amounts of methane (Hirschfeld et al. 2008, p. 16 ff.) and often goes hand in hand with rainforest clearance (cf. IPCC 2000, Chap. 3).

With regard to the ambivalences of bioenergy, it does not seem very convincing to argue that the standards for food production ought to be sufficient for bioenergy. First, existing standards are not even satisfactory relating to agricultural food production. Second, energy crop farming actually aggravates some of the problems of conventional agriculture, for instance the problem of monocropping (cf. KBU 2008, passim; Haberl and Erb 2006, p. 177 ff.). Third, energy crops appear in addition to food crops, thus increasing the total amount of problematic implications of crop farming (cf. Nonhebel 2004).

Approaches: Sustainability Criteria, Energy Efficiency in Bioenergy Usage, General Energy Efficiency, Promotion of Solar Energy, New Forms of Land Use

Let us now examine whether the existing regulations, incentives and quality standards can actually manage the ecological and social ambivalences of bioenergy. Both binding "sustainability criteria" and financial incentives for biomass that is produced and used in accordance with a given set of quality standards may help here. However, compared to a general efficiency policy, any specific bioenergy "sustainability criteria" are of limited effect. This is especially true for national or European regulations but generally applies to international regulations, too:[5]

- First, it seems very difficult to address all aspects concerning e.g. the climate balance of bioenergy and its production chain by regulatory instruments (e.g. "bioenergy has to achieve a reduction in greenhouse gas emissions of XY% compared to fossil fuels")
- Second, there is a high risk of a mere shifting of the problems addressed. How, for instance, could sustainability criteria possibly address the problem of indirect land-use? If biomass from areas once covered by rainforest is not admitted by sustainability criteria, the production of animal feed may be shifted to these areas. To put it simply: climate protection does not benefit at all, if – in favour of western meat consumption – animal feed soy is cultivated in the (former) rainforests. The same problem occurs if the "good" biomass, i.e. biomass from other than former rainforest land, is reserved for Europe, while the export of the "bad" biomass is simply shifted towards other countries, e.g. USA, India, and China. In

[5]Wissenschaftlicher Beirat Globale Umweltveränderung (2008) does not consider the following problems and does not explicitly propose a global carbon price, although the statements made in this direction often go along with our point of view.

this scenario, the European sustainability criteria would have virtually no effect on the total amount of "bad" biomass produced. Just as with the first problem, this problem occurs especially when trying to include imported biomass in the regulations in question. A global emission trading system with a global carbon price (hereinafter referred to as C-price) would avoid these difficulties (as well as those we will discuss shortly). As the C-price would curb our primary energy consumption, it would address a number of other problems that sustainability criteria or other regulatory instruments are not capable of resolving, e.g. the increasing ploughing up of grassland and the problems of security of energy supply already mentioned
- Third, it is very difficult to represent social aspects, for instance, food security, in a list of sustainability criteria, no matter if it be a list for a regulatory or an incentive instrument. We cannot measure the impact an individual bioenergy-producing region might have on the global food market. Nonetheless, there probably are statistical impacts that we should not lose sight of. A global C-price would help in this respect, at least if assumed that land use can be covered by emissions trading
- Fourth, enforcement of any bioenergy criteria will be very difficult, especially outside the EU

These difficulties show that, in theory, we need distinct rules in order to use biomass in an effective way. These could include regulations on the minimum efficiency of biomass, by taking into account the climate balance of cultivation, processing, and transport of the biomass. Also, an increase in CHP usage and a moderate usage of biofuels would make bioenergy a lot more efficient, thus reducing its negative implications whilst keeping its benefits (European Commission 2005, p. 7; The German Council of Environmental Advisors CEA and Umweltfragen 2007). But we should regulate these ambivalences by using an approach other than sustainability criteria. At any rate, any kind of regulation ought to apply worldwide in order to have an actual impact on the bioenergy-producing countries. What kind of global "non-criteria" regulation do we mean?

A more cross-cutting, global approach to climate change, resource management and security of energy supply would ideally be suited to direct bioenergy in the right direction and to set up proper limits. Needless to say, this approach does not, at first glance, seem to be easily acceptable from a pragmatic perspective (whereas this proposal would actually benefit most countries concerned), although there are some advocates of it in the sphere of IPCC (cf. Edenhofer et al. 2008; Wicke 2005; in more detail Ekardt 2009a, Chaps. 19–22; Ekardt and von Hövel 2009; Ekardt et al. 2009; the same basic intentions are shown in Kartha et al. 2007). Our idea of a cross-cutting and truly global approach is conceived as a post-Kyoto protocol and aims at the enormous and economically attractive potentials of solar energy, energy efficiency, and a general reduction of primary energy use, as well as a limited, highly efficient use of bioenergy, including energy savings by demand-side management (energy sufficiency/*Suffizienz*). Our approach consists of a steadily decreasing and rigid global (!) cap on greenhouse gas emissions in conjunction with emissions trading between all countries, based on an initial allocation of emission certificates according to the principal of worldwide equal emissions rights per capita, starting with approximately 5 tonnes of CO_2 per capita and arriving at 0.5 tonnes per capita in 2050 (cf. on the philosophical justification Ekardt 2009a, Chaps. 28–39). The emission certificates for all inhabitants of a country are initially held by the government of each participating state and are tradable between countries. Each country's government (or a regional government such as the EU Commission) then auctions the certificates among companies that market primary energy with a relevant greenhouse gas balance (such as coal, oil, gas, bioenergy, etc.). Our approach also includes some monetary compensation for developing countries and for the socially weak within the industrialized countries.

Thus, emissions trading would actually cover all greenhouse gas emissions, especially if land use is included here. Fertilization with chemical fertilizers produced from mineral oil would already be covered by the C-price for fossil fuels. In order to include land use in this model, we would need to include certain actions, e.g. the ploughing up of greenland, in the general obligation to get a correspondent carbon certificate. The carbon certificate would be based on the greenhouse gas emissions we typically expect from the specific action. In case of land use, this would include methane and nitrous oxides. By this means, emitting greenhouse gases would quickly become increasingly expensive due to the strictly decreasing emissions cap. The market-based price for an emission certificate would therefore offer the right incentives for climate-protecting conduct, since the primary energy companies (and land users) would hand down the prices for electricity, natural gas, fuels, and land use to all end consumers and companies. Contrary to hitherto existing climate policy, this model would go beyond a cursory impact on individual conduct and economic activities. Instead, this model would strongly induce conduct that would be energy efficient, produce only very little greenhouse gases, and save energy by measures of energy sufficiency. The western model of continuously increasing prosperity for the last 200 years would come to an end – mainly in the interest of climate protection and equal treatment of developing countries (and respecting the fact that the world is not physically endless and therefore does not allow unlimited growth). Without a rapidly decreasing cap on greenhouse gas emissions, energy efficiency and the promotion of renewable energies are likely to activate an "additional" use of the fossil fuels that were "saved" before (rebound effect). The additional use will occur either in the occident or in southern countries.[6]

As a result of global emissions trading, primary energy consumption would decrease substantially due to increased energy efficiency (a). Energy sufficiency (see above) would play a role here, too (b). At the same time, global emissions

[6]Despite problematic exaggerations, this is correctly noted by Sinn (2008); however, Edenhofer and Kalkuhl (2009) offer a more sophisticated view.

trading would minimize the problems of indirect land use and other effects of shifting (c) and favour solar power as the most preferable renewable energy source[7] (d), although solar power might still seem more expensive than bioenergy, at least from a short-term microeconomic perspective. All of this would at the same time help to establish a more decentralized energy sector (regarding the import dependency of the European Communities, see European Commission 2000). Admittedly, the implementation of a global emissions trading system will only succeed if global surveillance and enforcement can be guaranteed. We acknowledge that an enforcement policy similar to that of the WTO is not exactly what a number of countries would like to see. However, unlike a (truly effective) certification system (which would not find much favour in energy crop-growing countries, either), this model would indeed be a fair trade-off, respecting the interests of developing countries in an explicit and permanent manner (cf. Ekardt 2009a, Chaps. 19–22).

The decrease in primary energy consumption and the actual energy savings help to protect the climate and at the same time support the security of world sustenance and ecological land use, the latter being achieved by including land use in the emissions trading system and thus strictly limiting the cultivation of energy crops. Furthermore, only a global carbon emission cap can ensure that bioenergy actually replaces fossil energies and its greenhouse gas emissions instead of being used in addition to it. Altogether, a global emissions trading system would strengthen climate protection and security of energy by channelling bioenergy in the right direction without denying its opportunities. That way, a unique price would represent the climate balance of e.g. cars made from bioplastics, thermal insulation of buildings, CHP bioenergy, and show at what moment these measurements' climate balance is superior to the climate balance of biodiesel and bio heating oil. Moreover, this model would help to overcome the flaws of the existing international and European emissions trading system that is rather bureaucratic and has so far not been very effective. New aspects include (1) more stringent goals; (2) avoiding effects of shifting; (3) less bureaucracy, since the administration of primary energy emissions trading is easier and (4) not stipulating any exceptions and (5) no CDM, the latter's ecological advantage being quite doubtable. Of course, the EU emissions trading system, which is not very effective at all, is often seen as an indication for a general weakness of this instrument. However, this assumption is not correct. The weakness of the EU emissions trading is due to its very moderate goals and the great number of exemptions. This does not tell us anything about the instruments' general qualities (in detail on the European emissions trading, sharing important aspects of our approach: Hentrich et al. 2009; Hansjürgens 2009, p. 137 f. – while Winter 2009; Wegener 2009; Beckmann and Fisahn 2009 ignore the possibility of further developing emissions trading).

[7] To practitioners, this may appear unlikely. However, we need to take into account the following: first, the production costs for solar installations would decrease at a much higher rate once we truly reach mass production. Second, our global emissions trading concept is not about raising prices for greenhouse gas-emitting fossil fuels by 10 or 20% but about multiplying the prices. In return, energy consumption would be reduced considerably.

Needless to say, the idea of a global emissions trading system is based on the inconvenient but inevitable insight that an effective climate protection policy cannot coincide with the idea of unlimited economic growth (cf. Daly 1996; Ekardt 2009a, Chap. 1; Wuppertal-Institut 2008). Although solar radiation is inexhaustible, even an extremely rapid development of solar energy would not totally change this diagnosis, since economic growth is not based on energy alone but depends on other, undoubtedly limited resources, particularly raw materials and land as well. Of course, we acknowledge that there are a number of obstacles to the implementation of this model. However, the existing legal instruments are equally difficult to execute and have – despite many good intentions – not yet been very effective, if you compare the actual per capita emissions to the requests of the IPCC. Besides the general reluctance towards radical climate policies, the existing mix of legal instruments can hinder a radical shift, as it is well established and has created employment in legal and economic consulting, lobbying, and other sectors. This may unconsciously and latently favour objections towards a medium-term general change of climate policy, as economists or psychologists would probably acknowledge – unlike jurists who tend to dislike even the most clear-cut anthropologic statements. However, the purpose of climate law cannot be to ensure steady growing of a certain policy field, field of law or an area of life. Instead, society needs to solve the problems it is facing in an effective manner and then make sure the correspondent policy field, field of law, or area of life is downsized again.[8] Nevertheless, the idealism of many people involved in climate change policy gives reason to hope that the problems just mentioned will not be grave in the end.

A few sustainability criteria, e.g. criteria for the approval or non-approval of green genetic engineering, could still be relevant in a new global emissions trading system. Limiting the total bioenergy production by introducing a unique carbon price, however, would already address a number of environmental problems besides climate change. Even so, we will obviously still need regulatory instruments in order to pursue other goals of environmental policy, e.g. in biotope protection.

The New EC Directive on Renewable Energies and the Sustainability of Bioenergy

To what extent do existing European regulations (including sustainability criteria) actually manage the ambivalences of bioenergy? And can we optimize the existing legal framework, given the fact that the European Union currently does not intend to establish anything even close to a radical efficiency policy but rather clings to very moderate intentions? Indeed, the European Union's current intentions do not

[8]For a "classical" analysis of the impending self-perpetuation of any new organization or administrative field see Weber (1978). This aspect is not mentioned by e.g. Müller (2009).

aim at effectively setting up a carbon-free economy and do not even address e.g. agricultural subsidies and the enormous problems of the agricultural sector in general.

Let us start with the European framework for renewable energies. Besides more specific biofuel regulations that we will discuss later, the European Union initially passed a directive on renewable energies (Directive 2001/77/EC) in 2001. This directive, however, was not very focused in general and did not include any positions towards the specific problems of bioenergy. The new directive on renewable energies (Directive 2009/28/EC) sets more ambitious goals: For the sake of climate protection and energy security, the general share of renewable energies ought to increase to 20% by 2020 (cf. Art. 3 of the Directive; European Commission 2006b). However, the affordability of energy, yet another (economic) goal set by the directive, is in conflict with the goal of climate protection and resource conservation because cheap energy tends to result in an increase of energy consumption. Furthermore, the directive does not broach the issue of the social ambivalences, apart from reporting requirements of the Commission. While this is indeed disappointing, it is at the same time not very astonishing, as social ambivalences cannot really be covered by bioenergy criteria alone. However, it would be possible to come up at least with some social criteria, e.g. "biomass has to come from family farms" (whereas it is not even clear whether the advantages or disadvantages of such criteria prevail from a food policy perspective).

Apart from these goals, the directive does not lay out any concrete instruments for the promotion of renewable energies. As a consequence of this, the EU member states can choose between different instruments e.g. feed-in tariffs, and quota and certificate systems. However, the directive sets out some ecological (not social) criteria that have to be met when using bioenergy. In accordance with the directive's focus on the goals, these criteria are not meant as regulatory instruments but more as an incentive: bioenergy not matching the criteria will not count for the fulfilment of the national targets for renewable energies. This way, the directive motivates the member states to allow for "ecological" biomass only and to ensure that only this type of biomass will be rewarded any financial aid. At the same time, member states will need to direct their demand for imported biomass in the same direction, although the directive does not stipulate any explicit import ban (cf. Ekardt et al. 2010 for more detail on the conformity of bioenergy related import restrictions and import bans with WTO law). As a matter of fact, the directive is even less detailed and precise than one would expect in view of the general difficulties of bioenergy sustainability criteria. It basically stipulates only three requirements (a) compliance with general rules of proper agriculture, (b) no use of nature protection areas and areas with high biodiversity value or carbon stock, e.g. wetlands, (c) a greenhouse gas emission saving from the use of biofuels and bioliquids of at least 35% (cf. Art. 17–19 of the Directive). A lot of aspects are missing in this list of criteria. The impact of bioenergy on biodiversity, nature, ground water, and soil cannot be reduced to a few valuable areas. Genetic engineering is not even mentioned. Furthermore, an energy saving requirement of only 35% (or even a little bit more) compared to fossil fuels is a rather limited inducement to bring e.g. new energy crops and more efficient production methods on to the market. Furthermore, this criterion allows for a rather large amount of greenhouse gas emissions and therefore is not suitable to pave the way for a zero carbon economy. Also, the directive fails to address the problems of indirect land use (meat production, etc.), as the attempt to standardize the calculation of the climate balance is not very promising and will not be capable of covering all of these effects. The criteria and regulations (that are – as we have seen – of limited scope) will be applicable to imported biomass by means of international treaties and international certification. While the international applicability is indeed necessary, it does not solve any of the problems mentioned above. Additionally, it will be very difficult to enforce the criteria and regulations, especially if the private sector is to set up certification systems for the quality of biomass. Ultimately, the sustainability criteria thus far are only applicable to liquid biomass (biofuels for transport and heating).[9]

Thus, the approach the EU has taken in order to manage the ambivalences of bioenergy is unsatisfactory, even if we leave aside the more general criticism of bioenergy sustainability criteria as opposed to a global strategy for energy efficiency. During the legislative procedure leading to the directive, the European Parliament favoured sustainability criteria for all sorts of biomass and not just liquid biomass; apparently, the Commission is going to come back to this. Also, many members of Parliament favour higher energy-saving requirements compared to fossil fuels and more precise definitions and standards that whenever possible relate to multilateral environmental agreements. These ideas are part of a more general efficiency strategy and are a step in the right direction. However, instead of promoting fossil fuels for public transport, it would have been much more effective to promote the use of bioenergy in CHP. Further environmental criteria and a general efficiency policy, e.g. with more radical emissions trading, are necessary. Some members of parliaments called for a priority of food supply, respect for the property and land rights of the local population, and fair payment. It remains an unsolved problem, however, how bioenergy criteria can ever effectively deal with problems of food supply, shifting effects, and problems of survey and enforcement.

A national regulation such as the German Ordinance on the Sustainability of Electricity from Biomass (Biomassestrom-Nachhaltigkeitsverordnung/BioSt-NachV, cf. Ekardt and Hennig 2009) and the rather identical ordinance for the fuel sector (Biokraftstoff-Nachhaltigkeitsverordnung) are mostly just the implementation of European law, as the EU aims at a consistent regulation in Europe and as the new directive mostly prohibits additional sustainability criteria on national level. Accordingly, German regulations mostly just copy the criteria of the directive, as meeting these criteria is a pre-condition for achieving the German binding goals

[9]This is not meant to be understood as a general criticism of a regulation at EU level (in view of the structure of the climate problem), this level is just right in order to avoid a “race for the lowest standards”; cf. Ekardt and von Hövel 2009; for the same reasons, it is not advisable to rely on CSR solutions. Our criticism rather aims at the faulty “sustainability criteriology” and the general problems of “criteriologies”.

concerning renewable energies. (It seems unclear whether this interdiction complies with Art. 95, 176, EC Treaty. This problem will be analysed in a separate essay.) According to the Biomassestrom-Nachhaltigkeitsverordnung, the fulfilment of the criteria has to be verified by a certificate; this applies to imports as well. A new strategy paper by the German Federal Ministry for the Environment (hereinafter referred to as BMU) seems a lot more ambitious and promising. In this paper, the BMU considers a general resource policy partially in line with our approach mentioned above. BMU wants to "radically shift" agricultural aids and ban animal feed from rainforest clearance areas. We should deliberate further in this direction and emphatically demand this strategy at the EU level.

Bioenergy and the German National Electricity Feed-in System[10]

Taking Germany as an example, let us examine now whether the current law of bioenergy offers additional regulations (as far as it is allowed by EC law). Let us start with the electricity sector. According to the Renewable Energy Sources Act (EEG and Gesetz für den Vorrang Erneuerbarer Energien Erneuerbare-Energien-Gesetz of 25 Oct 2008, hereinafter referred to as EEG), grid system operators are obliged to grant grid access to any renewable energy plant and – as a sort of financing – to pay a legal minimum feed-in tariff for the electricity fed into the grid. The costs of the feed-in system are to be paid for by all consumers of electricity (§ 34 ff. EEG). Generally speaking, the EEG has proven to be a very effective instrument for the promotion of electricity from renewable energy sources. The feed-in tariffs vary depending on the kind of energy and technology used, the location and size of the power plant, and the input materials. Thus, the government can effectively direct the development of the renewable energies in the power sector. Regarding bioenergy, for instance, small installations will get a higher compensation per kilowatt hour than larger installations, thus promoting the idea of a decentralized energy sector with many competitors beneficial to security of energy supply and democratic structures. (Other reasons for higher feed-in tariffs for smaller installations include avoiding long-distance biomass transports that larger installations depend on.) Once an installation is commissioned, the feed-in tariff for the power produced in this installation generally stays the same for 20 years plus the year of commissioning, thereby offering a very high investment protection that is one of the main reasons for the effectiveness of the EEG.

Moreover, biogas plants with an electric capacity of more than 5 MW need to be operated in CHP, using the waste heat in an economically and environmentally effective way (§ 27 para. 3 No. 1 EEG). According to § 27 para. 4 No. 2 and

[10]On some of these aspects: Oschmann and Sösemann (2007); Ekardt and Richter (2007); Stephany (2006), p. 5 ff.; Ekardt and Hennig (2010).

Appendix 2 EEG, operators of biogas plants receive a special bonus if the electricity is generated from energy crops or manure (energy crop bonus). According to Appendix 2, energy crops mean plants or parts of plants which originate from agricultural, silvicultural, or horticultural operations, or during landscape management and which have not been treated or modified in any way other than for harvesting, conservation, or use in the biomass installation. § 27 para. 4 No. 3 EEG and Appendix 3 stipulate a bonus for installations operated in CHP. Further on, § 27 para. 4 No. 1 and Appendix 1 provides for a "technology bonus" for the use of innovative, especially energy-efficient, and thus, environmentally friendly and climate saving techniques. According to § 20 para. 2 No. 5 EEG, the feed-in tariffs decrease by 1% p. a. for plants commissioned from 2010 on. Thus, a plant commissioned in 2010 will still get a feed-in tariff that is stable for 20 years; however, this feed-in tariff is 1% lower than the feed-in tariff for a plant commissioned in 2009. The CHP bonus particularly helps to manage the ambivalences (climate protection and reduction of the demand for fossil fuels) and therefore is unequivocally to be welcomed, and the "technology bonus" most probably will raise the efficiency of plants. Moreover, a number of more technical regulations in Appendices 1 and 3 seem very useful. For instance, if biogas is conditioned in order to feed it into the natural gas grid, the technology bonus is only granted if this process emits very little methane (for more details on the technology bonus, see von Bredow 2009). The annual degression (even though it is little) supports energy efficiency at all levels of biomass use, too. With regard to the greenhouse gas balance and the biomass production conditions, § 27 EEG relies on the new directive on renewable energies and the BioSt-NachV. However, as we mentioned before, the regulations of the new directive, and thus the BioSt-NachV, were not designed with enough ambition and comprehension and do not pay enough attention to problems of shifting effects and enforcement.[11] If there were a demanding and broadly applicable Renewable Energies Directive, the EEG would be an important complement to this. The EEG alone, on the contrary, cannot manage the ambivalences.

Heat from Bioenergy According to the Renewable Energies Heat Act

The Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz, hereinafter referred to as EEWärmeG) aims at increasing the use of renewable energies in buildings. In contrast to the EEG and its equivalents in other European countries, the EEWärmeG of 1 Jan 2009 does not focus on electricity, but on heating, and to

[11]The German Energy Tax Act (Energiesteuergesetz) grants tax concessions to CHP. The Electricity Tax Act (Stromsteuergesetz) in some situations grants tax exemption to electricity from renewable energies.

some extent, on cooling. The EEWärmeG aims at raising the share of renewable energies in the heat sector from 6% in 2009 to 14% in 2020 – a goal, by the way, that is not very ambitious and should not prove very difficult to achieve (BUND 2008, p. 1). According to the EEWärmeG, new buildings have to adhere to a specific percentage of heat from renewable energies: 15% for solar energy, 30% for biogas and 50% for other renewable energies, e.g. solid and liquid bioenergy (§ 5 EEWärmeG). While the legal obligation to rely on heat from renewable energies is to be welcomed, this obligation unfortunately and contrary to earlier intentions only applies to new buildings, hence affecting only 20% (cf. once more BUND 2008, p. 1) of the overall potential of renewable energies in the building sector – contrary to the Renewable Energies Heat Act of the state of Baden-Württemberg (www.landtag-bw.de/WP14/Drucksachen/1000/14_1969_d.pdf). In accordance with § 3 para. 2 of the prevailing EEWärmeG, this act stipulates the obligation to retrofit certain existing buildings. As far as existing buildings are concerned, there is no legal obligation but a "market incentive programme" (Richtlinien zur Förderung von Maßnahmen zur Nutzung erneuerbarer Energien, Marktanreizprogramm, 20 Feb 2009) with an annual budget of €500 million, granting investment subsidies for e.g. solar panels, pellet heating, and heat pumps. Nevertheless, the EEWärmeG will most probably increase the demand for liquid bioenergy. Therefore, there is a need for an ambitious European directive on renewable energies or an ambitious national sustainability directive in order to manage the ambivalences of bioenergy. It is, in this context, very reasonable that the quota for solar energy is lower and can thus be more easily fulfilled than the quota for bioenergy. The difference may have other reasons as well, however, e.g. the higher investment costs and performance of a bioenergy heating system and the fact that in many cases rooftop installations will not allow for more than 15% solar heat. It is also helpful that CHP use is allowed to replace the use of bioenergy according to the EEWärmeG. Nevertheless, the EEWärmeG should force solar energy and energy efficiency even more.

German and European Legal Framework for Biofuels[12]

In this chapter we will examine if there are any mechanisms besides the European directive's criteria that help to manage the ambivalences of biofuels. In the context of biofuels, the German Biofuels Quota Act (BiokraftstoffquotenG; more about this act: Jarass 2007) made important changes to the Energy Tax Act (EnStG) as well as to the Federal Immission Control Act (BImSchG et al. 2002). The BiokraftstoffquotenG stipulates a particular quota for diesel and gasoline, as well as a much higher and steadily increasing general quota that fuel marketing companies have to

[12]Cf. Wuppertal Institut and Rheinisch-Westfälisches Institut für Wirtschaftsforschung (2008); Jarass (2007).

comply with by blending biofuels with fossil fuels or by marketing biofuels. Compliance with the quotas is subject to legal sanction (§ 37c BImSchG). According to § 37a BImSchG, the quotas exceed even the European Directive on Biofuels (Directive 2003/30/EC). Additionally, § 50 EnStG provisions tax reductions for biofuels. This tends to compensate for the higher production costs of biofuels and to accent the technically advanced biofuels (§ 50 para. 5 EnStG). However, tax reductions will no longer be granted for biofuels used for fulfilling the compulsory quota (§ 50 para. 1 pp. 4–5 EnStG). All of these mechanisms promote the least efficient form of bioenergy, i.e. the biofuels (although biomethane is comparatively efficient). In this respect, a more strident directive on renewable energies would be necessary in order to manage the ambivalences. The German government has at least recently opted not to expand the biofuel quota as originally planned (cf. Gesetz zur Änderung der Förderung von Biokraftstoffen).

Approval of Bioenergy Facilities in the German Federal Building Code and in the German Federal Immission Control Act[13]

The law applicable to the approval of bioenergy plants (cf. e.g. Klinski 2005) deserves closer consideration, although its role is very limited with regard to climate policy and social ambivalences, cultivation standards, and suchlike. According to §§ 4 and 6 BImSchG, for example, installations that are particularly liable to cause harmful effects on the environment are subject to licensing. The types of installations that are subject to licensing are listed in the Verordnung über genehmigungsbedürftige Anlagen in the version of the proclamation of 14 Mar 1997 (4. BImSchV). The licence shall only be granted if precautions are taken to prevent harmful effects on the environment, including remote effects. However, remote effects (*Vorsorgeaspekte*) are left aside with regard to numerous smaller installations not subject to licensing under the BImSchG according to §§ 22, 23 BImSchG. Hence, the limit for contaminants laid out in the TA Luft does not apply to these installations, thus giving rise to the issue of nitrogen and climate gases already mentioned in the introduction of this essay.

§ 5 BiomasseV stipulates only a few requirements in addition to those set by the BImSchG. Please note that we do not have the space to cover additional requirements set by the 1. BImSchV and 17. BImSchV, for instance for waste using installations. When using animal by-products not intended for human consumption, i.e. offal, liquid manure, etc., the operator needs a licence according to Art. 15 of the EC Regulation No 1774/2002 laying down health rules concerning animal by-products not intended for human consumption. This licence is included in the licence according to the BImSchG (§ 13 BImSchG).

[13]On this topic Ekardt and Kruschinski (2008); Mantler and Baurecht (2007); Lampe (2006); Hinsch (2007), p. 401; on wind energy plants see Ekardt and Beckmann (2007).

Introduced in 2004 by the EAG Bau and Gesetz zur Anpassung des Baugesetzbuchs an EU-Richtlinien Europarechtsanpassungsgesetz Bau of 24 June 2004, § 35 para. 1 No. 6 BauGB – the BauGB being the German land use and zoning law – favours small agricultural facilities that use biomass from the same farm. As mentioned above, the promotion of small facilities has advantages as well as disadvantages: regional improvement of security of energy supply vs. a less efficient energy production.

Biomass Cultivation and Legal Regulation Concerning Soil and Nature Conservation, Waste and Fertilizers; Subsidy Law

In terms of ecological and social ambivalences, the rules covering energy crop farming (please note that we will not cover the law of genetic engineering) are even more important (on this chapter cf. KBU 2008, Chapter 3.5, under participation of Felix Ekardt; similarly Ginzky 2008 – however, both do not fully cover the ambivalences). The relevant regulations are to be found in the rather general context of agricultural and silvicultural land use and are not specifically designed for the regulation of bioenergy. The main problem in this context is that energy crops share the problems of conventional agriculture, including large-scale subsidies, and will augment the overall land use, aggravating the existing problems of conventional, non-ecological agriculture. All of this will turn out to be particularly problematic if we do not – by means of a more rigid directive on renewable energies or a more general regime of efficiency – manage to sufficiently promote the development of highly efficient energy crops and at the same time reduce other problematic forms of land use, e.g. excessive meat production.

We will now briefly describe some aspects of the European Union's subsidy system (Ginzky 2008, p. 193; Raschke and Fisahn 2006, p. 57; Ekardt et al. 2008a, b). The first pillar of the EU's agricultural aid comprises the basic subsidization of farmers, while the second, not yet very important, pillar stipulates special subsidies for environment protection measures.[14] The second pillar is laid out in Council Regulation (EC) No 1257. Art. 88 EC Regulation No. 1782/2003 grants direct financial aid of €45/ha for the cultivation of biomass. This subsidy was originally limited to 1.5 million ha. By the end of 2006, however, the limit was raised to 2.0 million ha. In case the applications exceed this limit, Art. 89 EC Regulation No. 1782/2003 stipulates a pro-rata reduction. However, there was a controversial discussion of this energy crop bonus and apparently the EU has stopped it by now. In regard to the first pillar, energy farmers will still be eligible to the single

[14]The complex system of regulations and directives is comprised in the Council Regulation (EC) No. 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers and amending certain regulations.

farm payment according to the EC Regulation No. 1782/2003. By 2013, the single farm payment will be reshaped into an acreage payment, without any substantial changes. Additionally, there are subsidies for sugar beet growing.

According to Art. 4 EC Regulation No. 1782/2003, the subsidies we just mentioned are only granted if the farmers meet particular environmental requirements (cross compliance). On cultivated farmland, these requirements do not go beyond the statutory management requirements (Appendix III of EC Regulation No. 1782/2003). The requirements to keep set-aside land in good agricultural and environmental condition by ensuring a minimum level of maintenance (Appendix IV of EC Regulation No. 1782/2003) are noticeable. However, agricultural set-asides were paused lately due to inter alia the increase of bioenergy production EC Regulation No. 1107/2007. More importantly, the European subsidy law is not designed to prevent long-term contamination of soil and ground water due to over-fertilization, excessive use of pesticides and deterioration of biodiversity, and many more (for a general discussion on this cf. Ekardt et al. 2008a, b). The German Federal Soil Protection Act (Bundes-Bodenschutzgesetz, hereinafter referred to as BBodSchG of 17 Mar 1998), for instance, does not add anything essential to the rather moderate rules of cross compliance. The Act's and its ordinance's precautionary requirements mostly do not apply to agriculture and silviculture. The precautionary requirements for soil stipulated in § 17 paras. 1–2 BBodSchG are the only requirements for agriculture. The "Principles and recommendation for good agricultural practice" (Grundsätze und Handlungsempfehlungen zur guten fachlichen Praxis der landwirtschaftlichen Bodennutzung, published in the German Federal Gazette of 20 Apr 1999) substantiate these requirements. In practice, these requirements do not really have any effect, due to a lack of legal enforcement and of substantiation of the principles of good agricultural practice. Agriculture and forestry are privileged when it comes to avoiding soil contamination and decontaminating. Generally, other legal stipulations, which do not necessarily bear any result in this case, have priority (cf. § 17 para. 3 BBodSchG and Ekardt et al. 2008a, b, p. 169; Notter 2008; Ekardt and Seidel 2006).

National regulations, such as the German Plant Protection Act (Pflanzenschutzgesetz, PflSchG), the Regulation on the Usage of Fertilizers (Düngeverordnung, DüngeV), the Regulation on Biological Wastes (Bioabfallverordnung, BioAbfV) and the Regulation on Sewage Sludge (AbfKlärV Klärschlammverordnung of 15 Apr 1992), as well as their counterparts in other countries, are not of very much help in managing the ambivalences of bioenergy, either, as they do not provide for any regulations specific to bioenergy. Instead, some of the regulations promote the utilization of some problematic biomass waste products as raw material and fertilizer. The AbfKlärV, for instance, allows for the utilization of sewage sludge as fertilizer. While the utilization of waste products of bioenergy as fertilizers may help to achieve a good balance of nutrients, this may lead to further pollutant accumulation in soil: firstly, the amount of pollutants permitted by the BioAbfV depends on the amount of pollutants in the dry mass and on the amount of dry mass per hectare. This way, further pollutant accumulation is likely to occur, since the amount of pollutants brought out onto the fields may surpass the amount of pollutants absorbed by the plants. Secondly, the limit set by § 4 DüngeV (170 kg nitrogen per hectare per year) only applies to livestock manure only and unfortunately not to biomass waste products.

Agriculture and forestry, and thus the cultivation of energy crops, are also privileged with regard to conservation law. According to § 18 para. 2 of the Federal Nature Conservation Act (Bundesnaturschutzgesetz, hereinafter referred to as BNatSchG), agricultural and silvicultural land use is not considered as environmental intervention (*Eingriff in Natur und Landschaft*) as long as the principles of good professional practice and all legal regulations are observed. However, these principles are of limited scope. Good professional practice in agriculture is defined in § 5 para. 3 BNatSchG from a conservation perspective. (The BNatSchG names site-specific cultivation, sustainable crop rotation, and ensuring long-term usability; avoidance of any avoidable impact on habitats; preservation of the interconnectedness of habitats and landscapes; good balance of livestock breeding and crop production, as well as avoidance of harmful effects on the environment; no ploughing up of grassland in especially sensible areas; no disproportionate exploitation of resources; documentation of fertilizer and pesticide use.) However, this definition is not very concrete and is limited in scope, and it is unclear how the principles of good professional practice can be enforced. Even if public authorities had the right to enforce precautions, they would probably be reluctant to make any use of their rights. According to the prevailing opinion, third parties generally cannot enforce precautionary obligations in Germany. Certainly, the prevailing opinion is not convincing, and the question may be asked whether this opinion coincides with new tendencies in European law (cf. Ekardt and Schmidtke 2009; Ekardt and Schenderlein 2008).

The environmental liability law shows the same difficulties as the agricultural regulations in resolving the ambivalences of bioenergy. According to the German Environmental Damages Law (Umweltschadensgesetz, hereinafter referred to as USchG), which we will take as an example in the following analysis, a person causing environmental damage generally is obliged to take the necessary actions in order to limit the negative effects and to redevelop the affected areas. However, according to § 2 No. 1a and c UschG, only damage to species and natural habitats that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species, or, in case of land damage, only damage by impacts on soil functions as a result of the direct or indirect introduction of substances, preparations, organisms, or micro-organisms on, in or under land, that creates a threat to human health is included. However, the definition of environmental damage seems too narrow, as – apart from fertilization and waste management – not all agricultural and silvicultural activities are included. This aspect, as well as the fact that a threat to human health is, according to the USchG, a pre-condition for any environmental damage, and the fact that energy-cropping is not even mentioned, illustrate that the USchG so far does not have any effect on the ambivalences of bioenergy and therefore needs to be changed. Also, § 9 USchG which allows the *Länder* to grant cost release for pesticide use, could be deleted. It is important to keep in mind, however, that liability regulation is only an accompanying measure, whereas the focus of our endeavours should be on the remodelling of the subsidy system, preferably within the framework of a cross-cutting resource efficiency approach.

Global Bioenergy Regulation and WTO Law

Existing international public law is still very far from a radical climate protection and resource efficiency policy as, for instance, a comprehensive global emission trading in the sense of "one human, one emission right" would represent. Instead, existing international climate laws as well as the currently debated further developments post-2012 include only half-hearted and very consensual goals and only insufficient penalties for unwilling countries. Due to globalization, it seems as if the majority of countries are in competition for low taxes and low social and environmental standards. This competition increasingly constrains at the same time an effective climate policy and a balanced legal framework that could address the social and environmental ambivalences of bioenergy. Nevertheless, in the interest of both North and South, climate protection and the ambivalences of bioenergy have to rely on global policy solutions with global social and environmental standards in order to control the global economy and to avoid the disastrous competition for the lowest standards ("race to the bottom"). These global policies would also have to impose a more rigid climate protection and go far beyond existing and forthcoming European standards, for instance by introducing an emissions trading system according to the principle of "one human, one emission right" (which, however, would have to take into account the historic emissions of western countries). By trading emission certificates, developing countries will get the financial support necessary for climate protection and poverty reduction (cf. Ekardt and von Hövel 2009). The "second best" solution would be a global convention on bioenergy, ending the race to the bottom – a problem we encounter permanently in the context of global climate change.

If this proves unfeasible due to the current reluctance of developing countries in particular, the European Union should get in the lead by taking unilateral actions (on climate change as well as on bioenergy). In the context of a general climate policy, emissions trading would be one way to go, provided it included a more definite cap and reduction path and was based on primary energy consumption (including land use). In order to reduce the competitive advantage of biomass not being within the scope of such a new EU emissions trading scheme (in the case of implementing a new EU emissions trading scheme without implementing a new global emissions trading scheme at the same time), the EU could charge the import of such biomass, instead of opting for import bans. In fact, the EU commission has already considered the introduction of a similar charge by 2011 in view of EU emissions trading. For instance, this charge would apply to cheap "rainforest-clearing" biomass (on this general topic cf. in more detail Ekardt and Schmeichel 2009; Ekardt et al. 2010, 2008a, b). In the reversed situation, i.e. if a European company exports a specific product, this company could be exempted from a percentage of the higher costs that are due to EU climate policy. However, this reversed situation does not seem very realistic in regard to bioenergy (unlike many other products).

This kind of border adjustment is also in accordance with WTO law. This way, the EU could lead the way in climate change policy (as well as in bioenergy policy) without suffering from competitive disadvantages and thus demonstrate to e.g. China, India, or the USA that climate protection and economic prosperity are not mutually exclusive. Without the unilateral border adjustment charge last mentioned, a more ambitious European climate policy aiming at a zero carbon economy (and thus being far more radical than the current EU policy) would probably simply shift the greenhouse gas emissions to non-European countries. This is especially true as far as a general efficiency policy is concerned; regarding bioenergy, the European sustainability criteria would not have any effect at all without a border adjustment charge. The revenues from the border adjustment tax could then be turned towards developing countries according to ecological and social criteria, optimizing the “southern” management of the ambivalences. Also, let us keep in mind that these unilateral measures would press for global rules against climate change and that climate change would harm the developing countries in particular.

If the European Union does not opt for emissions trading, we would at least need a new and more strident directive on renewable energies that stipulates strident criteria for imported (and domestic) biomass, including import restrictions for biomass non-consistent with the criteria. This would conform to WTO law (cf. Ekardt et al. 2010).

Conclusions

In accordance with the results of our general analysis, the analysis of different legal regulations within the law of bioenergy has shown that selective approaches are unsuited to resolve the ambivalences of bioenergy. Instead, climate policy has to bear a comprehensive approach that addresses reduction of greenhouse gas emissions, energy efficiency, energy sufficiency and renewable energies by introducing a global carbon price and a global cap on greenhouse gas emissions. This approach would at the same time help to deal with the ambivalence of bioenergy, since it would slow down the bioenergy boom and help avoid indirect land use.

References

AbfKlärV, Klärschlammverordnung of 15 April 1992, BGBl. I p. 912, last amended by Art. 4 of the regulation of 20 Oct 2006, BGBl. I p. 2298

Bachofen R, Snozzi M, Zürrer H (1981) Biomasse – so entsteht Bioenergie. Udo Pfriemer, Munich

Baumert KA, Herzog T, Pershing J (2005) Navigating the numbers, greenhouse gas data and international climate policy. World Resources Institute (WRI), Washington

BBodSchG, Gesetz zum Schutz vor schädlichen Bodenveränderungen und zur Sanierung von Altlasten (Bundes-Bodenschutzgesetz – BBodSchG) of 17 March 1998 (BGBl. I p. 502), last amended by Art. 3 of the act of 9. Dec 2004 (BGBl. I p. 3214)

Beckmann M, Fisahn A (2009) Probleme des Handels mit Verschmutzungsrechten – eine Bewertung ordnungsrechtlicher und marktgesteuerter Instrumente in der Umweltpolitik. In: Zeitschrift für Umweltrecht 2009, p. 299 et seq

BImSchG, Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz) in the version of proclamation of 26 September 2002, BGBl. I p. 3830, last amended by article 1 of the act of 23 Oct 2007; BGBl. I p. 2470

BioAbfV, Verordnung über die Verwertung von Bioabfällen auf landwirtschaftlich, forstwirtschaftlich und gärtnerisch genutzten Böden (Bioabfallverordnung) of 21 September 1998, BGBl. I p. 2955, last amended by Art. 5 of the regulation of 20 Oct 2006, BGBl. I p. 2298

Biokraftstoff-Nachhaltigkeitsverordnung (Biokraft-NachV), Verordnung über Anforderungen an eine nachhaltige Herstellung von Biokraftstoffen, of 30 Sept 2009, BGBl. I p. 3182

BiokraftstoffquotenG, Gesetz zur Einführung einer Biokraftstoffquote durch Änderung des Bundes-Immissionsschutzgesetzes und zur Änderung energie- und stromsteuerrechtlicher Vorschriften of 18 Dec 2006, BGBl. I p. 3180

Biomassestrom-Nachhaltigkeitsverordnung (BioSt-NachV) Verordnung über Anforderungen an eine nachhaltige Herstellung von flüssiger Biomasse zur Stromerzeugung of 23 July 2009, BGBl. I p. 2174

BNatSchG, Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz) of 25 Mar 2002, BGBl. I p. 1193, last amended by Art. 2 of the act of 8 April 2007, BGBl. I p. 686

BUND (2006) Bund-Position, Energetische Nutzung zur Biomasse – Ergänzungen und Aktualisierung, May 2006. www.bund.net

BUND (2008) BUND-Analyse zum Entwurf des "Erneuerbare-Energien-Wärme-Gesetzes" of 7 Feb 2008. www.bund.net

Council Regulation (EC) No. 1257/1999 of 17 May 1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) and amending and repealing certain regulations

Daly HE (1996) Beyond growth. the economics of sustainable development. Beacon, MA, USA

Directive 2001/77/EC of the European Parliament and the Council of 27 September 2001 on the promotion of the electricity produced from renewable energy sources in the international electricity market, L-283/33

Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport, L-123/12

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, L-40/16

Duffield JA et al (2005) Assessment of Biofuels. In: Dewulf J, van Langenhove H (eds) Renewables-based technology: sustainability assessment. Wiley, New York

DüngeV, Verordnung über die Anwendung von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsstoffen nach den Grundsätzen der guten fachlichen Praxis beim Düngen of 26 Jan 1996 (Düngeverordnung – DüngeV), reformulated by proclamation of 27 Feb 2007, BGBl. I p. 221

EAG Bau, Gesetz zur Anpassung des Baugesetzbuchs an EU-Richtlinien (Europarechtsanpassungsgesetz Bau) of 24 June 2004, BGBl. I p. 1359

Edenhofer O, Kalkuhl M (2009) Das "grüne Paradoxon" – Menetekel oder Prognose? In: Beckenbach F et al (eds) Diskurs Klimapolitik. Metropolis, Marburg, pp 115–151

Edenhofer O et al (2008) A global contract on climate change. Policy paper prepared for the conference "A Global Contract Based on Climate Justice: The Need for a New Approach

Concerning International Relations" in Brussels 11 Nov 2008. http://www.pik-potsdam.de/members/edenh/publications-1/contract-08-full/at_download/file
EEG, Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz) of 25 Oct 2008 (BGBl. I p. 2074), last amended by Art. 3 of the Act of 29 July 2009 (BGBl. I p. 2542). Please note that the BMU has published various translations of the EEG. These can be downloaded from http://www.erneuerbare-energien.de/inhalt/42934/40508/. Accessed 8 Oct 2009
EEWärmeG, Gesetz zur Förderung Erneuerbarer Energien im Wärmebereich (Erneuerbare-Energien-Wärmegesetz) of 7 August 2008 (BGBl. I p. 1658), amended by Art. 3 of the Act of 15 July 2009, BGBl. I p. 1804
Ekardt F (2007) Die Ambivalenz der Bioenergie. Politische Ökologie 105(3):64 f
Ekardt F (2009a) Cool down: 50 Irrtümer über unsere Klima-Zukunft – Klimaschutz neu denken. Herder, Freiburg
Ekardt F (2009b) Introduction. In: Frenz W, Müggenborg H-J (eds) Erneuerbare-Energien-Gesetz. Erich Schmidt, Berlin
Ekardt F (2009c) Recht, Gerechtigkeit, Abwägung und Steuerung im Klimaschutz. Ein 10-Punkte-Plan für den globalen Klimaschutz. In Voss M (ed) Der Klimawandel. Sozialwissenschaftliche Perspektiven,VS Verlag, Wiesbaden (forthcoming)
Ekardt F (2010) Theorie der Nachhaltigkeit: Rechtliche, ethische und politische Zugänge. Nomos, Baden-Baden
Ekardt F, Beckmann K (2007) Der Rückbau von Windenergieanlagen als Auslegungs- und Kompetenzproblem. LKRZ 2007:452 ff
Ekardt F, Hennig B (2009) Die Biomassestrom-Nachhaltigkeitsverordnung. Chancen und Grenzen von Nachhaltigkeits-Kriterienkatalogen. Zeitschrift für Umweltrecht 2009:543 ff
Ekardt F, Kruschinski H (2008) Bioenergieanlagen: Planungsrechtliche Minimierung möglicher Nutzungskonflikte. Zeitschrift für Neues Energierecht 2008:7 ff
Ekardt F, Richter S (2007) Gezielter Anbau und Zukauf nachwachsender Rohstoffe – vergütungsfähig nach § 8 Abs. 2 EEG? Zeitschrift für Neues Energierecht 2007:291 ff
Ekardt F, Schenderlein K (2008) Gerichtlicher Kontrollumfang zwischen EU-Bürgerfreundlichkeit und nationaler Beschleunigungsgesetzgebung. Neue Zeitschrift für Verwaltungsrecht 2008:1059 ff
Ekardt F, Schmeichel A (2009) Border adjustments, WTO law, and climate protection. In: Critical Issues in Environmental Taxation 2009. Oxford University Publishers, Oxford, pp 737 ff
Ekardt F, Schmidtke PK (2009) Die Reichweite des neuen Fluglärmrechts. Zugleich zu einigen Grundproblemen von Grenzwerten. Die öffentliche Verwaltung 2009:188 ff
Ekardt F, Seidel J (2006) Düngemittelrecht, Atomrecht und Bodenschutzrecht – lückenlose Anwendungsbereiche? Natur und Recht 2006:420 ff
Ekardt F, von Hövel A (2009) Distributive justice, competitiveness, and transnational climate protection: 'one human – one emission right'. Carbon Clim Law Rev 2009:102 ff
Ekardt F, Heym A, Seidel J (2008a) Die Privilegierung der Landwirtschaft im Umweltrecht. Zeitschrift für Umweltrecht 2008:169 ff
Ekardt F, Susnjar D, Steffenhagen L (2008b) WTO und Umweltvölkerrechtsverträge: Komplementäre oder sich blockierende Wirkung? Am Beispiel von Verstößen gegen das Kyoto-Protokoll. In: Jahrbuch des Umwelt- und Technikrechts 2008. Erich Schmidt Verlag, Berlin, pp. 225 ff
Ekardt F, Exner A-K, Albrecht S (2009) Climate protection, justice, and CDM. A Review of the Copenhagen Protocol Draft. Carbon Clim Law Rev 2009:261 ff
Ekardt F, Hennig B, Steffenhagen L (2010) Nachhaltigkeitskriterien für Bioenergie und das WTO-Recht. In: Jahrbuch des Umwelt- und Technikrechts 2010. Erich Schmidt Verlag, Berlin (forthcoming)
EnStG, Energiesteuergesetz of 15 July 2006, BGBl I p. 1534, last amended by Art. 1 of the Act of 18 December 2006, BGBl. I p. 3180

European Commission (2000) Communication, Green Paper: towards a European strategy for the security of energy supply. COM(2000):769
European Commission (2005) Communication, Biomass action plan, COM(2005):628 final
European Commission (2006a) Communication, An EU Strategy for Biofuels. COM(2006):34
European Commission (2006b) Communication, Renewable energy roadmap: renewable energies in the 21st century: building a more sustainable future. COM(2006):848 final
European Commission (2006c) Communication, Green Paper, A European strategy for sustainable, competitive and secure energy. COM(2006):105
Frondel M, Peters J (2007) Biodiesel: Eine teure Klimaschutzoption. In: Zeitschrift für Umweltpolitik und Umweltrecht, p. 233 ff
Gellings CW, Parmenter KE (2004) Energy efficiency in fertilizer production and use. In: Gellings CW, Blok K (eds) Efficient use and conservation of energy: Encyclopedia of life support systems (EOLSS). Eolss, Oxford
Ginzky H (2008) Der Anbau nachwachsender Rohstoffe aus Sicht des Bodenschutzes – Gegenwärtige Rechtslage und Änderungsbedarf. In Zeitschrift für Umweltrecht 2008, p. 188 ff.
Haberl H, Erb KH (2006) Assessment of sustainable land use in producing biomass. In Dewulf J, van Langenhove H (eds) Renewables-based technology: sustainability assessment. Wiley, New York, p. 173 ff
Hansen JE (2007) Scientific reticence and sea level rise. Environ Res Lett 2:024002
Hansjürgens B (2009) Internationale Klimapolitik nach Kyoto: Bausteine und Architekturen. In: Zeitschrift für Umweltpolitik und Umweltrecht 2009, p. 123 ff
Hentrich S, Matschoss S, Michaelis P (2009) CO2-Emissionsrechte auf der ersten Handelsstufe: Ansatzpunkte, Wirkungen und Probleme. In: Zeitschrift für Umweltpolitik und Umweltrecht 2009, p. 153 ff
Hinsch A (2007) Rechtliche Probleme der Energiegewinnung aus Biomasse. In: Zeitschrift für Umweltrecht 2007, p. 401 ff
Hirschfeld J, Weiß J, Preidl M, Korbun Th (2008) Klimawirkungen der Landwirtschaft in Deutschland. In: Schriftenreihe des IÖW 186/08, Berlin
Hornmann G (2007) Windkraft – Rechtsgrundlagen und Rechtsprechung. In: Neue Zeitschrift für Verwaltungsrecht 2006, p. 969 ff
Institut für Energetik und Umwelt (IFEU) (2007) Monitoring zur Wirkung des novellierten Erneuerbare-Energien-Gesetzes (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse. http://www.ifeu.de/energie/pdf/Arbeitspapier1_%20Biomasse%20und%20Effizienz-vorschlaege.pdf. Accessed 5 Oct 2008
IPCC (2000) Special report on land use, land-use change and forestry, Chap 3. Cambridge University Press, Cambridge
IPCC (2007) Climate change 2007. Mitigation of climate change, 2007. Cambridge University Press, Cambridge
Jarass HD (2007) Die neuen Regelungen zur Biokraftstoffquote. In: Zeitschrift für Umweltrecht 2007, p. 518 ff
Kaltschmitt M, Streicher W, Wiese A (eds) (2007) Renewable energy: technology, economics and environment. Springer, Berlin
Kartha S et al (2007) The right to development in a climate constrained world, the greenhouse development rights framework. Paper of the Heinrich-Böll-Stiftung, EcoEquity, and the Stockholm Environmental Institute
KBU (Kommission Bodenschutz der Bundesregierung beim Umweltbundesamt) (2008) Bodenschutz beim Anbau nachwachsender Rohstoffe. http://www.umweltdaten.de/publikationen/fpdf-l/3472.pdf
Klinski S (2005) Überblick über die Zulassung von Anlagen zur Nutzung erneuerbarer Energien, Berlin. http://www.erneuerbare-energien.de
Mantler M (2007) Biomasseanlagen im Außenbereich. In: Baurecht 2007, p. 50 ff
Müller Th (2009) Erneuerbare Energien im Klimaschutzrecht. In: Köck W (ed) Klimaschutzrecht. Nomos Verlag, Leipzig

Nonhebel S (2004) Renewable energy and food supply: will there be enough land? In: Renewable and Sustainable Energy Reviews 2004, p. 191 ff

Notter H (2008) Terra incognita legis – Stellt § 17 Abs. 3 BBodSchG die Landwirtschaft von den Pflichten des Bodenschutzrechtes frei? In: Zeitschrift für Umweltrecht 2008, p. 184 ff

OECD (2008) Conducting Sustainability Assessments. OECD, Paris

Oschmann V, Sösemann F (2007) Erneuerbare Energien im Deutschen und Europäischen Recht – Ein Überblick. In: Zeitschrift für Umweltrecht 2007, p. 1 ff

Parliament Committee on Agriculture and Rural Development (2006) Report on the promotion of crops for non-food purposes of 24 February 2006. 2004/2259 (INI). http://www.managenergy.net/products/R1287.htm

PflSchG, Gesetz zum Schutz der Kulturpflanzen (Pflanzenschutzgesetz) in the version of the announcement of 14 May 1998, BGBl. I p. 971, p. 1527, last amended on 22 June 2006, BGBl. I p. 1342

Raschke M, Fisahn A (2006) Politik für eine umweltverträglichere Landwirtschaft. In: Zeitschrift für Umweltrecht 2006, pp. 57–63

Reitter FJ, Reichert M (1984) Verwertung von Biomasse, Müller, Karlsruhe

Reshöft J (ed) (2009) Erneuerbare-Energien-Gesetz. In: Handkommentar, 3rd edn. Nomos Verlag, Baden-Baden

Schlegel S, Kraemer RA, Schaffrin D (2005) Bodenschutz und nachwachsende Rohstoffe, Gutachten für die Kommission Bodenschutz des Umweltbundesamtes. Ecologic Institute, Berlin

Sinn H-W (2008) Das grüne Paradoxon. Plädoyer für eine illusionsfreie Klimapolitik. Econ, Berlin

Stephany R (2006) Steuerliche Behandlung von Photovoltaik- und Biogas- Anlagen bei Land- und Forstwirten. In: Agrar- und Umweltrecht 2006, p. 5 ff

The German Council of Environmental Advisors (CEA; Sachverständigenrat für Umweltfragen) (2007) Sondergutachten "Klimaschutz durch Biomasse"

USchG, Gesetz über die Vermeidung und Sanierung von Umweltschäden (Umweltschadensgesetz) of 10 May 2007, BGBl. I p. 666, last amended by Art. 7 of the act of 19 July 2007, BGBl. I p. 1462

von Bredow H (2009) Der Technologiebonus für innovative Anlagentechnik. In: Loibl H, Maslaton M, von Bredow H (eds) Biogasanlagen im EEG 2009. Erich Schmidt, Berlin, p. 71 ff

Weber M (1978) Economy and society: an outline of interpretive sociology (English edition). University of California Press, California

Wegener BW (2009) Die Novelle des EU-Emissionshandelssystems. In: Zeitschrift für Umweltrecht 2009, p. 283 ff

Wicke L (2005) Beyond Kyoto – a new global climate certificate system. Springer, Berlin

Wicke L, Spiegel P, Wicke-Thüs I (2006) Kyoto Plus: So gelingt die Klimawende. Nachhaltige Energieversorgung PLUS globale Gerechtigkeit. Der Report an die Global Marshall Plan Initiative. C.H. Beck Verlag, München

Winter G (2009) Das Klima ist keine Ware: Eine Zwischenbilanz des Emissionshandelssystems. In: Zeitschrift für Umweltrecht 2009, p. 289 ff

Wissenschaftlicher Beirat Agrarpolitik (2007) Nutzung von Biomasse zur Energiegewinnung. http://www.bmelv.de

Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (2008) Welt im Wandel – Zukunftsfähige Bioenergie und nachhaltige Landnutzung, self-published, Berlin

Wuppertal-Institut (2008), Zukunftsfähiges Deutschland in einer globalisierten Welt: Ein Anstoß zur gesellschaftlichen Debatte, Fischer Taschenbuch Verlag, Frankfurt

Wuppertal-Institut, Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI Essen) (2008), Nutzungskonkurrenzen bei Biomasse. Studie für das Bundeswirtschaftsministerium. http://www.bmwi.de

Zimmer Y, Berenz S, Döhler H et al (2008) Klima- und energiepolitische Analyse ausgewählter Bioenergie-Linien. In: Landbauforschung, Sonderheft 318

Chapter 30
Normative Principles for Adaptation to Climate Change Policy Design and Governance

Ieva Bruneniece and Maris Klavins

Abstract A systemic approach on the elaboration of adaptation policy systems was begun in 2008 by the approval of the Report on Adaptation to Climate Change by the Latvian Government and a new task was put forward – to elaborate national strategy on adaptation. Several examples of sectoral adaptation policies and measures are already being implemented in Latvia (flood risk assessment and management, risk management and insurance in agriculture, coastal zone management, etc.) and research is being conducted on climate change impacts. A systemic approach is required for decision-making to solve such a huge, global, and unstructured problem as climate change impacts and risks. This involves facilitating work of different partners and stakeholders involved in decision-making to reach a common basis for efficient action, normative principles, and appropriate criteria (sustainability, and others subordinated to it – precautionary measures, solidarity and cooperation, dematerialization, sustainable resource use, triple bottom line, diversification, "polluter pays"). This paper analyses some key aspects integral to the development of a national system of adaptation to climate change, discusses practical considerations (policies and measures) already being implemented in Latvia, and proposes a new policy design approach for more efficient elaboration and implementation of adaptation policy.

Keywords Adaptation · Climate change · Latvia · Normative principles and criteria · Policy design · Sustainability · Systemic approach · Unstructured problem

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Introduction

The paper aims to describe theoretical considerations and practical approaches used in the preparation of Latvian adaptation to climate change policy. The cornerstones of the theoretical framework for policy design encompass a systemic approach in solving complex, unstructured problems and the design of appropriate normative criteria based on principles of sustainable development. An enhanced scheme for the policy development cycle is offered for the practical implementation of the proposed theoretical approach with particular emphasis on decision-making criteria in all stages of the cycle.

The first part of the paper describes the overall context and the adaptation to climate change policy development process in Latvia, pointing out the necessity of defining normative criteria for setting up a structured approach for policy design and governance.

The second part offers a methodological approach to be used for practical policy design, i.e. preparing Latvian national strategy for adaptation to climate change. Recent advances in overall development policy with a focus on climate change are listed in brief. Main principles declared fundamental in high level policy documents are also highlighted. Principles of sustainable development are further used to set up a framework for analysis of major issues raised by climate change in Latvia. Theoretical frameworks and analytical approaches, policy instruments, and normative criteria applicable for decision-making are proposed for each particular issue.

The third part includes detailed description of socio-economic consequences of climate change in Latvia, and characterizes the capacity of Latvian administrative and research institutions to provide reliable data for policy development.

The fourth part summarizes principles in the system of analytical approaches and decision-making criteria to be used in the policy cycle. Risk minimization and "polluter (user) pays" principles are chosen to be the most fundamental. Further information available on risks caused by climate change is provided, as well as costs and benefits arising from climate change impacts and policy response alternatives are considered.

In the final part, practical recommendations for the further development of adaptation to climate change policy are given.

Argumentation for Normative Principles and Criteria

As indicated in the United Nations (UN) Framework Convention on Climate Change (UNFCCC 1992),[1] Parties should take precautionary measures (according to sustainable development principles) to anticipate, prevent, or minimize the

[1]Adopted at the national level as "Law on the Framework Convention on Climate Change of the United Nations Organisation", by the national parliament of Latvia, Saeima, on 23 Feb 1995.

causes of climate change and mitigate its adverse effects. The Convention also specifies that the Parties should co-operate in preparing for adaptation to the impacts of climate change, develop appropriate and integrated plans for coastal zone management, water resources, and agricultural land, and for the protection and rehabilitation of areas affected by drought and floods. Establishment of funding, insurance, and transfer of technology are among the issues to be considered.

Similarly, impact assessment, formulated and determined nationally with a view to minimizing the potential adverse effects of adaptation projects on the economy, on public health, and on the quality of the environment, should be implemented to a feasible extent. At the same time, promotion of new innovative measures and development of technologies (including policy- and decision-making technologies), together with the adaptation measures already approved, are prescribed in the UN Decision 1/CP.10 regarding the Buenos Aires programme of work on adaptation and response processes (UNFCCC 2005).

Furthermore, as was stressed in the 2006 Nairobi UNFCCC conference, climate change is an issue directly related to the United Nations' Millennium Development Goals: starting from eradication of extreme poverty and hunger, ensuring environmental sustainability to the development of global partnerships for development (UNFCCC 2000). As said by the United Nation's Secretary-General: "We will have time to reach the Millennium Development Goals – worldwide and in most, or even all, individual countries – but only if we break with business-as-usual". The chair of the International Panel on Climate Change (IPCC), Rajendra K. Pachauri,[2] said on 25 March last year during a visit to the European Parliament: "We need policies to promote the development of new technologies or the employment of the existing ones. We [the IPCC] have clearly stated in our report that the technologies needed are already available or on the verge of being commercialized. These technologies will only be used if we have the right set of policies".[3]

But breaking with business-as-usual refers to the necessity for a radical new attitude (approach) to designing policy for such complicated and usually unstructured problems like climate change mitigation or adaptation to it; this new attitude requires a much more systemic approach if we want to find common points, borders, or parts – to take correct and, what is even more important, effective action.

One of the key conclusions from the EU project "Adaptation and Mitigation Strategies: Supporting European Climate Policy" (ADAM) stated: "Global climate policy beyond 2012 requires a strong, integrated governance architecture that involves both public and private actors and that provides a regulatory framework on both mitigation and adaptation. Highly fragmented global climate governance is likely to be more costly, less effective in terms of environmental goals, and less

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[2]Dr. Rajendra K. Pachauri (born 1940) has been elected as Chairman of IPCC (Intergovernmental Panel on Climate Change) from 20 Apr 2002 onwards. He has been active in several international forums dealing with the subject of climate change and its policy dimensions.

[3]*Source*: http://www.europarl.europa.eu/news/public/story_page/064-24711-084-03-13-911-20080319STO24704-2008-24-03-2008/default_en.htm.

equitable regarding smaller countries, particularly in the global South" (Hulme et al. 2009). A conclusion on fragmented adaptation governance is also recognized in the European Union's White Paper on Adaptation: "Adaptation is already taking place but in a piecemeal manner" (Commission 2009, 2).

To ensure successful and systemic adaptation policy design, it is crucial to remember that the climate change issue is a part of sustainable development and, as already concluded in the report of the Bellagio project (International Institute for Sustainable Development 1997), regarding sustainable development practice, the entire process is normative. The same approach is required to solve such huge and problems like climate change risks and adaptation to them, and for that purpose all relevant principles and criteria in a full policy cycle need to be assessed.

The national/state level (as a basic area for adaptation policy design and governance) is where overall political responsibility is located in all the stages involved in elaborating new policy during a complete policy cycle. At the state level, government sets policy-planning documents, formulates national positions on European Union (EU) legislative acts in its drafting stage, fosters national legislation and regulations, many of which directly or indirectly affect climate change risks the country and sectors are facing, or creates the incentives (or disincentives) for exploring climate change adaptation opportunities and advantages. This is also the main level for the coordination process of sectoral policies and branches, including many cross-cutting responsibilities and functions (e.g. risk assessment and management, the "polluter (user) pays" principle, the security dimension, integrated assessment, welfare, etc.), as well as providing the overall policy guiding framework within which lower levels (sectoral, municipal, communities) operate. The state also manages international (bilateral, multilateral) relations with other countries, climate change cross-border aspects, and international financing and co-operational mechanisms, participating in multilateral environmental agreements such as the United Nations Framework Convention on Climate Change (UNFCCC), and its Kyoto protocol, where political consensus could be reached only through successful policy dialogues and trade-offs between policy options.

The strong argument for talking about normative principles and criteria is the evidence of risks and losses from climate-related natural hazards increasing year by year (US$100 billion per annum in the last decade alone[4]). Thereby, climate change-related risk insurance is one of the policy instruments, being a strong complementary aspect of a wider adaptation framework that can, and should, provide financial security against natural disasters, such as floods, droughts, heat waves, forest fires and fires in peat bogs, windstorms, intense cold, snowstorms, etc.

On the global level, the Bali Action Plan, adopted by the UNFCCC Parties in Bali, Indonesia, December 2007, in this context calls for the "consideration of risk sharing and transfer mechanisms, such as insurance" to address loss and damage. To that end, talking about the post-2012 adaptation regime, the potential role of risk-pooling and risk-transfer systems must be firmly established (Bali Action Plan 2007).

[4]*Source*: Munich Climate Insurance Initiative.

The second extremely important policy planning document in the global context is the Hyogo Framework for Action 2005–2015[5] – "Building the Resilience of Nations and Communities to Disasters" – considers, inter alia, the integration of risk considerations into sustainable development and the development of institutions, mechanisms, and capacities at all levels to systematically build resilience to hazards. The Hyogo Framework specifically identifies the need to "promote the integration of risk reduction associated with existing climate variability and future climate change into strategies for the reduction of disaster risk and adaptation to climate change". The implementation of the Hyogo Framework therefore provides a powerful tool to support adaptation, through building resilience and reducing vulnerability to climate-related hazards. The Hyogo Framework sets out strategies for reducing disaster risks through the five priorities for action we need (1) ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation, (2) identify, assess, and monitor disaster risks and enhance early warning, (3) use knowledge, innovation, and education to build a culture of safety and resilience at all levels, (4) reduce the underlying risk factors, and (5) strengthen disaster preparedness for effective response[6] (UN 2005).

The best practices at the international level (Mills 2007) in the field of climate change risk are the Arkwright Mutual Insurance Company, examining climate change and trends in flooding (Zeng and Kelly 1997), the Insurance Australia Group[7] together with the University of Oklahoma working on high-resolution climate modelling, and Willis (a leading broker) collaborating with researchers in the UK and Japan on next-generation climate modelling, with greater resolution to enable the evaluation of changing typhoon risks and associated insurance implications (McLeod 2007). Swiss Re (2006) and the Association of British Insurers (Association of British Insurers 2005) have also coupled climate models with insurance loss models. Swiss Re projected an average increase in losses of 16–68% from European winter storms (and significantly higher for some individual countries) between 1975 and 2085, excluding the associated effects of storm surge

[5]Agreed at the World Conference on Disaster Reduction in Jan 2005 in Kobe, Japan, by 168 governments and endorsed by the United Nations General Assembly, the Hyogo Framework for Action 2005–2015: Building the resilience of nations and communities to disasters, provides the foundation for the global implementation of disaster risk reduction. See: http://www.unisdr.org/eng/hfa/hfa.htm.

[6]Disaster Risk Reduction Strategies and Risk management Practices: Critical Elements for Adaptation to Climate change. Submission to the UNFCCC Ad Hoc Working Group on Long-Term Cooperative Action by the Informal Task Force on Climate Change of the Inter-Agency Standing Committee 1 and The International Strategy for Disaster Reduction. 11 Nov 2008. This paper has been prepared as a submission to the UNFCCC Parties on the risk-related matters identified in the Bali Action Plan (1/CP.13, paragraph 1. (c)). The paper provides further background with respect to the submission to the AWG-LCA on 29 September 2008 from the International Strategy for Disaster Reduction (ISDR) titled "Proposals for the AWG-LCA Chair's Assembly Document on Enhanced Action on Adaptation", and it includes specific information from the humanitarian perspective.

[7]http://www.iag.com.au/.

and flooding and socio-economic factors (inflation, insurance penetration, settlement patterns) that would further compound losses (Swiss Re 2006). Munich Re, which has the leading role in insurance of natural catastrophes and is the world's largest re-insurer, is incorporating the physical effects of climate change into hurricane models (wind and storm surge), and associated economic effects such as the surge in demand (and prices) for construction materials following the events (Hoeppe ND). With support from AIG and Lloyds of London, Harvard University and the Insurance Information Institute are collaborating to better integrate climate change factors into insurance loss models.

As far as the adaptation issue in the EU Green Paper on Adaptation is concerned – when the first political notice regarding the necessity of adaptation to climate change was put on the EU policy agenda on 29 June 2007, Latvia realized separate sectoral adaptation policies (e.g. flood risk prevention with technical solutions, risk management and insurance in agriculture, rural development, coastal zone management, etc.) as well as research on narrow or specific themes of climate change impacts, vulnerability, and adaptation possibilities. A coordinated process on the elaboration of adaptation policy in a systemic manner started in 2008 upon acceptance of the Report on Adaptation to Climate Change by the Latvian government.

This Report deals with climate change impacts and vulnerabilities in different sectors, gives an overview of relevant research work at international and national level, and the most important policy initiatives, both global and at EU level, related to adaptation. The main finding was identification of the set of risks caused by climate change. The Report also describes the situation in Latvia until the beginning of 2008, presenting what has already been done concerning adaptation, and outlines recommendations for future adaptation policies and measures to be taken. It also identifies the need to prepare a national strategy on adaptation with scenarios on development, to be done within 1 year after the delivery of the White Paper on Adaptation by European Commission, i.e. up to 1 Apr 2010 (Ministry of the Environment of the Republic of Latvia 2008).

Methodological Approach for Design of Adaptation to Climate Change Policy

Unfortunately, sometimes it seems that we are forgetting the concept of dematerialization, which is fundamental for sustainable development, and means the decoupling of economic or welfare development and consumption of natural resources and waste (also GHG emissions) production. It can be resolved only by qualitative progress or development and clarification of how weak or strong our development is according to sustainability (sometimes recognizable as eco-efficiency) principles and criteria.

Such sustainable development principles as (1) solidarity and cooperation (intra-generational equity, inter-generational equity, international equity), (2) dematerialization, (3) precaution, (4) sustainable resource use, (5) "polluter (user) pays" or full-cost recovery, (6) triple bottom line (for societal or human plus social capital,[8] nature capital, man-made or economic capital), and (7) diversity (diversification) should be taken as a basis for adaptation to climate change policy design and implementation with clear conclusions from certain scientific studies, appropriate legislative acts, policy planning documents, public awareness campaigns, technologies, etc.

The essence of these principles has been postulated in the Delhi Ministerial Declaration on Climate Change and Sustainable Development: climate change could endanger future wellbeing, ecosystems and economic progress in all regions; in order to respond to the challenges faced now and in the future, climate change and its adverse effects should be addressed while meeting the requirements of sustainable development. Parties have a right to and should promote sustainable development (UNFCCC 2002).

The European Union declared sustainable development as the fundamental objective (see EU Sustainable Development Strategy or SDS). The EU's integrated climate and energy policy, an integrated approach to the sustainable management of natural resources, the protection of biodiversity and ecosystem services, and sustainable production and consumption are listed among the drivers for achieving objectives under both this strategy and the Lisbon strategy (Presidency 2007).

In Latvia, a reasonably used and preserved natural environment is listed as one of the preconditions for safe and stable development in the "National Development Plan 2007–2013" (Ministry of Regional Development and Local Government of the Republic of Latvia 2006); however, one of the tasks is the promotion of the assessment, reduction and monitoring of natural – including climate change – and industrial risks. Political objectives for reducing the adverse effects of global climate change have been already specified in the "National Environmental Policy Plan 2004–2008" (Ministry of the Environment of the Republic of Latvia 2004). At present, work on the development of "Environmental Policy Guidelines", in which the necessity for the policy of adaptation to climate changes is included in a separate section, devoted to climate change, is finalized by the Ministry of the Environment.

Preparation for the national strategy for adaptation to climate change is in line with strategic goals set in the long-term development strategy for Latvia, "Sustainable Development Strategy Latvia – 2030", which at the moment is in drafting stage. Experts from the Ministry of the Environment were involved in the preparation of parts of the strategy devoted to natural capital. Concerning environmental issues, this strategy proposes several goals for Latvia (1) to become a leading country in the EU in the preservation, enlarging and sustainable use of natural capital; (2) to retain its

[8]For principles used to introduce notions of three, four, or five capitals see Part II of "A framework for sustainable capitalism" in Porritt (2007), pp 137–212).

leading position in EU regarding the utilization of renewable energy resources and fully evolve the potential of "green economics", and (3) to make the living and natural environment attractive for people, to promote development in the entire country, as well as to strengthen development of the country and the entire Baltic Sea region. The Strategy proposes several directions for priority actions. First, management of natural capital, which should include (1) natural capital approach, (2) the Green Budget Reform, (3) nature preservation plan, and (4) the establishment of a nature restoration fund. Second, development of market-based instruments through (1) assessment of value of nature capital for land, (2) introduction of auctions for ecosystem services, (3) introduction of fees on natural capital, and (4) introduction of the programme of "eco-gifts". Third, capitalization of nature's activities, which means (1) establishment of the Investment Fund for Green Economy, (2) creation of networks for knowledge transfer, (3) establishment of the "green innovation programme", and (4) development of the programme for "digitalization of nature". Fourth, activities to support sustainable lifestyles with (1) environmental education programmes, promoting change, (2) introduction of "ecological footprint accounts", and (3) creation of the database for national heritage. Fifth, through wide use of renewable energy resources and innovation, e.g. promotion of the use of wind and solar energy, measures to promote energy-efficiency, diversification of rural economy, and maintenance and promotion of the spatial identity.

The principle of sustainability, which requires "a qualitative environment, balanced economic development, rational utilization of natural, human and material resources, development and preservation of the natural and cultural heritage for the present and next generations", as well as the task "to create pre-conditions for ensuring environmental quality and rational utilization of the territory, and the prevention of industrial and environmental risks", as specified in the "Spatial Planning Law" (2002), among other basic principles of sustainable development (Ministry of the Environment of the Republic of Latvia 2008).

With respect to practical policy design, the authors wish to clarify the definition and essence of adaptation or what is the subject of policy design. Although numerous definitions and explanatory articles on adaptation to climate change *anatomy* exist in policy design literature (UNFCCC 1992; Smit et al. 2000, etc.), the authors agree with the point of view that we have to talk about the adaptation issue, which is a problem for us, people, society, mankind, and therefore we, as human beings, are responsible for solving it to ensure wellbeing for ourselves and also to maintain balance on planet Earth overall. Nature has no problems, therefore we have to address adaptation to climate change from the social dimension, important policy options, or a response strategy concerning climate change (Frankhauser 1996; Smith 1996).

For this reason, the authors see adaptation to climate change as an issue which requires a logical set of policies and measures or PAMs, designed in a systemic way and by taking into consideration normative principles and appropriate criteria in all stages of the policy cycle, and making decisions. At the same time, this well-structured process is expected to be coordinated by state government, which would allow for proper cost-effective and responsible management of developments in society, consumption of natural resources, and use of technology at all levels (state, regional, municipality, enterprise, individual) in order to prevent natural disasters and threats, or to use all opportunities and advantages climate change is providing. In case of threat or real damage caused by climate change, the appropriate technical, financial, or other assistance to the population, particular species, or ecosystems should be given, thereby promoting the system's (society's, community's, dwelling's) preservation or minimizing unacceptable consequences or, again, to take advantage of climate change impacts.

Unfortunately, to date too many policy evaluations at basic political strategic levels (globally, nationally) have been applied in an ad hoc and unsystematic way due to (1) uncertain knowledge, (2) disagreement about normative elements (e.g. values, norms, or objectives), and (3) disagreement about cognitive elements (e.g. research or information) (Hisschemöller and Hoppe 2001). We can see it in international negotiations, trying to prepare new political agreements (e.g. on financial architecture on adaptation to climate change, new market-based policy instruments, intellectual property in technology transfer, etc.) in the post-Kyoto period. Thus, it is an obvious necessity to design adaptation to climate change policy and to ensure solutions according to the full policy cycle (assessing ex ante and ex post phases in it), and every decision made, descending from one policy cycle stage to another, should be based on taking a note of a spectrum of normative principles and appropriate criteria.

There are three components we should take into account for every decision we are talking about (1) criteria – the standards by which decision-makers evaluate alternatives (sometimes referred to as "interests", after Fisher and William 1983); (2) alternatives – specific courses of action or options, being considered as positions, and (3) cause and effect beliefs – cognitions linking specific alternatives to specific criteria (Decision-making models, 2007). Criteria for choosing policy instruments in the certain policy development cycle stage can be (1) causal – as answers to the basic question, for example, does the policy instrument address the underlying economic failure or not; (2) efficiency, e.g. economic efficiency criteria includes costs and benefits, public opinion, etc.; (3) equity; (4) macro-economic; and (5) legal – this criterion concentrates on the issue of subsidiarity, i.e. where policy is located most effectively (there are three main criteria upon which level of subsidiarity can be assessed: gains from cooperation, gains from harmonization, gains from sustainability). Having a clear vision on the policy cycle, the main actors, principles, transparent criteria etc. should help resolve the aforementioned difficulties dealing with this complex, unstructured problem.

Consequences of Climate Change Impacts in Latvia and Data Providers

Latvia's territory is 64,589 km^2, it has 2.3 million inhabitants, and a flat surface topography – 57% of Latvia's territory is below 100 m above sea level. The climate is mainly humid (mean precipitation ranges from 600 to 850 mm per year) and comparatively cold – mean annual air temperature in Latvia is +5.8°C (in 2008 +7.6°C!). Latvia is rich in waters and forest – mean density of the river network is 588 m per km^2, but forests cover ~54% of territory (Klavins et al. 2007).

Coastal zones are sensitive to erosion – approximately 67% from the coastal line of Latvia (496 km long) is exposed to washing away during storms. During the last 70 years, Latvia has lost one thousand hectares in storms, where a 50–200 m wide area of the basic coast has been washed away (Eberhards and Lapinskis 2008).

Over the last century, the average air temperature has increased by 0.5°C in Latvia on the whole, and by 1°C in the capital, Riga. The process of global warming and related changes in atmospheric circulation have led to higher air temperatures and greater cloudiness, which have led to lower sunshine durability and greater precipitation (higher values are observed in the western part of Latvia). It is found that the variability of annual mean temperatures of the Baltic Sea region is about five times larger than the variability of global mean temperatures.

The Climate Change Vulnerability Index for Latvia is determined at 26.0–30.0 in an average score between 0 and 100. As defined in the Stern Review, "vulnerability to climate change can be classified as *exposure* to changes in the climate, *sensitivity* – the degree to which a system is affected by or responsive to climate stimuli, and *adaptive capacity* – the ability to prepare for, respond to and tackle the effects of climate change" (Stern 2007). This index reflects exposure more than vulnerability.[9]

Eastern Europe is highly vulnerable to flood risks. In many of the newer EU member states (Poland, Romania, Bulgaria, Slovakia, Lithuania), annualized flood risk has exceeded one per cent of GDP. In some events, national authorities have had severe fiscal problems in financing the recovery process (Hulme et al. 2009). Latvia is among those flood-prone countries, and it is as risky, regarding the great fiscal deficit and possibilities for realization of efficient adaptation policy actions.

In the last 20 years, the water discharge of rivers in central and eastern Latvia has increased by ~4% and in the western part of the country by ~6%. The ice-cover period has been decreasing – the reduction of the ice-cover period for the last 30 years is 2.8 down to 5.1 days every 10 years. The change in the river breakup towards earlier dates can explain the increase of winter runoff of rivers in Latvia (Klavins et al. 2007).

Spring and summer phases in Latvia have occurred on average 4 days earlier over the past 50 years; the most recent changes were observed for early spring phases (the most significant shift has happened in the last 15 years). The flowering phase has advanced by 1.6 days per decade for the bird cherry (*Padus racemosa*) and 0.9 days per decade for the linden (*Tilia cordata*). The autumn phases in Latvia are starting earlier by 2.8 days per decade in contrast to Europe, where autumn

[9]Choice of individual indicators included in the CC vulnerability index is determined by: (a) change in population affected by river floods, (b) population in areas below 5 m, (c) potential drought hazard, and (d) vulnerability of fisheries, agriculture and tourism to changes in temperature and precipitation. We have to note, for example, that economic benefits of climate change, ecological effects, or effects on health are not included in this indicator.

phases start later. The length of the growing season, determined by the vegetation of birch and maple species, has increased by 9.8 days (3.3 days per decade) for the birch (*Betula pendula*) and 18.5 days (6.2 days per decade) for the maple (*Acer platanoides*) (Grisule and Briede 2007).

The scale of the economic losses of climate change is well characterized by compensations for the damages caused by agro-climatic conditions in agriculture, which were 630,080 lats in 2000; compensations for damages caused by natural phenomena and accidents (in storm, flood, fire) to persons engaged in fishing in coastal and internal waters or fish farming were 19,101.24 lats in 2001; the total compensation for the damages caused by agro-climatic conditions was 221,908 lats in 2004, and 440,641.94 lats in 2005 (including compensation for animals which died from gnat bites – 131,091.50 lats, for covering of material losses caused by floods –309,550.44 lats).[10]

Due to unfavourable agro-climatic conditions in 2006, more substantial losses were inflicted to agricultural producers. In order to ensure the disbursement of compensations for the losses caused by drought in agriculture and forestry, the Cabinet granted additional financing of 25.8 million lats to the subsidy programme on the basis of the information notice "Emergency Situation in Agriculture", approved on 19 Sept 2006. The following support costs in relation to the losses caused by the drought were made in 2006 (1) financing of 18.81 million lats was disbursed in the field of crop farming, (2) 5.76 million lats in the field of agriculture, and (3) 0.48 million lats in forestry.[11]

Excessive drought and strong winds strongly increase the possibility of forest combustibility or the outbreak of fire, for example, the largest number of forest fires in the state – 1,929 (the total calculated loss from forest fires was 1.96 million lats) – was registered in 2006, one of the most critical years in protection against forest fire. Artificially restored forest plantations suffer due to extreme natural conditions – fire destroyed 564 ha of young forest stands in 2006[12]; the spring drought and summer heat of 2006 were the main reasons for the replanting of approximately 25% of plantations planted in that year.[13]

The storm of Jan 2005 affected not only Latvia but also all of northern Europe and caused great damage. According to the EU criteria defined in Council Regulation (EC) No. 2012/2002 of 11 Nov 2002 establishing the European Union Solidarity Fund[14] or ESF, the total losses inflicted to Latvia were assessed to be approximately €192 million (the ESF granted €9.487 million), to Estonia €48 million (the ESF granted €1.29 million), to Lithuania approximately €15 million (the ESF granted

[10]*Source*: Rural Support Service.

[11]Publication of the Ministry of Agriculture of the Republic of Latvia (2007a, b) "Agriculture and Fields of Latvia" (in Latvian).

[12]*Source*: State Forestry Service.

[13]*Source*: JSC "Latvia's State Forests".

[14]OJ C 283, 20.11.2002.

€0.379 million). Particularly large damage was inflicted in Sweden – their evaluation amounted to almost €2.3 billion (the ESF granted €81.725 million).

In the informative report “Damage Inflicted by the Storm According to the Public, Local Government and Private Sectors on 8–9 Jan 2005”, developed by the Ministry of Finance and approved by the Cabinet of Ministers of Latvia, in 2005 total losses amounted to 154.2 million lats (Ministry of Finance of the Republic of Latvia 2005). The total damage inflicted by the storm, including the damage to the public sector, was indicated in this report. The costs for the liquidation of the consequences of the storm were itemized, and the resources for immediate restoration of infrastructure and facilities for energy, water supply and sewerage, telecommunication, transport, health care, and education were indicated. The financing necessary for the provision of shelter to residents who had suffered, provision of activities for the responsible rescue services, immediate restoration of the protective infrastructure, immediate rescue of cultural heritage, and immediate clean-up of the territories polluted by the natural disaster were clarified as well.

On 11 Apr 2007, the Cabinet adopted the “Information Notice on Granting Resources from the State Budget to Local Governments for Liquidation of Consequences of the Storm of 14 and 15 Jan 2007 at Schools and Kindergartens, as well as Local Government Objects, which are Necessary for Provision of Execution of Significant Functions of Municipalities”, developed by the Ministry of Regional Development and Local Government. It is mentioned therein that documents which confirmed the damage that occurred to local governments in 69 objects of infrastructure for the total amount of 836,330 lats (315,316 lats was granted), were received from municipalities until 16 Mar 2007 (Ministry of Regional Development and Local Government 2007).

In order to reduce scientific uncertainties regarding the effects of climate change and to find specific solutions for adaptation policy, several important international projects have taken or are taking place in the Baltic region: the “Sea Level Change Affecting the Spatial Development in the Baltic Sea Region” project (SEAREG, 2002–2005; Baltic Sea Region INTERREG IIIB Programme, 2000–2006); “Project of the Baltic Sea Region” (2005–2007), in which Finland, Germany, Estonia, Lithuania, Poland, Sweden, and Latvia participated; “Developing Policies and Adaptation Strategies to Climate Change in the Baltic Sea Region” (ASTRA) – a follow-up to the INTERREG IIIB project; SEAREG (Sea Level Change Affecting the Spatial Development of the Baltic Sea Region); an international project “Climate Impact Research Co-ordination for a Larger Europe” (CIRCLE ERA-NET) within the Sixth Framework Programme for Research and Technological Development of the European Commission. The new one – “Climate Change: Impacts, Costs and Adaptation in the Baltic sea region” (BaltCICA, 2009–2012) is running now, involving Finland, Estonia, Lithuania, Germany, Denmark, Norway, Sweden, and Latvia. Sea level changes and coastal vulnerability for Latvia are modelled and calculated by the Potsdam Institute for Climate Impact Research within the ASTRA project, but monthly average temperature changes up to 2100 are calculated within the Swedish Regional Climate Modelling Programme (SWECLIM).

Latvia is participating as an observer in the EU project CIRCLE ERA-NET, in EPA IG on adaptation, as well as in the European Environment Information Observation Network (EIONET) regarding climate change vulnerability and adaptation. Latvia had also prepared information (submissions) on national adaptation policies and measures to the Nairobi Work Programme on socio-economic aspects of impacts, vulnerability assessments, and adaptive capacity (2007), and to the Nairobi Work Programme on impacts, vulnerability, and adaptation to climate change (2009).

The main scientific authorities engaged in scientific research matters of climate change impacts and consequences in Latvia are: the researchers of the Faculty of Geography and Earth Sciences of the University of Latvia (research on climate change impacts), the Faculty of Biology of the University of Latvia,[15] the Institute of Biology of the University of Latvia,[16] the Latvian State Forest Research Institute "Silava",[17] Physical Energetic Institute (research on renewable energy or RES resources), Institute of Solid State Physics (hydrogen technologies), Riga Technical Institute (climate change technologies), and Agricultural University of Latvia.

In close cooperation with scientists and other stakeholders the National Research Programme "Impact of Climate Change on the Water Environment of Latvia" (KALME, 2006–2009) takes place for assistance in the development of the adaptation policy. The general goal of this programme is to assess short-, medium-, and long-term impacts of climate change on the environment and ecosystems of the inner waters of Latvia and the Baltic Sea, and to create a scientific basis for adaptation of environmental and sectoral policies of Latvia to climate change. Specific goals are (1) to create several mutually non-controversial scenarios of the regime – determining parameters; (2) to assess possible climate change impacts on the quality of inland waters of Latvia, their availability, flood and drought risk, to facilitate adaptation of the drainage basin management and secure protection and sustainable use of water resources; and (3) forecast possible climate change impacts on the physical regime, coastal dynamics, biogeochemical regime, and ecosystems of the Baltic Sea, as well as to facilitate protection of marine environmental quality, biological diversity, and sustainable use of its resources and services.

There are many institutions and informative modes providing network systems for the production and distribution of climate information and monitoring, covering the entire territory of Latvia, including big cities, locations in coastal zone areas, and near river estuaries, e.g. Riga (722,485 inhabitants in 2007), Liepaja

[15]Examples of research projects: "Biological Diversity of Swamp Woods under the Impact of Climate Change" (2006) and "Changes in the Growing of Trees under the Impact of Climate and Environmental Changes and Connection Thereof with Indicators of Biological Diversity" (2007).

[16]Examples of research projects: "Variability of Global Climate and Actions for Reduction of Impact Thereof in Latvia" (2005) and "National Adaptation Strategy for the Management of the Risk Caused by Variability of Climate: Extreme Climatic Phenomena and Effects Thereof" (2006).

[17]An example of a research project: "Impact Assessment of Extreme Wind Velocity on the Stability of Forest Stand, Development of System for Support of Decision Making" (2006).

(85,477 inhabitants, 2007), Ventspils (43,544 inhabitants, 2007), Jurmala (55,408 inhabitants, 2007) or Daugavpils city (108,091 inhabitants, 2007),[18] lying on the banks of river Daugava.

Primary data on direct climate change impacts (air temperature, precipitation, changes in river discharge, ice regime, wind regime, etc.), as well on GHG emissions, is gathered and distributed by the Latvian Environmental, Geological and Meteorological Agency (LEGMA); data on public and environmental health by the Public Health Agency; data on forests, including CO_2 removals, by the scientific research institute "Silava", monitoring of geological processes of sea coast by the University of Latvia, Faculty of Geography and Earth Science; geographic information systems, or GIS, maps of the surface of the territory of the state in different scales for modelling floods and other risks by the Latvian Geospatial Information Agency.

Responsibility for solving problems of common financing and institutional responsibility in a well-structured mechanism and regarding political requirements is stated in "Environmental Protection Law" (2007) and in Regulations of the Cabinet of Ministers of Latvia "A Programme for Environmental Monitoring 2009–2012" (2009). The aim of the Monitoring Programme is to ensure complete data and information for assessment of trends and perspectives, development of new environmental policy measures, and evaluation of the effectiveness of already existing measures (in policy cycle ex post stage). A cooperation criterion is taken into account in the financing mechanism for this environmental monitoring: financing from the state budget (including Latvian Environmental Protection Fund (LEPF), which is a separate state financial programme) *plus* financing from the European Reconstruction and Development Fund, or ERDF. For example, in 2009 the applicable financing is estimated at 2809.5 thousand lats (inter alia, 302.3 thousand lats from LEPF, 223.6 thousand lats other financing from state budget, and 1,267.1 thousand lats from ERDF).[19] The State Forest Monitoring Programme is exploring the impact of climate changes to forest ecosystems, forest biodiversity status and changes as well as to forest soils. Responsible institutions for this Programme are the Ministry of Agriculture, State Forest Service, and Latvian State Forestry Research Institute, "Silava".

The State Regional Development Agency of Latvia, among other functions, performs assessments and analyses of regional developments, including the preparation and publishing of analytical materials. One of the most recent studies has been devoted to socio-economic development tendencies of Latvian towns, including ecological footprint in the context of land use and land use change as a CO_2 sink, and energy consumption.

[18] *Source*: Central Statistical Bureau of Latvia.

[19] Regulations of the Cabinet of Ministers of Latvia No. 187 (11 Mar 2009) "A Programme for Environmental Monitoring 2009–2012" include a wide spectrum of indicator-reflected climate change impacts (air temperature, precipitation, wind strength, etc.).

Latvia has good experience in developing sustainable development indicator systems and assessing economy-wide natural resource flow, showing accounting schemes for natural material flows (direct and indirect flows, material accumulation, recycling, emissions, domestic extraction, exports, etc., Latvian Environmental 2004), reflecting sustainable development dematerialization principles. For example, the Latvian report "Report on Environmental Indicators in Latvia 2002" (LEA 2002) was compiled according to the causal chain principle, i.e. by grouping the data into five (driving force – pressure – state – impact – response) logical phases. In fact, all three sustainable development capitals were identified there, and indicators were connected in a unified cause–response chain, showing (a) what causes the environmental problem, (b) why it originated, (c) what effect it caused, and (d) how or with what instruments (tools, options) can a solution be found. In such a way, normative principles and criteria in the full policy cycle were taken into consideration.

The next step, mainstreaming development, which is not only essential for the state, but also for adapting and elaborating new methodological approaches for sustainable development evaluation in Latvia, was "Latvian Sustainable Development Indicators Report 2003" in which eco-efficiency indicators, among others, were like a central axis measuring decoupling and this level of dematerialization (Latvian Environmental 2003).

The project "Detection of Building and Coastal Erosion in the Protective Zone of Coastal Dunes of the Baltic Sea and the Gulf of Riga, Recorded in Orthophoto Maps" implemented by the survey and spatial planning company "Metrum 2007" (with the support of the LEPF) will facilitate planning, detecting the main risk zones of erosion, as well as problematic territories of building. The data obtained will be usable in the development of spatial plans and monitoring of the implementation thereof; specifically in protective zones and property boundaries, in the management of specially protected nature territories, in the planning of port development, for further monitoring of building changes, etc. Significant support in the formation of risk zoning could be provided also by the Latvian Geospatial Information Agency in developing a digital model of the surface of the territory of the state for modelling floods and other risks.

Risk Minimization and "Polluter Pays" Principles as Basis for Decision Criteria

When designing systems of analytical approaches and decision-making criteria to be used in the policy cycle, risk minimization – i.e. assessment and management – and "polluter (user) pays" principles are chosen to be the fundamental basis. For that reason, risks were identified in the Report on Adaptation in Latvia before starting work on the elaboration of the adaptation policy system, and the costs and benefits arising from climate change impacts and policy response alternatives were also considered.

1. For the damages and losses caused by negative climate change impacts the state may be forced to pay large compensations both to individual sectors (particularly in agriculture and forestry) and to residents for the damage caused by natural phenomena to their property, health, or even life. From a socio-economic perspective, such risks may distort the natural competition in the market economy and pose serious threats to individual sectors of the national economy or sub-sectors thereof (agriculture, forestry, fisheries, sea port sector).

   At the same time, the potential benefits in the energy sector (in relation to the installed generating powers), which would be initiated by such direct manifestations of climate changes as the increase of air temperature, and the increase of the average flow rate of water upon the increase of rainfall, should also be noted. It would affect the reduction of the consumption of energy resources for heating (in the context of measures of energy efficiency); increasing hydropower potential in rivers would ensure a higher generation of electricity and reduce dependence on imported energy resources.
   Criteria for biofuels sustainability have been determined in the directive on renewable energy sources (which means these criteria have to be implemented): (a) GHG saving at minimum of 35%, (b) no raw material from undisturbed forests, biodiverse grassland, nature protection areas (unless taken harmlessly), (c) no conversion of wetlands and continuously forested areas for biofuel production, and (d) all EU biofuels must meet "cross compliance" environmental rules. For providing that through monitoring and reporting requirements every 2 years, EU member states (including Latvia) will have to make analyses of land-use changes, commodity price changes and availability of foodstuff, cost–benefit analyses of different biofuels and import policy, and analyses of sustainable development issues.
   Positive effects from climate change impacts are related also to temperature changes and effects thereof on the biosphere: the increase in temperature will firstly affect the reduction of frost probability and cause significant increase of the length of the growing season; however, mortality of people from cold will decrease in temperate degrees of latitude due to a milder climate during winter months (Klavins et al. 2008).
   In Latvia, the first endeavour to develop policy in the direction of climate change risk insurance was done in agriculture. The first step was an adoption by the Cabinet of Ministers of Latvia of the "Conception on Risk Management Policy in Agriculture" (2007) with appropriate Regulations, which foresees administration and supervision of agricultural risk funds, and deals with the compensations' mechanism for damage inflicted by natural factors to producers (Regulations 2008), thereby reducing the direct state payments and involving farmers themselves in risk insurance and covering of losses.

2. Climate change may affect the distribution of invasive species and the migration of agricultural crop pests. In the field of public and environmental health, such changes may call forth the occurrence of diseases that are not typical to the region, such as malaria, and it is possible that the frequency and spread of

diseases carried by ticks will increase. The number of cases of health disorders related to the impact of excessive summer heat waves may increase, also promoting an increase in morbidity with cardiovascular diseases, chronic respiratory diseases for especially sensitive groups (chronic patients, children, and elderly people who are mainly also the poorest group) and the number of cases of death related to these factors may increase.

A warmer climate will strengthen eutrophication processes of waters not only in the Baltic Sea, but also in inland waters (one of the most negative forms is the “blossoming” of *cyanobacteria*), deteriorating the recreation potential of such waters (at first in relation to bathing waters). It is very hazardous for Latvia’s inland waters – one of the most sensitive ecosystems.

3. Climate change has many impacts on biological diversity, which is very rich in Latvia. For example, as confirmed by the information in *A Climatic Atlas of European Breeding Birds* regarding the predicted reduction in the diversity of birds in Latvia in the twenty-first century (Huntley et al. 2007), many special protected nature territories are exposed directly to sea storm overflowing and wash-off and erosion processes. The huge diversity of species and natural biotypes is characteristic for Baltic Sea coastal zones (dunes, bluffs, coastal pools, etc.). Approximately 90% of coastal zones are made up of natural biotypes. Sandy beaches (Latvia also has gravel and pebble beaches, high boulder beaches, etc.) are the most typical beaches in Latvia. Their length is approximately 240 km (of 496.5 km total sea coast in Latvia).

   The aim of the “Protection Zone Law” (1997) has hitherto been “to decrease or eliminate the effects of the anthropogenic negative impact on the objects for which the protection zones have been determined”. At present, an intermediate solution for reducing the effects of climate change is being introduced in relation to the protective zone of the Baltic Sea and the Gulf of Riga.

4. More frequent natural disasters (storms, floods) may cause industrial accidents, for example, discharge of dangerous chemical substances, which may cause a threat to the health of residents. Prevention of the risks caused by climate change is particularly urgent in the River Daugava because the Daugava hydropower plant, or HPP, cascade (Plavinas HPP, Kegums HPP, and Riga HPP) is recognized as a Flood Risk Territory of National Significance. Thus, an important factor in flood risk prevention is proper monitoring of hydrotechnical structures, technical maintenance, as well as strict observation of exploitation mode.

   According to the Latvian “Law on Environmental Impact Assessment” (it also includes Strategic Environmental Impact Assessment procedure), all risks should be forecast and assessed. The incompleteness derives from the fact that these procedures (according to appropriate EU directives) do not require natural disaster (including climate change impact) assessment. The positive trend is that in several cases in Latvia (in development programmes and plans), these risks already have been assessed.

The “Latvian Rural Development National Strategy Plan for 2007–2013” (2006) foresees risk management, including risks caused by climate change (flooding, drought and killing frost).

The 15 million euro financing of the National Programme for Acquisition of the European Regional Development Fund in the activity Reduction of Environmental Risk for the financial planning period 2007–2013 of the European Union is provided for measures to improve the infrastructure and establish new infrastructure for the prevention of flooding in increased flood risk territories of national significance.

Regarding specific flood risk management, the approach in relation to the water environment is integrated, adopting Directive 2007/60/EC of the European Parliament and of the Council of 23 Oct 2007 on the assessment and management of flood risks, which determines that the flood component should be included in intended plans for the management of river basins provided for in Directive 2000/60/EC of the European Parliament and of the Council of 23 Oct 2000 establishing a framework for Community action in the field of water policy (requirements thereof at a national level are included in the Water Management Law). The new directive provides for the performance of the initial risk assessment of flood throughout the state territory, specifying on the basis thereof the territories endangered by flooding, and for the preparation of a flood risk management plan for each river basin region.

According to these new requirements, all flood risk territories and criteria for these territories at a national level are defined in the “National Flood Risk Assessment and Management Programme for 2008–2015” (2007, based on two research studies). The programme deals with risk management, establishment of priority risk territories, prevention – real time schedule and financing, flood risk impact assessment (ex post), elaboration of maps for risk territories, plans’ elaboration for risk territories, including CC risk management incorporation into existing protection plans for individual territories, etc. The programme also foresees three scenarios (with appropriate criteria and financing) (1) floods with a low likelihood of occurring, (2) mid-sized floods (possible recurrence period: 100 years or more), and (3) floods with high likelihood of occurring.

5. Conflicts regarding non-renewable resources will intensify under the general impact of climate change, particularly in locations where access to such resources is related to state policy. Great changes in global land territory may take place in this century, thus possibly causing more disputes regarding land and sea borders and other rights to the territory.

   “Conception on Coastal Zones of Baltic Sea and Gulf of Riga Registration in Land Register in the name of the State” (2008) foresees coastal zone systemic legal protection and management, avoiding ineffective management in a piecemeal manner (zoning of territories according to risk level criteria).

6. As adaptation to climate change is closely related to development and society’s welfare (inter alia, energy security and independence), adaptation should be based on security concepts and risk management related to climate change.

These socio-economic problems, which may be caused by the migration of residents from climatically unfavourable world regions (which are usually the poorest regions) to regions where the manifestations of climate change will not be so sudden or unfavourable, may arise.

The “National Security Concept” is a policy-planning document elaborated on the basis of the analysis of danger to the state, which determines the basic strategic principles, priorities, and measures for the prevention of danger (including climate change risks) to the state. Besides other threats (e.g. military), the National Security Concept predicts responses to react to environmental risks, including those caused by climate change, and asks for appropriate policy and elaboration of tools. The goal of the Concept is to take into account not only risks cause by anthropogenic actions, but also (at the same level) natural disasters, and predict those risks and adapt to them. National Civil Protection is a well-functioning sub-system, which aims to include measures and responsible institutions, and to provide preventive, readiness, and response measures intended for states of emergency, and measures for the elimination of the consequences of such situations, and determines the actions of the civil protection system also in the case of damage and risks caused by climate change (Ministry of Defence of the Republic of Latvia 2007).

Natural disasters, according to the risk level criteria and likelihood of damage criteria and actions, as well as the functions of institutions involved in the management of such disasters, are most completely described and defined in the “Civil Protection Law” (2006) and the “National Civil Protection Plan” (2007). All cities in Latvia have their own civil protection plans, where natural disasters and actions, as well as the functions of institutions concerning climate change risks and their management are defined. Pursuant to the requirements of the “Law on State Material Reserves” (2007), there is a duty to form and store state material reserves within the framework of the system of civil protection in order to use them in case of national threat.[20] It is important that the planning of material reserves is ensured by ministries (involving institutions subordinate thereto), local government institutions, and merchants.

The “polluter (user) pays” principle (or “full cost recovery” principle) at the national level is transposed into the “Law on Pollution”, which determines how to prevent or reduce harm caused to human health, property, or to the environment caused by pollution. This law lays down conditions for greenhouse gas emissions, taking into account cost-effectiveness, and ensuring participation in the European Union emissions quota trading system. The overall conditions of the EU ETS[21] have been incorporated into the law, particularly the rights and responsibilities of

[20]State material reserves are to be understood as the aggregate of material and financial resources formed in accordance with the procedures specified in this Law, which is used by the institutions involved in the management of disasters when the resources at their disposal are insufficient for the implementation of measures.

[21]Conditions of the EU ETS are described in Directive 2004/101/EC of the European Parliament and Council of 27 Oct 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol’s project mechanisms.

state authorities and operators, the issuing of GHG emissions permits, the preparation of annual reports, procedures for the preparation and approval of a national allocation plan, the principles of allowance allocation, conditions for the creation and maintenance of a register of greenhouse gas emission units, operations with allowances, as well as conditions for the creation of an installations pool. The law lists those polluting activities for which GHG emissions permits are necessary, and thus are obliged to participate in the EU Emissions Trading Scheme. The law also prescribes the procedure for community involvement in decision-making on allowance allocation and the issuing of GHG emissions permits.

A new financial mechanism, also based on the "polluter pays" principle, has been developed in Latvia with regard to flexible mechanisms under Article 17 of the Kyoto Protocol. The Cabinet of Ministers made a decision on 12 Apr 2006 on participation in International Emissions Trading (IET) under Article 17 of the Kyoto Protocol. It gave the possibility to earmark 40 million AAUs to be potentially available during the first commitment period 2008–2012. A mandate to the Ministry of the Environment to design a legal institutional system of IET was given in November 2007. A Green Investment Options study completed the Financial Implementation of the Kyoto Protocol by Latvia. The "Law on Latvia's Participation in the Kyoto Protocol Flexible Mechanisms" (2007) foresees development of Climate Change Financial Instruments and strictly defines that every AAU sold will be used for *greening* purposes, including adaptation policy and measures.

The Latvian government is responsible for ensuring that all revenues are being earmarked for "greening" purposes, which means: (a) climate change mitigation and adaptation measures, (b) promotion of low carbon economic development by the application of innovative environmental technologies, (c) increasing renewable energy use and improving energy efficiency, (d) capacity building for climate change policy design and implementation.

Latvia is in the position to be a fast track provider of *greened* AAUs with low risk and low transaction costs. The market position of Latvia could be characterized by such comparative strengths as: low risk of non-delivery of AAUs; robust surplus estimates, advanced in compliance with Kyoto eligibility criteria; low reputational risk; solid legal background and strong political commitment to efficient, transparent, and accountable Green Investment Scheme; efficient institutions of the public and private sector; and terms tailored to buyer expectations. Comparative weaknesses of Latvia must also be specified: the relatively small size of tradeable headroom, and limited opportunities for greening with direct reductions of GHGs (Latvian Green Investment Scheme may need to include the relatively high share of the greening measures that do not generate immediate and easily measurable reductions in greenhouse gases[22]).

[22]ECSSD Sustainable Development Department and Carbon Finance Unit (2007), "Latvia's Participation in International Emissions Trading", Options Study, p. 136.

Key elements of the "Law on Latvia's Participation in the Kyoto Protocol Flexible Mechanisms" are postulated as (1) ownership of AAUs; (2) authorization of the Cabinet of Ministers to make decisions on each sale of AAUs, including the price and specific conditions; (3) authorization of the Ministry of Environment and Ministry of Finance to prepare and sign the sale of AAUs; (4) principles for using the revenues from the sale of AAUs, including a clear provision stating that all income from the sale of AAUs shall be earmarked for "greening" projects; (5) special budgetary arrangement defining that money from the sale of AAUs is transferred to a special account in the State Treasury, disbursements being organized under the budget programme climate change financial instrument from a special account in the State Treasury, while in the annual budget, the financing for the climate change financial instrument is ensured in the amount of received and unused proceeds from AAU sales in previous years; (6) principles for environmental and financial monitoring, verification, and reporting.

Latvia proposes a programmatic model for the Green Investment Scheme in which most programmes currently consist of a large number of small projects concerning energy-efficiency increasing in public buildings. Therefore, Latvia would propose to buyers "wholesale" greening programmes backed by a credible and accountable national mechanism to "retail" AAU revenues to multiple project owners. Latvia can offer a robust Green Investment Scheme implemented by competent national institutions that require only minor and targeted institutional strengthening.

The dematerialization principle of sustainable development underlies the Natural Resources Tax (NRT) (in our specific case – carbon tax as a component of the NRT system), which aims to reduce ineffective use of natural resources and pollution of the environment, reduce manufacturing and sale of environment-polluting substances (including GHGs), at the same time as promoting the implementation of new and improved technology with less pollution load, to increase energy efficiency and the share of renewable and local energy sources (wood, straw, and peat), thus reducing air pollution. The "Law on Natural Resource Tax" defines (from 1 July 2005) that a fee of 0.1 lats for each emitted tonne of CO_2 shall be paid by all combustion installations, except those using peat or renewable energy sources and those that are involved in the EU ETS. CO_2 tax increased to 0.3 lats per tonne of CO_2 after 1 July 2008. At any rate, this tax rate is low and extremely ineffective, and should be revised.

In Latvia, excise tax, besides other product categories, is applied to oil products that are imported, exported, produced, processed, stored, sold, received, or sent. A feed-in tariff support has been provided for electricity production from renewable energy resources (energy from small HPPs, biogas production, and wind power). However, the conditions for receiving the support have changed very often and are also not in correspondence with sustainable development criteria.

Recommendations

The attitude devoted and methodological approach applied to policy design for climate change adaptation should be perceived as of equal importance as the policy for mitigation of climate change. It is not an issue to be viewed separately, but should be solved as an integral part of sustainable development according to all principles and criteria on which sustainable development is based. It should thus be included in policy planning documents and sectoral policies with innovative approaches to the formulation and implementation of such policies, involving the most different partners at national and global level, as well as at the level of the European Union.

The national state level is the basic one on which the issue of adaptation to climate change (e.g. establishment of funding, insurance, and transfer of technology) should be designed in a full policy cycle and in all decision-making with particular criteria.

As risk minimization and "polluter (user) pays" principles are among the most important principles serving as a basis for decision-making criteria of sustainable development, in order to ensure preventive reduction of the potential risks to the business and national economy at large and to adapt rational economic activities, it must be a requirement that the private sector also develops measures for the prevention or reduction of such risks in cooperation with specialists of state administrative institutions, local governments, and foreign specialists, adapting technologies and planning the potential risks related to climate change. Although such management of risks will initially require certain investments, it will allow a reduction of the damages inflicted to undertakings or the national economy, and welfare overall, in the long term. It is intended to develop the potential forms of cooperation and development in the work groups referred to in the Protocol decision. Much attention should be paid to educating and informing the public about climate change, threats caused thereby, as well as the readiness to act in a situation of disaster or crises.

The regional level and level of local governments should be emphasized in relation to adaptation to climate change because the most accurate information regarding local nature and the living conditions of residents, as well as regarding conditions hindering or promoting environmental changes is available at these levels, and so an easier and more detailed assessment of the consequences caused by climate change and the foreseeable consequences is possible. This, in turn, gives an opportunity to develop measures for local-scale and spatial plans, which would ensure adaptation of the particular territories to climate change, as well as preparation for risks caused by climate change expected in the future. Spatial planning (including spatial plans of local governments), which determines the establishment of population structure, has a significant role, so it is essential to take into account the foreseeable effects and the potential risks of climate change to infrastructure and built-up areas in the process of spatial planning.

Exploration and management of the risks related to climate change, concurrently establishing or improving the necessary databases, an adequate monitoring system, regularly renewing maps of risk objects, and assessing the socio-economic effects from the point of view of a cost–benefit analysis would facilitate the process of identification and evaluation (including financial) of risks, improve the establishment of a system of different forecast and development models, including such systems which are related to the assessment of effects of climate change on different natural ecosystems and biological diversity, human health, and welfare overall.

It is important that the measures implemented for the reduction of the impacts of climate change (e.g. flood control, changes in agriculture or output of energy resources) at the same time would not harm ecosystems and biological diversity. It should be taken into account that natural biotopes (particularly forests and bogs) serve as carbon dioxide sinks. If such biotopes are significantly disturbed (even if it is done for the purpose of mitigation of climate change), the total benefit may not counterbalance the loss of the biotope as a carbon dioxide sink. The usefulness of biofuel and the impact of its production on ecosystems should be weighed with particular attention. It is necessary to organize scientific research and monitoring in order to trace the changes of biological diversity caused by climate change.

References

Association of British Insurers (2005) Financial Risks of Climate Change. Association of British Insurers, London

COM/ENV/EPOC/DCD/DAC(2008)2/REV2 (2009) Draft OECD guidance on integrating climate change adaptation into development Co-operation. OECD, Paris, p 40

Commission of the European Communities (2009a) Commission staff working document accompanying the White Paper Adapting to climate change: towards a European framework for action. Impact assessment. COM(2009) 147; SEC(2009) 386; SEC(2009) 388; p 132

Commission of the European Communities (2009b) Adapting to climate change: towards a European framework for action. COM(2009) 147; SEC(2009)386; SEC(2009)387; SEC (2009)388

Eberhards G, Lapinskis J (2008) Processes on the Latvian coast of the Baltic Sea – Atlas. University of Latvia Publishing House, Riga, p 64

ECSSD Sustainable Development Department and ENVCF Carbon Finance Unit (2007) Latvia's participation in international emissions trading: Options Study. CEPS, Brussels, p 136

European Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions "Adapting to climate change in Europe – options for EU action" –COM(2007)354 final; 29.11.2007

Frankhauser F (1996) The potential costs of climate change adaptation. In: Smith JB, Bhatti N, Menzhulin G, Benioff R, Budyko M, Campos M, Jallow B, Rijsberman F (eds) Adapting to climate change: an international perspective. Springer, New York, pp 80–96

Grisule G, Briede A (2007) Phenological time series in Latvia as climate change indicators. In: Klavins M (ed) Climate Change in Latvia. University of Latvia, Riga, pp 144–153

Hisschemöller M, Hoppe R (2001) Coping with intractable controversies: the case for problem structuring in policy design and analysis. In: Hisschemöller M, Hoppe R, Dunn WN, Ravetz JR (eds) Knowledge, power, and participation in environmental policy analysis. Transaction, New Brunswick and London, pp 47–72

Hoeppe P (no date) Munich Re's response to the challenges of climate change. Munich Reinsurance Company, Geo Risks Research, presentation

Hulme M, Neufeldt H, Colyer H (eds) (2009) Adaptation and mitigation strategies: supporting European climate policy. The final report from the ADAM project. Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK

Huntley B, Green RE, Collingham YC, Willis SG (2007) A climatic atlas of European breeding birds. Durham University, Barcelona, the RSPB and Lynx Edicions

Klavins M, Briede A, Rodinovs V (2007) Ice regime of rivers in Latvia in relation to climatic variability and North Atlantic Oscillation. In: Klavins M (ed) Climate change in Latvia. University of Latvia, Riga, pp 58–72

Klavins M, Blumberga D, Bruneniece I, Briede A, Grisule G, Andrusaitis A, Abolina K (2008) Climate change and global warming (in Latvian). University of Latvia Publishing House, Riga

Latvian Environmental Agency (2003) Latvian sustainable development indicators report 2003. LEA, Riga

Latvian Environmental Agency (2004) Economy-wide natural resources flow assessment. LEA, Riga

McLeod D (2007) Japan's earth simulator to model catastrophes. Business Insurance, 26 Feb 2007, p. 3

Metrum (2007) Project, Detection of building and coastal erosion in the protective zone of coastal dunes of the Baltic Sea and the Gulf of Riga, recording it in orthophoto maps. Riga

Mills E (2007) From risk to opportunity: 2007. Insurer responses to climate change. A Ceres report, p. 8

Ministry of Agriculture of the Republic of Latvia (2007a) Conception on risk management policy in agriculture. Adopted by the Cabinet of Ministers 22 Nov 2007. Ministry of Agriculture of the Republic of Latvia, Riga

Ministry of Agriculture of the Republic of Latvia (2007b) Regulations of the Cabinet of Ministers of Latvia No. 669 (18 Aug 2008) on "Order how to administrate and supervise the agricultural risk fund, and how to deal with the compensations mechanism for paying in and disbursements from the fund". Ministry of Agriculture of the Republic of Latvia, Riga

Ministry of Defence of the Republic of Latvia (2007) National security conception. Adopted by the Cabinet of Ministers 22 Nov 2007. Ministry of Defence of the Republic of Latvia, Riga

Ministry of Economics of the Republic of Latvia (2005) National Lisbon Programme of Latvia 2005–2008. Adopted by the Cabinet of Ministers 19 Oct 2005. Ministry of Economics of the Republic of Latvia, Riga

Ministry of Finance of the Republic of Latvia (2005) Information notice on damage inflicted by storm according to the fields in the public, local government and private sector on 8–9 Jan 2005. Adopted by the Cabinet of Ministers 15 Feb 2005. Ministry of Finance of the Republic of Latvia, Riga

Ministry of Regional Development and Local Government (2007) Information notice on granting resources from the state budget to local governments for liquidation of consequences of the storm of 14 and 15 Jan 2007 at schools and kindergartens, as well as local government objects, which are necessary for provision of execution of significant functions of municipalities. Adopted by the Cabinet of Ministers 11 Apr 2007. Ministry of Regional Development and Local Government, Riga

Ministry of Regional Development and Local Government of the Republic of Latvia (2006) National development plan for 2007–2013. Adopted by the Cabinet of Ministers 4 July 2006 with Regulation No. 564. Ministry of Regional Development and Local Government of the Republic of Latvia, Riga

Ministry of the Environment of the Republic of Latvia (2002) Guidelines for sustainable development of Latvia. Adopted by the Cabinet of Ministers 15 Aug 2002. Ministry of the Environment of the Republic of Latvia, Riga

Ministry of the Environment of the Republic of Latvia (2004) National environmental policy plan 2004–2008. Adopted by the Cabinet of Ministers on 4 Feb 2004. Ministry of the Environment of the Republic of Latvia, Riga

Ministry of the Environment of the Republic of Latvia (2005) Law on the framework convention on climate change of the United Nations Organization. Adopted by the Saeima of Latvia 23 Feb 1995. Ministry of the Environment of the Republic of Latvia, Riga

Ministry of the Environment of the Republic of Latvia (2008) Report on adaptation to climate change. Accepted by the Cabinet of Ministers 5 Aug 2008. Ministry of the Environment of the Republic of Latvia, Riga

Ministry of the Environment of the Republic of Latvia (2009) Regulations of the Cabinet of Ministers of Latvia No. 187 (11 Mar 2009), "On programe for environmental monitoring 2009–2012". Ministry of the Environment of the Republic of Latvia, Riga

Porritt J (2007) Capitalism as if the world matters. Earthscan, UK

Presidency Conclusions to Brussels European Council 8/9 March 2007

Rittel H, Webber M (1973) Dilemmas in a general theory of planning. Policy Sci 4:155–169

Senge P (1990) The fifth discipline. Doubleday Currency, New York, pp 142, 150–55, 156, 226

Smit B, Burton I, Klein RJT, Wandel J (2000) An anatomy of adaptation to climate change and variability. Clim Change 45(1):224–251

Smith JB (1996) Using a decision matrix to assess climate change adaptation. In: Smith JB et al (eds) Adapting to climate change: international perspective. Springer, New York, pp 68–79

Stern N (2007) The economics of climate change: the Stern review. Cambridge University Press, Cambridge

Swiss Re (2006) The effects of climate change: storm damage in Europe on the rise. Report 6/06 2500en

UN Millennium Development Goals. http://www.un.org/millenniumgoals

UNFCCC (1992) The United Nations framework convention on climate change, A/AC.237/18, 9 May

UNFCCC (2002) Delhi Ministerial Declaration on climate change and sustainable development (decision 1/CP.8). In: Conference of the Parties on its eight Session, from 23 Oct to 1 Nov 2002, New Delhi, India

UNFCCC (2004) The Buenos Aires Declaration on the ethical dimensions of climate change. 9 Dec 2004

UNFCCC (2005) Decision 1/CP.10 Buenos Aires programme of work on adaptation and response measures. FCCC/CP/2004/10/Add.1, 19 Apr 2005

UNFCCC (2006) Five-year programme of work on impacts, vulnerability and adaptation to climate change. FCCC/SBSTA/2006/L.26 Conference of the Parties on its twelve Session, Nairobi, 6–17 Nov 2006

UNFCCC (2007) United Nations framework convention on climate change. Decision -/CP.13 – Bali Action Plan

United Nations (2005) Hyogo Framework for Action 2005–2015: building the resilience of nations and communities to disasters (HFA). Kobe, Hyogo, Japan, 18–22 Jan 2005

Zeng L, Kelly PJ (1997) A preliminary investigation of the trend of flood events in the United States. Presented by Arkwright Mutual Insurance Company (now part of FM Global) at the National Association of Real Estate Investment Managers Senior Officer Property Insurance Forum, Boston, 18–19 Mar 1997

Part IV
Practical Aspects, Initiatives, Frameworks and Projects

Chapter 31
Accurate Estimation of CO_2 Background Level from Near Ground Measurements at Non-Mixed Environments

Francis Massen and Ernst-Georg Beck

Abstract Atmospheric CO_2 background levels are sampled and processed according to the standards of the NOAA (National Oceanic and Atmospheric Administration) Earth System Research Laboratory mostly at marine environments to minimize the local influence of vegetation, ground or anthropogenic sources. Continental measurements usually show large diurnal and seasonal variations, which makes it difficult to estimate well mixed CO_2 levels.

Historical CO_2 measurements are usually derived from proxies, with ice cores being the favourite. Those done by chemical methods prior to 1960 are often rejected as being inadequate due to poor siting, timing, or method. The CO_2 versus wind speed plot represents a simple but valuable tool for validating modern and historic continental data. It is shown that either a visual or a mathematical fit can give data that are close to the regional CO_2 background, even if the average local mixing ratio is very different.

Keywords CO_2 · Historical CO_2 · Measurements · Mixing ratio · Validation · Wind speed

Introduction

Many of the discussions concerning anthropogenic global warming centre on the important role of atmospheric CO_2 as a greenhouse gas. Having good CO_2 measurement data at many regional locations is particularly important. When these locations do not fulfil the usual criteria for obtaining CO_2 background levels, a procedure to derive these levels with the help of other meteorological parameters will be useful. The same holds for the study or the validation of historical CO_2

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measurements. These measurements have often been made under varying conditions, different from those used currently at carefully selected locations. It will be shown that using concurrent wind speed measurements allows the extracting of meaningful conclusions from these historic CO_2 data series.

Data and Methods

Daily Pattern of CO_2 Mixing Ratios

The daily pattern of the CO_2 mixing ratio depends essentially on the presence and/or the strength of the near ground inversion layer. This layer (which exists mostly at night, during the morning hours, or at late afternoon) prevents a thorough mixing up of the atmosphere and coincides usually with large CO_2 peaks (Massen 2007). During the midday hours, solar heating is normally at a maximum and creates the strongest convective air movements. As a consequence, the atmospheric boundary layer is well mixed up, and CO_2 mixing ratios fall to their daily minimum. This minimum is seen as the most representative measure of the regional CO_2 background level.

The inversion periods are much shorter and less intense at the border of open sea or at smaller islands, where a quasi continuous breeze mixes up the boundary layer at most periods of the day. As a consequence, the daily CO_2 variation is much lower at these locations, considered as the most suitable for background CO_2 measurements (Fig. 31.1).

Meanwhile vertical profiles of the atmospheric CO_2 concentration are available at many environments; they usually show different mixing ratios, with location having a much greater influence than altitude.

The North Hemisphere (NH) mean near ground mixing ratio shown in Fig. 31.2b differs by only 1.13 ppm from the background level above 4 km altitude. Extrapolation to ground level results in a 2.56 ppm difference. Large seasonal variations of the order of 30 ppm are typical at continental environments, e.g. Surgut (SUR, Wetland, Siberia); at marine locations (e.g. Cape Grim Baseline Air Pollution Station, Bass Strait, Cape Grim, Australia) the variations around the local background level are small.

The Problem of Continental Near-Ground CO_2 Measurements

CO_2 data sampled at continental environments near ground usually shows large diurnal and seasonal variations which make it difficult to estimate the proper well mixed levels. Historical measurements prior to the high quality continuous recordings available since 1958 have been shown as being often very precise, done with

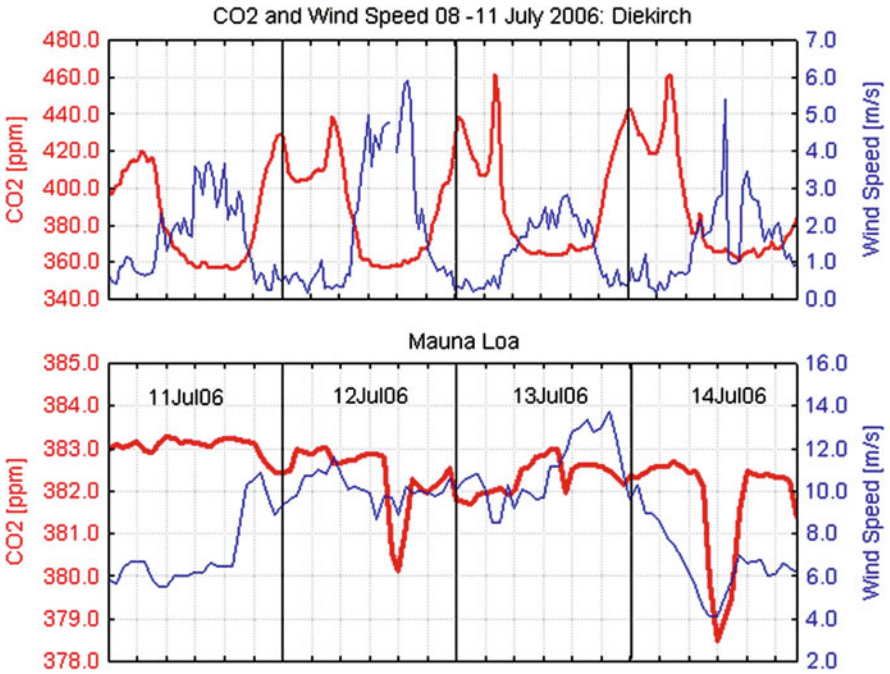

Fig. 31.1 Daily pattern at Diekirch, Luxembourg and Mauna Loa for the 11–14 July 2006 period (Massen 2007): very strong diurnal variations of up to 100 ppm exist at the semi-rural location of Diekirch, practically none (less than 4 ppm) at Mauna Loa (island of Hawaii). Note the different scales of the two plots

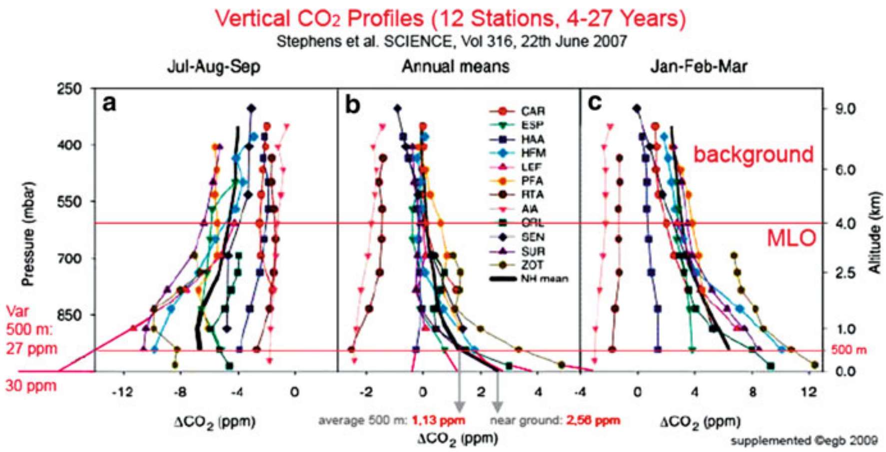

Fig. 31.2 Vertical CO_2 profiles from 12 global stations derived from flask samples collected from aircraft during midday with records extending over periods from 4 to 27 years (Stephens et al. 2007). Additions to the original Figure 1 of the paper by E.-G. Beck. MLO = the Mauna Loa sampling station as a reference. B has been calculated by subtracting the MLO data. Stations were located from lat. 40.37 N, long. – 104.30 E, to lat. 40.5 S, long. 144.30 E

great care by outstanding scientists. Many have been done in rural, semi-urban, and marine environments (Beck 2007). These measurements were usually spot measurements, made at different times of the day, and as such are difficult to evaluate: depending on the measurement routine, they may have a positive bias (for instance for measurements done during the morning hours) or show large variations. Nevertheless, there exist historical continuous sampling series done under fixed conditions over one or more seasons.

When meteorological parameters have been registered together with the CO_2 mixing ratios, there is a good chance to validate historical as well as modern continental data by using a CO_2 versus wind-speed plot.

The Typical CO_2 Versus Wind-Speed Profiles

It is well-known that CO_2 patterns vary with latitude and time: mixing ratios and seasonal amplitude are lowest at the South Pole and highest at northern locations (Fig. 31.3).

If we plot CO_2 versus wind speed, a few typical patterns show up, as given in Fig. 31.4 for a group of selected stations ranging from North to South.

When CO_2 data has a strong seasonal amplitude, as is the case for Barrow (Alaska), Pallas (Finland) and Mauna Loa (Hawai), a typical "multi-fingered" figure appears (Fig. 31.5).

In the Barrow example, the top finger corresponds to the "mean" CO_2 mixing ratio during the first part of the year (January to May); the middle one to the two

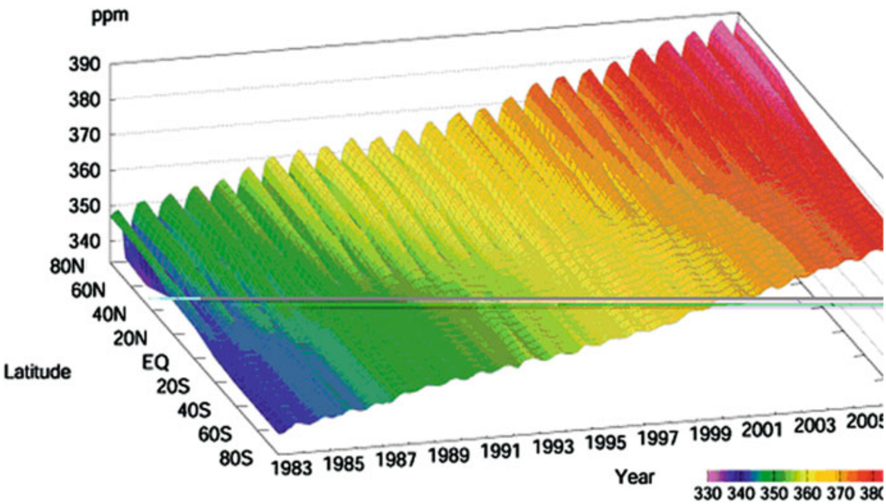

Fig. 31.3 CO_2 pattern from South Pole to North Pole
source: WDCGG, http://gaw.kishou.go.jp/wdcgg/

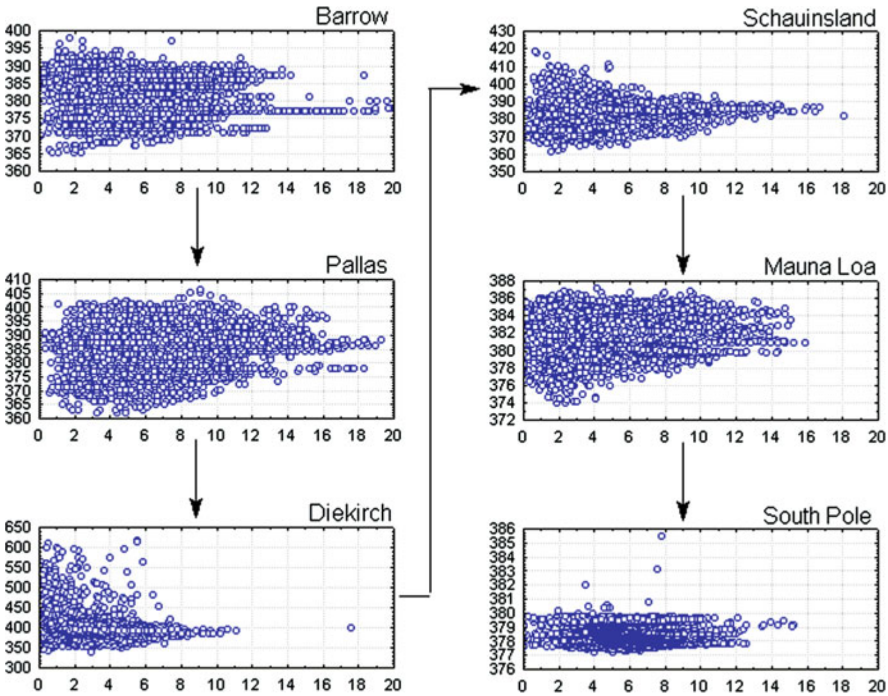

Fig. 31.4 Typical CO_2 versus wind-speed pattern for selected stations from North Pole to South Pole (2006 data from NOAA, WDCGG and meteoLCD)

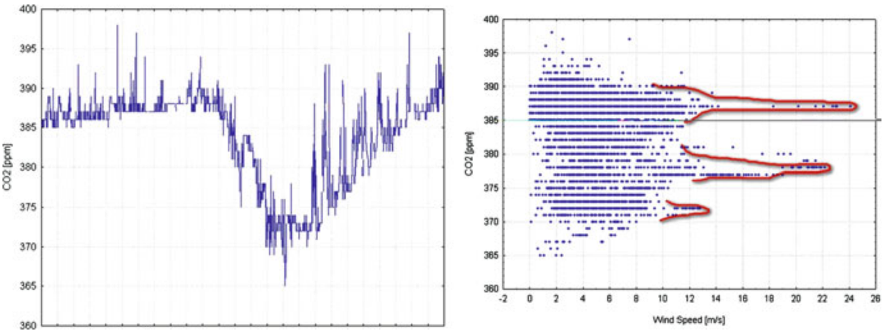

Fig. 31.5 CO_2 data and "finger pattern" for Barrow, Alaska, 2006 (data source: NOAA)

periods of either decreasing or rising values, and the lowest one to the bottom summer mixing ratio (here, month of August). Simple inspection locates these finger-levels at about 387, 378, and 372 ppm. The average for the year 2006 is 383.6 ppm.

Period	Number of data points	Calculated average CO_2 mixing ratio in ppm	Approx. finger location
01 Jan to 31 May 2006	3,322	387	387
Jun, Jul, Sept–Dec 2006	3,922	378	378
Aug 2006	713	372	372

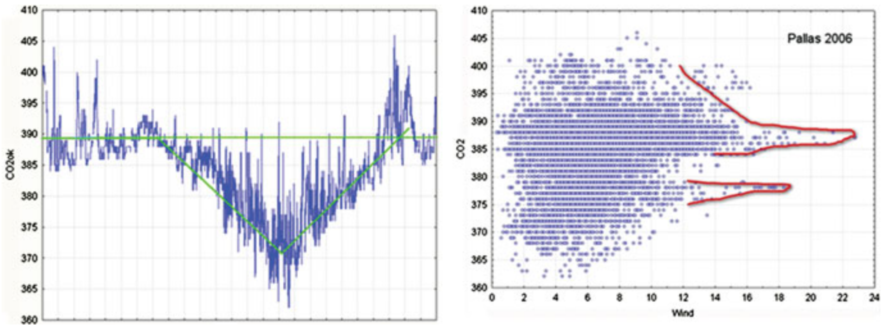

Fig. 31.6 CO_2 and finger pattern for Pallas, Finland, 2006 (data: WDCGG)

What these "fingers" tell us is that most relevant data should be in the interval [372. . .387]; in the Barrow case, 60% of the data belong to that interval. A second important conclusion is that the overall regional global background mixing ratio should also be in the interval defined by the extreme fingers.

The same calculation for the Pallas data shows two fingers located at about 388 and 378 ppm; the yearly average is 384.5 ppm. The Pallas graph has only two fingers, because there is practically no longer period of low summer CO_2 levels. The top finger corresponds to the winter/spring background CO_2 levels, the lower to those of the two mid-year periods of falling or rising levels (Fig. 31.6).

Semi-rural, inland located stations like Diekirch (L) have a very different CO_2/wind-speed pattern: the absence of a strong seasonal swing gives a typical boomerang-shaped graph (Fig. 31.7).

This boomerang pattern is typical for inland stations, and shows up for instance at the Neuglobsow and Schauinsland stations, located in the North and in the Black Forest of Germany.

The pattern of the graph shows the magnitude of the regional background level; a primitive mathematical model allows calculation of the asymptotic mixing ratio that would be present if wind speed was infinite.

The authors found that a simple dilution formula like:

$$CO_2 = a + b^* e^{-c^* windspeed} \quad (31.1)$$

often is adequate. For the Diekirch data shown in Fig. 31.7 this model suggests

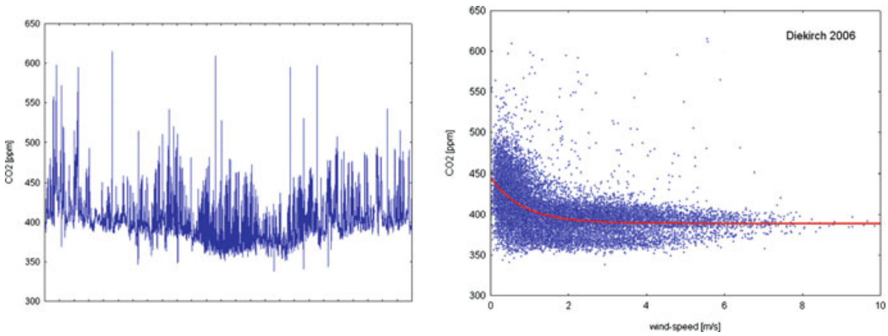

Fig. 31.7 Year 2006 CO_2 levels and CO_2 versus wind-speed pattern at Diekirch, Luxembourg

Table 31.1 Results of the wind-speed plot for selected stations

Station	Lat.	Environment	Asymptotic CO_2 level(s)	Method	R	Significant?	2006 mean
Barrow	71	Tundra/ice	382	(31.1)	0.14	Yes	384
Pallas	68	Forest	407	(31.1)	0.24	Yes	385
			385	(31.3)	0.04	Yes	
Neuglodsow	53	Semi-rural	382	Visual			400
			373	(31.1)	0.48	Yes	
Diekirch	50	Semi-rural	400	Visual			404
			389	(31.1)	0.51	Yes	
Schauinsland	48	Rural	385	Visual			384
			382	(31.1)	0.04	Yes	
Mauna Loa	20	Volcanic	382	(31.1)	0.14	Yes	382
South Pole	−90	Ice	379	Visual			379

$$CO_2 = 389 + 56.1^* e^{-1.2^* windspeed} \tag{31.2}$$

with an asymptotic value of 389 ppm (red curve in right plot of Fig. 31.7). R = 0.51 and the fit parameters are all significant at the 5% level (calculations done using the Statistica 7 package, Levenberg–Marquardt algorithm applied). The yearly average was 404.1 ppm, considerably higher than this asymptotic value.

The year 2006 Mauna Loa average was 381.7 ppm. If we assume a latitudinal gradient of 0.06 ppm/degree (as suggested by a prior unpublished study of one of the authors) this would correspond to $381.7 + 0.06 \times (50 - 20) = 383.5$ ppm for a sea-side station at the latitude of Diekirch. The NOAA CO_2 average for the whole globe is *382.5 ppm* for 2006.

It can be concluded that the "finger method" deviating by less than 7 ppm from the "official" global average gives an acceptable and very easy to implement validation tool.

Table 31.1 shows the 2006 results for all the above-mentioned stations, including Neuglodsow (D); all results are rounded to the nearest integer. Significant means statistically significant at the 5% level.

We found on several occasions that a rational function like:

$$CO_2 = a + \frac{b^* windspeed}{c + windspeed} \tag{31.3a}$$

or

$$CO_2 = a + \frac{b + windspeed}{c + windspeed} \tag{31.3b}$$

can give a better fit (higher R); the asymptotic CO_2 levels are $a + b$ (31.3a) or $a + 1$ (31.3b). One has to check the validity of the fitting equation from case to case.

Table 31.2 shows the differences between the asymptotic value given by the wind-speed model and the global background level for seven locations (all results rounded to the nearest integer).

The examples shown above represented the single year 2006 situation. It is quite interesting to note that applying the wind-speed method to multi-year data can also give a very close estimate of the mean global background CO_2 mixing ratio for this extended period. We will use the 17 year series from the Harvard Forest Station (Ameriflux project) to document this (Fig. 31.8).

Let us make a first conclusion. To validate CO_2 data the procedure to follow would be the following:

1. If the CO_2 versus wind-speed plot has visible unambiguous fingers, use these to obtain a first interval for the regional background level of the year. A single finger directly points to that level.
2. If the plot is boomerang-shaped, either detect the asymptotic level by simple inspection, or use one or two mathematical fits. Be sure that applying the fit gives a statistically significant result, with parameters having meaningful physical magnitudes and signs (for instance the parameter c in $e^{-c^*windspeed}$ must be positive).

Table 31.2 Difference between asymptotic and global background

Station	Smallest difference to global background (ppm)	Comment
Barrow	−1	(31.1)
Pallas	+8	Avg. of (31.1) and (31.3) results
Neuglodsow	−1	Visual inspection
Diekirch	+6	(31.1)
Schauinsland	−1	(31.1)
Mauna Loa	−1	(31.1)
South Pole	−4	Visual inspection

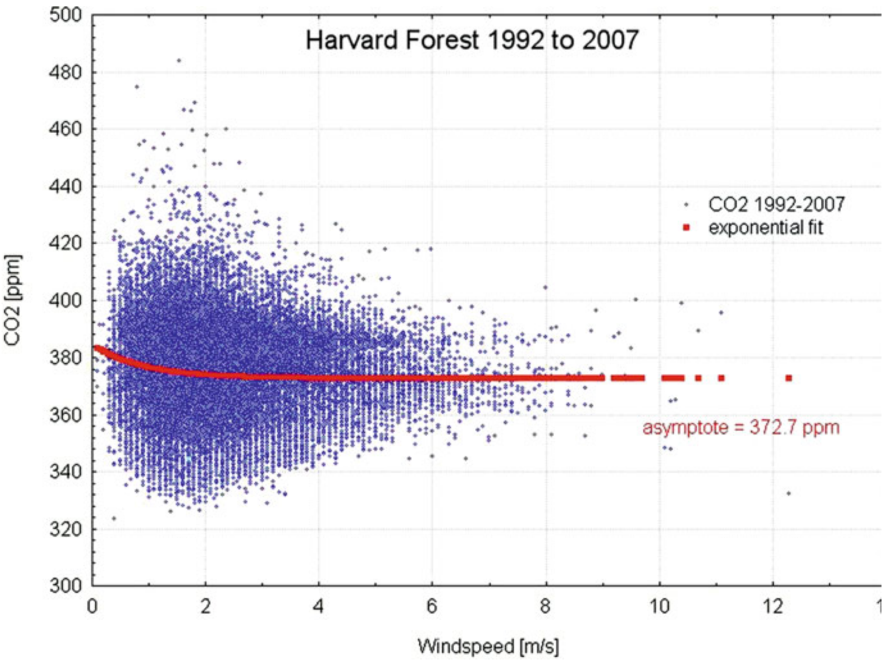

Fig. 31.8 1992–2007 yearly averaged data from Harvard Forest, Ameriflux (data source: Bill Munger, Steven Wofsy): the asymptotic value of 372.7 ppm deduced by an exponential fit differs only by 1.2% from the mean global value at sea level (and only by 0.6% from the latitude adjusted mean Mauna Loa levels over the same 16 years period)

3. If there is neither a finger nor boomerang shape present, a mathematical fit by an exponential or rational function of CO_2 to wind-speed should be used with the usual caution.

Applying an average of visual inspection and/or mathematical fits should give a value that differs not more than about 10 ppm from the convential *global* background CO_2 level.

Validation of Historical Data

The accuracy of historic measurements is estimated at being least at 3% (Beck 2007); this means that the insecurity interval of a result of, for example, 355 ppm is [344. . .366 ppm]. We will apply the preceding validation checks to three historical CO_2 measurement series made at Giessen (D), Liège (B) and Vienna (AU) during the nineteenth and twentieth centuries.

The Giessen (Germany) Measurements by W. Kreutz

CO_2 and weather data were measured by Wilhelm Kreutz in Giessen, Germany (latitude 50.5°) from 31 Aug 1939 to 31 May 1941 by a volumetric chemical method, a variant of the Pettenkofer method (Kreutz 1941; Beck 2007). The instrument used was a commercially available Riedel RICO C gas analyser with an accuracy of ~1.5%.

Figure 31.9 shows the analysis done by Kreutz in 1939–1941 on the influence of wind-direction on CO_2 levels: the urban effect of the city of Giessen upwind in the SW direction from the measurement point is quite visible. North and East winds from the open rural regions correspond to the lowest afternoon CO_2 levels (~377 ppm).

The CO_2 versus wind-speed plot using data sampled at 2 m above ground until May 1940 has neither a clear finger nor a boomerang shape, but the high wind speed data suggest a possible CO_2 range between 466 and 326 ppm, a range too large to be of much use. The mathematical fit by an exponential function (31.1) points to a regional background level of 398 ppm ($R = 0.17$, the asymptote and damping parameter being statistically significant). The IPCC (Intergovernmental Panel on Climate Change) consensus is that global CO_2 levels were about 310 ppm during that period. If we agree to the fact that the Giessen measurements were done with

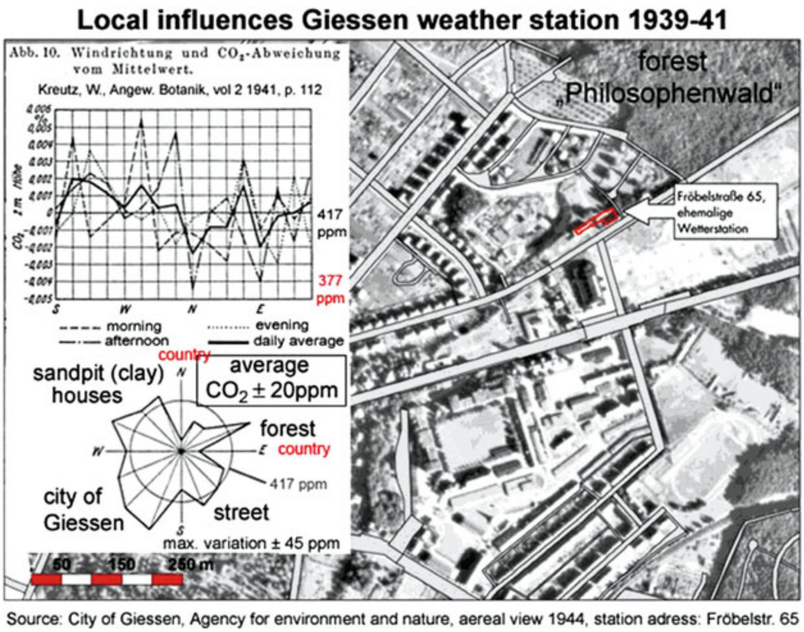

Fig. 31.9 Location of the Giessen weather station at the periphery of Giessen and the CO_2–wind analysis done by W. Kreutz. Data from Kreutz 1941 cited in Beck (2007). The legend "country" means "rural environment"

uttermost care and great precision, that higher wind speeds cause a more thorough mixing up, and that as a consequence the asymptotic level detected will not be an artefact due to poor sampling time and sub-optimal siting, the 310 ppm global CO_2 level seems much lower than the regional background level at Giessen during 1939–1940 (Fig. 31.10).

The Liège (Belgium) Measurements by W. Spring

Much older historical measurements by Spring and Roland were made during the 1883–1884 period at Liège, Belgium (latitude 50.6°) (Spring and Roland 1886). This series is characterized by a careful calibration of the Pettenkofer method and the used gas analyser and by daily sampling conditions held constant. Sampling location was the laboratory of the chemical institute of the University of Liège with air sampled by a tube through the laboratory window at a height of 6 m. Despite the urban location, the Spring measurements can be regarded as one of the most accurate nineteenth century measurement series of CO_2. Figure 31.11 shows the CO_2 versus wind-speed plot of this Spring data.

The asymptotic fit by an exponential function (31.1) has a poor goodness of fit (R = 0.13), but the asymptote is still statistically significant. Similar to Giessen,

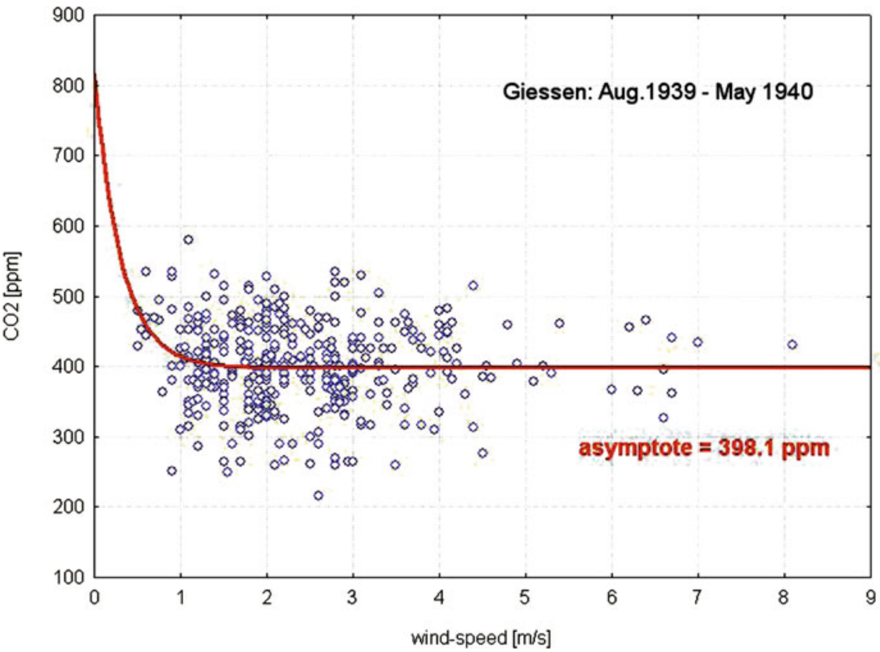

Fig. 31.10 The CO_2 versus wind speed plot of the Giessen measurements by W. Kreutz (average = 402, stdev = 61)

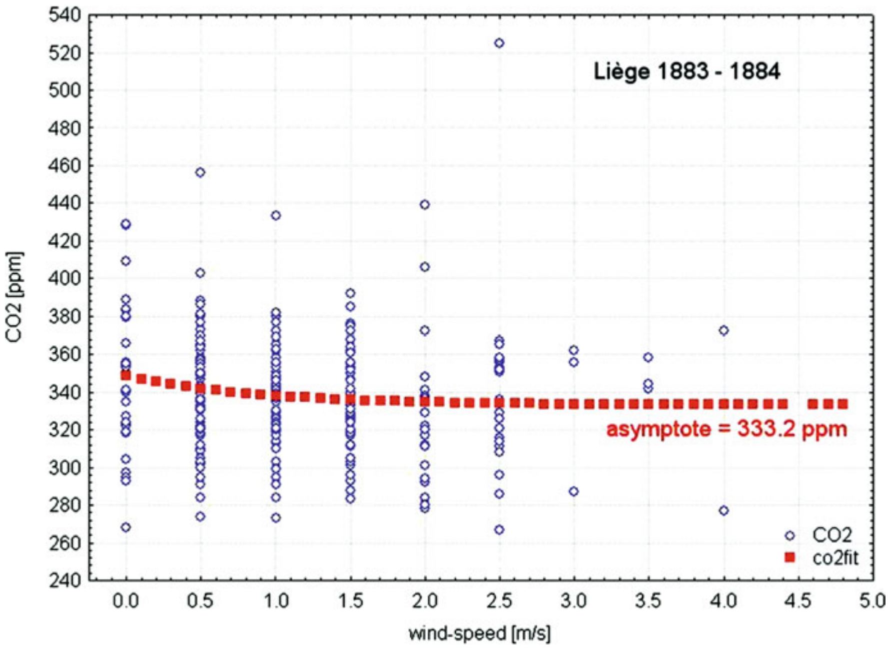

Fig. 31.11 The CO_2 versus wind-speed plot of the Liège measurements by W. Spring in 1883–1884 (average = 338.9, stdev = 32.9)

the local background mixing ratio would be considerably higher than the global ice cores samples consensus value of about 280 ppm for the 1883–1884 period.

The Vienna (Austria) Measurements by F. Steinhauser

There is no obvious pattern visible in this collection of the CO_2 measurements done by Ferdinand Steinhauser from May to Aug 1957 and from Nov 1957 to Feb 1958 at the Zentralanstalt für Meteorologie (located at a hill on the north/west boundary of Vienna, Austria, latitude 48.2°) (Steinhauser 1958). Sampling was done once a day at a height of 25 m above ground. Usually the wind blew from a West/North direction, with the corresponding CO_2 levels lower than the average (as given by the WDCGG). The absence of any finger or boomerang pattern leaves a mathematical fit as a last resort (Fig. 31.12).

Here $R = 0.29$, the parameters of the exponential fit (31.1) are all statistically significant and suggest a regional background level of 324 ppm, reasonably close to the extrapolated Mauna Loa level of 314 ppm for 1957; if we apply a latitudinal correction of $0.06 \times (50 - 20) = 2$ ppm, the difference between the asymptotic Wien background and the latitude adjusted Mauna Loa levels is only 8 ppm, well

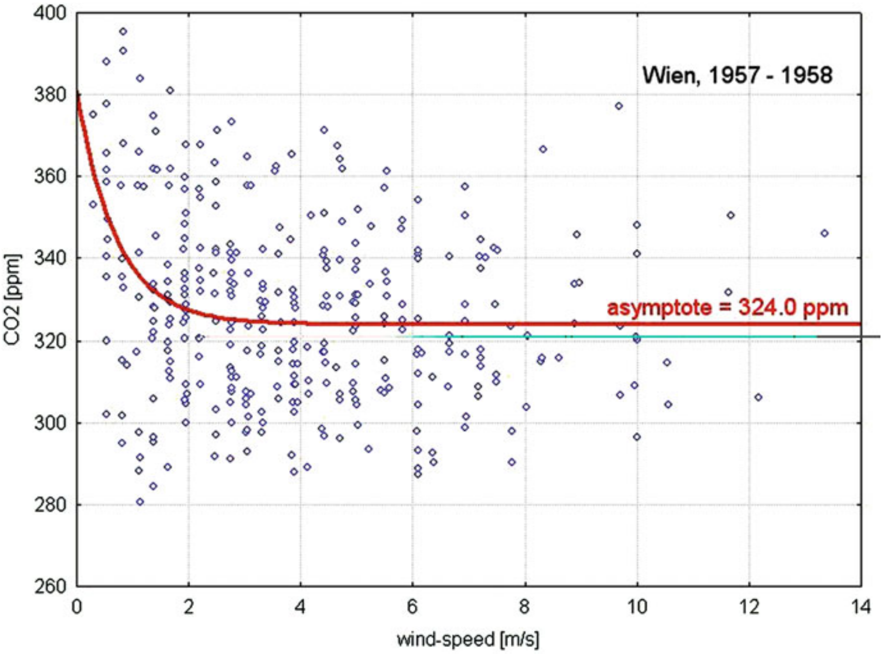

Fig. 31.12 The CO_2 versus wind-speed plot of the measurements made by F. Steinhauser at Vienna in 1957–1958 (average = 327.4, stdev = 22.7)

below the 12–13 ppm criterion suggested in Chap. 3. As a consequence, the Steinhauser measurements should be considered as valid.

Conclusion

It has been shown that the CO_2 versus wind-speed plot can represent a valuable tool to estimate continental local background CO_2 levels despite distorted mixing ratios or local influences. Applying the procedure to recent well-known data gives results that are relatively close to the yearly average of the observational data at Mauna Loa and suggest a maximum difference of about 10 ppm with the global CO_2 background as given by NOAA (National Oceanic and Atmospheric Administration).

A validation check has been made for three historical CO_2 series. The overall impression is one of continental European historic regional CO_2 background levels significantly higher than the commonly assumed global ice-core proxy levels.

The CO_2 versus wind-speed plot seems to be a good first level validation tool for historical data. With the required caveats, it could deliver a reasonable approximation of past regional and possibly past global CO_2 background levels.

References

Ameriflux Network, Harvard Forest Station, http://cdiac.esd.ornl.gov/programs/ameriflux/data_system/aaHarvard_Forest_g2.html

Beck EG (2007) 180 years of atmospheric CO_2 gas analysis by chemical methods. Energy Environ 18(2):259–282

Kreutz W (1941) Kohlensäure Gehalt der unteren Luftschichten in Abhangigkeit von Witterungsfaktoren. Angew Bot 2:89–117

Massen F (2007) Seasonal and diurnal CO_2 patterns at Diekirch, LU. http://meteo.lcd.lu/papers/co2_patterns/co2_patterns.html

Massen F (2009) Pattern of CO_2 and other atmospheric gases during a cold weather inversion. http://meteo.lcd.lu/papers/

Meteorological Station of the LCD. http://meteo.lcd.lu

NOAA, National Oceanic and Atmospheric Administration, Earth System Research Laboratory, Boulder California USA. http://www.esrl.noaa.gov/gmd/ccgg/about/co2_measurements.html

NOAA, National Oceanic and Atmospheric Administration (NOAA). ftp://ftp.cmdl.noaa.gov

Spring W, Roland L (1886) Untersuchungen über den Kohlensäuregehalt der Luft. In: Chemisches Centralblatt No. 6, 10.2.1886, vol 17, 3rd edn.

Steinhauser F (1958) Der Kohlendioxydgehalt der Luft in Wien und seine Abhängigkeit von verschieden Faktoren. Berichte des deutschen Wetterdienstes 51:54, DK 551.510.41

Stephens et al (2007) Weak Northern and strong tropical land carbon uptake from vertical profiles of atmospheric CO_2. Science 316:1732–1735

WDCGG, World Data Center for Greenhouse Gases. http://gaw.kishou.go.jp/wdcgg/

Chapter 32
Adaptation to Climate Change: Challenges for Transboundary Water Management

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Abstract A large part of the world's freshwater resources is contained in river basins and groundwater systems that are shared by two or more countries. As climate change essentially changes the hydrological situation in many basins, increasing the number of extreme situations of flooding and drought, transboundary management of these water resources in order to prevent negative effects of unilateral adaptation measures and in order to choose the most effective measures has become highly urgent.

Transboundary water management is in essence more complex than national water management because the water management regimes usually differ more between countries than within countries. Transboundary water management requires coordination over different political, legal and institutional settings as well as over different information management approaches and financial arrangements.

A Guidance on Water and Climate Adaptation has been developed under the UNECE Water Convention with the objective to support cooperation and decision making in transboundary basins, addressing adaptation to climate change impacts on water resources, such as flood and drought occurrences, water quality, and health related aspects, as well as practical ways to cope with the transboundary impacts. It illustrates steps and adaptation measures that are needed in order to develop a climate-proof water strategy, starting from the transboundary context.

In all the work towards adaptation to climate change, the major challenge for politicians is to have a vision of how to implement the ideas, as well as the courage to withstand criticism and to share power with other actors.

Keywords Climate change adaptation · IWRM · Transboundary water management · Water management regimes

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Introduction

Observational evidence from all continents and most oceans shows that many natural systems are being affected by anthropogenic climate changes. The hydrological cycle which encompasses water availability and water quality as well as water services is severely impacted by these changes (IPCC 2007) and will affect all economic sectors. Adaptation in water management to climate change is, consequently, of central and urgent importance. The impacts will certainly vary considerably from region to region and even from basin to basin, posing serious challenges for water resources management (Ludwig et al. 2009). A particular challenge for water resources management is connected to the fact that many river basins and groundwater systems are transboundary; i.e. the basin is shared by two or more countries. Recent studies identify a total of 279 international river basins (Bakker 2006), draining almost half of the world's total land surface (Wolf et al. 1999).

Similarly, there are also many internationally shared groundwater resources hidden beneath the ground surface around the world. Two UNECE surveys of Europe have indicated that there are some 200 transboundary aquifers in the UNECE region alone (Almássy and Buzás 1999) and an overview of internationally shared aquifers in Northern Africa shows that these aquifers underlie a substantial part of the land surface (Puri et al. 2001). A study done by UNESCO has identified 273 shared aquifers worldwide.[1] The amount of water resources, both surface and subsurface, shared by two or more countries is consequently substantial. This makes transboundary water resources management one of the most important water issues today.

Freshwater supplies are limited. Increasing water scarcity including the availability of water of sufficient quality, partly as a consequence of climate change, leads to a potential increase in water conflicts between countries that share transboundary waters (Yoffe et al. 2004). On the other hand, shared waters can also be a source of cooperation. In fact, initiatives aiming at river basin management regimes and institutions committed to bilateral and/or multilateral cooperation regarding transboundary water resources prevail (UNEP 2002). Such cooperation often starts with exchanging information between countries. Over time, cooperation may come to pass on different water management issues such as joint projects and even joint planning (Enderlein 1999). It should be noted, however, that while many initiatives are in place to jointly manage surface water resources, the same cannot be said about transboundary aquifers, which are usually less developed. By its nature, the beneficial use of groundwater is more particularly subject to socio-economic, institutional, legal, cultural, ethical, and policy considerations than surface water (Puri et al. 2001). Its national development is often hampered by weak social and institutional capacity, and poor legal and policy frameworks. In a transboundary

[1] World-wide Hydrological Mapping and Assessment Programme (WHYMAP). http://typo38.unesco.org/en/about-ihp/associated-programmes/whymap.html

context, this can be even further amplified because of contrasting levels of knowledge, capacities and institutional frameworks on either side of many international boundaries.

But water scarcity is not the only problem confronting neighbours who share transboundary waters. A recent study on floods in a transboundary context concluded that although only 10% of all river floods are transboundary, these floods represent a considerable amount of the total number of casualties, displaced/affected individuals, and financial damages worldwide (Bakker 2006). The situation is compounded by the inherent difficulties in managing floods that cross borders.

Water scarcity is, however, caused not only by natural processes but also by inadequate and inefficient water management and competition between water uses (Wester and Warner 2002). Thus, where water resources management is complex, water management in a transboundary situation is even more complicated, in particular when this management has to account for the consequences of climate change. Given the abundance of water resources that are shared between countries, transboundary water management is an essential element to consider in sustainable water resources management and adaptation to climate change worldwide. As there are many other pressures on water resources next to climate change, such as population growth, migration, globalization, changing consumption patterns and agricultural and industrial developments, water management should look at all the pressures in an overall strategy in order to adapt to global changes.

This paper addresses adaptation to climate change in transboundary water resources management, concerning both quantity and quality. It discusses the theoretical background of transboundary water management and the way climate change adaptation can be addressed. In addition to that, the UNECE Guidance on Water and Climate Adaptation is described as an important tool to guide countries in putting water adaptation to climate change into practice.

Assets and Limitations in Transboundary Water Management

Several factors exist that will support or hinder cooperation between countries in transboundary water management. First, the characteristics of a given problem will influence the likelihood of successful cooperation; if the cooperation incentives are largely symmetric and the problem pressure is high, the prospects for effective cooperation are good. Second, cooperation between countries in collecting data and performing joint projects builds trust at the technical level and enhances cooperation on political levels. Thirdly, a clear institutional setting that is problem-oriented, flexible and equipped with a centralized organization structure enhances cooperation. (Joint bodies can be instrumental in this regard. Economic-technological capacities in the national water sectors as well as political stability are important factors for the development of joint water management). Finally, the international context is essential: if bilateral relations (characterized by mutual trust and cooperation), exist, effective transboundary water management will be possible (Lindemann 2006).

Transboundary water management nevertheless heavily depends upon circumstances at the national level. Weak social and institutional capacity, poor legal and policy frameworks, and bad management practices bear great consequences in the transboundary context where they are even more amplified by differences between riparian countries. Improving transboundary cooperation is therefore enhanced by promoting development and implementation of (formal or informal) transboundary agreements, accounting for different political and cultural settings in the riparian countries, and involving major stakeholders (different national government bodies, regional and local governments, international governments and donors, the media, civic society, individual water users and/or influential individuals) to maximize the likelihood of agreement (Mostert and Barraqué 2006). The method of achieving this goal is, however, context-specific – there is no single template that can be applied to all situations.

Water Management Regimes

Water management is based on certain (implicit or explicit) principles, rules, and decision-making procedures that enable convergence of stakeholders' expectations. Such a set of principles, rules, and procedures is called a regime. Transboundary water regimes usually include formal rules such as international water conventions, statutes of transboundary water commissions, cooperative agreements adopted by national governments aimed at coordinating national water management activities in transboundary water basins, and relevant national laws and procedures. Regimes also include informal rules such as traditional ways of using natural resources (traditional ways of transport or fishing, for example) that are informally accepted in transboundary water basins but are not documented as formal norms in agreements or contracts (Roll et al. 2008).

Prevention and resolution of (potential) conflicts between water uses in riparian countries, and avoidance of severe effects of floodings, droughts, accidents, etc., especially in transboundary waters, compels countries sharing a water resource to reach agreement on common rules and procedures of cooperation to jointly manage these water resources (Nilsson 2006). This cooperation is a component of the overarching term "water governance", which depicts a change in thinking about the nature of policies. The notion of government as the single decision-making authority is being replaced by a more contemporary, multi-scale, polycentric governance. Governance takes into account that a large number of stakeholders in different institutional settings contribute to policy and management of a resource. Governance differs from the old hierarchical model of government in which state authorities exert sovereign control over the people and groups making up civil society. Governance includes the increasing importance of basically non-hierarchical modes of governing, where non-state actors (formal organizations such as NGOs, private companies, consumer associations, etc.) participate in the formulation and implementation of public policy. Governance thus encompasses a broad range of processes related to the coordination and steering of a wide range of stakeholders by formal and informal institutions. The water management regime is consequently a pivoting point in achieving a well organized water governance system which supports adaptive management of water resources (Timmerman et al. 2008).

The principles of Integrated Water Resources Management (GWP-TAC 2000) are the generally accepted basis for water management regimes and, if well implemented, can be very supportive in adaptation to climate change. IWRM includes the water-related sectors such as agriculture and forestry in its approach and water – related sectors should adopt these principles. Water-related sectors rely on the availability of water resources but should be aware of their responsibility for these water resources as well.

Water management faces major challenges caused by the variability and changing nature of water supplies as a result of climate change, along with the limited nature of scientific information and technical knowledge. Reliance on conventional methods of water management, based on the statistical analysis of historical data series, is in many cases not sufficient. Under such conditions, analysis should proceed iteratively with an emphasis on uncertainties rather than on the known (Kabat and van Schaik 2003; Pahl-Wostl 2002). Adaptive management is advocated as a timely extension of IWRM to cope with these challenges. Adaptive management aims at increasing the adaptive capacity of river basins based on a profound understanding of key factors that determine a basin's vulnerability. More attention has to be devoted to understanding and managing the transition, the structural change in the way a societal system operates (Van der Brugge et al. 2004), towards more adaptive regimes that take into account environmental, technological, economic, institutional, and cultural characteristics of river basins (Pahl-Wostl et al. 2005; Pahl-Wostl 2007). This transition implies a change towards understanding management as learning rather than control, and towards including the human dimension as integral part of the management process (Gleick 2003) (Fig. 32.1).

Thus far, different elements of management and use of water resources have been mentioned. These elements are structured here into five central elements that describe transboundary regimes: policy setting, legal setting, the institutional setting including the actor networks, information management, and financing systems (Anon 2001; Raadgever et al. 2008). These elements are discussed in detail below.

Policy Setting

Water policies that are in place in a country can be found in the formal documents which contain current and future water management strategies. They refer to the goals of government, or other organizations and strategies to reach those goals. As

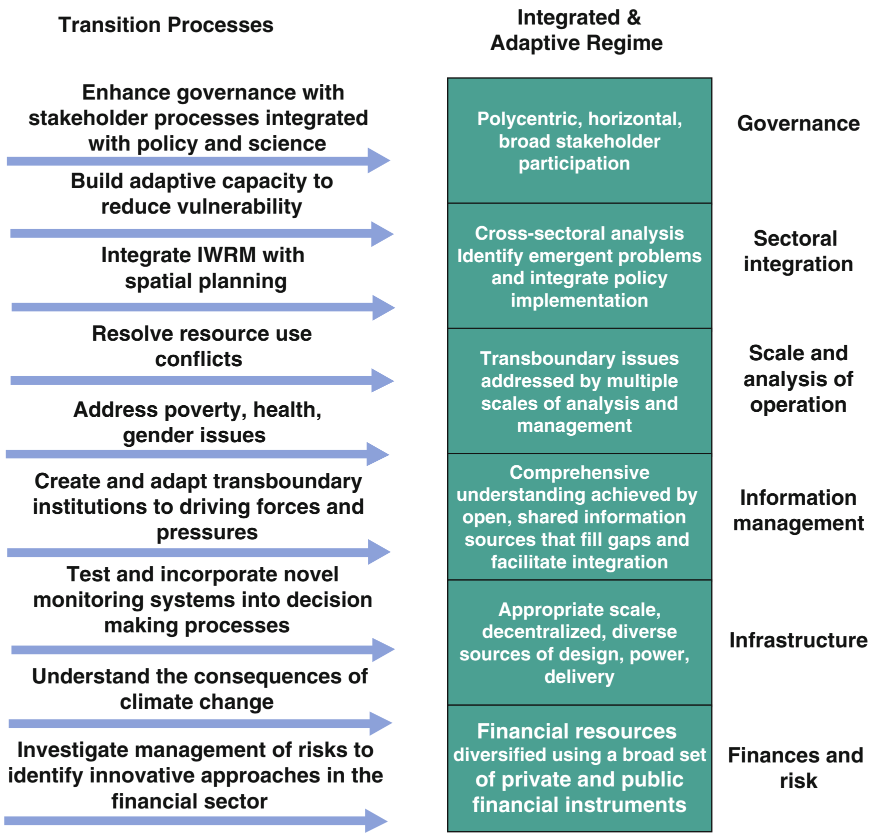

Fig. 32.1 The transition towards adaptive regimes (Timmerman et al. 2008)

policies have a strategic character, especially in view of climate change, they should have a long-term time horizon: current management should actively prepare for future changes. Policy strategies should fulfil current needs and have the ability to perform well in multiple possible futures and in a changing environment. Multiple societal drivers and pressures are influencing water demand. Economic developments and growing wealth, for instance, lead to changes in demands for food and fuels. The price of oil is fluctuating and the demand for biofuels is increasing due to climate change, which, however, has negative impacts on food production. Such developments have large implications for water management. The concept, for instance, of virtual water/water footprint (Hoekstra and Chapagain 2007) tries to capture these implications by enabling comparison of such non-equivalent entities.

This example shows that, in part, water and energy are two sides of the climate change issue (adaptation and mitigation). Water can be an important producer of energy (for instance, hydropower) but can also be an important consumer of energy (for instance, desalinization or pumping). Energy production and use, on the other hand, is an important driver for climate change and thus complicates water management. Energy production and use also affects the aquatic community through infrastructure development and warming of water. Energy is nevertheless also sometimes necessary for adaptation measures, for example irrigation. Some measures such as increasing water use efficiency serve, however, both adaptation and mitigation purposes (Bates et al. 2008; Swart and Raes 2007). The challenges for the water sector and the energy sector are therefore to find solutions that minimize the negative effects and maximize the synergies between adaptation and mitigation measures.

Because today's information is not sufficient to identify all possible futures, strategies should be flexible and keep as many options open as possible (Raadgever et al. 2006). To promote effective implementation, policies should be tailored towards the specific interests and resources of the involved parties. From the perspective of adaptation to climate change in water management, dealing with the inherent uncertainties implies that water management becomes more and more a learning activity in which policies become hypotheses and the consequent management actions become experiments to test those hypotheses. This requires continuous monitoring of progress toward achieving policy objectives as well as learning from the results of management actions (Raadgever et al. 2008).

A major challenge in managing transboundary waters is that no single government has complete control. As a consequence, the waters are managed in the context of potential inconsistency and conflict of policies of the different countries involved. In a transboundary water management situation, the upstream country often has control of the volume of water discharged to the downstream country. Using water inefficiently in the upstream country can result in water shortages in the downstream country. Transboundary water management is consequently faced with the task of solving complicated problems dependent on the specific conditions created by the interaction of two or more political systems (Gooch et al. 2003). Harmonization of policies, or at least coordination and consultation, is needed to prevent situations in which management actions in one country neutralize or counteract management actions in other countries. In such situations, communication and exchange of policies and plans is imperative.

One essential strategy that is not sufficiently used is management of water demand. Water use is often not efficient and is frequently wasteful, usually because the incentives to use water efficiently are not in place. As climate change and climate variability affect the availability of water resources, water management and water use can no longer be driven by the demand for water resources (Allan 2008). On the contrary, water demand should adapt to the possibilities for supplying water. This does not exclude the necessity to improve and safeguard the availability of water resources. Adaptation measures should therefore be explored that not only cover the water sector, but also include sustainable land management, both on the national and transboundary level.

Water-related sectors, especially those that rely on large amounts of water, can be expected to face more severe problems as a result of climate change impacts. This will require them to reconsider their current practices and improve them. The need for reconsideration alone can be believed to be an opportunity to improve sectors' performance. Moreover, climate change not only poses threats to water-related sectors, but may also have impacts that can be advantageous to some sectors, such as protracted growing seasons or improved weather conditions for tourism. And the development of new technologies and approaches may become unique selling points for which a potentially global market is available. Climate change thus opens the need for sectors to critically review and adapt. In the transboundary context, climate change might be an incentive to find cooperative arrangements which benefit the whole basin, such as joint water conservation projects, and joint flood protection management strategies and infrastructures. Climate change adaptation policies in water management should consequently include aspects such as spatial planning, water quality, regulatory and operational measures, capacity building, financial instruments, awareness building, and involvement of the public. In the transboundary context, this also includes solidarity between countries.

Legal Setting

The legal framework consists of the full set of national and international laws and agreements. Legal frameworks can support transboundary water management in various ways. First, law should be complete and clear and contain sufficient detail to offer guidance and support without being too restrictive. A complete water law reflects the principle of integrated water management and includes requirements for public participation and access to information. Furthermore, water laws can establish or influence formal networks, structures for information management and financial aspects of water management. Water management planning and implementation should be based on the existing legal framework and in turn may influence the legal framework. In addition, a transboundary legal framework should support enforcement of management policy and include liability aspects, as well as dispute settlements provisions. Due to climate variability and the large uncertainty associated with climate change impacts, law should not limit management options but should provide incentives to alter management actions to changing circumstances. This can be achieved by including regulations for (periodical) review and change of laws and regulations including changes in the institutional setting, information management, and financial systems (Raadgever et al. 2008).

The Convention of the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (UNECE 1992) is an important example of a legal setting in a transboundary context. The Water Convention is intended to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwaters and represents one of the most essential legal frameworks in the UNECE region, and potentially beyond, to cooperate on the transboundary aspects of climate change and on the development of adaptation strategies. Its provisions include, among others, the obligation to Parties to prevent, control, and reduce transboundary impacts. Consequently, adaptation measures, such as the construction of dams and reservoirs, should be designed and managed to avoid negative transboundary impacts and to generate the best possible benefit for the whole river basin. Therefore, the Water Convention requires consultation between the riparian countries.

An important principle of the Water Convention is the precautionary principle which implies, in the case of climate change, that action be taken even before adverse impacts are fully scientifically proven. This principle is especially important in climate change adaptation as high uncertainties exist regarding the exact impact on water and other ecosystems. The Water Convention also includes provisions for exchange of information, common research and development, and joint monitoring and assessment, thus providing a framework for riparian countries to cooperate in the development of adaptation strategies.

One of the most important provisions of the Convention is the establishment of joint bodies, such as river commissions, to jointly manage the shared water resources. These joint bodies are the most appropriate framework where integrated adaptation strategies, addressing all main environmental, social, and economic impacts of climate change, should be designed and implemented. The Water Convention thus sets the provisions to develop and implement the elements of a transboundary water management regime.

Institutional Setting

Water management in literature is currently described in terms of complexity where problems are termed wicked (Rittel and Webber 1973) or persistent (Van der Brugge et al. 2004). Given the differences in assessments between countries and the increased difficulty for countries to jointly manage their shared waters, impacts of climate change may hit water resources hardest in transboundary water management situations. The study of Bakker (2006) mentioned earlier showed that transboundary river floods, which only include 10% of the total number of worldwide floods in the period 1985–2005, are more severe in their magnitude and account for 32% of all casualties, almost 60% of all affected individuals and 14% of all financial damage.

The complexity of water management implies that a wide range of governmental and non-governmental stakeholders should be actively involved (Ridder et al. 2005). All stakeholders in this approach should be invited to share and discuss their perspectives in the subsequent stages of the policy process and develop a process of active learning. These interactions can promote constructive conflict resolution which can result in inclusive agreements that the parties are committed to. In addition to formal networks, informal multilevel actor networks can enhance information flow, ensure collaboration across scales, and provide for social memory (Raadgever et al. 2006).

The study by Bakker (2006) revealed that the institutional capacity in transboundary river basins is low and, even where joint bodies are in place, only few of these deal with transboundary flooding. The lack of transboundary cooperation in water resources management is consequently likely to aggravate the climate change impacts. The need to establish joint bodies is therefore imperative. Joint bodies responsible for the management of shared waters, either surface or subsurface, can realiue participation in transboundary water management. To achieve this, they should support an interdisciplinary and intersectoral approach, and include stakeholders in their water management planning and implementation strategies (Raadgever et al. 2008).

Information Collection and Management

Information is needed to assess the current situation and existing vulnerabilities (water quantity and quality for example) to develop understanding of the possible futures, but it is also needed to monitor policy progress. Such information should be collected based on an understanding of the need for information for policy making and policy evaluation. One of the essential elements in narrowing the gap between the available knowledge and concrete decision-making is the creation of mutual understanding. Scientists need to share knowledge between different disciplines (e.g. hydrology and climatology). They also need to connect to the problems decision makers are facing. They should, for instance, not try to explain what the models they use are capable of doing, but rather explain why their predictions give a range of possible futures. Decision-makers, on the other hand, should try base their decisions as much as possible on scientific results, recognizing, however, that science has limitations. They should, for instance, not expect an unequivocal answer but rather be satisfied with a limited range of possibilities. A one-time meeting between scientists and decision-makers will not achieve mutual understanding – this will require intensive cooperation between the groups (Timmerman and Langaas 2004). Decision-makers should therefore be closely involved in specifying information needs (Timmerman et al. 2000). Moreover, a broad range of governmental and non-governmental stakeholders should have an opportunity to express their perspectives in the decision-making process and should provide sufficient information to support their opinions. They should also be invited to articulate their information needs and formulate the production of information.

To be truly integrative, information should not only reflect multiple perspectives, but also consider current and future uncertainties. Furthermore, a system to exchange and discuss data, information, and viewpoints should be developed to support cooperation and participation within, but even more importantly between, countries. Only then can information production and exchange result in the use of information in policy debates, and influence water management decisions (Timmerman and Langaas 2004). This also requires clear communication about the interpretations and assumptions used to produce the information and critical (self-)reflection by the producers (Ridder et al. 2005).

In a transboundary context, the situation can become more complex as data needs to be shared. However, there may be differences in the availability of knowledge and data between countries. Countries often use different techniques, approaches, and models for their water management, which may result in different assessments of river basins and groundwater aquifers (Almássy and Buzás 1999; UNECE 2007). This requires riparian countries to exchange information and come to agreements on the methodologies of data collection or to do joint monitoring of the waters they share upon which joint water management strategies can be built.

In reality, information and data are, however, not always shared between countries, and information management faces the challenge of exchanging comparable information of sufficient quality. In other cases, information and data are collected and reported only because of the legal obligation to do so, without consideration of their actual applicability. Information and data collection can also be considered a hideout or safeguard where collecting information provides a sense of doing much useful work without actually having to implement solutions. Through this approach, the argument of lack of information can be used to postpone decisions on real actions. Evidence of climate change occurring is, however, conclusive. Postponing adaptation measures because the information is insufficient to prove beyond reasonable doubt that change is occurring cannot be an option.

Information can also be (mis)used as a “weapon”, by using it to direct blame at other parties and to validate claims that it is the other party who is polluting the water or causing floodings. Information is, in this sense, also used to direct decision making. Information that supports the desired outcomes will be put to the fore, while information that counters the desired outcomes will be hidden. Ideally however, information should be used to support decision-making; the available information should be the basis for the decision taken, guiding and supporting the decisions (Timmerman and Langaas 2004). The latter use of information is the preferred one, as this supports the necessary participative approach towards adaptation. It nevertheless requires that information collection be tailored to the needs of the stakeholders, at local, regional, national, and international levels. All this depends on the willingness of actors to invest in improved understanding of the mutual differences as well as commonalities.

Effective adaptation to climate change requires capacity building at all levels. Adaptation should be done in a participative way and this can only be achieved if all stakeholders involved have sufficient knowledge of the circumstances and the methods and tools that are used to develop possible futures, but also about possible adaptation measures. This is even more important since a major part of adaptation is expected to occur through autonomous adaptation which might have negative unintended consequences. Moreover, they should have the available information at their disposal. Because water management also requires involvement of local communities and local stakeholders, special attention should be given to the information channels used to inform and involve these groups. Communication on the local level often takes place through local newspapers, some of which are distributed free of charge. Next to that, information campaigns and local meetings are important in developing a dialogue with local authorities and inhabitants. The use of the internet is not yet commonplace in many communities but access is growing. The internet is therefore a potentially important vehicle to share information with local entities (Roll and Timmerman 2006).

Financial Systems

Sufficient resources should be available to ensure sustainable water management. In particular, climate change adaptation requires significant additional financial resources. Financial as well as ecological sustainability can be improved by recognizing water as an economic good and recovering the costs as much as possible from the users. Cost recovery from the users of the resource is an important funding source which can be directly linked to the intensity of use, but equity considerations need to be taken into account. This makes the users aware of the consequences of their activities and helps to avoid overexploitation. While water pricing can reduce excessive water use, access to clean water and sanitation should be offered to all humans at an affordable price (GWP-TEC 2003). The cost of providing affordable public goods can be financed from national taxes.

Transboundary river basin management faces the costs of producing a diverse set of public goods (e.g. flood protection) and market goods (e.g. hydropower), as well as the costs of the management process itself (e.g. travel costs). Resources for this should come from public as well as private sources. International donors and banks often bear the management costs of negotiating an international treaty, but they may also finance river basin commissions and projects for a longer time, and give loans for specific projects. However, too much dependence on donors and banks makes management vulnerable and not sustainable in the long term. The challenges confronting financing systems for transboundary river basin management are to ensure sufficient funding, prevent perverse price incentives, and maximize learning opportunities. Moreover, the total costs should remain acceptable. Although participatory approaches, experimentation, and monitoring outcomes cost money, in the long run they may prevent costly delays and construction of unnecessary, expensive infrastructure. And financing systems are most robust when they can rely on multiple sources (Raadgever et al. 2008).

The Stern Review clearly declares that it is important that action regarding climate change adaptation and mitigation should be taken as soon as possible because delay will surely result in increased costs (Stern 2007). This not only relates to mitigation but also to adaptation. The money, however, should be wisely spent. To determine the best options for taking measures, a vulnerability assessment should be performed to identify the most vulnerable areas. Planning of measures should target these most vulnerable areas. Cost-benefit analysis is also necessary. In a transboundary context, measures that support adaptation in one country might be more effective if they are implemented in another country. Prevention of flooding, for instance, might be realized by creating retention areas upstream and such areas may be located in an upstream country. Financing should be equitably shared, where the party that gains most, pays most.

As riparian countries may have different approaches towards developing adaptation measures, a common understanding of the situation between the countries and a common approach is needed. Existing international agreements provide directions in this respect and the Guidance will be supportive in developing measures that are not only effective in one country but will also benefit others. The Guidance, for instance, states that in general, costs of implementation of adaptation measures should be borne by each country and governments should make efforts to include budgets and economic incentives in relevant bilateral and multilateral programs (UNECE 2009). The poorest countries, that are often also most vulnerable to climate change, should be supported by more affluent countries in their development towards climate proofing of water management.

Guidance on Water and Climate Adaptation

In 2006, the fourth Meeting of the Parties of the UNECE Water Convention established a Task Force on Water and Climate which was entrusted with the development of a Guidance on Water and Climate Adaptation that was adopted by the Parties to the Water Convention in November 2009. The objective of the Guidance is to support cooperation and decision-making in transboundary basins on a range of relevant or emerging issues related to climate change. For this purpose, the Guidance addresses adaptation to possible impacts of climate change on flood and drought occurrences, water quality, and health-related aspects. It also addresses practical ways to cope with transboundary impacts through, inter alia, integrated surface and groundwater management for flood and drought mitigation and response (UNECE 2009).

The Guidance utilizes the existing knowledge base as developed under the Water Convention, as well as additional experiences and knowledge and describes the stepwise approach towards climate proofing of transboundary water management. The work on the Guidance builds on the experiences from many national experts and experts from international organizations. It also builds on a questionnaire that was sent out in early 2008 to identify expected impacts of climate change on water resources as well as the adaptation measures planned or implemented in southeastern Europe, eastern Europe, the Caucasus, and Central Asia. Moreover, the work on the Guidance builds on the outcomes of an international workshop that was held in Amsterdam on 1–2 July 2008 to discuss the first draft of the document. In addition, the Guidance was reviewed by experts in an expert review and by focal points. Thus, the contents of the Guidance are aimed to reflect the state of the art in climate change adaptation, support the existing challenges that countries face, and, through its comprehensive and integrative character, add to the existing water management practices.

The Guidance illustrates steps and adaptation measures that are needed to develop a climate-proof water strategy, especially in a transboundary setting. It focuses on the additional new challenges for water management deriving from climate change: what are the impacts of climate change on water management planning and how should this planning be modified to adapt to climate change? Moreover, the Guidance promotes the integration of specific water management aspects in general national adaptation strategies.

The document begins from a transboundary context, but is intended to be relevant to national policy and planning strategies and to be based on measures developed for national purpose. The major target groups of the document are decision-makers and water managers, including those responsible for water management in the transboundary context. It therefore addresses primarily issues relevant to the water management sector, but can also be relevant for other water-related sectors.

The Guidance is a roadmap towards climate proofing of water management which will focus on adaptation or coping options. The document follows a step-wise approach (Fig. 32.2), which forms the basic structure of the document. The guidance thus addresses the five central elements of transboundary regimes: policy setting, legal setting, institutional setting, information management, and financing systems. The policy, legal, and institutional settings form a triangle and influence each other. Their interrelationships should be such that they create an enabling environment in which adaptation to climate change can be shaped.

Whereas there is a general tendency to consider climate change as a self standing issue – as was also shown by the survey questionnaire distributed by the Task Force – the Guidance promotes the integration of climate change adaptation into water management. Climate change can thus act as an important driver to improve water

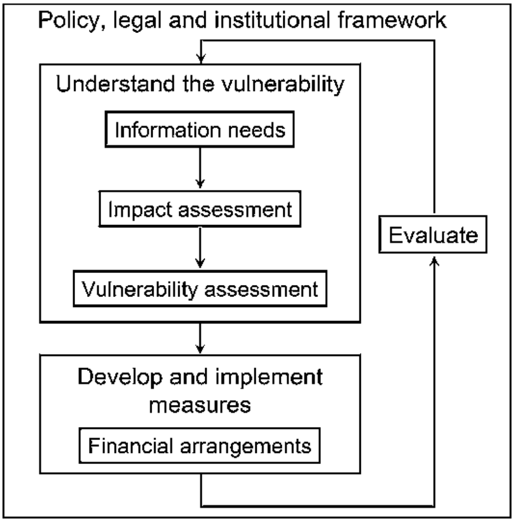

Fig. 32.2 Development of an adaptation strategy (UNECE 2009)

management strategies. In the Guidance, climate change information is, next to, among others, hydrological and socio-economic information, one of the elements upon which the vulnerability of communities in a basin is assessed. The criteria to determine vulnerability are subjective and politically sensitive. Therefore, meticulous consideration of the information needs is required because it steers the outcomes of the vulnerability assessment. Additionally, this information is needed to evaluate the effectiveness of measures, as well as reflect upon the validity of the policy base under changing circumstances.

Regarding the financial arrangements, riparian countries should focus on generating basin-wide benefits and on sharing those benefits in a manner that is agreed to be fair. A focus on sharing the benefits derived from the use of water, rather than the allocation of water itself, provides far greater scope for identifying mutually beneficial cooperative actions. Payments for benefits (or compensation for costs) might be made in the context of cooperative arrangements. Riparian countries can be compensated, for example, for land flooding as a consequence of water impoundment by another riparian. In some instances, it might be appropriate to make payments to an upstream country for management practices of the basin that bring benefits downstream (e.g. reduced flooding and sediment loads or improved water quality). This solidarity in the basin might entitle upstream countries to share some portion of the downstream benefits that their practices generate, and thus share the costs of these practices (Bernardini 2007).

The Guidance is an important building block in the implementation of the UNECE Water Convention. It is expected that the Meeting of the Parties to the Water Convention will assist countries in applying the Guidance in development of their water management regime. In addition, the Meeting of the Parties will promote application of the Guidance by assisting in the establishment of pilot projects under existing programmes as well as encouraging application of the Guidance in capacity building programmes.

Pilot projects are especially important because they illustrate how transboundary cooperation can grow. In initiating a pilot project, riparian countries must show their willingness to engage in dialogue and cooperation with other riparian countries. The size of this step is limited because it concerns a pilot project supported by international regulations. Performing a pilot project enables countries to collaborate on a working level that may also influence decision-making. As a result, it is expected that, in the longer term, the Guidance will support the revision of formal cooperation arrangements (such as bilateral and multilateral agreements, mandates and actions of joint bodies) to include adaptation to climate change.

Conclusions

While water management is a key factor for adaptation, adaptation of water management to climate change is not a standalone issue that needs to be tackled: it should be an integral part of integrated water resources management. Starting from this premise, politicians should be aware that there are five main approaches that need attention in the overall water management that will also help in finding solutions for climate change effects.

First is that collaborative governance in water management should be strengthened. Adaptation measures should be built on a joint effort of government, society and science to ensure that measures will be effective and sustainable. This requires building of trust and social capital to ensure the problem solving process takes place. As stated before, pilot projects can be very supportive in achieving this. It will also require improving disciplinary integration, on the technical as well as the policy level (e.g. inclusion of spatial planning in water management). The development of new governance and participation models is indispensable in dealing with transboundary water management situations. This includes harmonization of political, legal, and institutional settings over administrative borders. Joint bodies are the obvious institutions to lead such changes, but often lack the mandate to implement such provisions. Improved information management is needed to support the processes on national and international levels.

Second is a paradigm shift from water supply management, where the water resources are managed in a manner designed to supply the needs for water, to water demand management, wherein the use of water by a wide range of sectors is adapted to the availability of water while deterioration of the water quality is avoided. Use of water is often not efficient and as long as water management efforts are made to meet this use, for instance through redirection of flows, there is little need to modify existing use requirements. Measures should therefore focus more on improving efficiency and sustainability of water use to ensure continued supply of water of sufficient quality to the different uses in times when the resources become scarce. A specific issue in this regard is avoidance of conflict and contradiction between mitigation and adaptation strategies. Measures intended to increase water availability may also increase the use of energy (desalinization plants and pumping of groundwater, for example), thus adding to the emission of greenhouse gases. Mitigation measures, on the other hand, such as the development of biofuels, increase the need for water, thus aggravating water stress. Adaptation measures should therefore be evaluated for their energy efficiency while mitigation measures should be evaluated for their water efficiency.

Thirdly, this underlines the need to look for non-structural adaptation measures. This relates, among others, to the need for demand management, where legal and policy agreements are needed to alter the use of water to improve efficiency. In addition, incentives should be created to promote more sustainable use of water in not only agriculture and industry but in domestic use as well. Next to that, human activities that increase vulnerability, such as building settlements in flood-prone areas, should be discouraged through policy and legal actions. In all this, attention is specifically needed for subsurface water resources.

Fourthly, adaptation to climate change and other drivers of change such as energy and food prices, demographic trends, migration flows, and changing production and consumption patterns should be viewed as a long-term, continuous exercise and not a “one-off” set of measures.

Finally, financing of measures is an important element of adaptation. An important principle here is that the use of water resources comes with a price, for instance based on the valuation of the service provided by water and the water-related ecosystems. It should, however, be noted that such an approach may lead to unexpected and unwanted effects, particularly for the most vulnerable groups. Close attention is warranted to avoid such unintended consequences.

While all this may appear obvious, implementation of these recommendations is highly demanding and will have to overcome the inertia of traditional approaches and resistance from various actors. The need to start climate change adaptation now, disregarding the high uncertainties, the need for flexibility, the inherent interrelationships with other pressures and water-related sectors, and the involvement of stakeholders, is urgent. The challenge for politicians is to have the vision of how to put the ideas into practice, as well as the courage to withstand criticism and to share power with other actors.

References

Anon (2001) Transboundary water management as an international public good, Study 2001:1, Ministry for Foreign Affairs, Stockholm, Sweden, p 129

Allan JA (2008) Knowing water and understanding why we use and consume it as we do. 2008 Stockholm Water Prize Laureate Lecture. http://www.worldwaterweek.org/Downloads/2008/SWP-Allan-Final.Final.pdf

Almássy E, Buzás Z (1999) Inventory of transboundary groundwaters, Working Programme 1996/1999, vol 1. UNECE Task Force on Monitoring and Assessment, Lelystad, The Netherlands

Bakker MHN (2006) Transboundary river floods: vulnerability of continents, international river basins and countries. Oregon State University, Oregon, USA, p 276

Bates BC, Kundzewicz ZW, Wu S, Palutikof JP (2008) Climate change and water. Technical Paper of the Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva, Switzerland

Bernardini F (2007) The UNECE water convention: a unique framework to foster transboundary water cooperation and security. In: Second Preparatory Conference to the 15th OSCE Economic and Environmental Forum, Zaragoza, Spain, 12–13 Mar 2007

Enderlein RE (1999) Paper presented at the UN/ECE Working Group on Water Management meeting, Bonn, Germany, 15 Sept 1999

Gleick PH (2003) Global freshwater resources: soft-path solutions for the 21st century. Science 302:524–528

Gooch GD, Höglund P, Roll G, Lopman E, Aliakseyeva N (2003) Review of existing structures, models and practices for transboundary water management in Europe – The implementation of transboundary water management – identification of present problems and a design for future research. In: Proceedings of the International Conference on Sustainable Management of Transboundary Waters in Europe, edited by Bernardini F, Landsberg-Uczciwek M, Haunia S, Adriaanse M, Enderlein RE, Szczecin, Miedzyzdroje, Poland, 21–24 Apr 2002

GWP-TAC (2000) Integrated water resources management, TAC Background Papers No. 4, Global Water Partnership – Technical Advisory Committee, Stockholm, Sweden

GWP-TEC (2003) Poverty reduction and IWRM, TEC Background Papers No. 8, Global Water Partnership – Technical Committee, Stockholm, Sweden

Hoekstra AY, Chapagain AK (2007) Water footprints of nations: water use by people as a function of their consumption pattern. Water Resour Manage 21:35–48

IPCC (2007) Climate change 2007: Synthesis report. In: Pachauri RK, Reisinger A, (eds) Contribution of Working Groups I, II and III to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, pp. 104

Kabat P, van Schaik H (2003) Climate changes the water rules: how water managers can cope with today's climate variability and tomorrow's climate change. In: Synthesis Report of the International Dialogue on Water and Climate, ISBN 9032703218, p. 106

Lindemann S (2006) Water regime formation in Europe. A research framework with lessons from the Rhine and Elbe river basins, FFU Report 04-2006. Freie Universität Berlin, Berlin, Germany, p. 44

Ludwig F, Kabat P, van Schaik H, van der Valk M (2009) Climate change adaptation in the water sector. Earthscan, London, UK, ISBN: 978-1-84407-652-9

Mostert E, Barraqué B (2006) Transboundary River Basin Management in Europe. Thematic paper for Human Development Report 2006, 2006/21. UNDP, Europe, 16 pp

Nilsson S (2006) Managing water according to river basins. Information management, institutional arrangements and strategic policy support – with focus on the EU Water Framework Directive. Royal Institute of Technology, Stockholm, Sweden

Pahl-Wostl C (2002) Participative and stakeholder-based policy design, evaluation and modeling processes. Integr Assess 3(1):3–14

Pahl-Wostl C (2007) Transition towards adaptive management of water facing climate and global change. Water Resour Manage 21(1):49–62

Pahl-Wostl C, Downing T, Kabat P, Magnuszewski P, Meigh J, Schlueter M, Sendzimir J, Werners S (2005) Transition to adaptive water management, The NeWater project. NeWater Working Paper 1, Institute of Environmental Systems Research, University of Osnabrück, Osnabrück, Germany

Puri S, Appelgren B, Arnold GE, Aureli A, Burchi S, Burke J, Margat J, Pallas Ph (2001) Internationally shared (transboundary) aquifer resources management. Their significance and sustainable management. A framework document, IHP-VI, IHP Non Serial Publications in Hydrology, Non Serial Document SC-2001/WS/40. UNESCO, Paris, France, p 73

Raadgever GT, Mostert E, Kranz N, Interwies E, Timmerman JG (2008) Assessing management regimes in transboundary river basins: do they support adaptive management? Ecol Soc 13 (1):14. http://www.ecologyandsociety.org/vol13/iss1/art14/

Raadgever GT, Mostert E, van de Giesen NC (2006) Measuring adaptive river basin management. In: Colosimo M, Potts DF (eds) Proceedings of the AWRA 2006 Summer Specialty Conference "Adaptive Management of Water Resources". American Water Resources Association (AWRA), Middleburg, Virginia, USA

Ridder D, Mostert E, Wolters HA (2005) Learning together to manage together – Improving participation in water management, ISBN 3-00-016970-9. University of Osnabrück, Osnabrück, Germany

Rittel HWJ, Webber MM (1973) Dilemmas in a general theory of planning. Policy Sci 4:155–169

Roll G, Alexeeva N, Interwies E, Timmerman JG (2008) Analysis of European IWRM research on transboundary regimes. In: Timmerman JG, Pahl-Wostl C, Möltgen J (eds) The adaptiveness of IWRM: analysing European IWRM research. IWA, London, UK, ISBN 1843391724

Roll G, Timmerman JG (2006) Communicating with stakeholders and the public. In: Gooch GD, Stålnacke P (eds) Integrated transboundary water management in theory and practice: experiences from the new EU Eastern borders. First Integrated Environmental Technology Series (Lens, P.). IWA, London, UK, ISBN: 1843390841

Stern N (2007) The economics of climate change. The Stern review. Cambridge University Press, Cambridge, UK

Swart RJ, Raes F (2007) Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies. Clim Policy 7(4):288–303

Timmerman JG, Langaas S (2004) Environmental information in European transboundary water management. IWA, London, UK, ISBN: 1843390388

Timmerman JG, Ottens JJ, Ward RC (2000) The information cycle as a framework for defining information goals for water-quality monitoring. Environ Manage 25(3):229–239

Timmerman JG, Pahl-Wostl C, Möltgen J (2008) The adaptiveness of IWRM. In: Timmerman JG, Pahl-Wostl C, Möltgen J (eds) The adaptiveness of IWRM, analysing European IWRM research. IWA, London, UK, ISBN: 1843391724

UNECE (1992) Convention on the protection and use of transboundary water courses and international lakes. Helsinki, Finland

UNECE (2007) Our waters: joining hands across borders. First Assessment of Transboundary Rivers, Lakes and Groundwaters, Economic Commission for Europe, Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Geneva, Switzerland, http://www.unece.org/env/water/publications/assessment/assessmentweb_full.pdf

UNECE (2009) Guidance on water and adaptation to climate change. United Nations Economic Commission for Europe, Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Geneva, Switzerland. http://www.unece.org/env/water/publications/assessment/assessmentweb_full.pdf

UNEP (2002) Global environment outlook. Past, present and future perspectives. Earthscan, London, UK, p 155

van der Brugge R, Rotmans J, Loorbach D (2004) The transition in Dutch water management. Reg Environ Change 5(4):164–176

Wester Ph, Warner J (2002) River basin management reconsidered. In: Turton A, Henwood R (eds) Hydropolitics in the developing world: a Southern African perpspective. African Water Issues Research Unit, Centre for International Political Studies (CIPS), Pretoria, South Africa, ISBN 0-620-29519-8

Wolf AT, Natharius JA, Danielson JJ, Ward BS, Pender J (1999) International river basins of the world. Water Resour Dev 15(4):387–427

Yoffe SB, Fiske G, Giordano M, Giordano M, Larson K, Stahl K, Wolf AT (2004) Geography of international water conflict and cooperation: Data sets and applications. Water Resour Res 40

Chapter 33
Carbon, Conservation, Communities Under Sustainability (C3S) Paradigm for Forests

Pallavi Pant

Abstract *Purpose*: REDD is being criticized on several fronts and thus, there is a need for an integrated, comprehensive paradigm that incorporates emissions reduction, biodiversity conservation, and community development, and is leveraged towards sustainability in forests and livelihoods rather than narrower goals such as emissions reduction or conservation.

Design/methodology/approach: A SWOT analysis of REDD is conducted and based on the results of the analysis, a new framework is proposed.

Findings: Although REDD has enormous potential to not just reduce emissions but also provide significant co-benefits, there has also been criticism on various fronts. A new theoretical framework with carbon, conservation, and community as the three pillars has been proposed.

Originality/value: The paper proposes a new paradigm that addresses GHG emission reduction, conservation of forests and biodiversity, community livelihoods support, and valuation of environmental services provided by forests. Forests, covering one-third of the earth's surface, are home to more than half of the biodiversity on earth, provide multiple ecosystem services, and contribute to more than a billion livelihoods globally. However, forests have largely been mismanaged and remain one of the key challenges in international as well as national policy and governance. The dual role of forests in climate change, both as a source and sink of GHG emissions, adds to the urgency for action. Reducing Emissions from Deforestation and Degradation (REDD) is being intensely discussed for its likely role in climate change mitigation. The argument had originated with avoided deforestation, subsequently broadened to REDD and is currently being discussed around REDD+, an indication that there is more to this debate than just incentivizing emissions reduction. Although REDD has enormous potential to not just reduce emissions but also provide significant co-benefits, there has also been criticism on various fronts. The author proposes the climate, community, conservation, and sustainability (C3S) paradigm which would include objectives such as GHG

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emissions reduction, valuation of environmental services provided by forests, conservation of forests and biodiversity, and community livelihoods support.

Keywords Climate change · Framework · REDD · SWOT

Introduction

Forests cover about 30% of the total land surface and play an important role in maintaining key ecosystem services and functions such as biodiversity conservation, soil conservation, carbon sequestration, flood control, climate regulation etc. They have the inimitable capability of simultaneously reducing GHG emissions, reducing the vulnerability of people and ecosystems to climate change, and capturing carbon (TFD 2008). It has also been realized that forests play a key role in realizing the Millennium Development Goals (MDGs) and are vital for sustainable development, and societal wellbeing (UNFF 2009). However, in order to maximize co-benefits from forestry mitigation activities, forests have to be seen in the framework of multiple dimensions of sustainable development (IPCC 2007).

Globally, forests store 283 Gt of carbon in biomass, 38 Gt in deadwood and 317 Gt in soil and litter (Joint Liaison of the Rio Conventions, n.d.). Annually, there is approximately 1.5 Gt C per year loss of carbon due to forests in terms of GHG emissions, i.e. 17.4% of global GHG emissions (IPCC 2007). The Stern Review (2006) reported that globally, loss of natural forests contributes more GHG emissions than the transport sector and added that reducing deforestation is one of the cheapest mitigation options. The report also concluded that the opportunity cost of avoiding 70% of the emissions from deforestation would be around US$5 billion per year.

In the recent past, there have been discussions on the role that forestry can play in climate change mitigation. Carbon sequestration, carbon substitution, and carbon conservation are three mechanisms by which forestry can contribute to GHG emission abatement as described in Fig. 33.1. Of the three options, carbon conservation is considered to be the most feasible alternative for quick and low-cost climate change mitigation (Montagnini and Nair 2004). Especially in tropical countries, reducing deforestation is a key mitigation option since it would enable addressing two thirds of GHG emissions due to the forestry sector (IPCC 2007). Carbon conservation, namely addressing deforestation and degradation, is thus being discussed as one of the key mitigation options for reducing GHG emissions.

There have been a large number of unsuccessful non-climate international multilateral initiatives that address deforestation directly or indirectly. However, reducing deforestation had not been addressed as a possible mechanism for climate change mitigation until recently. The Conference of Parties (COP) 7 negotiations in Marrakech (2001) concluded with inclusion of only afforestation/reforestation (A/R) projects while leaving avoided deforestation out of the framework. Consequently, in present times, although countries can earn rewards for planting new

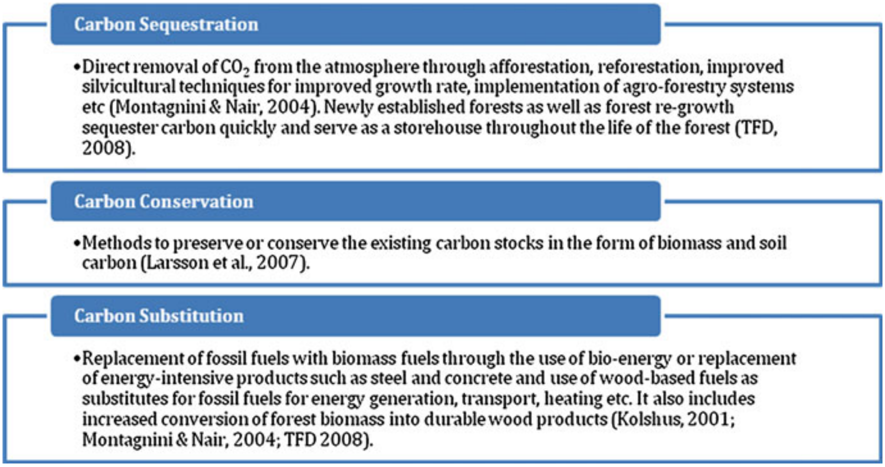

Fig. 33.1 Different mechanisms through which forestry can contribute to climate change mitigation

Technical concerns	Risks	Miscellaneous
Uncertainty about the estimation of avoided deforestation and estimation of hot air	Non-permanence of forestry projects due to natural or anthropogenic disturbances	Issue of sovereignty of nations; *forests were not considered as a global public good* (Engel and Palmer, 2008)
Uncertainty about the scale for emissions reduction	Concern for leakage; avoided deforestation in one region may result in increased deforestation in another region	Fear of dilution of emissions reduction from fossil fuel use due to larger scale of carbon credits generated from avoided deforestation
Uncertainty about the drivers of deforestation; assumed to be diverse and complex		

Fig. 33.2 Reasons for keeping avoided deforestation out of the Kyoto Protocol (Schlamadinger et al. 2005; Skutsch et al. 2007; Benndorf et al. 2007; Fry 2008; O'Connor 2008; Strassburg et al. 2009; Tacconi 2009)

trees under A/R projects, there are no incentives for avoiding deforestation or reducing degradation. The current regime, therefore, presents an interesting proposition in the sense that countries actually have the incentive to deforest and then reforest in order to get rewarded.

Several reasons resulted in the decision to omit avoided deforestation from the Clean Development Mechanism (CDM), including technical factors and risks as elaborated in Fig. 33.2. In addition, Skutsch and Bressers (2008) note that the general sentiment against avoided deforestation during the earlier negotiations could have arisen due to a general lack of information as well as lack of trust in whatever information was available. Until now, the key beneficiaries of the CDM process have been countries such as India and China which are relatively industrialized. Also, the emissions from the forestry sector have been addressed solely through A/R projects under CDM within the Kyoto Protocol. However, such projects have not been very successful and to date, there are only three registered projects.

The argument around REDD originated with avoided deforestation, was subsequently broadened to REDD, and is currently being discussed around REDD+, an indication that there is more to this debate than just incentivizing emissions reduction. There has been a high degree of optimism towards REDD in recent years and it is interesting to note the trigger for such enthusiasm. REDD is seen as being important from a climate as well as a biodiversity perspective. Scientists and policy makers are of the opinion that tropical deforestation needs to be addressed in order to make the international emissions reduction regime holistic. Several assessments and reports in the recent past have concluded that deforestation and forest degradation contribute to global GHG emissions in a significant way. From a difficult-to-handle issue, REDD is now at the centre stage of the international climate negotiations (Angelsen 2008). During its 13th meeting in Bali, the COP stated that REDD should help meet the ultimate goal of the United Nations Framework Convention on Climate Change (UNFCCC), i.e. stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system while addressing the needs of local and indigenous communities and taking sustainable forest management and conservation into consideration.

REDD can be defined as a set of actions to reduce emissions from deforestation and forest degradation in developing countries. It is based on the idea of providing incentives to Non-Annex I countries who voluntarily reduce emissions from the land use sector with the objective of addressing GHG emissions; the idea being that by attaching monetary value to the rate at which carbon is emitted from a tree, the economic incentives for deforestation can be reversed (Angelsen 2008). Furthermore, Chomitz et al. (2007) suggest that it is practical to push for forest conservation since key environmental, social, and economic co-benefits can be seen by considering forestry mitigation options. Additionally, it has been established that the carbon mitigation potential of REDD activities is multiple times that of A/R activities while the cost is much lower (Myers 2007). An important point to note is that although there is much enthusiasm and activity around REDD, many of the concerns that were initially raised earlier still remain.

While REDD(+) has enormous potential to not just reduce emissions but also provide significant co-benefits, there has also been criticism on various fronts. REDD is not a panacea; it is only one of the possible mitigation options for GHG emissions reduction, albeit a low-cost one. A complex, global challenge of reducing GHG emissions is staring us in the face and in this scenario, mitigation options should not be limited to just one or two. There is a need for us to explore various possibilities and try to achieve our end objective with minimal negative externalities. Also, emissions reduction is not the only challenge we are facing and hence, it is time to look for integrated solutions, wherever possible. Such solutions would require a paradigm shift with a focus on multi-faceted programmes that seek to leverage various sectors in one go.

Through this paper, an integrated, comprehensive framework is presented that incorporates emissions reduction, biodiversity conservation and community development. Such a framework would seek to leverage sustainability in forests and livelihoods rather than narrower goals, such as emissions reduction or conservation. The idea is to include various objectives, such as GHG emissions reduction, valuation of environmental services provided by forests, conservation of forests and biodiversity, and community livelihood support, and to find solutions that are all-encompassing.

SWOT Analysis of REDD

In order to assess the feasibility of REDD as an effective GHG emissions abatement option, a qualitative analysis using Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis is carried out. SWOT, a widely used decision-making and planning tool, constitutes an important basis for learning about the situation and for designing future procedures which can be seen as necessary for thinking in a strategic way (Kurtilla et al. 2000; Lozano and Vallés 2007). Table 33.1 shows the results obtained from the SWOT analysis on REDD. The analysis reveals that although REDD has a number of strengths , it also has a lot of causes for concern. One of the key concerns highlighted by many is that implementation of REDD would convert forests into a money-making reservoir and the expected co-benefits would never be achieved. Also, there is speculation regarding countries deliberately slowing down national/local reforms in forestry in order to claim a higher historical baseline (Palmer and Obidzinski 2009 in Engel and Palmer 2008). Furthermore, although a national approach will ensure that there is no sub-national or within country leakage, there would still be chances of international leakage. There is also an apprehension that REDD might lead to out-of-the-system leakage which is to say that reducing deforestation could potentially lead to an increase in pressure on other ecosystems, particularly grasslands (Schmidt 2008).

PES

One of the mechanisms that is being widely discussed and implemented for successful integration of climate change mitigation, communities, and conservation is the use of Payment for Ecosystem Services (PES) schemes. PES can be defined as a voluntary transaction where an environmental service is purchased by a buyer from a provider (Ognowski et al. 2009). PES is defined by five criteria (1) voluntary

Table 33.1 SWOT analysis of REDD

Strengths	*Weaknesses*
Cost-effectiveness: Helps save up to 2 trillion USD A source of revenue for communities and governments in developing nations Addresses deforestation and emissions reduction simultaneously Involves a large number of developing countries in climate change mitigation efforts Does not require technology innovation Easier and faster implementation can be achieved Targets one fifth of global GHG emissions at once	Non-permanence: Disease outbreak, pest attack or fire might lead to forest damage which can result in emissions Leakage: Within country leakage can be addressed through a national approach but risk of international leakage would still remain Limited technical capacity would lead to difficulty in establishing historic baselines in countries with limited and unreliable high-resolution deforestation data Ineffective implementation due to weak governance and institutions; e.g. in case of inadequately defined land rights, land grabbing might occur Flexibility: Lack of standardization would lead to non-comparable systems while internationally standardized verification system might impinge on national sovereignty Countries that have a high rate of deforestation are likely to gain more than countries that have successfully addressed deforestation despite increasing population pressure Could result in cherry-picking, i.e. not accounting for deforestation but reaping benefits from A/R projects In the absence of definitions for forests and plantations, natural biodiversity would suffer and so would efforts to reduce GHG emissions
Opportunities	*Threats*
Co-benefits: Besides emissions reduction, REDD helps reduce poverty, conserve biodiversity, promote community development, sustain/preserve ecosystem services and contribute towards sustainable development Economic development and local capacity building: Greater financial flow into developing countries would not only support economic development measures but also strengthen resilience of local communities' in the wake of threats posed by climate change GHG emissions reduction target can be made more ambitious without significantly increasing the overall cost of emissions reduction Sustainable Forestry: Forest reforms would be promoted within the sustainable forest management paradigm. Also, adding carbon value for forests may lead to an increase in proactive forest conservation and protection	Risk of perverse incentive such that countries may slow down reform in forestry sector to establish higher baselines Flooding of carbon markets with cheap credits in case REDD is integrated in existing carbon market Could lead to cases of land grabbing, land speculation It could lead to increasing pressure on other ecosystems, especially grasslands, savannahs Since good governance is crucial for successful REDD projects, there could be discrimination against countries with weak governance and institutional capacity Forced migration could occur as a result of creation of protected areas for implementing REDD projects In case of a national approach where a national institution is responsible for funds allocation, there is potential for the process becoming bureaucratic and hence leading to increase in corruption. Poor people might never benefit from REDD Large-scale REDD implementation could result in rise in prices of food as well as fuel

transactions; (2) involvement of a well-defined environmental service; (3) the service is "bought" by at least one buyer; (4) the service is "provided" by at least one provider; and (5) the transaction is conditional on provision of that service (Wunder 2005). PES schemes have been implemented in various countries to accomplish a range of environmental goals and objectives. Successful examples have been seen in Costa Rica, Mexico, Australia, etc. In most cases, PES schemes tend to benefit the poor even if poverty alleviation is not a direct goal of the scheme.

Although there are multiple benefits of PES schemes, such as direct incentives and benefits to local people, there are still issues like the impact of poor governance and limited institutional capacity to establish and apply rules.

Thus, it can be concluded that for a successful framework, the key factors are data inventory and modelling, analysis of stakeholders and institutions, and effectiveness of governance in the local context.

The Carbon, Conservation, Communities Under Sustainability (C3S) Paradigm

There have been attempts in the past to move from one ideal, win-win solution to another, and often such attempts have failed in one way or another. However, in order to have successful solutions, we need to attack the underlying institutional problems as well as the drawbacks in the existing development model. In the recent past, the focus on forests has been primarily based on reducing carbon emissions. However, there has been a need for using the ecosystems approach which focuses on ecosystems' impact on development, as well as developmental impacts of ecosystems. Sustainability of forests has emerged as an issue which is being debated currently. Furthermore, since one of the Millennium Development Goals is environmental sustainability, it is imperative to manage forests in a sustainable way. The idea so far has primarily remained as achieving emissions reduction. The next step is to aim to achieve sustainability through linking communities to climate change and conservation. There is an urgent need for establishment of secure land tenure and effective governance in order to promote climate change adaptation and mitigation and biodiversity conservation.

Figure 33.3 shows the C3S paradigm that is being proposed for integrating climate concerns with conservation efforts while taking due care of the community rights within the purview of sustainability. As is illustrated in Fig. 33.3, the key domains for consideration include land use, status of wildlife, and community rights. The first step would be to assess the trends and patterns in these three domains in the past, followed by identification of drivers in the sector. This would help in understanding the synergies between the different sectors and also in shedding light on the drivers need to be addressed. The next step would be to assess the current policies and programmes, followed by an assessment of the effectiveness of the policies based on lessons learnt from past endeavours. Such

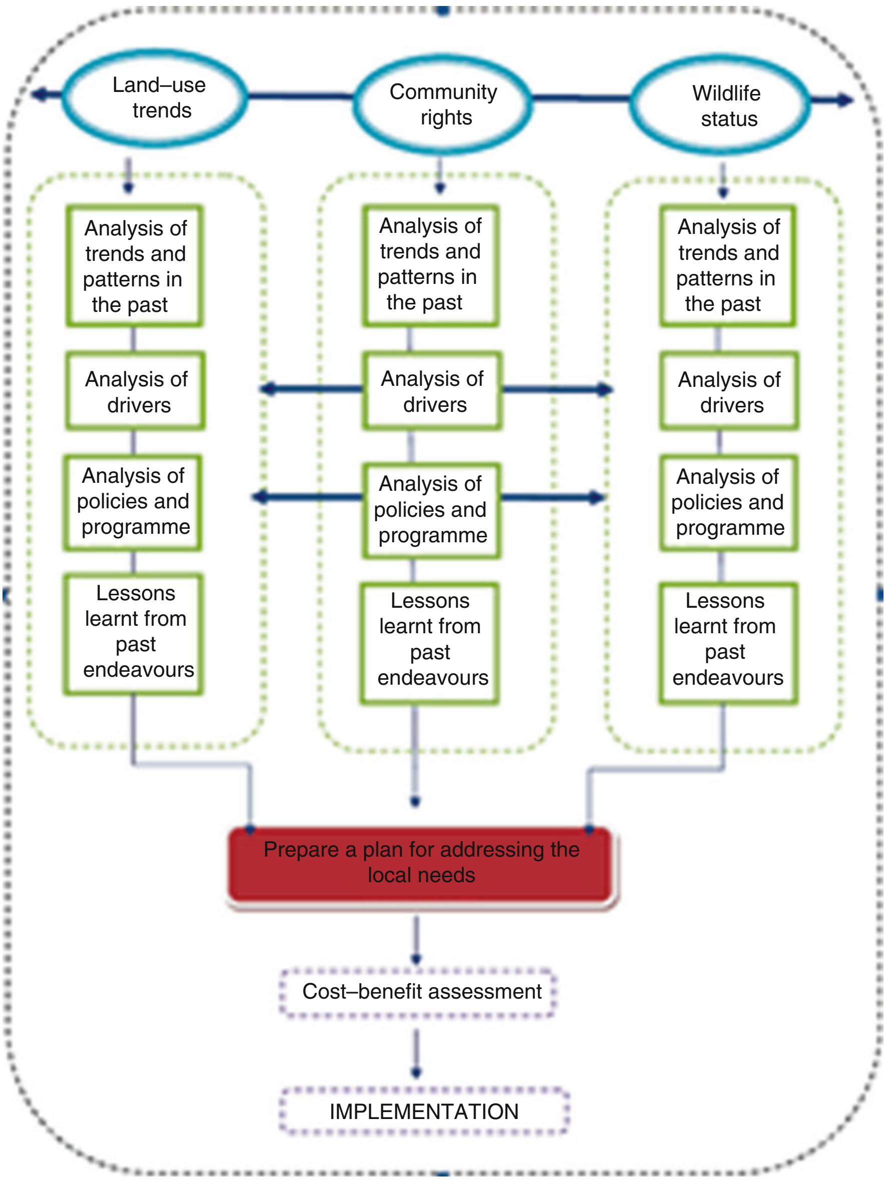

Fig. 33.3 The proposed C3S framework

an analysis would ensure that the shortcomings encountered in previous efforts are flagged.

Once this assessment has been conducted across the domains, the next step would be the preparation of a plan for action that takes into account the analysis carried out in the previous step. This should be followed by a rigorous cost-benefit analysis would have to be undertaken to assess the economic feasibility of the project. Changes can be made in the plan after this step. Once all the steps of the process are complete and independently reviewed, the programme/plan can be implemented.

The framework that has been presented will need to be substantiated with well-defined procedures. To begin with, accurate mapping of areas that have a high carbon-conservation potential, rich biodiversity and large populations of indigenous communities will need to be identified and cost-effectiveness of implementation of a C3S programme will need to be tested. Based on the conclusions from such an analysis, sites/regions with the highest potential would need to be targeted. Care would have to be taken to ensure that the programme development is bottom-up so as to incorporate local lessons and experiences to get better end-results.

Funding would need to focus on creating value for ecosystems rather than for specific services such as carbon sequestration or conservation; irrespective of whether it comes from voluntary funds or a market-mechanism. However, a caveat that exists when trying to create a system for multiple services together is that the knowledge of ecosystem functions and services is not complete. In addition, monitoring changes over time, and designing indicators for the success of a programme as defined above is a challenge in itself. This could impede efficient planning (Wendland et al. 2009). The success or failure of such a framework would, as a final point, depend on the willingness of the government to carry out the assessment fairly and make the process stakeholder-inclusive.

Conclusions

Across the globe, both at an international and national level, REDD is being considered as an important piece of climate change mitigation policy in the post-2012 regime. However, in the past couple of years, the negotiations remained on technical and financial aspects of REDD. Concerns have been raised about REDD becoming a mere carbon-trading platform with no real co-benefits. Hence, there is a need for initiating dialogue on a more comprehensive framework that includes various activities such as GHG abatement, biodiversity conservation, and due benefits to indigenous people and forest-dwelling communities under the umbrella of sustainability. The framework presented through this paper is the first step in that direction, and calls for immediate attention to such a programme.

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References

Angelsen A (2008) REDD models and baselines. Int For Rev 10(3):465–475

Benndorf R, Federici S, Forner C, Pena N, Rametsteiner E, Sanz MJ, Somogyi Z (2007) Including land use, land-use change, and forestry in future climate change agreements: thinking outside the box. Environ Sci Policy 10:283–294

Chomitz KM, Buys P, De Luca G, Thomas TS, Wertz-Kanounnikoff S (2007) At Loggerheads? Agricultural expansion, poverty reduction and environment in the tropical forests, Jakarta, Indonesia, The World Bank. Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2006/10/19/000112742_20061019150049/Rendered/PDF/367890Loggerheads0Report.pdf. Accessed 2 Feb 2009

Fry I (2008) Reducing emissions from deforestation and forest degradation: opportunities and pitfalls in developing a new legal regime. Rev Eur Commun Int Environ Law 17(2):166–182

IPCC (2007) Summary for Policymakers. In: Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (eds) Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK

Joint Liaison of the Rio Conventions (n.d.) Forests: climate change, biodiversity and land degradation. Available at: http://www.unccd.int/publicinfo/factsheets/pdf/forest_eng.pdf. Accessed 21 Jan 2009

Kolshus HH (2001) Carbon sequestration in sinks: an overview of potential and costs, CICERO Working Paper 11. Centre for International Climate and Environmental Research, Oslo. http://www.cicero.uio.no/media/1616.pdf. Accessed 13 Feb 2009

Kurtilla M, Pesonena M, Kangas J, Kajanus M (2000) Utilizing the analytic hierarchy process AHP in SWOT analysis – a hybrid method and its application to a forest-certification case. For Policy Econ 1:41–52

Larsson T-B, Barbati A, Bauhus J, van Brusselen J, Lindner M, Marchetti M, Petrriccione B, Petersson H (2007) The role of forests in carbon cycles, sequestration and storage: climate change mitigation, forest management and effects on biological diversity, Issue 5, n.s. www.iufro.org/download/file/2018/3754/issue5_aug07-c.pdf. Accessed 3 Feb 2009

Lozano M, Vallés J (2007) An analysis of the implementation of an environmental management system in a local public administration. J Environ Manage 82:495–511

Montagnini F, Nair PKR (2004) Carbon sequestration: an underexploited environmental benefit of agroforestry systems. Agrofor Syst 61:281–295

Myers EC (2007) Policies to reduce emissions from deforestation and degradation (REDD) in tropical forests. Resources for the Future, Washington DC. http://www.rff.org/RFF/Documents/RFF-DP-07-50.pdf. Accessed 13 Jan 2009

O'Connor D (2008) Governing the global commons: linking carbon sequestration and biodiversity conservation in tropical forests. Global Environ Change 18:368–374

Ognowski M, Guimaraes L, Ma H, Movius D, Schmidt J (2009) Utilizing payments for environmental services for reducing emissions from deforestation and forest degradation (REDD) in developing countries: challenges and policy options. Centre for Clean Air Policy, Washington DC

Schlamadinger B, Ciccarese L, Dutschke M, Fearnside PM, Brown S, Murdiyaso D (2005) Should we include avoidance of deforestation in the international response to climate change? In: Murdiyarso D, Herawati H (eds) Carbon forestry: who will benefit? Proceedings of Workshop on Carbon Sequestration and Sustainable Livelihoods, held in Bogor on 16–17 Feb 2005, Centre for International Forestry Research, Bogor, Indonesia. http://www.joanneum.at/carboinvent/post2012_/Bird/Schlamadinger_et_al_2004.pdf. Accessed 1 Feb 2009

Schmidt L (2008) Broadening the horizon – assessing REDD from an integrated perspective – a discussion paper. German Development Institute, Bonn, Germany. http://www.scribd.com/doc/13259028/DRAFT-Assessing-REDD-From-an-Integrated-Perspective-German-Development-Institute-2008-COP14. Accessed 15 Feb 2009

Skutsch M, Bressers H Th A (2008) Power, motivation and cognition in construction of climate policy: the case of tropical forestry. Science, Enfield NH, USA

Skutsch M, Bird N, Trines E, Dutschke M, Frumhoff P, de Jong BHJ, van Laake P, Masera O, Murdiyarso D (2007) Clearing the way for reducing emissions from tropical deforestation. Environ Law Policy 10:322–334

Stern SN (2006) Stern review: the economics of climate change. Cambridge University Press, Cambridge, UK

Strassburg B, Turner RK, Fisher B, Schaeffer R, Lovett A (2009) Reducing emissions from deforestation – The 'combined incentives' mechanism and empirical solutions. In: Global environmental change. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VFV-4VH330V-1&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=151809f8ba2ee5a1bc18a2fa6920a402 (in press, accepted 29 Nov 2008)

Tacconi L (2009) Compensated successful efforts for avoided deforestation versus compensated reductions. Ecological Economics. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VDY-4VGCGNT-1&_user=483692&_coverDate=01%2F27%2F2009&_alid=860057761&_rdoc=1&_fmt=high&_orig=search&_cdi=5995&_sort=d&_docanchor=&view=c&_ct=10&_acct=C000022720&_version=1&_urlVersion=0&_userid=483692&md5=554756e5ba30d5c3f340312cfab20f87 (in press, Accepted 16 Dec 2008)

The Forests Dialogue (TFD) (2008) Beyond REDD: the role of forests in climate change. The Forests Dialogue, New Haven. http://research.yale.edu/gisf/tfd/pdf/fcc/TFD%20Forests%20and%20Climate%20Statement%20w%20Briefing%20Notes.pdf. Accessed 9 Feb 2009

United Nations Forum on Forests (UNFF) (2009) Forests and climate change. http://www.un.org/esa/forests/pdf/session_documents/unff8/2009_4_AV.pdf. Accessed 16 Mar 2009

Wendland KJ, Honzak M, Portela R, Vitale B, Rubinoff S, Randrianariosa J (2009) Targeting and implementing payment for ecosystem services: opportunities for bundling biodiversity conservation with carbon and water services in Madagascar. Ecol Econ Doi. 10.1016/j.ecolecon.2009.01.002

Wunder S (2005) Payments for environmental services: some nuts and bolts. Center for International Forestry Research Occasional Paper No. 42, Center for International Forestry Research (CIFOR), Bogor, Indonesia

Chapter 34
Changing Climate Change Communication

A. Henderson-Sellers

Abstract I analyse the jargonized climate change language used in very common material including the Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (AR4), recent economic policy papers (Stern, The economics of climate change, 2006 and Garnaut, Garnaut climate change review, 2008), government responses, and the full set of abstracts for the Climate Congress held in Copenhagen in March 2009. Despite the best efforts of experts who try explain messages of climate action urgency, the fact of climate change seems to still suffer from a credibility shortfall. At least part of this problem are the climate change communication "code words" as described by Hassol, Eos 89(11):106, 2008. She explains that words such as "anthropogenic", "bias", "debate", "enhance", "positive" (as in positive feedback and trend), and, perhaps most dangerous of all, "theory" have common language meanings very different from their climate change meaning. She says that terms that now seem perfectly reasonable to global change scientists are still jargon in the wider world and always have simpler substitutes. For example few people say "spatial" and "temporal," they say "space" and "time". Surely, in day-to-day speech, people say "caused by us (or people)" rather than anthropogenic. The very terminology we have developed to talk about this diabolical challenge for humanity may be slowing down our ability to galvanize the actions so urgently required.

Keywords Anthropogenic · Climate change · Code · Communication · Garnaut · IPCC · Stern · Terminology · Theory

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Introduction: A Rose by Any Other Name Should Smell as Sweet

As evidenced by the joint award of the 2007 Nobel peace prize to Al Gore and the Intergovernmental Panel on Climate Change (IPCC), most of our politicians know about the reality of climate change. Despite the best efforts of these high profile communicators and all of us who try to get the messages of urgency and certainty out there, the fact of climate change seems to still suffer from recurring challenges. As Ereaut and Segnit (2006) say in their very persuasive report, "For every argument or perspective, whether on the scale of the problem, its nature, seriousness, causation or reversibility, there is a voice declaring its opposite. The conclusion must be that the battle is not won: climate change is not yet an issue that is taken for granted. It seems likely that the overarching message for the lay public is that in fact, nobody really knows." (Ereaut and Segnit 2006, p. 7). There are many reasons. One is, as we all know, the denialists. "Don't feed the troll!" is a widely shared view in the expanding global change blogosphere. Trolls are, in web vernacular, tiresome people who intentionally espouse false or controversial messages to create conflict, to gain funds, or simply to attract attention. Another reason is the media, which we all love to blame. In the face of a more than 100-fold increase in mass media coverage of climate change (e.g. Power et al. 2008), journalists' pursuit of "balance", when most of us believe that the science argument is over, can be very frustrating, especially when it gives yet more oxygen to those trolls. Suggestions have been made that the concept underpinning why climate change cannot be quickly reversed is not understood by the general public (e.g. Sterman 2008). I think there may be another reason, mostly unnoticed and unexplored – the climate change secret code.

This paper considers the possibility that at least part of the problem negatively affecting climate change communication is the "code words" we use. Words that now seem perfectly reasonable to global change scientists and a widening sphere of policy analysts are still jargon in the wider world and always have simpler substitutes (Hassol 2008). For example, very few regular guys would say "spatial" and "temporal"; they say "space" and "time". How many citizens do you know from whose tongues trips the term "anthropogenic": an English word only since about the 1920s and one about which a well known web-based English learning tool states under its familiarity information: "use as an adjective is very rare". Surely, in day-to-day speech, the proverbial person on the top deck of the Clapham omnibus would be more likely to say "caused by us (or people)". This process of developing a specific scientific language is typical for newly developing disciplines. It serves to establish a boundary between insiders and outsiders. In the sociology of science this has been extensively analysed (e.g. Gieryn 1983; 1999).

The very terminology climate change practitioners have developed to talk about this diabolical challenge for humanity may be slowing down our ability to galvanize the urgently needed actions. Hassol (2008) addresses this issue in this context, while Gieryn et al. address the sociology of specialized language more generally (Gieryn and Cozzens 1999). Although we do much to communicate climate change facts, science, and questions clearly, we can and should, and indeed must, do more. (Hassol 2008) says it is necessary to try to clearly distinguish settled science from the details on which scientists frequently focus their attention. She encourages scientists to avoid unnecessary "weasel words" and to state clearly what is known. For example, the common saying that human activity "contributes" to global warming makes it sound like human activity might be only a minor contributor. It would be more accurate and clearer to say "most of the warming...".

Here we report on a simple evaluation of jargonized climate change terms in very important texts including the Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (AR4), recent economic policy papers (such as Stern 2006 and Garnaut 2008), government responses, and even abstracts for a major global warming conference. We analyse the use of words such as "anthropogenic", "bias", "debate", "enhance", "positive" (as in positive feedback and trend), and, perhaps most dangerous of all, "theory". All of these, and many other, code terms have a vernacular meaning that is very different from their climate change meaning (Hassol 2008). Perhaps the media and even wider community reporting and responses might be more favourable (to social change) if different terminology were to be employed.

For example, Garnaut (2008), in his excellent review of the economic consequences for Australia of global warming and its associated climatic disturbances, uses one of these ambiguous words, "enhanced", to mean its reverse in a section heading: "International trade – effects of enhanced impacts in developing nations" (Garnaut 2008, Sect. 10.2.1, Heading 10.2.1, p. 261). This is an odd choice of title since this section is precisely about very bad consequences of climatic change impacts on developing countries. Indeed, Garnaut says in this section of these nations that, (their) "less stable political systems may also mean that societies could fracture in response to extreme climate change impacts [...]. [They are] vulnerable to sea-level rise and disruption of established patterns of rainfall and river flows [and] [s] evere shocks can destabilize governance in developing countries and lead to regional conflicts" (Garnaut 2008, p. 261). This is not an enhanced impact in the normal sense of being an improvement or increasing the value of the impact. Garnaut uses the code in line with the widespread phrase usage in climate change circles: "the enhanced greenhouse effect" which means the worsening situation!

Global warming described in other terminology might gather faster and broader community involvement. Here, eight words or word pairs that appear ambiguously in the climate change literature are considered as examples. The meaning of these is given first as a dictionary definition and then the possible problem with these terms when they become entrained in climate change communication is identified. Finally, for each, I suggest a possible improvement that the climate change writers might find gives rise to better communication of climate change issues with a wider audience [All definitions from the Oxford English Dictionary online (2008)].

Positive (the term)

- An adjective expressing or implying affirmation, agreement, or permission (*the dictionary definition*)

- Good (or nice) thing (*the problem with the term for climate change*)
- Exacerbating, exaggerating (*a possible improvement for this context*)

Anthropogenic/anthropogenerated (increases in greenhouse gases)

- Adjective (chiefly of pollution): originating in human activity
- Meaning unclear: not a commonly used word. Even when recognized, uncertainty exists about whether it means only due to people or due to "natural" as well as human-created gases
- Human-caused, caused by people's actions

Bias (e.g. in data)

- Noun: inclination or prejudice in favour of a particular person, thing, or viewpoint
- Means manipulated or a distortion to most people
- Addition (or subtraction) of an amount

Debate (about climate change)

- Noun: (1) a formal discussion in a public meeting or legislature, in which opposing arguments are presented; or (2): an argument
- Suggests balanced (or aggressive) discussion. Often implies equal weight for and against, i.e. in which a regular person cannot yet reasonably draw conclusions
- Description of well-founded information (facts)

Enhance

- Verb: increase the quality, value, or extent of
- Generally taken to mean "improve"
- Make larger (perhaps even: make worse)

Positive trend

- Adjective: (5) (of a quantity): greater than zero; or noun: (1) a general direction in which something is developing or changing
- Good change which improves a situation
- Rising (fast)

Positive feedback

- Adjective: (2) expressing or implying affirmation, agreement, or permission; noun: (1) information given in response to a product, performance etc., used as a basis for improvement
- Good thing, e.g. from one's boss
- Furthering or compounding increase (generally making a bad change worse)

Theory

- Noun: a supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained

- A guess or perhaps an hypothesis
- Explanation, law, rule, fact

The occurrences of these eight words/word groups have been collected from the four Summaries for Policy Makers (SPMs) of the IPCC AR4 (i.e. Reports of Working Groups 1–3 and of the Synthesis Report). Two economic reviews commissioned by OECD nations (Stern 2006; Garnaut 2008) have been analysed together with the Australian government's response to the latter: the Carbon Pollution Reduction (CPR) green paper (2008). Table 34.1 lists the number of occurrences of the words in these eight sources. Care must be taken in comparing the totals listed in Table 34.1 as the texts searched are of very different lengths: the four IPCC AR4 Summaries for Policy Makers are rather dense (~700 words per page) but short (around 20 pages each), the Australian Government green paper "Carbon Pollution Reduction" has around 500 words per page whereas Stern has over 600 pages and about half the IPCC word density (roughly 450 per page), and finally Garnaut has 548 pages with a still lower word density (around 425 per page).

Despite this caveat, it can be seen that the IPCC Synthesis Report SPM and WG1 SPM both use the term 'anthropogenic/-generated' a great deal, while other commentators tend not to use it much less. For example, Garnaut uses this term as much as IPCC WG1 SPM but distributed over 30 times as many pages and 8 times as many words. Considering the analysed "code" words in terms of frequency of occurrence (Fig. 34.1), it can be seen that Stern (2006) exhibits the most wide-ranging use in stark contrast to the IPCC's WG1 SPM and its full Synthesis Report in both of which all except one occurrence is of the word "anthropogenic", the single exception being "positive" and "enhance" respectively.

Table 34.2 makes the comparison among the eight sources in terms of percentage occurrence. The highest exploitation (0.2%) of the words/word groups analysed here is IPCC WG1 SPM (a text written by scientists for policy makers) and the lowest (0.02%) is the Australian CPR green paper (written by bureaucrats for the general public) with an order of magnitude lower frequency of occurrence of these climate change code words. Interestingly, although the full Stern report rates quite

Table 34.1 Number of times selected words/word groups appear in eight very widely read and cited climate change literature

Document	S Ex	Stern totl.	IPCC SPM wg1	IPCC SPM wg2	IPCC SPM wg3	IPCC Synt SPM	IPCC Synt full	Gar-naut	CPR Green Paper
Anthropogenic/-generated	0	10	25	9	2	22	44	25	5
Bias		12	0	0	0	0	0	9	1
Debate	0	40	0	0	1	0	1	14	4
Enhance	2	64	0	3	5	1	5	26	31
Positive	2	59	1	1	6	0	4	39	10
Positive trend	1	1	0	0	0	0	0	0	0
Positive feedback	0	15	0	0	0	0	2	4	0
Theory	0	120	0	0	0	0	1	11	7

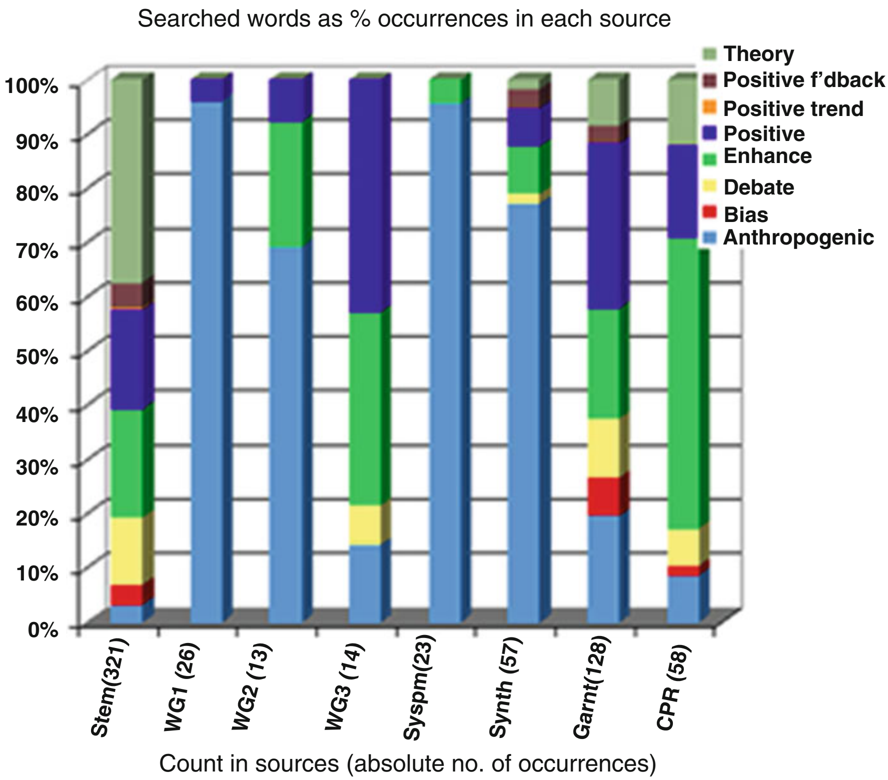

Fig. 34.1 Percentage distribution of "climate code" words (word pairs) (*colours*) in each of the eight sources searched (columns). The absolute number of occurrences of all the code words is given in parentheses below each column

Table 34.2 Numbers of words and density of occurrence of selected words/word groups in searched documents

Document	Pages	Approx. words	Percentage of 8 words
Stern (includes executive summary)	602	270,900	0.118
Stern executive summary	27	12,150	0.041
IPCC AR4 SPM wg1	18	12,600	0.206
IPCC AR4 SPM wg2	22	15,400	0.084
IPCC AR4 SPM wg3	23	16,100	0.087
IPCC AR4 synthesis SPM	22	15,400	0.149
IPCC AR4 synthesis report (excl SPM)	52	36,400	0.157
Garnaut draft report (July 2008)	548	232,900	0.055
CPR (carbon pollution reduction)	532	266,000	0.022

high (6th of 9 in Table 34.2) in terms of density of code words, his Executive Summary (which is listed separately in Table 34.2 as well as being included in the full Stern values) has the 2nd lowest density after the Australian CPR green paper. This seems to indicate that the authors of these two documents recognized the hazard of climate change code words and attempted to reduce their occurrence.

Analysis of Terminology Use in Eight International Sources

In all the sources analysed, great care had obviously been taken to make meaning as clear as possible and overall there was little in the English terminology that could improve communication clarity. This is not surprising, as the selected sources had all been written recently (since 2006) and intended for policy makers and, since a policy change was desired, the wider public. For example, the Summary for Policy Makers of the IPCC AR4 Working Group 3 (Metz et al. 2007) has 14 occurrences of the 8 selected words/word groups (Table 34.1). These are mostly appropriate usage, although there are a few sentences where clearer text might have been helpful e.g. "Including co-benefits other than health, such as increased energy security, and increased agricultural production and reduced pressure on natural ecosystems, due to decreased tropospheric ozone concentrations, would further *enhance* cost savings" (p. 12, col. 2, para. 8, line 5 – added italics). Here the word "enhance" might have been better given as "increase", or even the sense reversed so that the sentence read, "Including co-benefits other than health, such as increased energy security, and increased agricultural production and reduced pressure on natural ecosystems, due to decreased tropospheric ozone concentrations, would *save money on costs*" However, throughout the following analysis I wish it to be clearly understood that I have chosen to "criticize" the selected works *not* because they are poorly written or misuse English but precisely because in all cases the texts are excellently well written and in general use English appropriately and with the intended audience in mind.

Generally these authors take care to use code words clearly. The best example is that the term "positive" frequently appears in sentences also containing "negative" and in these cases the meaning is almost invariably clear. However, one wonderfully contradictory example is found in Part V of Stern: "Adaptation will reduce the negative impacts of climate change (and increase the *positive* impacts), but there will almost always be residual damage, often very large" (p. 405 (3/45), line 1 in description of Fig. 18.1, Stern 2006 – underlining added for emphasis). Even very careful unpicking fails to elicit clarity. What is meant here is presumably that adaptation is a good thing but what is said is that adaptation

- Increases the positive impacts of climate change
- Reduces the negative impacts of climate change

In other words, apparently exactly the opposite of the intended meaning.

CPR Is Not Always Beneficial

Overall, the Australian government's green paper entitled Carbon Pollution Reduction (CPR 2008) is well written. As it is the least internationally read of the text analysed here, I have taken less time on it in this analysis. However, three of the selected words/word groups give rise to almost classic examples of climate change code usage that could be termed: the good, the bad, and the ugly.

The good – a definitional statement for “anthropogenic”:

“Developed countries will be required to take the lead on reducing greenhouse gas emissions, as they have contributed the bulk of the existing stock of *human-caused, or so called anthropogenic*, greenhouse gases already in the atmosphere” (CPR 2008, p. 9 (25 of 532), line 1 – underlining added).

The bad – an utterly obscure use of the word ‘enhance’:

“Being part of the group of countries acting on climate change *will enhance our seat* at the international negotiating table” (CPR 2008, p. 9 (25 of 532), para. 2, line 1 and again on p. 70 (86 of 532), para. 2, line 1 – underlining added).

And the ugly – three uses with three meanings of the term “positive/positively”:

- To mean “constructively”: “The third pillar reflects the fact that Australia has the standing and capacity to *positively shape* the post-2012 outcome” (CPR 2008, p. 68 (84 of 532), line 1 of pillar 3, line 1 – underlining added)
- To have the mathematical meaning (as the text says) “greater than zero”: “The price will be *positive (that is, greater than zero)* if permits are scarce – that is, if intended emissions exceed the number of available permits” (CPR 2008, p. 74 (90 of 532), para. 8, line 2, line 1 – underlining added)
- In an economic and rather obscure sense probably meaning “helpfully”: “In the case of energy efficiency, it is likely that the more important market failures relate to. . ...*positive spillovers*, for example where innovations in one field lead to associated benefits in another unrelated field” (CPR 2008, p. 285 (301 of 532), para. 1, bullet point no. 4, line 1 – underlining added)

There are still less clear meanings of “positive” which can be deduced from carefully reading, e.g. “For cropland management, the outcome would only be *positive if rainfall conditions* from 2008 to 2012 consistently exceeded those in 1990” (CPR 2008, p. 120 (136 of 532), para. 2, line 94 of Box 2.3, line 1 – underlining added).

Table 34.1 and particularly Fig. 34.1 underline how differently the selected words/word groups are used by the two economists reviewed here (Stern 2006 and Garnaut 2008) as compared to the CPR green paper and even to the IPCC AR4, even though Working Group 3 of IPCC is composed in part of economists and economic analysts (Table 34.1). The next two sections review the two economist’s texts in some detail.

Being Stern with Stern

The very different use of terms between economic and policy texts as compared to scientific documents, especially the IPCC WG1 SPM, is illustrated in Fig. 34.2. In the Executive Summary of the Stern Report (2006) there are only 5 occurrences of the 8 selected words/word groups and all usages are broadly appropriate. However, turning to the main text of Stern analysis becomes a little more interesting and more complicated (Fig. 34.3). For example in Stern Part I, there are 66 occurrences of 6

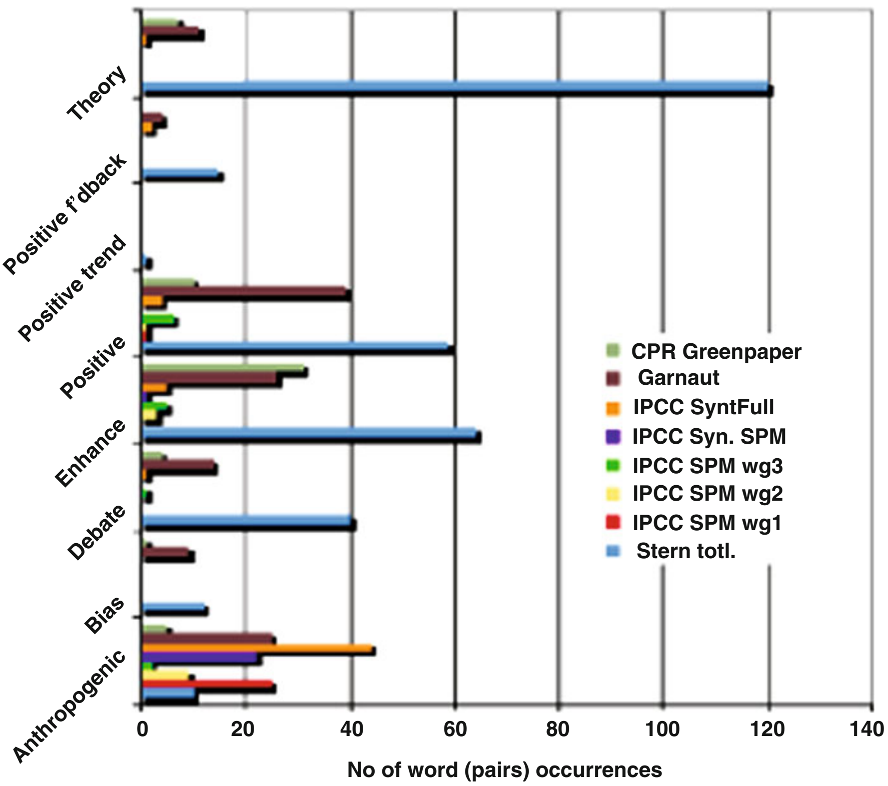

Fig. 34.2 Histograms of absolute occurrences of the words (word pairs) searched for in all eight sources documents (*colours*)

of the 8 selected words/word groups (none for either "bias" or "positive trend"). Anthropogenic (4 occurrences) always clearly means human-induced. The most interesting word groups in Stern are "enhance", "theory" plus the set of "positive" and "positive feedback". Figure 34.3 illustrates the almost bipolar usage of these climate change codes, showing Part I dominated by the word "theory", while Part VI has a large use of the term "enhance".

Stern uses "enhance" and its derivatives quite frequently and often slightly ambiguously. The term almost always means either "increase" or "improve" and although not incorrect in any use in the whole 602-page report (Stern 2006), the substitution of one of these words could have helped out-of-context interpretation.

"It must also make sense within an international context: if there are good prospects for a robust international framework, this will greatly *enhance the credibility* of national goals for emissions reductions" (p. 325 (18/95), para. 5, line 6, Stern 2006 – underlining for emphasis). Here the meaning is to "improve".

"Another important research area in agriculture will be how to *enhance carbon storage* in soils, complementing the need to understand emissions from soils (see

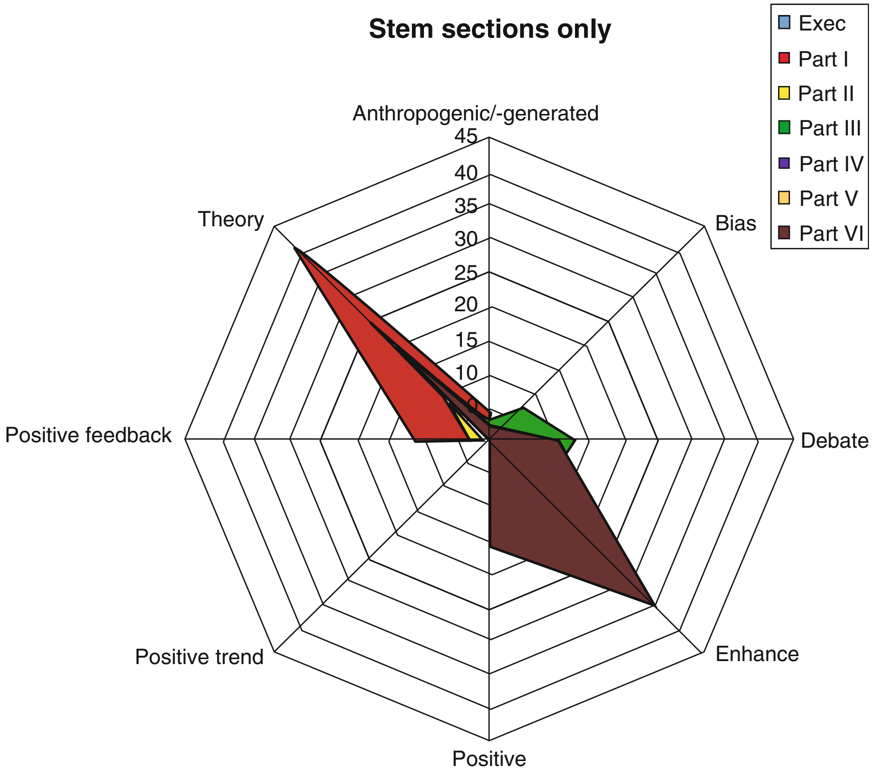

Fig. 34.3 Web diagram showing the distribution of the eight climate code words (word pairs) for the Stern (2006) report only separated by section (*colours*)

Sect. 25.4)" (p. 358 (51/95), para.2, line 1 of Box 16.2, Stern 2006 – underlining for emphasis). And in "Possible changes in extratropical cyclone activity due to enhanced greenhouse gases and aerosols" (p. 19, line 10, Stern 2006).

In both these quotations, the meaning is to "increase". However, there are other times when even Stern's meaning remains somewhat elusive. For example in: "*Enhancing* resilience to disasters and improving disaster management" (p. 430 (28/45), bullet point 3 in Key Messages box, Stern 2006 – underlining for emphasis).

Positive is often used by Stern in the mathematical sense (i.e. not "improve" but "greater than zero") but even so, there might be ambiguity in the absence of full context, e.g. "Nevertheless, efficient adaptation to climate change is also hindered by market failures, notably inadequate information on future climate change and positive externalities in the provision of adaptation (where the social return remains higher than the return that will be captured by private investors)" (p. 37, para. 2.8, line 14).

"Positive feedback", which occurs 11 times, is also always used correctly in the "climate change" sense, i.e. to exacerbate and thus in climate change terms "making worse". However, specific sentences taken out of context could be confusing, e.g. “Over the past 2 decades, the air in the upper troposphere has become wetter, not drier, countering Lindzen’s theory and confirming that water vapour is having a positive feedback effect on global warming.” (p. 7, footnote 17, line 4). This contains two of the words/word groups selected here for analysis viz. “positive feedback” and “theory” (see below). Although Stern is correct and consistent in his use of the term “positive feedback”, this sentence might be interpreted, if read without context, to mean that water vapour feedback is a good outcome (e.g. reducing warming), while Lindzen hypothesized it would be bad. This interpretation is incorrect and exactly the reverse of both beliefs. In fact, Lindzen hypothesized a cooling (or reduced warming, i.e. negative feedback) while observations show increasing warming.

Stern (2006) uses “theory” 120 times roughly 10 times as many as in any other source examined and the same is roughly true of “enhance” (Fig. 34.2 and Table 34.3). “Theory” takes a wide repertoire of meanings (underlining added to highlight in all quotations). For example, “We look at the range of *theories required* and explain some of the technical foundations necessary for the economics that the scientific analysis dictates.” (p. 1, dot point 2, line 4, Stern 2006) and from “The *pure theory* of public expenditure” (p. 40, line 19, Stern 2006) to “Thus the *theory covers time and uncertainty*.” (p. 28, para. 2.3, line 27, Stern 2006). At best, this could confuse readers and at worst, such ambiguity might be exploited by denialists to obfuscate Stern’s real and intended meaning and call to urgent action. Specific occurrences warranting note include, “The *theory* of comparative advantage suggests that the world as a whole can gain from the global reduction of trade barriers.” (p. 451 (3/124) footnote 3, line 3, Stern 2006). Here, the meaning is hypothesis or explanatory rule. This contrasts starkly with, “Solar energy can *in theory* meet the world’s energy needs many times over, but will, like energy from wind, waves and tides, eventually depend on the storage problem being solved.” (p. 363 (56/95) para. 5, line 7, Stern 2006). This is not theory; it is fact that available solar energy far outweighs the world’s needs. The problem is, as stated in the latter half of this sentence, that of storage and transfer of this energy.

Table 34.3 Details for Stern (2006) of numbers of occurrences of selected words/word groups

Sections	Stern (2006)							Stern total
	Ex	I	II	III	IV	V	VI	
Anthropogenic/-generated	0	4	1	3	0	0	2	10
Bias		0	3	7	0	0	2	12
Debate	0	10	0	13	6	1	9	40
Enhance	2	2	4	10	5	6	35	64
Positive	2	7	10	11	10	3	16	59
Positive trend0	1	0	0	0	0	0	0	1
Positive feedback	0	11	3	1	0	0	0	15
Theory	0	42	11	16	25	2	23	120

Garnering Meaning from Garnaut

Professor Ross Garnaut is the only one of the sources surveyed to have produced tautologies in his text. There are two in the 8 word group search conducted:

"The 'sceptics' variously contest the relationship between *human-induced anthropogenic* emissions and atmospheric concentrations, or the relative importance of the enhanced greenhouse effect and other factors that influence climate" (p. 48, para. 1, line 3 – underlining added to highlight tautology) and a partial tautology:

"Interested stakeholders were encouraged to respond to a series of five issues papers, a discussion paper on the proposed emissions trading scheme and an interim report released in January 2008, all of which stimulated *public discussion and debate* on some of the most critical issues for climate change mitigation and adaptation in Australia" (p. ix, Preface, para. 7, line 5 – underlining added to highlight tautology).

Garnaut also takes a very catholic view of the best meaning of the word "debate" with four instances, in particular highlighting a wide range of meanings that could cause confusion if these quotations were taken out of context:

"There are nevertheless large uncertainties in the science. While there is a clear majority view that there are high risks, there is *debate and honest recognition* of limits to knowledge about the times and ways in which the risk will manifest itself" (p. 1, para. 3, line 2 – underlining added to highlight use of word debate). Here debate is linked to belief (recognition).

"Observation of daily *debate and media discussion* in Australia and elsewhere suggests that this issue might be too hard for rational policy making" (p. 2, para. 6, line 1– underlining added to highlight use of word debate). Here debate seems to mean discussion.

"The Review is not in a position to independently evaluate the considerable body of scientific knowledge, and it is not the intent of this chapter *to debate the existence or extent of human-induced climate change*" (p. 47, para 5, line 2– underlining added to highlight use of word debate). Here debate means "argue".

"In recent *public debate and commentary*, it has been apparent that industries will seek to influence the design of any such assistance arrangements in ways that maximize their respective returns from the scheme" (p. 383, para. 1, line 1– underlining added to highlight use of word debate). Here debate seems to mean discussion or perhaps knowledge sharing.

What Can We Do?

We have analysed eight important and internationally read source documents on the topic of climate change and reviewed the use in them of eight words or word pairs. Of these, one of the texts written by scientists specifically to communicate their results to policy makers, the IPCC WG1 SPM, has the highest exploitation (0.2%) of the selected words/word groups. In contrast, the text written by bureaucrats for the general public, the Australian CPR green paper, has ten times less climate change code use (0.02%), the lowest of the sources considered. The most audience-savvy of the reviewed documents is, perhaps, the Stern Report of which the Executive Summary (arguably written for a broad UK public) has the 2nd lowest density after the Australian green paper while the overall report (including this Executive Summary) rates quite high 6th of 9 sources in terms of density of selected code words. This lends credence to my hypothesis that the authors of these three documents recognized the hazard of climate change code words and attempted to reduce their occurrence.

Decoding the Future

It must be clearly emphasized that I am not in any way criticizing Lord Stern, the Nobel peace prize-winning IPCC editors, Professor Garnaut or any other author. In truth, I find the eight texts I have analysed remarkably (really astoundingly!) clear. However, in common with most of the climate science community, I know how easy it is even for clear communications to be used to argue exactly the opposite case from the one its authors believed they were propounding. To cite just one recent example (Fachon 2008), I find the 27 May 2008 blog piece entitled "Science can't prove man's 'carbon footprint' is tipping balance to global warming", which copiously cites my textbook on climate modelling (McGuffie and Henderson-Sellers 2005) to disprove global warming quite irritating, but the quotes are not incorrect, cf. http://www.climatemodellingprimer.net/)

The use of special terms is nothing unusual, at least if a field is emerging as a new scientific discipline (e.g. Gieryn 1999). Communication of meaning depends on good journalists interpreting scientific papers correctly for the general public. However, the ambiguities demonstrated in the field of climate change seem to pose a serious problem. The question arises, "What can we do?" Here I argue that although we do much to communicate climate change knowns and remaining questions, we can – and should – do more, and do it more clearly. I follow Hassol (2008), who particularly exhorts the climate change writers to not overdo "weasel words" nor to pad texts excessively with caveats. She also lists a large number of words virtually encompassing the alphabet that we could use more wisely (Table 34.4).

Figure 34.4 summarizes the results found here, showing the occurrences of the eight words/word groups in rings, ordered from most used to least in absolute numbers and segmented by the sources which used them. Of the words analysed, "anthropogenic" is the most used and the most evenly distributed among sources (Fig. 34.4). Generally, the texts seem to have been written with a desire to ensure clarity. For example, in the two instances below, Garnaut repeats the term in other words while the IPCC Synthesis Report authors ensure that natural sources are separated from human-produced.

Table 34.4 Nearly a full alphabet of confusing terminology (bold words are dealt with in this paper), after Hassol (2008)

Term	Problem with term
Aerosol	Spray can
Anthropogenic/-generated	Means people or natural plus people?
Bias (e.g. in data)	Intentionally distorted or manipulated
Contribution/contributes (by humans)	Sounds like small component
Debate (about CC)	Implies equal weight to and against
Degrees per decade (?)	Arithmetic too hard
Discipline (?)	Being strict
Enhanced/enhancement	Means improvement/better outcome
Error	Mistake
Fahrenheit	Must use for Americans
Fresher (i.e. less saline)	Cleaner/nicer
Greenhouse	Natural or human-made or both?
Manipulated/manipulation	Distortion
Nutrient	Good food
Organic	Clean food
Positive trend/feedback	Good thing
PDF	File transfer system
Radiation	Bombs/Chernobyl
Scheme	Cheating method
Sign (error/not right)	Astrology/religious revelation
SST	Fast/high aeroplane
Theory	Guess or hypothesis
THC	Marijuana ingredient
Uncertainty	Often we mean "range"

- Garnaut: "The 'sceptics' variously contest the relationship between *human-induced anthropogenic* emissions and atmospheric concentrations, or the relative importance of the enhanced greenhouse effect and other factors that influence climate" (p. 48, para. 1, line 3 4, Garnaut 2008 – underlining added to highlight).
- IPCC: "Growth rates have declined since the early 1990s, consistent with total emissions (*sum of anthropogenic and natural sources*) being nearly constant during this period" (p. 37, col. 2, para. 3, line 4, IPCC 2007, Synthesis Report – underlining added to highlight).

The next most frequent occurring word (Fig. 34.4), is "enhance". In my opinion, this is the most pernicious climate change "code word" which may follow us forever. For example, in reference no. 10 of Stern (2006, p. 446): Tompkins and Adger (2005): "Defining a response capacity to enhance climate change policy", Environmental Science & Policy, 8" – do the paper authors here mean enhanced climate change – i.e. getting warmer and worse, or do they mean enhanced policy, i.e. getting better and more capable? Or both? In fact, both is what the world will need. In my view, the word "enhance" should be removed from future texts about climate change as the next pair of examples demonstrate:

"While these gases do not present a direct risk to the ozone layer, they have high global warming potentials and contribute significantly to the *enhanced greenhouse effect* if emitted" (CPR 2008, p. 104 (120 of 532), para. 8, line 4 – underlining

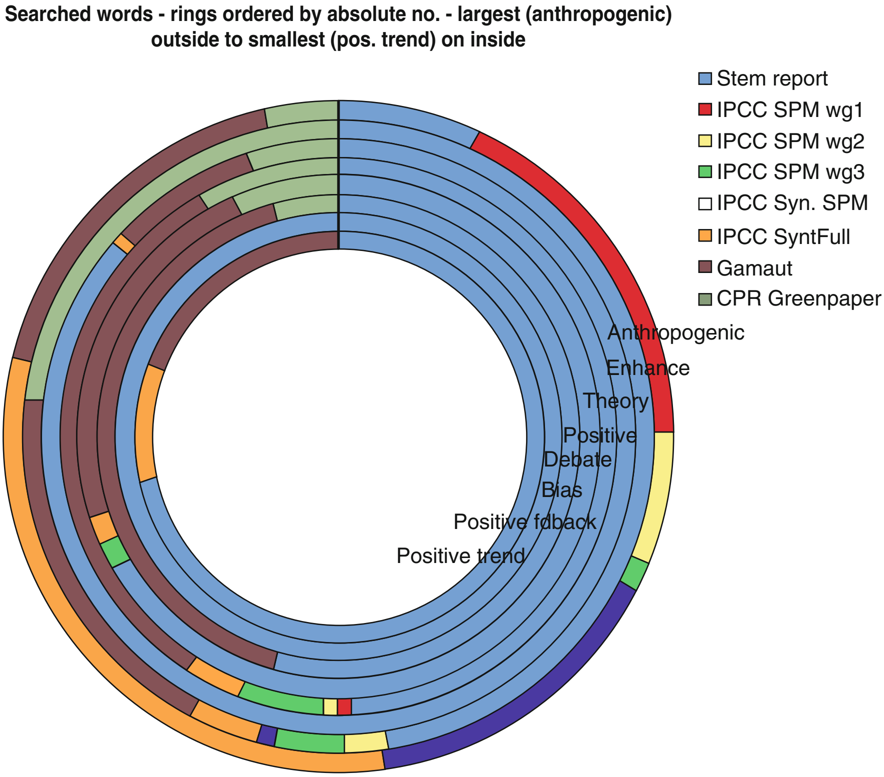

Fig. 34.4 Occurrence of 8 words (word pairs) in the eight climate change documents searched (*colours*). *Rings* are ordered by absolute number of occurrences from the term exhibiting the greatest number of occurrences (anthropogenic) on the outside to that with the least number (positive trend) on the inside

added) – meaning climate change will get worse. But then to use the same "code" in the opposite sense:

"*Enhancing* climate change science" (CPR 2008, p. 68 (84 of 532), Box 1.3 title – underlining added) – meaning the climate change science will get better.

"Theory" is the third most found word, but the vast majority of these occurrences are in the Stern Report (Stern 2006) that has been discussed at length above. I find it hard to propose not using this term but encourage all climate change authors in the future to take great care in its use.

"Positive/positively" is used very differently in the various source texts:

Stern (at least Executive Summary and Parts I–III) uses it almost always in the strict mathematical sense of a "positive number'", i.e. there can be little or no confusion about what meaning is intended. In contrast, the IPCC WG3 SPM uses this word only 6 times but each time it could be replaced by another word to create a clearer meaning (Table 34.5). These quotations contrast with the more formal use of

Table 34.5 Examples of alternatives for the word "positive/positively" in two components of IPCC AR4

Quotes from IPCC WG3 SPM & IPCC synthesis full report	Alternative	Repeat?
IPCC WG3 SPM		
Management practices can also have a positive role	Beneficial	y
Efficiency improvement has a positive effect on energy security	Beneficial	n
Renewable energy generally has a positive effect on energy security	Beneficial	n
Land uses can have positive and negative environmental impacts	Helpful	n
The waste sector can positively contribute to GHG mitigation	Usefully	n
Awareness campaigns may positively affect environmental quality	Beneficially	y
IPCC Synthesis Full Report		
The resulting positive or negative changes in energy balance	Correct mathematical	n
Management practices can also have a positive role.	Beneficial	y
Examples that can have positive impacts on mitigation include	Helpful	n
Awareness campaigns may positively affect environmental quality	Beneficially	y

the same word in WG1 SPM (it occurs only once), viz. "Positive forcing tends to warm the surface while negative forcing tends to cool it." (p. 2, footnote, line 2).

Pop Go the Weasel Words

Amongst the eight words/word groups considered here two stand out as being the cause of the most trouble: "enhance" and "theory". "Enhance" takes too many different meanings to be a good word to employ in clear communications. I must stress that very few of the uses I criticize here are wrong in the fair but broad English sense, but many could lead to serious misunderstandings of climate change issues if taken out of context. We, the climate change scientists, are surely to blame – there can be no other word for "enhance/enhanced". The phrase "enhanced greenhouse warming" has been in the science literature for at least 10 years and probably over 20. There is no excuse for this terminology which only confuses "enhancement" meaning "getting better" with the actual reality of this enhancement meaning getting worse. We need to stop using "enhance" in our texts now.

"Theory" is less easy to resolve because the meaning is itself broad. However, I can again criticize the climate change science community for abusing this term for a long period in the phrase "greenhouse theory" or "global warming theory". Perhaps it was once a theory, so real blame is less clear, but now we are certain about our facts. We need to stop talking about global climate change as a "theory" when we know it to be a fact.

Lastly, the word "anthropogenic" is a trap. The authors analysed here know this and mostly mange to avoid its pitfalls. One can compare the way in which Garnaut (an economist reviewing the greenhouse literature for government policy decisions regarding emissions reductions) uses the word “anthropogenic”, as compared to the IPCC Synthesis Report writers. The IPCC Synthesis Report is always the last to be written and in many ways the most carefully crafted of these diligent and thorough assessments. In AR4, the full Synthesis Report shares characteristics with the three SPMs in that it uses the term “anthropogenic/-generated” much more than the non-IPCC texts considered here (44 occurrences, cf. Stern’s 10 occurrences in a text about 8 times longer).

We, the climate change writing community, have, to some extent, created a monster on which Dr Frankenstein might have first smiled and then frowned. Our creature is a small collection of code words that we have trained others to be confused about and we have, to some extent, even become confused ourselves. While there may be many social limits to climate change action (e.g. Adger et al. 2009), we owe it to the general pubic to be better at communicating overall and specifically to expunge misuse of these bad climate change code words.

Conclusions

Climate change is real and requires action (Doherty et al. 2009; Climate Change Congress Report, 2009). However, despite the best efforts of the IPCC and many others, the messages of urgency and certainty continue to be prey to a perplexing credibility shortfall. There are many possible explanations for the international failure to act effectively, including the understandable self-interest of rapidly and newly industrializing nations; the denialist spin encouraged by parts of the fossil fuel industry; the sluggishness of the democratic process; and the mass media: on the one hand captured as evidenced by the orders of magnitude increase in coverage of climate change but whose journalists still seek a “balance”. I explored a further possible explanation for the world’s sloth on climate change: the communication confusion that underpins even the most carefully crafted texts. I explored the possibility that, to date unnoticed and unexplored, climate change action is hindered by an accidental but exclusive “code”. Words that now seem perfectly reasonable to global change analysts still remain jargon in the wider world. I argue that the very terminology we have developed to talk about this diabolical challenge for humanity may be slowing down our ability to deal with the problem.

Notes

Note on searching of Stern Report

The searches were conducted on the web-downloadable version available in August 2008. However, Sect. VI of Stern (2006) on the web at this time has an oddly re-numbered Sect. 23. Pages as far as this are as in the 2006 version. However, p. 490 (2006 version) is missing and pages after p. 489 are numbered from 1 to 25 when the original numbering begins again. Herein all these page numbers have had 490 added.

Note on CPR Green Paper

The Australian government has since issued a White Paper on its proposed Emissions Trading Scheme which has been the subject of considerable debate. At the time of writing this paper (June 2009), the legislation was before the Federal Parliament.

References

Adger W, Dessai S, Goulden M, Hulme M, Lorenzoni I, Nelson D, Naess L, Wolf J, Wreford A (2009) Are there social limits to adaptation to climate change? Clim Change 93(3–4):335–354

Climate Change Congress Report (2009) Synthesis Report from the IARU Climate Change Congress. Available at: http://www.climatecongress.ku.dk/pdf/synthesisreport/

CPR (2008) Carbon pollution reduction scheme", Green Paper, July 2008, Department of Climate Change. Commonwealth of Australia, Canberra, Australia, ISBN: 978–1–921298–25–7, p 532. Available at: http://www.climatechange.gov.au/greenpaper/index.html

Doherty SJ, Bojinski S, Henderson-Sellers A et al (2009) Lessons learned from IPCC AR4: scientific developments needed to understand, predict and respond to climate change. Bull Am Meteorol Soc 90(4): 497–513. Available at: http://ams.allenpress.com/archive/1520-0477/90/4/pdf/i1520-0477-90-4-497.pdf

Ereaut G, Segnit N (2006) Warm words: how are we telling the climate story and can we tell it better? Institute for Public Policy Research, p 32. Available at: http://www.ippr.org

Fachon D (2008) Science can't prove man's 'carbon footprint' is tipping balance to global warming. Available at: http://www.warwickonline.com/warwickonline/index2.php?option=com_content&do_pdf=1&id =37318

Garnaut R (2008) Garnaut climate change review, Draft report (June, 2008). Available at: http://www.garnautreview.org.au/domino/Web_Notes/Garnaut/garnautweb.nsf

Gieryn T (1983) Boundary-work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists. Am Sociol Rev 48(6):781–795

Gieryn T (1999) Cultural boundaries of science: credibility on the line. University of Chicago Press, Chicago, p 398

Gieryn TF, Cozzens SE (1999) Theories of science in society. Science, technology, and society. Books on demand, Ann Arbor, MI

Hassol SJ (2008) Improving how scientists communicate about climate change. Eos 89(11):106. doi:10.1029/2008EO110002

IPCC Synthesis Report (2007) Climate change 2007: synthesis report. Cambridge University Press, Cambridge, UK. Available at: http://www.ipcc.ch/

IPCC Synthesis SPM (2007) Summary for policymakers. In: Climate change 2007: synthesis report. Cambridge University Press, Cambridge, UK. Available at: http://www.ipcc.ch/

IPCC WG1 SPM (2007) Summary for policymakers. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. Available at: http://www.ipcc.ch/

IPCC WG2 SPM (2007) Summary for policymakers. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental

Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp 7–22. Available at: http://www.ipcc.ch/

IPCC WG3 SPM (2007) Summary for policymakers. In: Metz B, Davidson OR, Bosch PR, Dave R, and Meyer LA (eds) Climate change 2007: mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. Available at: http://www.ipcc.ch/

McGuffie K, Henderson-Sellers A (2005) A climate modelling primer, 3rd edn. Wiley, Chichester, UK

Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (eds) (2007) IPCC, 2007: Climate change 2007: mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK

Oxford English Dictionary online (2008). Available at: http://www.oed.com

Power S, Plummer N, Pearce K, Walland D, Edwards S, Jones D, Gipton S, Holper P, Whitehead R (2008) Changes in Australian attitudes towards global warming. WMO MeteoWorld, April issue

Sterman S (2008) Understanding climate change complacency. Available at: http://web.mit.edu/newsoffice/ 2008/climate-sterman-0820.html

Stern N (2006) The economics of climate change. Cambridge University Press, Cambridge, UK. Available at: http://www.sternreview.org.uk

Chapter 35
Climate Change along Italian Coasts: Consciousness for Actions

Edi Valpreda

Abstract Starting from some key outcomes of the first agreement on the Protocol on ICZM (Integrated Coastal Zone Management) in the Mediterranean Region recently signed in Madrid, the paper seeks to contribute to an evaluation of what the application of climate change adaptation policies along Italian coasts really could mean.

This research aims to provide a concrete comparison between the present coastal land use and substantive obligations stated in the Protocol. Among these, we have mainly considered building limitations in an area of at least one hundred metres from the sea. In this context, the paper analyses the present land use and its spatial features regarding the coastal vulnerability to climate change and the feasibility of adaptation strategies.

An index-based evaluation of the aptness of application of the Protocol along Italian coasts has been prepared, showing substantial differences in regional potential.

The research presents methods to select zones where the Protocol could be applied and used to consider non-standard solutions, such as converting the impact of the railways into a coastal protection perspective.

This study intends to offer a concrete stimulus for a national coastal adaptation programme that is still lacking in Italy, suggesting innovative methods for a national comparison of regional particularities regarding coastal adaptation.

Keywords Adaptation · Coast · ICZM · Italy · Land use · Planning · Risk · Sprawling

Introduction

The Integrated Coastal Zone Management (ICZM) has been adopted as the key paradigm for the sustainable development of coastal areas around the world and it is now a major public policy issue in most European countries, while few, such as

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Italy, are still reluctant. In Italy, there still persists a lack of awareness of the strategic and economic relevance of having a national approach to ICZM that harmonizes the currently decentralized and voluntary approach. This means that Italian coastal environments are very ineffectively coping with the growing economic pressure of increasing littoral vulnerability: the natural coastline and its resilience are largely decreasing without a supraregional plan to decide risk adaptation practices and apply ICZM proceedings.

Europe is implementing coastal adaptation topics as a natural continuation of its ICZM project, not caring about delaying countries. In fact, within the majority of the countries of the European Union, ICZM and adaptation have already been supported by organized communities of scientists and practitioners, with substantial national budgets for both research and implementation.

This paper will discuss a possible new coastal adaptation strategy in Italy, caused by the Madrid Protocol, and offers a national approach on this topic, necessary to bring about national awareness.

The peculiar history of Italy is the reason for both the origin of today's limited harmonized risk management and for the incompetencies in sustainable regional planning; the speed of climate change and the relevance of its impact (in terms of damage and mitigation costs) mean that this approach must be revised quickly in order to make up for lost time.

This paper suggests a national framework, beyond scientific expectations, to give statistics, tools, and methods useful to realizing what happens and what could happen in terms of coastal planning and adaptation in the whole country from a European perspective. This work could be either unrealistic or helpful. It could offer two kinds of reflection: a national reading, that makes it possible to appraise different coastal planning outcomes in the country, and also a supranational reading of the Italian status as a possible scenario resulting in a European system based solely on proactive policies for risk adaptation.

Climate Change Adaptation in Coastal Zones

The intrinsic characteristics of coastal areas mean that adaptation is absolutely vital in response to the risk caused by natural phenomena (flooding, storms, and tsunamis). Adaptation is, in a broad sense, synonymous with integrated planning and sustainable development which, as a crucial starting point, need knowledge, legislative tools and the political and social will to implement the principles of sustainability and ethics in land planning.

Over the coming years and decades, climate change in coastal areas will increase the general trend towards overwashing and loss of transitional coastal environments and fresh water that has been proceeding for at least 30 years in the Mediterranean area.

Today, this situation is mostly due to anthropogenic effects that will be worsened by the greater concentration in time and intensity of weather events (in the basins and the sea) and the rising of the sea level that climate change scenarios envisage for the next 100 years.

In the Mediterranean (more than in other European regions), there is a significant growth in human settlements (housing, towns, roads and railways) and expectations regarding the exploitation of coastal areas (bathing establishments, marinas, harbours, industries). In Italy, this occurs against a planning background that does not really link the coastal zone and basin zone management. This hampers the mitigation of conflicts due to different uses of the land and results in a generalized increase in coastal retreat. As a result, there has been a drastic reduction in the material available for the beaches, together with a hardening of coastlines which has prevented the natural coastal flexibility towards erosive events and increased the aggressiveness of river flooding, resulting in devastating effects on the coast in recent years (Caputo et al. 1991; EEA 2006). Moreover, in Italy, these events occur in the absence of a national adaptation strategy for the government of coastal environments.

Institutional decentralization in land planning in Italy (stipulated by law no. 142/90) has created a system that values the needs and autonomy of local districts and their experiences, but in which the participatory approach has not been able to guarantee an organic and homogeneous country-wide system regarding national strategic issues, such as water resources management, the effects and impact of climate change, coastal and hydro-geological risks, etc. While sustainability is perceived as an abused expression, sustainable coastal management is a real requirement in planning within a dynamic transition area under significant economic pressure and with a high level of environmental and ecological vulnerability, as is the case for coastal environments, in particular in the Mediterranean region.

The fragmentation in land planning (and risk management) limits or undermines the principle of geographic reciprocity that should be a basic element for integrated and sustainable coastal management which the presence of a “high” level of decision-making (national, European) could better sustain. Overall, land planning and risk management (like adaptation) in Italy needs a different and more efficient model to integrate bottom-up and top-down experiences, knowledge and authority under the “act local, think global” principle. Only in this way will the ongoing environmental emergency be halted and new competences developed to address the residual risks as unexpected events develop.

ICZM Perspectives in Europe and in Italy

ICZM is an adaptive, multi-sectoral governance approach which strives for the balanced development, use, and protection of coastal environments as well the improvement and coordination of local activities. It is, therefore, a basic tool in land planning and in coastal risk adaptation practice.

Adaptation will include increasing physical protection from rising sea levels and more extreme weather, as well as the abandonment of non-sustainable land use practices. Protecting and restoring coastal ecosystems will require coordinated multidisciplinary efforts involving all levels of government, the private sector, and the general public.

Since 1995 (Protocol of Barcelona), the European Union has supported a European strategy to integrate the environmental and development policies that the ICZM recommendation proposes for coastal regions even as a model for non-coastal land.

As result of this continued institutional interest, the deployment in Europe of ICZM has had significant effects on the general awareness of the economic and the environmental importance of the coastal problem and its transnational dimension (Ciscar et al. 2009; European Commission 2007).

The EEA report (EEA 2006) shows that there has been a different response in Italy. Only the Emilia Romagna region has so far completed the institutional procedure provided for ICZM recommendation. The most recent act in a complex procedure is the Protocol on ICZM in the Mediterranean, signed in Madrid on 21 January 2008 by 14 Mediterranean countries including Italy. This is the first European regulation to implement ICZM.

Evidently, there is a deep divide between institutional ratification (both by Government and the Council of Regions) of the Protocol and its implementation. The large number of actors involved in coastal planning in Italy together with the complexity of the coastal system (8,000 km of coasts with high environmental value and highly exploited by business; over 5,000 km are low beaches, of which approximately 40% have existed for at least 30 years) have made coastal risk governance very complicated.

The proactive, bottom-up approach (determined by lawmakers) has so far not been sufficient to overcome the lack of coordination between different levels and sectors of the administration, nor to produce for the country as a whole adequate information on the state of the coastline and the impacts (economic and otherwise) of local policies.

According to some projections, by 2010 about 75% of the world's population will be established in coastal areas. Since 2001, over 50% of land in Italy within 1 km of the coast has shown a population density of approximately 200–500 inhabitants/sq km, with a growth rate (since 1991) of 10% (EEA 2006). Recent estimates indicate an increase by 2025 to 45% of coastal urban area in Italy (Blue Plan 2008). By 2025, the number of tourists in the Mediterranean coastal area is estimated to be 130 million more than today (three times the 2005 figure) (Blue Plan 2005, 2008).

In the Italian context, this pressure creates a real risk of loss of both identity and coastal resilience (Blue Plan 2008) and highlights the need to recognize the national value of risk management and coastal development that cannot be entrusted solely to regional or local authorities.

With this objective, we have carried out the present research which, following certain principles enshrined in the Madrid Protocol, has examined the current use of Italian coasts and reflected on the potential need for a national approach to coastal zone planning as a way to solicit implementation of the Protocol implementation.

Applying the Madrid Protocol: Its Suitability in Italy

Within the Madrid Protocol, there are two specific principles which concern the area contiguous with the sea, the so-called “100 m strip”, and areas influenced by the coast.

The Protocol identifies the *non edificandi* nature of the 100 m or more coastline strip contiguous with the sea, save for installations dedicated to public services or to economic activities, which require the immediate proximity of water.

Moreover, it specifies severe regulations concerning the development of areas influenced by the coastline for a distance which varies according to the location but has not yet been defined in law (approximately 1–10 km).

The application of these principles depends essentially on the ability of coastal areas to introduce the adaptation concept within their development project. Starting from the current status, future assumptions regarding coastal development and use will significantly differ from the past. In Italy, adaptation could mean a massive de-location or, more pragmatically, the start of a strategy for a reciprocal territorial pact (inter-regional). This implies a capacity for large-scale strategic planning which requires appropriate knowledge to support the possible options, as well as any actions of local compensation. In Italy, the relevant and country-wide geographical knowledge regarding important environmental issues (such as coastal risk) is still very inconsistent and fragmented.

The standardized set of land use information available for the whole country “Corine Land Use Project” (APAT 2005) is not suitable to describe and analyse in detail land use within the 100 m of the sea. The most recent position of the coastline also needs to be mapped, in order to calculate, from this line, the “restricted exploitation area” at a distance of 100 m.

The position of the border between land and sea was drawn from OrthoMaps updated in 2006 (at the nominal scale 1:10,000) that are available in the WMS protocol of the Portal of the Ministry of Environment, Land and Sea. The documents also provide the land use classification.

Classes of land use have been divided into 13 types:

1. Urbanized area
2. Sprawl
3. Anthropized area (permanent lido, camping structure)
4. Railway
5. Agricultural land
6. Pinewood
7. Beach
8. Coastal dunes
9. High coast – natural
10. High coast – urbanized
11. Harbour
12. Industry site
13. River mouth

These features have been associated with polygons delimited between the coastline and a line at a distance of 100 m. These are the primary geometric entities of the database and are classified according to the “predominant type of use”, their concomitance with Sites of Community Importance (SIC) and their regional pertinence. This site (European Directive 43, 1992, May 21) depicts the high biodiversity habitats networks in Europe. As defined in agreements between European and national authorities, the sites should not be used for new industrial purposes or human settlements.

All data are entered into a vector geo-database which has been built using applied models of spatial analysis and indices, in order to construct and test a means to analyse and compare land use spatially as a tool for the development, comparison, and monitoring of present and future policies at local or national level.

In some of the analyses presented, some land use types have been merged to create derived classes, e.g. the “natural” class which includes the simple categories “beach, pinewood, river mouth, natural high coast, lagoon”. This is a decision taken by the author in order to obtain focused results in the present study and is not a binding approach for more detailed analyses.

Data and Results

To develop and test the methodology, seven regions (out of a total of 17 coastal regions) representative of the country as a whole were considered: Tuscany and Emilia Romagna in the north, Marche, Lazio and Abruzzo in central Italy, and Molise and Basilicata in the south.

The study of the use of the coastal lands was undertaken by means of a series of integrated analyses using the extent and topological characteristics of the elements contained in the database (lengths, areas, inclusion) merged with geomorphologic aspects (from cartography).

In particular, we analysed the relationship between the length of the regional coastline and the spatial distribution of different coastal land uses by calculating the percentage for each category (or significant associations) with respect to the entire coast in the region (Fig. 35.1).

This distribution (as a %) was then compared with the spatial presence of SIC areas (geographical coincidence) (Table 35.1) and the morphology of the coast (high and low coast) (Table 35.2).

From this first set of comparisons, it is possible to express, with indices, the result of applying the main criteria of the Madrid Protocol to the development of the coast area overlooking the sea.

First, the assessment of the current type of land use (combining the various types of classified urbanization) reveals that already in 2006 and in all the regions examined about 30% of the “*non edificandi*” area was occupied by anthropogenic fixed settlements, with percentages as high as 50% in Molise and Abruzzo. Only the Basilicata region (the Ionian coast) differs with a figure of about 5%.

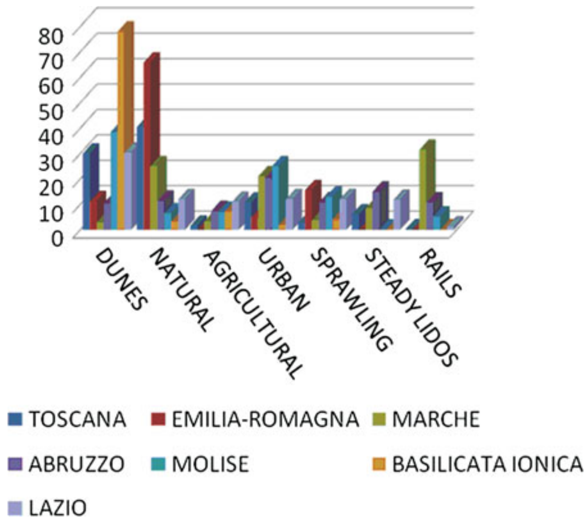

Fig. 35.1 Coastal land use (% of the length of the regional coastline)

Table 35.1 Presence of SIC (first data column) and various land use classes within 100 m of the shore: (X/..) percentage with respect to the length of the regional coast and (../X) percentage with respect to SIC areas

Region	SIC	Urban area	Urban sprawl	Beach fixed structure	Natural	Dunes	Agricultural	Railways
Emilia Romagna –/–	32.7	5/–	15.5/1	–/–	77.4/	31.2	11.2/6	–/–
Toscana 0.2/0.2	31.3	15.8/−0.1	2.8/0.1	6/0.03	70.4/	30.6	30/12.3	1.6/–
Marche	17.3	21/0.45	4.6/–	10/–	19/15.6	2.6/0.9	4.2/–	30.2/1.1
Abruzzo	13	20.3/0.1	10.8/0.7	15/–	11.4/4.2	10.5/3.2	7.4/2.4	10.8/1.1
Molise	73.7	25/15.5	5.6/4.6	–/–	36.6/32	38.5/38.5	7/7	5.2/5.2
Basilicata Ionian Sea side	70	2/–	4.1/1.5	–/–	3.4/3.4[a]	78/65	7.3/4.4	–/–
Lazio	31	15.4/0.4	12/2	11.8/1.8	12/1.7	30.3/21.3	11/2.4	1.3/–

[a]All mouths

Table 35.2 Percentage of low coast in each region (first column); percentage share in function of morphological distribution (high coast/low coast) of SIC and some classes of land use

Region	Low coast	SIC H/L coast	Urban H/L coast	Natural H/L coast	Railways H/L coast
Emilia Romagna	100%	–/32.7	–/5	–/77.4	–/–
Toscana	45%	15.3/16	5.3/10.6	18.6/51.8	0.2/–
Marche	83.7	12.4/4.9	21/–	13.8/5.2	–/30.2
Abruzzo	79.2	2.2/10.8	1.6/18.7	1.1/10.3	1.1/9.9
Molise	99	–/73.7	1/25	–/36.6	–/5.2
Basilicata ionica	100	–/80	–/2	–/3.4	–/–
Lazio	74.5	2/31	0.6/9.24	1.7/10.3	–/1.3

Where the % of urban settlement is smaller, the % of sprawling shows proportions twice or three times as high (in Basilicata and Emilia Romagna). This value plus the % of coastal lands occupied by the national rail network reach a figure of 37% in Lazio and more than 60% in the Abruzzo and Marche.

On average, agricultural activities occupy approximately 5.4% (range from 0 to 11%) of the coastal zone.

The natural areas are well represented in the regions examined: 70–80% in Tuscany, Emilia Romagna, and Basilicata (Ionian coast), about 30–40% in Molise, Lazio, and Marche and about 20% in Abruzzo. Within this class of land use, coastal dunes still account for a significant share of the regional coastal territory in all regions (on average 33%, and over 70% in Basilicata), apart from Marche, where dunes represent less than 3% of the area.

Analysing the presence of SIC areas within "*non edificandi*" coastal areas there is an overall average of 38%, with values of over 30% in three cases and 70% and more in two cases (see Table 35.1).

The comparative analysis between the presence of SIC and land use is very interesting, as it highlights the effect of different regional sensitivities in applying the principle of environmental sustainability. The sample can be divided into two groups. The first includes areas where there are significant urban settlements (continuous or not) within SIC areas. In this case, we note that the natural areas or the coastal dunes are present almost exclusively within the SIC. In contrast, the second group has a limited presence of human settlements in the SIC (maximum values of 0.4% for urban and 2% for discontinuous settlements) and a significant presence of natural areas and coastal dunes also outside the SIC.

The lack of the class "permanent lidos" in some regions (Emilia Romagna, for example) does not indicate the real absence of these structures, but is rather the result of their inclusion within the urban fabric.

Another important element to analyse when considering the current status of human pressure in coastal areas in Italy as well as the real possibility of reducing this pressure in the future is the morphology of the coast. Table 35.2 shows the respective land use and presence of SIC in high coast and low coast areas.

In the case of SIC in high coast areas, there is a greater capacity to safeguard these areas within regional development policies, even if they constitute a very high percentage of the regional area. On the other hand, there is a large proportion of natural areas and coastal dunes within the low-lying coastal areas in all cases analysed.

Another assessment that is crucial for the evaluation of opportunities to intervene effectively in the development of new policies for the coastal territory is the fragmentation of land use.

In terms of landscape, excessive fragmentation of land use is an element which limits geographical connectivity and makes the maintenance of specificity for the environments more complex (Forman 1995; Battisti and Romano 2007). In ecological terms, the "connectivity conservation" principle is recognized as crucial in assessing the fragility of areas of high environmental value. The peculiarity and vulnerability of coastal areas are determined not only by ecological peculiarities, but by the entire set of human and natural elements that define the cultural particularities, as well as by morphological or environmental considerations. Consequently, the management, protection, and development of these areas become even more complex.

In this study, we consider the spatial fragmentation of land use as an element able to determine serious difficulties in the general management of the coastal territory when, in a given geographical area, there is excessive residual size resulting from the fragmented distribution of land use classes.

In order to transform this conceptual approach into an evaluation and monitoring tool, we have analysed the fragmentation of the coastal territory with an index, the Spatial Breakup Index (SBI), derived by comparing the average length (projection on the coastline) of any class of land use (or their significant associations) with the length of the regional coastline (Fig. 35.2).

The SBI values express the fragmentation on the coast of homogeneous stretches. Figure 35.2 shows the values for some of land use classes and for SIC. With regard to the latter, it is interesting to note that there seems to be a correlation between higher percentages and a greater geographic discontinuity.

In general, land use fragmentation is more common in Abruzzo, Tuscany, and Marche and found least in Lazio. The phenomenon is not widespread in Emilia Romagna and Molise, and percentages are small in Basilicata (Ionian coast). The coastal dunes clearly show the relationship between the fragmentation of land use and the possibility to safeguard the coastal environments more effectively. The highest values for geographical fragmentation are in Marche and Abruzzo (Fig. 35.2), where the proportion of dunes along the coast is considerably lower than in the other areas examined (Table 35.1). This result seems to support the hypothesis of greater difficulty in developing policies for the development of environmentally fragile coastlines (of various kinds) in a highly fragmented coastal system.

Without using a multi-temporal approach, it is not easy to assess whether the state of fragmentation of the territory is a current trend or depends on choices made in the past. This type of analysis would be of great interest to evaluate regional

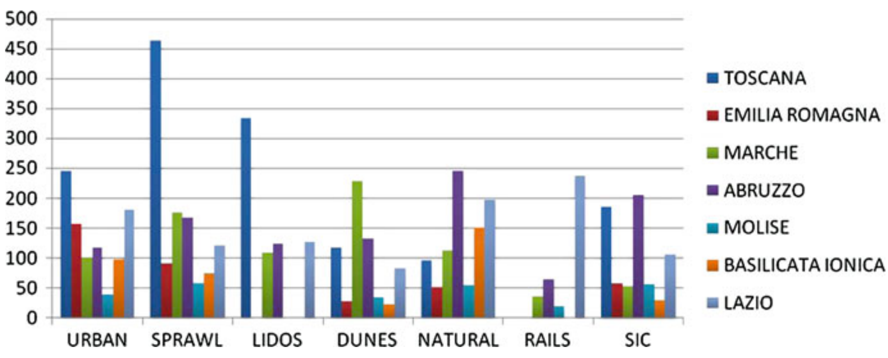

Fig. 35.2 Coastal land use Spatial Breakup Index (SBI)

policies and, in particular, to interpret the current state of human-urban settlement in the coastal zones.

This study investigates the current state of coastal adaptability. Since it is proposed to provide tools to analyse the current status and also to track future planning choices, the research will be extended to include a multi-temporal and dynamic evaluation.

Finally, Table 35.3 shows an integrated analysis of data from this research with a view to proposing a criterion to assess the potential to implement the Madrid Protocol (specifically regarding human pressure). This evaluation will depend on many concurrent aspects and interacting physical-geographical, historical, political, and cultural elements.

This analysis is a method to establish a national benchmark to compare the prerequisites for the application of adaptation policies and, at the same time, to monitor the trend in the development of such practices along the national coastal territory.

The analysis examines the regional situation by comparing (in a qualitative way) three factors:

- The availability of free land ("Land Resource availability potential") based on % of prevailing current use in the coastal region
- The fragmentation of natural areas ("Natural Resources Sustainable Planning Potential") based on the value of the SB index for the composite land use class: "Natural"
- The fragmentation of the areas occupied by coastal dunes ("Dunes Sustainable Planning Potential") based on the value of the SB index for the land use class: "Dune"

Each factor is assigned a different degree based on the data (Fig. 35.3) and according to a quantitative, and necessarily, subjective principle.

In the sample examined, three regions out of seven still have a lot of "free coastal land" (up to 70%) suitable for maintaining and strengthening non-invasive coastal policies and implementing practices for coastal adaptation.

This is the case of coastal dunes that (as this research confirms) could become a real opportunity in practices of adaptation to coastal risks (Table 35.4).

Awareness of the importance of coastal dunes in adaptation practices implies innovation in approaches and in social sensitivity, e.g. in expectations regarding the economic development of beaches. As recognized in international experience, this

Table 35.3 Criteria used to evaluate the adaptive capacity of the regions

Degree	A	B	C
Very Low (LL)	<20%	>150	>150
Low (L)	20–30%	100–150	100–150
Medium (M)	30–50%	50–100	50–100
High (H)	50–70%	20–50	20–50
Very High (HH)	>70%	<20	<20

is a step toward reconciling environmental protection with its development, but demands significant changes in the coastal development model.

The procedures for adapting to risk in coastal areas should be chosen not only with a view to protecting the reclaimed land at all costs. The current condition of the risk of erosion and flooding of the coast of Italy is already extremely serious, and the scenarios of climate change will exacerbate the situation by acting on the triggering factors. Given the length of the Italian coast (about 8,000 km of which about 5,000 km are low coast), this suggests a risk scenario for the coming decades that will have to be managed and mitigated over time and over vast areas (national and perhaps even Mediterranean).

Adaptation involves choices of planning for the future and also options for displacement of settlements or the abandonment of territories to the sea force. In particular, "flexible" systems of defence are being proposed more forcefully, as they adapt better to environmental conditions that will certainly change, although we do not know at present when and how this change will occur. Interventions to increase the safety of coasts with sand nourishment, rebuilding of dunes, or the creation or restoration of wetlands in the river mouths are considered the most

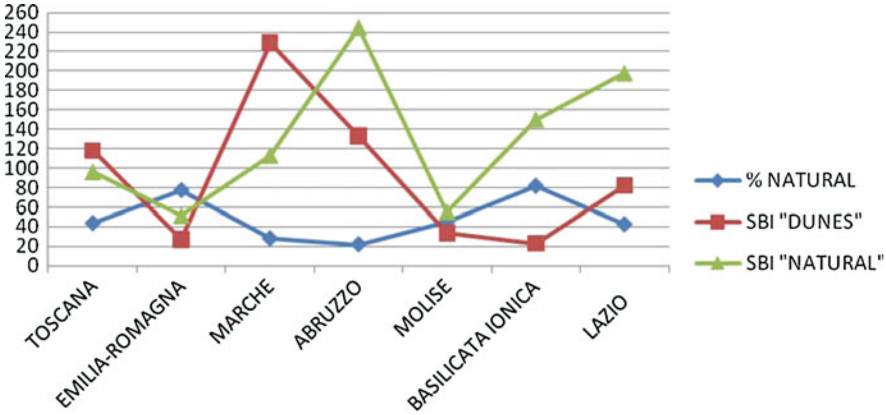

Fig. 35.3 Data on which the adaptive capacity assessment of Italian regions is based

Table 35.4 Potential adaptive capacity to apply the Madrid Protocol in Italian regions

Region	Land resource availability potential	Natural resources sustainable planning potential	Dunes sustainable planning potential	Adaptation potential degree
Toscana	M	M	M	M
Emilia Romagna	HH	H	H	H
Marche	L	L	LL	L
Abruzzo	L	LL	L	L
Molise	M	M	H	M
Basilicata Ionica	HH	LL	H	H
Lazio	M	LL	L	L

suitable in these uncertain conditions of change and are highly supported in the European recommendations.

However, in many regions of Italy, it is difficult in the short term to reverse policy trends (e.g. cementification) that are already underway. The built-up environment is still expanding. Although classified as SIC, marinas are frequently located in river mouths, for example in Molise or on the Ionian coast of Basilicata. Consequently, the theoretical possibility to improve the coasts is in fact much less feasible than it might be.

Conclusions

The criteria and methods proposed and used are an opportunity to assess (from a common observatory) the potential to implement concrete strategies in Italy in order to adapt to coastal risk in agreement with the principles of a sustainable response to climate change, as specifically required for the Mediterranean by European laws and the sensitivity of the broader international scientific community.

The Madrid Protocol for the Mediterranean is the latest (and strongest) European appeal for concrete policies to adapt to coastal risk on the basis of the contents of the recent White Paper on climate change adaptation (European Commission 2009). Italy has officially signed the Madrid Protocol, but unlike other European countries, it has not yet started any national strategy for adaptation to coastal risks. Dramatically, the new local authority in Sardinia has recently annulled previous laws that were the only case in Italy of the regional application of the principles enshrined in the Madrid Protocol, i.e. avoiding new buildings in its coastal area up to 1,200 m from the sea (Sardinia regional law no. 8, 2004).

At present, there is a disparity between formal adherence to European rules and principles and their national application. In Italy, the forms of regional and local administration of the territory do not favour the capacity to foster an awareness of national problems and consider the country-wide opportunities in terms of innovation in risk management, in particular for coastal areas. This analysis seeks to propose a tool to be used throughout the country. The aim is to provide a cognitive framework, but also to highlight the necessity to act at country level to compensate (or resolve) the local differences in adaptation strategies, while respecting the autonomy to decide and the value of local expertise.

The concept of sustainability that currently appears to be a theoretical and abused idea involves facts of land management: the implementation of ICZM is one such action which, however, Italy has not pursued. To date, only the Emilia Romagna region has completed actions to accomplish the ICZM procedures (EEA 2006). Sustainability in coastal areas is also based on rules of planning reciprocity that often cannot work within the administrative boundaries and cannot be left to voluntary acts between the parties. In Italy, this voluntary approach triggers a complex and lengthy process that imprisons the planning of risk and choices of mitigation inside the short time and space of the local political mandate. This is exactly the opposite of planning in a sustainable way and thinking about adaptation. Climate change will probably produce a major discontinuity with the tradition of past development, expectations, and potential use of the coastal territory.

As coastal risk is not only related to climate change effects (because in these environments the likelihood of erosion and flooding is often due primarily to anthropogenic factors), a social reaction is also necessary, such as greater awareness and a new capacity to modify traditional assumptions. In this sense, the presence of the railway infrastructure in the coastal environment has been analysed. The main railway lines that still cross the country were built soon after the proclamation of the Kingdom of Italy in 1861.

The morphological conformation of the peninsula, combined with the fact that in those years the coastal area had no environmental, ecological, or economic value (and in particular, coastal dunes were only heaps of sand suitable to support the rail infrastructure) meant that most of the railway lines were designed and constructed near the coast. In those years, there was no perception of the possible retreat of the sea–land border. The beaches were wide; the material came from large rivers to the sea to supply the natural coastal dynamic. Port facilities were not widespread, and the country did not present the conditions for the widespread risk to the artefacts as a result of erosion or flooding.

Obviously, the conditions have now completely changed, and the main railway lines are close to the sea–land border. In the regions examined, over 75 km of railway lines are located within the range of 100 m from the sea and are often in low-lying and even retreating coastal areas. While this infrastructure appears to be suitable for the needs of environmental quality and safety of manufactured goods (subject to erosion and storm surge impact), the presence of the railway lines has prevented the urbanization of the confined stretch of coast between the railway and the sea (where there is still a beach). We have stretches of "wild" coast, because access to them is made difficult by the presence of the railway. In a logic of non-historical continuity with the traditions of spatial planning, we are seeking to imagine that the railways in Italy could become an element of adaptation rather than risk.

Sharing the costs of adaptation interventions among private investors and government (local or national) will be an element of the success of future policies of land management. The safety of the railway infrastructure near to the sea can be an interesting opportunity for the implementation of innovative projects for coastal risk adaptation. These can be planned as long-term scenarios and for extensive areas, and could be co-financed by the public and private actors. Certainly it will be necessary to overcome cultural conflicts between protection and land use, for example accepting that the adaptation (or mitigation) of coastal risk is never absolute and can never quite transform a dynamic area into a static and unmovable environment.

References

APAT (2005) "La realizzazione in Italia del progetto europeo CORINE Land Cover 2000", Agenzia per la Protezione dell'Ambiente e per i servizi Tecnici. Report No. 36/2005, Rome

Battisti C, Romano C (2007) "Frammentazione e connettività. Dall'analisi ecologica alla pianificazione ambientale", Città Studi Ed., Milano

Caputo C, D'Alessandro L, La Monica GB, Landini B, Palmieri EL (1991) Present erosion and dynamics of Italian beaches. Zeitschrift Geomorphology Suppl 81:31–39

Ciscar JC, Soria A, Iglesias A, Garrote L, Pye S, Horrocks L, Watkis P, Nicholls R, Roson R, Bosello F, Feyen L, Dankers R, Moreno A, Amelung B, Labeaga JM, Labandeira X, Christensen OB, Goodess C, van Regemorter D (2009) "Effects of climate change in Europe: Results from the PESETA study", in IOP Conference Series: Earth and Environmental Science 6, IOP Publishing Ltd, London

EEA (2006) "The Changing faces of Europe's coastal areas", EEA Rep.6/2006, Copenhagen Available at: http://www.eea.europa.eu/publications/eea_report_2006_6/ (July 2006)

European Commission (2007) "Green paper from the commission to the Council, the European Parliament, the European economic and social Committee and the Committee of the Regions. Adapting to climate change in Europe – options for EU action", COM/2007/0354 final. Available at: http://ec.europa.eu/environment/climat/adaptation/ (June 2007)

European Commission (2009) "White paper – Adapting to climate change: towards a European framework for action", SEC (2009) 386. Available at: http://ec.europa.eu/environment/climat/adaptation/ (April 2009)

Forman RTT (1995) Land mosaics: The ecology of landscapes and regions. Cambridge University Press, Cambridge

Plan Bleu (2005) "Dossier sur le tourisme et le développement durable", MAP Technical Report No. 159

Plan Bleu (2008) "Climate Change and Energy in the Mediterranean", Regional Activity Center, Sophia Antipolis. Available at: http://www.planbleu.org/publications/changement_clim_energie_med_EN.pdf (June 2008)

Chapter 36
Climate Change Impacts on East Africa

Muawya Ahmed Hussein

Abstract Africa contains about one-fifth of all known species of plants, mammals, and birds, as well as one-sixth of amphibians and reptiles. These species make up some of the world's most diverse and biologically important ecosystems, such as savannahs, tropical forests, coral reef marines and freshwater habitats, wetlands, and montane ecosystems. These globally important ecosystems provide the economic foundation that many Africa countries rely on, by providing water, food, and shelter. However, because of climate change, these ecosystems and the livelihoods that depend on them are threatened. The aim of this paper is to highlight some of the major impacts of climate change on conservation for East African countries including Kenya, Tanzania, Uganda, and Rwanda. As this paper illustrates, climate change in Africa is not only a conservation problem, but a socio-economic issue that must be dealt with on a global scale.

Keywords Climate change · Food · Impacts · Shelter · Species · Water

Introduction

Climate change is really happening now. The average global surface temperature has warmed by 0.8°C in the past century and 0.6°C in the past three decades (Hansen et al. 2006), in large part because of human activities (IPCC 2001). A recent report produced by the U.S. National Academy of Sciences confirms that the last few decades of the twentieth century were in fact the warmest in the past 400 years (National Research Council 2006). The Intergovernmental Panel on Climate Change (IPCC) has projected that if greenhouse gas emissions, the leading cause of climate change, continue to rise, the mean global temperatures will increase by 1.4–5.8°C by the end of the twenty-first century (IPCC 2001).

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The effects of climate change, such as rising temperature and changes in precipitation, are undeniably clear, with impacts already affecting ecosystems, biodiversity, and people. In both developed and developing countries, climate impacts are reverberating through the economy, from threatening water availability to sea-level rise and extreme whether impacts to coastal regions and tourism. In some countries, climate impacts affect the ecosystem services that communities are largely dependent upon, threatening development and economic stability. Future impacts are projected to worsen as the temperature continues to rise and as precipitation becomes more unpredictable.

One region where the effects of climate change are being felt particularly hard is Africa. Because of the lack of economic, development, and institutional capacity, African countries are likely among the most vulnerable to the impacts of climate change (IPCC 2001). Climate change impacts have the potential to undermine and even undo progress made in improving the socio-economic wellbeing of East Africans. The negative impacts associated with climate change are also compounded by many factors, including widespread poverty, human diseases, and high population density, which is estimated to double the demand for food, water, and livestock forage within next 30 years (Davidson et al. 2003).

Observed and Projected Climate Change

Overall, Africa has warmed 0.7°C over the twentieth century, and general circulation models project warming across Africa ranging from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario) (Hulme et al. 2001; IPCC 2001). Hulme et al. (2001) suggest that under intermediate warming scenarios, parts of equatorial East Africa will likely experience 5–20% increased rainfall from December–February and 5–10% decreased rainfall from June–August by 2050. Climatic change of this magnitude will have far-reaching, negative impacts on the availability of water resources, food and agricultural security, human health, tourism, coastal development, and biodiversity, highlighted below.

Water Availability

Arguably, one of the most widespread and potentially devastating impacts of climate change in East Africa will be change in the frequency, intensity, and predictability of precipitation. Changes in regional precipitation will ultimately affect water availability and may lead to deceased agricultural security, human health, tourism, coastal development, and biodiversity.

Projections of climate change suggest that East Africa will experience warmer temperatures and a 5–20% increased rainfall from December–February and 5–10% decreased rainfall from June–August by 2050 (Hulme et al. 2001; IPCC 2001). Not only are these changes not uniform throughout the year, they will likely occur in sporadic and unpredictable events. It may also be likely that the increased precipitation will come in a few very large rainstorms, mostly during the already wet season, thereby adding to erosion and water management issues and complicating water management. It is also expected that there will be less precipitation in East Africa during the already dry season, which may cause more frequent and severe droughts and increased desertification in the region.

Recent research also suggests that warming sea surface temperatures, especially in the southwest Indian Ocean, in addition to inter-annual climate variability (i.e. El Niño-Southern Oscillation (ENSO)), may play a key role in East African rainfall and may be linked to the change in rainfall across some parts of equatorial and subtropical East Africa (Cane et al. 1986; Plisnier et al. 2000; Rowe 2001). Warm sea surface temperatures are thought to be responsible for the recent droughts in equatorial and subtropical East Africa during the 1980s to the 2000s (Funk et al. 2005). According to the UN Food and Agriculture Organization (FAO 2004), a number of African food crises per year were caused by water supplies reducing crop productivity, and have resulted in widespread famine in East Africa.

In addition to declining moisture needed for pastoral and agricultural activities, the availability of water for human consumption is of paramount concern. Currently, two-thirds of rural Africans and a quarter of urban dwellers in Africa lack access to clean, safe drinking water (Simms 2005). In Tanzania for example, two out of three rivers have reduced flow due to declining regional rainfall, which has had ecological and economic impacts such as water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity, and variable hydropower production (Orindi and Murray 2005). High temperatures and less rainfall during already dry months in the Tanzania river catchments could affect the annual flow to the River Pangani by reductions of 6–9% and to the river Ruvu by 10% (VPO-URT 2003). The Pngani Basin is also fed by the glaciers of Kilimanjaro, which have been melting alarmingly fast and are estimated to disappear completely by 2015–2020 (Thompson et al. 2002). The population living around the base of Kilimanjaro uses this meltwater and the fog water from the rainforests that cover the mountain's flanks for drinking, irrigation, and hydropower. The Pangani Basin is one of Tanzania's most agriculturally productive areas and is an important hydropower production region. Because of this, climate change threatens the productivity and sustainability of this region's resources, which hosts an estimated 3.7 million people.

Food Security

There is a strong link between climate and East African livelihoods and food security highly vulnerable to climate variability, such as shifts in growing season conditions (IPCC 2001). Furthermore, agriculture contributes 40% of the region's gross domestic product (GDP) and provides a living for 80% East Africans (IFPRI 2004). However, because temperature has increased and precipitation in the region has decreased in some areas, many are already being affected. For example, from 1996 to 2003, there was a decline in rainfall of 50–150 mm per season (March to May) and corresponding decline in long-cycle crops (e.g. slowly maturing varieties of sorghum and maize) across most of East Africa (Funk et al. 2005). Long-cycle crops depend upon rain during this typically wet season and progressive moisture deficit results in low crop yields in the autumn, thereby impacting the available food supply.

Increased variability (i.e. deviation from the mean) of crop production is also a major concern of farmers in eastern Africa. Inter-annual climate variability (e.g. ENSO) has huge impacts on the region's climate. Warm ENSO events, also referred to as El Niño events, produce abnormally high levels of precipitation in parts of equatorial East Africa and can result in flooding and decreased agricultural yields. Further south, in Zimbabwe, researchers correlated past El Niño events and warm sea surface temperatures in the eastern equatorial pacific with more that 60% of the change between above and below average agricultural production of maize (Patt et al. 2005).

Climate change may also impact the region's fisheries. While many tropical fishes have evolved to survive in very warm water, many have a critical thermal maxima and cannot survive temperatures that exceed this threshold. For example, spotted tilapia, (*Tilapia mariae*), native to parts of Africa, prefer temperatures between 25 and 33°C, depending upon acclimation temperature, and have a critical thermal maxima of 37°C (Siemien and Stauffer 1989). Although tropical fishes can endure temperatures very near their temperature threshold, a slight (1–2°C) increase in regional temperatures may cause the daily temperature maxima to exceed these limits, particularly for populations that currently exist in thermally marginal habitats (Roessig et al. 2004). However, because there is little data on the ability of this species to adjust their tolerance to water temperature, their response to climate change is largely unknown.

An increase in mean temperature may also affect the dissolved oxygen concentrations in the layer of water below the thermocline (hypolimnion) in two ways: increased metabolism of fish and other organisms in a slightly warmer hypolimnion will lead to the faster depletion of the limited oxygen supply, and lake overturn, the primary means of replenishing hypolimnetic dissolved oxygen, will occur less frequently (Fick et al. 2005). The African General Lakes contain deep anoxic hypolimnia and tropical lakes also contain high concentration of hydrogen sulphide. This chemical compound is a byproduct of anaerobic decomposition of organic matter and is highly toxic to fish. Moderate amounts of mixing allow nutrient influx into the layer of water above the thermocline and benefit fisheries' productivity without introducing high concentration of toxic hydrogen sulphide (Fick et al. 2005). This is demonstrated at the stratified northern end of Lake Tanganyika, Africa, which supports a less productive fishery than the well-mixed southern arm and the main basins (Vuorinen et al. 1999). A comparative study of historical and current levels of primary production in the northern end of Lake Tanganyika indicated that current levels are much lower as a result of strengthened stratification (Verburg et al. 2003). Recent changes in the limnology of Lake Victoria have also negatively affected its fishery. In the 1980s, decreased turnover in the lake led to low levels and dissolved oxygen and, consequently, fish kills. Stratification in this lake now appears to be permanent (Kaufman et al. 1996).

Human Health

Climate variability has had far-reaching affects to human health, and includes, but is not limited to, the following: heat stress, air pollution, asthma, vector-borne diseases (such as malaria, dengue, schistosomiasis (also referred to as swimmer's itch or snail fever) and tick-borne diseases), water-borne and food-borne diseases (such as diarrhoea diseases). For this report, we concentrate on just two of these effects, malaria and Rift Valley fever; however, other health issues are likely to be affected by climate change.

Climate change is expected to exacerbate the occurrence and intensity of future disease outbreaks and perhaps increase the spread of diseases in some areas. It is known that climate variability and extreme weather events, such as high temperatures and intense rainfall events, are critical factors in initiating malaria epidemics, especially in the highlands of western Kenya, Uganda, Ethiopia, Tanzania, Rwanda, and Madagascar (Zhou et al. 2004). While other factors, such as topography and health preparedness, can influence the spread of malaria, scientists have found a correlation between rainfall and unusually high maximum temperatures and the number of malaria cases (Githeko and Ndegwa 2001; Zhou et al. 2004). From 1920 to 1950, the highlands of eastern Africa experienced infrequent malaria outbreaks; however, since then, the current pattern is characterized by increased outbreak frequencies, expanded geographic range, and increased case-fatality rates (Zhou et al. 2004). The spread of malaria is seasonal and limited to the warm and rainy months; however, changing climate conditions, such as the persistence of warm and rainy days for more of the year can increase the incidence of malaria events (Craig et al. 2004). In addition to longer seasons that are suitable for malaria spread, temperatures have also been warming in formerly cooler, higher elevation East African highlands. Subsequently, these areas are experiencing a spread of malaria in populations that had not previously been frequently exposed to the disease (Patz et al. 2005; Zhou et al. 2004).

Rift Valley fever epidemics are also correlated to climate variability. Between 1950 and 1988, three-quarters of the Rift Valley Fever outbreaks occurred during warm ENSO event periods (i.e. El Niño events). During El Niño, the East African highlands typically receive unusually high rainfall which is correlated with Rift Valley fever outbreaks (Patz et al. 2005).

Extreme Weather Events

Warming temperatures are projected to cause more frequent and more intense extreme weather events, such as heavy rain storms, flooding, fires, hurricanes, tropical storms, and El Niño events (IPCC 2001). Tropical storms can ravage coastal areas and intensify the impacts of sea-level rise by accelerating erosion in coastal areas and by removing protective natural buffer areas that absorb storm energy, such as wetlands and mangroves (Magadza 2000). Extreme rainfall and subsequent heavy flooding damage will also have serious effects on agriculture, including the erosion of topsoil, inundation of previously arid soils, and leaching nutrients from the soil. Regional fluctuations in lake levels are another impact of regional climate variations and are expected to worsen with projected climate change. While land use change can have a dramatic effect on lake levels, climate variability is more unpredictable and difficult to manage. For example, lake levels in Lake Tumba in the Democratic Republic of Congo (Inogwabini et al. 2006) and Lake Victoria in Kenya (Birkett et al. 1999; Latif et al., 1999) have been attributed to climate variations and may become more variable in the future. In 1997, floods and high rainfall, triggered by an El Niño event in eastern Africa, resulted in a surface rise of 1.7 m in Lake Victoria and disrupted agricultural production and pastoral systems (Lovett et al. 2005). While climate change is projected to cause more frequent and intense ENSO events (Wara et al. 2005) impacts are not uniform across East Africa. In fact, the same year that the waters were rising in Lake Victoria, El Niño triggered a severe drought in another location in Kenya, significantly decreasing hydroelectric power output, limiting the availability of electricity to East Africans (Lovett et al. 2005). Furthermore, a projected increase in precipitation may also have an effect on hurricanes and storms in the Atlantic. Landsea and Gray (1992) has found that rainfall in the Sahel is positively correlated with the intensity of hurricanes in the Atlantic Ocean.

Climate change-induced warming land and sea surface temperatures are projected to cause more frequent and intense hurricanes and tropical storms that inundate coastal areas (IPCC 2001). These same extreme weather events can lead to decreased precipitation in interior regions, causing increased drought and desertification, subsequently threatening food security. Threats to food security can then lead to widespread migration of human settlements in order to seek better agricultural land, more available water resources, and escape increased exposure to malaria and other diseases. The impacts of climate change also have the potential to disrupt and potentially reverse progress made in improving the socio-economic wellbeing of East Africans such as infrastructure development, sustainable agriculture, and tourism.

Sea-Level Rise

Sea-level rise along coastal areas where high human populations occur is likely to disrupt economic activities there, such as tourism, mining, and fisheries. Sea-level rise and resulting coastal erosion is of particular concern in coastal Kenya and Tanzania. Warm sea surface temperatures, extreme weather events, and sea-level rise can lead to the destruction of coral reefs, which absorb the energy of ocean swells (IPCC 2001). Coral reef loss is a significant cause of coastal erosion and a major coastal management issue in both Kenya and Tanzania (Magadza 2000).

Productive mangrove ecosystems along coastal areas serve as a buffer against storm surges by providing protection from erosion and rising tides associated with sea-level rise. However, mangroves are at threat from deforestation, coastal erosion, and extreme weather and have been identified as the most vulnerable species to sea-level rise and inundation (IPCC 2001). Sea-level rise is also threatening the availability of freshwater by causing saltwater intrusion into Tanzania's aquifers and deltas.

In the tea-producing regions of Kenya, the world's second largest exporter of tea, a small temperature increase (1.2°C), and the resulting changes in precipitation, soil moisture and water irrigation, would cause large areas of land that now support tea cultivation to be largely unusable. Economically, this would have far-reaching impacts because tea exports account for roughly 25% of Kenya's export earnings and employ about three million Kenyans (10% of its population) (Simms 2005).

Biodiversity

Despite Africa's fast-growing human population and the associated impacts on natural resources, it is one of the least studied continents in terms of ecosystem dynamics and climate variability (Hély et al. 2006). However, climate change is already having an impact on the dynamics of Africa's biomes and its rich biodiversity, although species composition and diversity is expected to change due to individual species response to climate change conditions (Erasmus et al. 2002). The projected rapid rise in temperature combined with other stresses, such as the destruction of habitats from land use change, could easily disrupt the connectedness among species, transforming existing communities, and showing variable movements of species through ecosystems, which could lead to numerous localized extinctions. If some plant species are not able to respond to climate change, the result could be increased vulnerability of ecosystems to natural and anthropogenic disturbance, resulting in species diversity reductions (Malcolm et al. 2002). Climate change is expected to significantly alter African biodiversity as species struggle to adapt to changing conditions (Lovett et al. 2005).

Historically, climate change has resulted in dramatic shifts in the geographical distributions of species and ecosystems and current rates of migration of species will have to be much higher than rates during post-glacial periods in order for species to adapt (Malcolm et al. 2002). Species that have the capability to keep up with climate shifts may survive; others that cannot respond will likely suffer. For example, biome sensitivity assessments in Africa show that deciduous and semi-deciduous closed canopy forests may be very sensitive to small decreases in the amount of precipitation that plants receive during the growing season, illustrating that deciduous forests may be more sensitive than grasslands or savannahs to reduced precipitation (Hély et al. 2006). Invasive species and other species with high fertility and dispersal capabilities have been shown to be highly adaptive to variable climatic conditions (Malcolm et al. 2002). Due to its climate-sensitive native fauna, East Africa may be particularly vulnerable to exotic and invasive species colonization.

Migratory species that use Africa may also be vulnerable to changes in climate. In fact, climate change has the potential to alter migratory routes (and timings) of species that use both seasonal wetlands (e.g. migratory birds) and track seasonal changes in vegetation (e.g. herbivores), which may also increase effects on humans, particularly in areas where rainfall is low (Thirgood et al. 2004). Land use patterns in Africa can also prevent animals from changing their migratory routes, for example, park boundary fences have been demonstrated to disrupt migratory journeys, leading to a population decline in wildebeest (Whyte and Joubert 1988).

Climate change also threatens some of the large protected areas (including ones that protect migratory species) that have been designated to conserve much of Africa's magnificent biodiversity. It is expected that vegetation will migrate or move in order to utilize suitable habitats requirements (i.e. water and nutrient availability); however, this may mean that in some locations, the geographical range of suitable habitats will shift outside the protected area boundaries. In addition, weather extremes can also affect biodiversity in more complex ways. For example, in African elephants (*Lozodonta africana*), breeding is year-round, but dominant males mate in the wet season and subordinate males breed in the dry season. Subsequently, a change in the intensity or duration of the rainy versus drought seasons could change relative breeding rates and, hence, genetic structures in these populations (Poole 1989; Rubenstein 1992). Strategies for future designations of protected areas in East Africa need to be developed that include projections of future climate change and corresponding changes in the geographic range of plant and animal species to ensure adequate protection.

Large changes in ecosystem composition and function because of regional climate change would have cascading effects on species diversity (Sykes and Prentice 1996; Solomon and Kirilenko 1997; Kirilenko and Solomon 1998). Vast forest disappearance due to climate change-induced die-back and land use change would substantially affect species composition and global geochemical cycling, particularly the carbon cycle (Malcolm et al. 2002). In the savannahs of Zambia, research shows that climate change substantially affects growth in certain tree species. Chidumayo (2005) showed that dry tropical trees suffer severe water stress at the beginning of the growing season and that a warmer climate may accelerate the depletion of deep-soil water the species depend on for survival. In sub-Saharan Africa, which includes parts of East Africa, several ecosystems, particularly grass and shrub savannahs, are shown to be highly sensitive to short-term availability of water due to climate variability (Vanacker et al. 2005). Shrub and grassland vegetation types generally have root systems that are shallow and dense; these plants draw their moisture from water that is available in upper soil layers and growth in these species depends highly upon the timing, intensity, and duration of rainfall. Climate projections suggest that during already dry months, less precipitation will occur, likely reducing the resilience of these plants (Vanacker et al. 2005). Changes in plant composition will also have an impact on ecosystem resilience; less diverse systems can be more sensitive to precipitation fluctuations. For example, ecosystems that are composed of uniform herbaceous cover, such as in savannah plant communities, show the highest sensitivity to precipitation fluctuations when compared to plant communities of a mix of herbaceous, shrub, and tree species that support a higher diversity of species (Vanacker et al. 2005).

Climate change may also affect species range, which could have profound impacts on species population size. For example, in South Africa, a modelling study found that a reduction in the range of a species is likely to have an increased risk in local extinction climate change (Erasmus et al. 2002). The authors suggest that this may be due to the positive inter-specific relationship between population size and range size; if range size decreases, there is the likelihood that there will be a rapid decline in population size. Additionally, this relationship could be exacerbated if climate change restricts the range of a species to just a few key sites and an extreme weather event occurs, thus driving up extinction rates even further (Erasmus et al. 2002). Species ranges will probably not shift in cohesive and intact units and are likely to become more fragmented as they sift in response to changing climate (Channel and Lomolino 2000). In fact, up to 66% of species may be lost due to predicted range shifts caused by climate change in south Africa's Krueger National Park (Erasmus et al. 2002). To be able to better conserve biodiversity in the future, it is imperative to understand how species and ecosystems are likely to change under varying climate change scenarios (Erasmus et al. 2002).

Building Resilience and Resistance to Climate Change

Both short- and long-term adaptation strategies in response to regional climate change are beginning to emerge in a region that is rife with challenges. For every US$1 spent preparing for disaster, US$7 is spent recovering from disaster (Simms 2005). As organizations test and develop new conservation concepts, it is clear that poverty alleviation must be considered alongside the conservation of nature and biodiversity. As some resources become scare, conflicts between conservation and other land uses are likely to increase under climate change scenarios. However, human communities across Africa are banding together cooperatively to conserve resources and protect their livelihood.

Along the Tanzania coast, leading conservation groups are working with natural resource managers and other stakeholders to integrate climate change adaptation strategies into their management philosophies and plans (Hansen et al. 2003). Initial vulnerability assessments and adaptation planning from Tanzania point to the need for mangrove protection, reforestation with "climate-smart species", integrated land-use and marine planning, as well as activities to improve resource use technology. Coordinating the testing of adaptation methods in geographically diverse locations within a common habitat type aims to increase the replicability so that the project result can be transferred to other conservation efforts around the globe (Hansen et al. 2003). Conservation of ecosystems and natural resources requires that adaptive management strategies are developed or that we accept that many natural systems will be lost to climate change. Projects should aim to build the capacity of natural resource managers to assess vulnerability and to adapt management strategies to respond to expected climate change impacts (Hansen et al. 2003).

Climate change impacts to rural farming communities can be reduced by distributing climate data regarding seasonal climate forecasts (based on short-term and long-term forecasts) to small farmers so that they can make more informed farming decisions and adapt to the changing climate conditions. Some farmers have already started to use this information and are preparing themselves for dry conditions by planting drought-tolerant crops (Patt et al. 2005).

Food production can be improved dramatically in dry areas when governments and/or organizations use climate forecasts and prepare accordingly by potentially distributing drought-tolerant seeds (Patt et al. 2005). Farmers can also take advantage of climate forecasts by planting less drought-tolerant and higher-yields, and long-season maize when wetter than usual growing seasons are forecast (Patt et al. 2005). While seasonal forecasts can be useful in some situations, it should be noted that they cannot be applied everywhere and that often they do not consider multiple climate extremes, for example, they may forecast drought but not extreme rainfall. The aforementioned approaches are just a few of the many examples that governments, organizations, and communities need to consider in order to adapt to challenges of subsistence food production and assure future food security (Patt et al. 2005; Ziervogel 2004).

Conclusion

The impacts of climate change during the first half of the current century will pose a serious problem for development in East Africa, and will add burdens to those who are already poor and vulnerable. Many of these impacts will be felt in agriculture, which nevertheless will continue to play a crucial role in East Africa, through its direct and indirect impacts on poverty, as well as in providing an indispensable platform for wider economic growth that reduces poverty far beyond the rural and agricultural sectors.

In East Africa, the link between climate and livelihood is very strong, because agriculture is mainly rain-fed. It contributes 40% of the region's GDP and provides a living for 80% of its citizens. A small increase in temperature of 1.2°C will make most of Kenya's tea-growing areas unsuitable for the crop. An increase of 2°C makes most coffee-growing areas unusable for growing coffee. A sea-level rise will greatly affect the fishery industries and cash crops such as mangoes, cashew nuts and coconuts in the coastal regions. Unreliable rainfalls with alternating droughts and floods not only have an impact on agricultural outputs, but also on hydropower-based energy supplies, and thus on infrastructure and industrial development. Changes in biodiversity will certainly have a negative impact on tourism, and the generally changing level of ecological awareness may lead to a further drop in tourist travel activities. Lastly, climate change impacts, in particular droughts resulting in the scarcity of water and grassland, may lead to increased migration flows and therefore bring great potential for armed conflicts.

References

Anyamba A, Tucker CJ, Mahoney R (2002) From El Niño to La Niña: vegetation response patterns over east and southern Africa during the period 1997–2000. J Clim 15:3096–3103

Birkett C, Murtgudde R, Allan T (1999) Indian Ocean climate event brings floods to East Africa's lake and the Sudd marsh. Geophys Res Lett 26:1031–1034

Cane MA, Zebiak SE, Dolan SC (1986) Experimental forecast of El Niño. Nature 321:827–832

Channel R, Lomolino MV (2000) Dynamic biogeography and conservation of endangered species. Nature 403:84–86

Chidumayo EN (2005) Effects of climate on the growth of exotic and indigenous trees in central Zambia. J Biogeogr 32:111–120

Intergovernmental Panel on Climate Change (2001) Climate Change 2001. Synthesis report, Cambridge University Press, Cambridge

Craig MH, Kleinschmidt I, Nawn JB, Le Sueur D, Sharp BL (2004) "Exploring 30 years of malaria case data in KwaZulu-Natal, South Africa: part I. The impact of climatic factors". Trop Med Int Health 9:1247–1257

Davidson O, Halsnaes K, Huq S, Kok M, Metz B, Sokona Y, Verhagen J (2003) The development and climate nexus: the case of sub-Saharan Africa. Climate Policy 3S1:S97–S113

Erasmus BFN, van Jaarsveld AS, Chown SL, Kshatriya M, Wessels KJ (2002) Vulnerability of South African animal taxa to climate change. Glob Chang Biol 8:679–693

Fick AA, Myrick CA, Hansen LJ (2005) Potential impacts of global climate change on freshwater fisheries. A report for WWF, Gland, Switzerland

Food and Agricultural Organization (2004) Monitoring progress towards the World Food Summit and Millennium development goals. The State of Food Insecurity Report, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy

Funk C, Senay G, Asfaw A, Verdin J, Rowland J, Michaelson J, Eilerts G, Korecha D, Choularton R (2005) Recent drought tendencies in Ethiopia and equatorial-subtropical eastern Africa. FEWS-NET, Washington, DC

Githeko AK, Ndegwa W (2001) Predicting malaria epidemics in the Kenyan Highlands using climate data: a tool for decision-makers. Glob Change Hum Health 2:54–63

Hansen LJ, Biringer JL, Hoffman JR (2003) Buying time: A users' manual for building resistance and resilience to climate change in natural systems. World Wildlife Fund, Washington, DC

Hansen J, Ruedy R, Sato M, Lo K (2006) NASA Goddard Institute for Space Studies and Columbia University Earth Institute, New York, NY, 10025, USA, http://data.giss.nasa.gov/gistemp/2005/

Hély C, Bremond L, Alleaume S, Smith B, Sykes TM, Guiot J (2006) Sensitivity of African biomes to changes in the precipitation regime. Glob Ecol Biogeogr 15:258–270

Hulme M, Doherty R, Ngara T, New M, Lister D (2001) African climate change: 1900–2100. Clim Res 17:145–168

Inogwabini B, Sandokan BM, Ndunda M (2006) A dramatic decline in rainfall regime in the Congo Basin: evidence from a thirty four-year data set from the Mbali Scientific Research Center, Democratic Republic of Congo (in press)

International Food Policy Research Institute (IFPRI) (2004) Ending hunger in Africa: prospects for the small farmer. Washington, DC, USA

Kaufman L, Chapman LJ, Chapman CA (1996) The Great Lakes. In: McClanahan TR, Young TP (eds) East African ecosystems and their conservation. Oxford University Press, New York, pp 191–216

Kirilenko AP, Solomon AM (1998) Modeling dynamic vegetation response to rapid climate change using bioclimatic classification. Clim Change 38:15–49

Landsea CW, Gray WM (1992) The strong association between western Sahelian monsoon rainfall and intense Atlantic storms. J Clim 5:435–453

Lovett JC, Midgely GF, Barnard PB (2005) Climate change and ecology in Africa. Afr J Ecol 43:279–281

Magadza CHD (2000) Climate change impacts and human settlements in Africa: prospects for adaptation. Environ Monit Assess 61:193–205

Malcolm JR, Markham A, Neilson RP, Garaci M (2002) Estimated migration rates under scenarios of global climate change. J Biogeogr 29:835–849

National Research Council of the National Academies (2006) Surface Temperature Reconstructions for the Last 2,000 Years, Committee on Surface Temperature Reconstructions for the Last 2,000 Years, Board of Atmospheric Sciences and Climate, Division of Earth and Life Sciences. The National Academies Press, Washington DC

Orindi VA, Murray LA (2005) "Adapting to climate change in East Africa: a strategic approach." In: Gatekeeper Series 117: International institute for environment and development

Patt A, Suarez P, Gwata C (2005) "Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe". In: Proceedings of the national academy of sciences of the United States of America, Vol. 102, pp 12623–12628

Patz JA, Campbell-Lendrum D, Holloway T, Foley JA (2005) Impact of regional climate change on human health. Nature 438:310–317

Plisnier PD, Serneels S, Lambin EF (2000) Impact of ENSO on East African ecosystems: a multivariate analysis based on climate and remote sensing data. Glob Ecol Biogeogr 9:481–497

Poole JH (1989) Announcing intent: the aggressive state of musth in African elephants. Anim Behav 37:140–152

Roessig JM, Woodley CM, Cech JJ Jr, Hansen LJ (2004) Effects of global climate change on marine and estuarine fishes and fisheries. Rev Fish Biol Fish 14:251–275

Root TL, Price JT, Hall KR, Schneider SH, Rosenzweig C, Pounds JA (2003) Fingerprints of global warming on wild animals and plants. Nature 421:57–60

Rowe DP (2001) Teleconnections between the tropical Pacific and the Sahel. Q J R Meteorol Soc 127:1683–1706

Rubenstein DI (1992) "The greenhouse effect and changes in animal behavior: effects on social structure and life-history strategies", In: Peters RL, Lovejoy TE (eds) Global warming and biological diversity, Yale University Press, pp 180–192

Siemien MJ, Stauffer JRJ (1989) Temperature preference and tolerance of the spotted tilapia and Rio Grande cichlid. Arch Hydrobiol 115:287–303

Simms A (2005) Africa: up in smoke? The second report from the Working Group on Climate Change and Development, New Economics Foundation, London

Solomon AM, Kirilenko AP (1997) Climate change and terrestrial biomes: what if trees do not migrate? Glob Ecol Biogeogr 6:139–148

Sykes MT, Prentice IC (1996) "Climate change tree species distributions and forest dynamics: a case study in the mixed conifer/hardwoods zone of northern Europe". Clim Change 34:161–177

Thirgood S, Mosser A, Tham S, Hopcraft G, Mwangomo E, Mlengeya T, Kilewo M, Fryxell J, Sinclair ARE, Borner M (2004) "Can parks protect migratory ungulates? The case of the Serengeti wildebeest". Anim Conserv 7:113–120

Thompson LG, Mosley-Thompson E, Davis ME, Henderson KA, Brecher HH, Zagorodnov VS, Mashiotta TA, Lin P-N, Mikhalenko VN, Hardy DR, Beer J (2002) Kilimanjaro ice core records: evidence of Holocene climate change in tropical Africa. Science 298:589–593

Vanacker V, Linderman M, Lupo F, Flasse S, Lambin E (2005) Impact of short-term rainfall fluctuation on interannual land cover change in sub-Saharan Africa. Glob Ecol Biogeogr 14:123–135

Verburg P, Hecky RE, Kling H (2003) Ecological consequences of a century of warming in Lake Tanganyika. Science 301:505–507

Vice-President Office, The United Republic of Tanzania (2003), Initial National Communication Under the United Nations Framework Convention on Climate Change (UNFCCC)

Vuorinen I, Kurki H, Bosma E, Kalangali A, Mölsä H, Lindqvist OV (1999) Vertical distribution and migration of pelagic Copepoda in Lake Tanganyika. Hydrobiologia 407:115–121

Wara MW, Ravelo AC, Delaney ML (2005) Permanent El Niño-like conditions during the Pliocene Warm Period. Science 309:758–761

Whyte IJ, Joubert SCJ (1988) Blue wildebeest population trends in the Kruger National Park and the effect of fencing. S Afr J Wildl Res 18:78–87

Zeng N (2003) Atmospheric science: drought in the sahel. Science 302:999–1000

Zhou G, Minakawa N, Githeko AK, Yan G (2004) Association between climate variability and malaria epidemics in the East African highlands. Proc Natl Acad Sci USA 101:2375–2380

Ziervogel G (2004) Targeting seasonal climate forecasts for integration into household level decisions: the case of smallholder farmers in Lesotho. Geogr J 170:6–21

Chapter 37
"*CO_2 Causes a Hole in the Atmosphere*": Using Laypeople's Conceptions as a Starting Point to Communicate Climate Change

Kai Niebert and Harald Gropengießer

Abstract Translating public concern for global warming into effective action requires knowledge about the causes and risks of climate change. The aim of this study is a theory-guided analysis of everyday and scientific conceptions of global warming. These conceptions will be the basis for the design of communicating strategies in a separate study.

Framed by the model of educational reconstruction, scientific concepts of global warming were compared with everyday conceptions that were identified in interviews and a re-analysis of empirical studies. The analysis of conceptions of climate change based on the theory of experientialism (Lakoff and Johnson, Philosophy in the Flesh. The Embodied Mind and Its Challenge To Western Thought, 1999) shows that laypeople and scientists refer to the same schemata: the use of the container-flow schema is omnipresent in conceptions on the global carbon cycle as well as in conceptions of the radiative equilibrium between earth and space. To explain the causes of global warming three principles were found: global warming by (a) an imbalance in the global carbon cycle, (b) man-made carbon dioxide, and (c) natural vs. man-made carbon dioxide. Laypeople explain the processes leading to global warming either through warming by more input or warming by less output.

Keywords Carbon dioxide · Climate change · Communication · Education · Everyday conceptions · Greenhouse effect

Introduction

The enhanced greenhouse effect leading to global warming is one of the greatest challenges facing humankind in the twenty-first century (IPCC 2007). Translating public concern for global warming into effective everyday action requires knowledge about the causes and risks of climate change (Bord et al. 2000; UNCED 1992).

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The aim of our study is an evidence-based and theory-guided identification of key aspects in understanding global warming. Based on the key aspects identified, educationally reconstructed communication guidelines will be developed.

A wide range of studies show a confusion among laypeople of causes and mechanisms leading to global warming with other ecological phenomena, such as the depletion of the ozone layer. Interestingly, this confusion is constant over age and nationality: Swedish 10-year-old pupils hold the same everyday conceptions of global warming as English pre-service teachers or American laypeople (Bord et al. 1998; Bostrom et al. 1994; Boyes and Stanisstreet 1997; Boyes and Stanisstreet 1993; Boyes et al. 1999; Christidou and Koulaidis 1996; Read et al. 1994). Additionally, these conceptions are very resistant to conceptual change (Hansen 2005). This study analyses the sources of students' alternative conceptions to explain the origins of these conceptions and what prevents students from using more scientific conceptions to explain the causes and mechanism of global warming.

The main focus of our study is the interpretation of students' and scientists' conceptions of aspects of global warming, such as the greenhouse effect, and the emission and fixation of greenhouse gases. It draws on the perspective of experientialism (Lakoff and Johnson 1980; 1999), which contributes to an improved understanding of the sources of conceptions of climate change.

Theoretical Framework and Key Objectives

Several studies (Bord et al. 1998; Bostrom et al. 1994; Boyes and Stanisstreet 1993, 1997; Boyes et al. 1999; Christidou and Koulaidis 1996; Read et al. 1994), have investigated school students' and adult lay peoples understandings of concepts related to global atmospheric change, such as the greenhouse effect or ozone layer depletion. These studies either state explicitly that they are pre-instructional or do not to follow any specific global atmospheric change instruction. The findings of these studies indicate that students often hold conceptions about global atmospheric change that differ from scientific knowledge. Furthermore, studies by Österlind (2005) and Jeffries et al. (2001) show that those everyday conceptions of climate change are resistant to conceptual change even after instruction given by school or media. Our study aims to understand why some everyday conceptions are so common and what makes them resistant to conceptual change.

The theoretical framework of this investigation relies on two different but interdependent theories. The moderate constructivist epistemology (Duit and Treagust 1998) states that learning is a construction of individual conceptions. This epistemological orientation concerns the understanding of students' perspectives as well as the interpretation of the scientific content. From this perspective, everyday conceptions are not seen as obstacles to learning but as starting points for learning and mental instruments to work with in further learning.

An important empirical finding emerging from linguistic studies (Lakoff 1987; 1991; Lakoff and Johnson 1980, 1999) is that many concepts might not be understood literally but metaphorically in terms of another domain of knowledge. An important related proposal is that the understanding of abstract concepts is ultimately grounded in experiential image schemata (Lakoff and Johnson 1999). Lakoff and Johnson (1980) identified metaphorical schemata, which transfer understanding from an experience based domain into an abstract domain: an example is the metaphor *"Argument is war"*, which is implicit in the following sentences listed by Lakoff and Johnson: "Your claims are indefensible." "He attacked every weak point in my argument." "If you use that strategy, he'll wipe you out." Rather than view such sentences as simply a matter of isolated instances of a figurative language, Lakoff and Johnson pointed out that they reflect a systematic way in which arguments are conceptualized in terms of our understanding of physical conflict: attacking and defending, the success or failure of which will result in gaining ground or retreating, winning or losing, and so forth. The claim is that our understanding of physical conflict organizes how we talk and think about arguments.

The cognitive linguistic theory of experientialism (Gropengießer 2007; Lakoff and Johnson 1980; Riemeier and Gropengießer 2008) describes how we employ metaphors and analogies to project understanding from an experience-based source domain to an abstract target domain. Experientialism guides us to gain an insight into the sources of students' everyday conceptions.

Constructivism and experientialism are used to interpret students' everyday conceptions of global warming to gain a deeper understanding of their ways of thinking and to explain their perspectives. These findings provide an insight into individual ways of thinking and how everyday conceptions foster or hinder students' conceptual development. Based on this framework, the study deals with three research questions:

1. What conceptions do students and scientists employ in explaining biological aspects of global warming?
2. What different and shared views can be drawn between students' and scientists' conceptions of global warming?
3. Which concepts can foster or hinder conceptual development in understanding global warming?

Research Design and Method

The research design is shaped by the Model of Educational Reconstruction (Duit et al. 2005). Within this design, scientists' and students' conceptions are compared in order to develop effective teaching and learning activities (cf. Fig. 37.1). Scientists' conceptions are extracted from different scientific textbooks (Campbell and Reece 2002; Houghton 2002; Schönwiese 2003; Smith and Smith 2006) and the most recent IPCC Report (IPCC 2007).

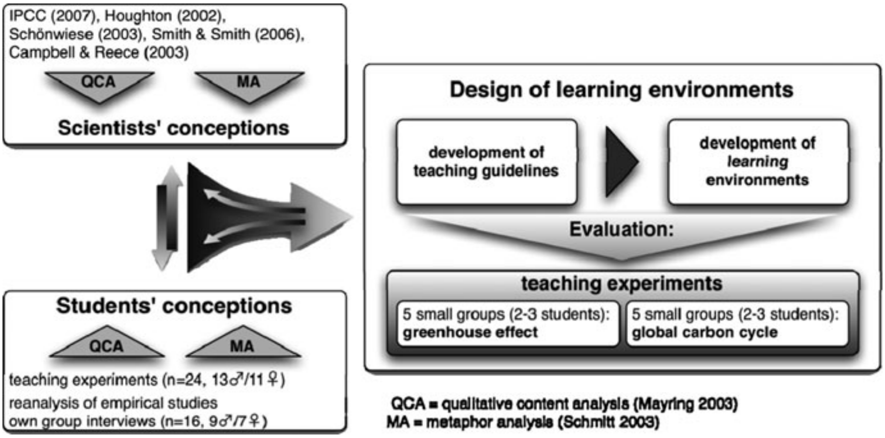


Fig. 37.1 Research design – the model of educational reconstruction

Students' conceptions of global warming are derived from a re-analysis of empirical studies on everyday concepts of global warming (Bostrom et al. 1994; Boyes and Stanisstreet 1992; Ekborg and Areskoug 2006; Koulaidis and Christidou 1998), our own interview study and an interventional study.

The interview study was conducted with 16 students (18 years old; 9 male, 7 female) from different grammar schools in Hannover (Germany) using semi-structured group interviews (Cohen et al. 2007) with two students per interview. The students were taking advanced courses in biology and had a medium proficiency level in the subject (German school grades between 2 and 4, equating approximately to English grades B to D). In the interventional study, 24 students (18 years old; 13 male, 11 female) from the same population as the interview study attended university for teaching experiments. The conceptions of the students in the interventional study were taken from an initial interview phase; the effects of the interventions are analysed in a separate study. The problem-centred interviews in the interview study, as well as the initial interviews in the teaching experiments, were guided by students' conceptions. Thus, not all interviews contained sequences to all parts of this study: Some interviews focused on the greenhouse effect (12 students), some on the global carbon cycle (12 students), and some on both (16 students).

Students' and scientists' conceptions are analysed using qualitative content analysis (Mayring 2002) and metaphor analysis (Schmitt 2005). In the qualitative content analysis, a category system was developed in the following steps: (1) transcription of the interviews and rewriting the texts, (2) arrangement of statements, (3) explication of the conceptions, and (4) summary of the categories. The metaphor analysis (Schmitt 2005) provides the basis for our interpretation of the conceptions from the perspective of experientialism. In our study, we identified a metaphor by a term or sequence, which has or can have more than one meaning. Inthe first step, (1) we identified all metaphors in the material and (2) chose the ones crucial for the understanding of climate change. Later, we arranged all metaphors with the same target and source domains (3) to describe the metaphorical principles used by the students and scientists. The results of the metaphor analysis were integrated into the explication of the conceptions during qualitative content analysis.

Based on the results of the educational reconstruction of global warming, learning activities are evaluated in a separate intervention study.

Results

A re-analysis of empirical studies and data from our interview study shows that students' conceptions of the causes and mechanisms of global warming are different from scientists' conceptions. In the following sections, the conceptions of both are presented and interpreted, guided by the theory of experientialism.

Conceptions of the Causes of Global Warming

In our interview study, CO_2 is cited as being the most important cause of global warming by both scientists and students. Thus, the focus of our interviews was on the emission and fixation of CO_2 in the global carbon cycle. Our results underline the findings of Hildebrandt (2006), who has shown that learners' conceptions of the biogeochemical processes of the global carbon cycle are different to scientists' conceptions. Metaphor analysis shows that students as well as scientists refer to a container-flow schema. In this schema, carbon is stored in different containers (e.g. fossil carbon, land, oceans, atmosphere) connected by bidirectional flows of carbon caused by varying processes (e.g. photosynthesis, burning, respiration). Thus, the container schema and the source-path-goal schema (Lakoff and Johnson 1999) are combined into the larger complex container-flow schema (cf. Fig. 37.2). In the following section, this schema is used to interpret conceptions of carbon flows.

Scientists' Conception: Global Warming by Imbalanced Carbon Cycle

Climatologists (Houghton 2002) and ecologists (e.g. Smith and Smith 2006) use the container-flow schema in different ways. While the climatologists focus on the location of the reservoir (e.g. lithosphere, atmosphere), ecologists highlight the stored carbon compound (organic vs. inorganic). Both views on the global carbon cycle are complementary in the explanation of the causes of global warming (Fig. 37.3).

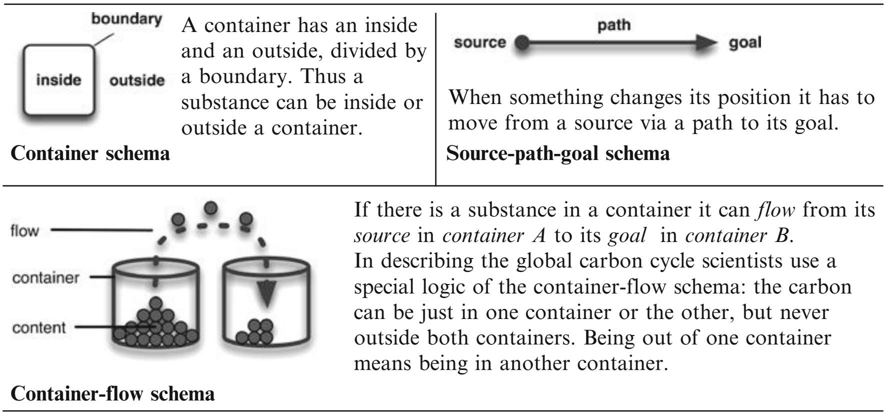


Fig. 37.2 Logic of the container-flow schema

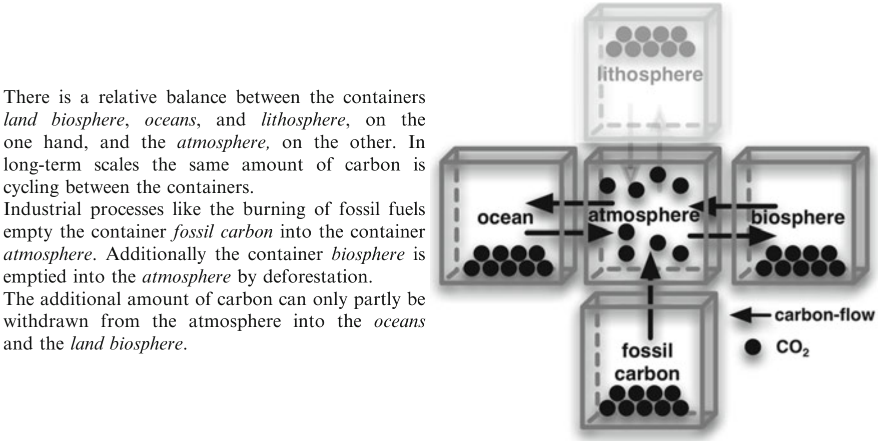


Fig. 37.3 Imbalance in the global carbon cycle

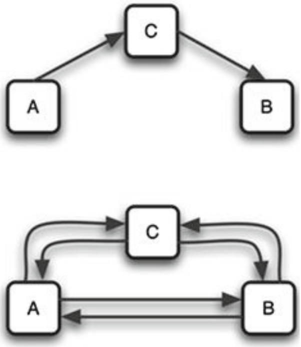
In the context of global warming, scientists focus on the atmosphere and its carbon flows. For the sake of clarity and brevity, all flows between the other carbon containers (e.g. solution of minerals in oceans) as well as the container *lithosphere* with very small rates of carbon flows are excluded here.

Scientists use different terms to describe the global carbon cycle. While ecologists describe a flow of *carbon* between the reservoirs, climatologists describe a flux of *carbon dioxide*. So the quality of the content flowing between the containers differs between the scientific disciplines. Climatologists concentrate on a part of the carbon cycle and do not treat the whole cycle. Metaphor analysis shows the different usage of the container-flow schema by climatologists and ecologists (Fig. 37.4).

The scientists' conception is based on the schema of a natural balance in the global carbon cycle, which is disturbed by processes such as the burning of fossil

"Carbon dioxide is emitted by the burning of fossil fuels. […] CO_2 can be withdrawn from the atmosphere by photosynthesis.“ (Houghton, 2002)

With the description of sources and sinks for carbon dioxide, a starting point and a destination of the container-flow schema are set.



“Carbon cycles through the terrestrial ecosystem” (Smith & Smith, 2002).

The description of a circulation of carbon assumes a variable assignment of the starting points and destinations of carbon. Every reservoir contains carbon temporarily and can act as a source or a sink.

Fig. 37.4 Schemata of carbon flow

carbon or deforestation. Thus, we named this thinking pattern global warming by imbalanced carbon cycle.

Everyday Conception: Man-Made Carbon Dioxide

In some students’ conceptions CO_2 is a man-made gas causing climate change:

> CO_2 is produced by the burning of coal and oil. [. . .] Burning biofuel or wood does not emit CO_2, because they are climate-friendly. [. . .] CO_2 stays in the atmosphere and cannot be removed again
> (Dirk, 18)

> CO_2 gets into the atmosphere through the burning of oil and petrol. To destroy the CO_2 we have to shoot little molecules into the atmosphere.
> (Jakob, 18)

Students with this conception think that the only source of CO_2 is the burning of fossil fuel. Al Gore’s demand, *“Reduce your CO_2 emissions to zero”*, (Gore 2006) is rejected by the students not on physiological grounds (e.g. the need for respiration) but because *“even without industry and cars we have to make a fire to cook and have a warm home”* (Emma, 18). In this conception, natural processes such as the physiological or biogeochemical fixation and emission of carbon (respiration, photosynthesis, solution, dissolution in oceans) are either not mentioned or rejected. The structure of this conception is presented in Fig. 37.5.

The emission of CO_2 is connected with the process of burning and the substance that is burned. In this conception, students argue that carbon dioxide is detrimental to the climate. Furthermore, they argue that fossil fuel is hostile to the climate, while renewable fuels are not detrimental to the climate. So they conclude that fossil fuel does emit CO_2, while renewable fuels do not emit CO_2 (Fig. 37.6).

Carbon dioxide is seen as something unnatural, chemical, or toxic, which is underlined by statements like *“normal air has no carbon dioxide”* (Daniel, 18) or *“carbon dioxide is a toxic gas”* (Jacob, 18).

The burning of fossil carbon emits CO_2.
Organisms do not emit CO_2.
CO_2 cannot be removed from the atmosphere.

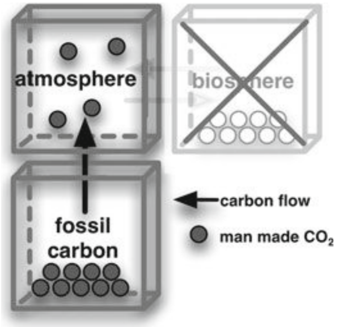


Fig. 37.5 Man-made carbon dioxide

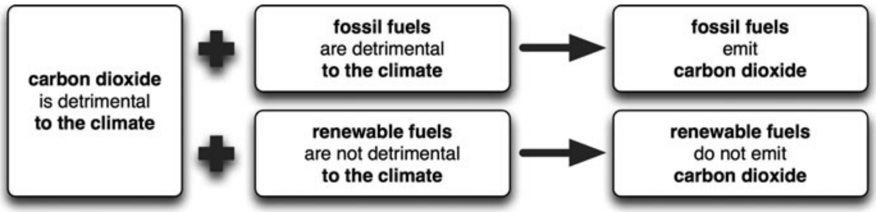


Fig. 37.6 Two attribution patterns for the emission of CO_2

Everyday Conception: Natural Versus Man-Made Carbon Dioxide

A typical conception of the causes of global warming is the emission of different sorts of CO_2:

> CO_2 emitted by the burning of oil cannot be removed again from the atmosphere because it rises higher than CO_2 from respiration.
> (Dirk, 18)

> CO_2 emitted by burning cannot be removed from the air. It is chemical not biological.
> (Emma, 18)

Students who distinguish between *"natural and man–made carbon dioxide"* (Fig. 37.7) refer to physiological processes (respiration and photosynthesis) but do not contextualize them in climate change terms. Their knowledge of physiology (CO_2 emitted by respiration) and ecology (CO_2 emitted by burning of fossil carbon) is used in parallel but is not connected. The different sources of carbon dioxide lead to the conception of different kinds of CO_2 with different properties. Metaphor analysis validates this interpretation. Like the scientists, the students also use the container-flow schema to explain the emission of carbon dioxide. But the students' containers hold different kinds of carbon dioxide: natural and man-made CO_2. The conception *flow of man-made carbon dioxide* is – as in the conception *man-made carbon dioxide* – conducted by a one-way metaphor: man-made CO_2 can only flow from the container *fossil carbon* to the container named *atmosphere*, and there is no way back.

1. The burning of fossil carbon emits CO_2.
2. Organisms emit CO_2.
3. CO_2 emitted by organisms can be removed from the atmosphere.
4. CO_2 emitted by burning cannot be removed from the atmosphere.

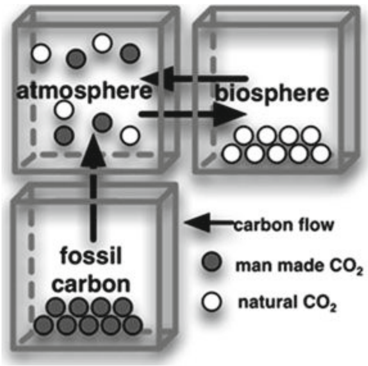


Fig. 37.7 Natural vs. man-made CO_2

Comparison of the Conceptions of the Causes of Global Warming

The comparison of students' and scientists' conceptions of the biogeochemical origins of global warming shows differences in the use of the container schema and the content of the containers. The only concept used by both scientists and students is the emission of carbon dioxide through the burning of fossil carbon. The majority of the interviewed students (20 of 28) argued that the carbon dioxide produced by burning is bad and detrimental in general. Eight students were able to refer to the scientific conception of a relative imbalance in the global carbon cycle (without mentioning the lithosphere as a carbon container) (Table 37.1).

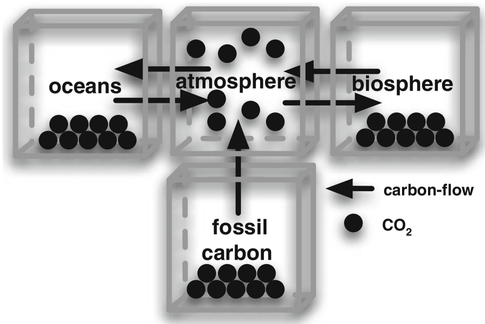
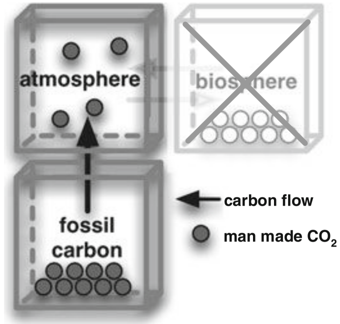
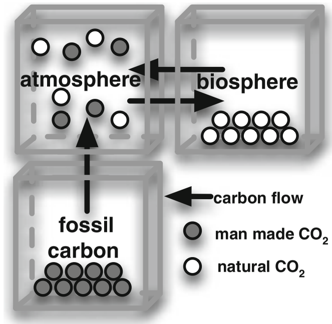
Scientists' conception of an imbalance in the global carbon cycle is based on the idea of a natural balance in the carbon cycle. This idea was criticized by Kattmann (2008), who argues that the actual concentration of O_2 – and thus the concentration of CO_2 – is a product of a series of imbalances and not of a long-lasting balance: the first atmosphere about 4.5 billion years ago did not contain any O_2 but about 500 times more CO_2 than the present atmosphere. If the atmospheric concentration of CO_2 had been balanced at all times, CO_2 and O_2 concentration would not have changed and life on earth would not have evolved as it did.

To describe the carbon flows, two different metaphorical concepts were found in students' and scientists' conceptions: *"Burning is producing"* (*"CO_2 is produced by the burning of fossil fuel"*) and *"Burning is emitting"* (*"Carbon is emitted by the burning of fossil fuel"*). These two concepts show different perspectives on the global carbon cycle: while the first concept focuses on the conversion of hydrocarbons into CO_2, the second concept emphasizes the flow of carbon from one container to another and thus on the balances in the global carbon cycle.

Conceptions of the Mechanisms of Global Warming

Different conceptions of global warming were identified in our study. Experientalism shows that similar to carbon flows, students and scientists explain the mechanisms of

Table 37.1 Conceptions of the causes of climate change

Imbalanced carbon cycle	Man-made CO_2	Natural vs. man-made CO_2
Frequency: 8 of 28 students[a] and scientists	Frequency: 8 of 28 students[a]	Frequency: 12 of 28 students[a]
		
The burning of fossil carbon emits more CO_2 than oceans and biosphere can capture	The burning of fossil carbon emits detrimental CO_2	The burning of fossil carbon emits man-made CO_2, while respiration emits natural CO_2

[a]Due to the research design, not all students argued on all topics discussed in this paper; 28 of the 40 students elaborated their conceptions on the emission and fixation of CO_2

global warming with a container-flow schema. Atmosphere and earth are seen as a container, where energy is irradiated by the sun and reradiated by the earth again.

Scientists' Conception: Warming by Warming Blanket

An analysis of scientists' conceptions (Houghton 2002; Schönwiese 2003) of the mechanisms of global warming shows that scientists differentiate between the atmospheric phenomenon of ozone depletion, which leads to the intensified penetration of UV rays to Earth, and the intensified greenhouse effect which leads to global warming. Both phenomena are different in their temporal, structural and regional impacts (Table 37.2).

Scientists conceptualize the processes leading to global warming as follows (Fig. 37.8): (1) Greenhouse gases are in a first approximation evenly distributed in the atmosphere. (2) Special molecular properties enable greenhouse gases to absorb infrared radiation very effectively. (3) The intensified emission of greenhouse gases leads to an enhanced absorption of radiation. (4) Greenhouse gases emit heat in all directions and the emission to the earth adds up to the direct radiation from the sun and (5) the lower atmosphere warms up.

Metaphor analysis shows that scientists are referring to a container schema and a balance schema, where earth and atmosphere are represented as a container and the sun sends a constant amount of energy into the container. In the case of the natural greenhouse effect there is a radiation equilibrium, i.e. the same amount of energy that gets into the container leaves it by re-radiation. With every emitted greenhouse gas molecule, more outgoing radiation is captured and a new equilibrium arises. Viewed from outside the container, a constant amount of energy flows into the container, but the output is reduced until a new equilibrium is reached. The atmosphere with greenhouse gases acts like a thick warming blanket, which insulates the earth.

Table 37.2 Ozone depletion and greenhouse effect

	Ozone depletion	Greenhouse effect
Projection	Decreasing until the year 2100	Increasing until the year 2100
Altitude	Ozone layer at 35 km altitude	Greenhouse gases in the whole atmosphere
Process	Decreased absorption of UV radiation	Increased absorption of IR radiation
Effect	Regional	Global
Impacts	Skin diseases, skin cancer	Heat diseases, change in ecosystems

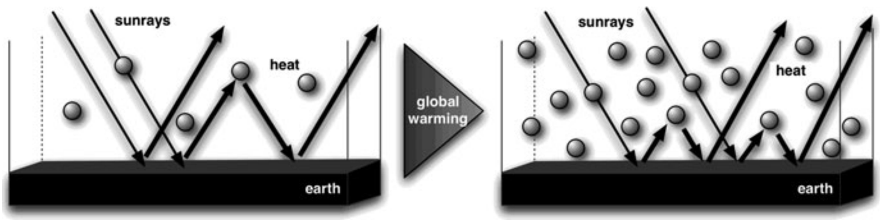


Fig. 37.8 Scientific conception: the warming blanket

Students' Conception: Warming by Holes in the Ozone Layer

The conception of global warming being caused by holes in the ozone layer is a typical conception held by students:

> CO_2 destroys the ozone layer. Radiation coming from the sun passes into the atmosphere through the layer and heats up the earth.
>
> (Dirk, 18)

> The ozone hole is getting bigger, which is caused by industrial emissions. More sunrays enter the atmosphere and warm the earth. They cannot leave the atmosphere again because the heat is captured between the ozone layer and earth.
>
> (Nanni, 18)

With this conception, students imagine the mechanisms causing global warming as follows (Fig. 37.9): (1) Normally the ozone layer reflects some sunrays back into space. (2) CO_2 causes a hole in the ozone layer, and (3) sunrays penetrate the layer through the hole and (4) warm the earth. In a variant of this way of thinking, students imagine that (5) infrared radiation is captured between the earth's surface and the ozone layer.

In our study, 11 of 16 students expressed the conception of more sunrays passing through a hole in the *atmospheric protection shield ozone layer*. Metaphor analysis indicates students' use of the container schema to describe the mechanisms of global warming. Compared to the radiative equilibrium where input equals output, the conception *warming by hole in the ozone layer* is based on a *warming by more input*.

Students using this conception do not distinguish between long-wave and short-wave radiation. From an experientialist point of view, this is not surprising because we experience the sunrays as warming us directly – the more there are, the warmer it is (see also Hansen 2005).

The hybridization of the ozone problem with the greenhouse effect is a well described finding in science education research (e.g. Ekborg and Areskoug 2006; Koulaidis and Christidou 1999). The concept of a perforated *atmospheric protection shield* combined with the concept of an *atmospheric warming blanket* leads to a quite simple idea: *the atmosphere warms up, because more heat gets in.*

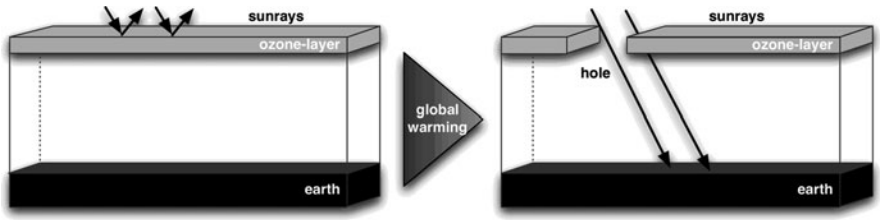


Fig. 37.9 Students' conception: Warming by holes in the ozone layer

Students' Conception: Warming by Greenhouse Effect

The greenhouse effect is one of the students' principles for explaining climate change:

> The sunrays are absorbed by the earth's surface. [. . .] The heat is released again, but a layer of greenhouse gases hinders the heat going back into space. So the heat is reflected between the greenhouse layer and the earth.
> (Claudia, 18)

> CO_2 hinders the visible light coming to earth from going back to space again and reflects the light back to earth. So the earth is warming.
> (Jürgen, 18)

In this conception, the greenhouse gases (mainly CO_2) form a special layer in the atmosphere which is permeable for sunrays but nearly impermeable for the radiation coming from the earth. The greenhouse gas layer works like a *"perforated mirror, which lets some heat back to space. [. . .] CO_2 closes the holes in the mirror and no more heat can escape to space."* (Jakob, 18) (Fig. 37.10).

This conception is similar to the greenhouse effect communicated in the media or in school books. The central element of this conception is a layer of greenhouse gases, which acts as a barrier. By reflection of heat radiation between the layer and earth, the heat in the atmosphere is "captured". The basic idea is: *the earth warms up, because less heat gets out.*

Comparing Jürgen's and Claudia's conceptions, one important difference can be found: while Claudia differentiates between sun's rays and heat rays, Jürgen just argues on the level of sun's rays. The latter does not use the concept of energy transformation in the process of absorption sun's rays and the re-radiation of heat rays.

Students' Conception: Warming by Pollution

Furthermore, some students hold simple and straightforward conceptions of the causes of global warming. For them "*the rubbish, exhaust emissions and pollution lead to climate change*" (Diana, 18 years) In this pollution concept students sum up all environmental problems and project them onto global warming. The concept *pollution causes global warming* names a cause but does not explain the mechanism leading to global warming.

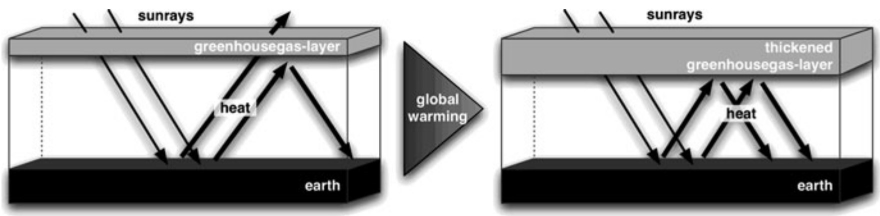


Fig. 37.10 Warming by greenhouse effect

Comparison of Conceptions of the Mechanisms of Global Warming

In Table 37.3, the conceptions of the mechanisms of global warming are compared. In addition to the different schemata used to describe reasons for global warming, there is one main difference between students' and scientists' conceptions. Students think on a macroscopic level (*reflection on layers*) while scientists argue on a microscopic level (*absorption by molecules*). This is not a surprising finding, as we experience our life world as a macroscopic one.

The comparison shows three fundamental schemata of the mechanisms of global warming: *"Earth warms up, because more heat gets in"*, *"Earth warms up, because less heat gets out"* and *"Earth is warming in a dynamic equilibrium"*. The conceptions differ in the mentioned structures (ozone layer, greenhouse gas layer, whole atmosphere) and the mechanisms (reflection vs. absorption/emission).

Metaphors of Global Warming

The metaphor analysis shows different receptions of the terms used to communicate global warming. Especially the terms *"warmth"* and *"heat"* are used in different in varying contexts (Table 37.4):

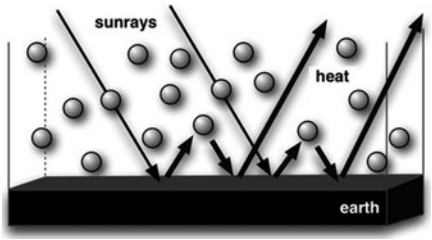
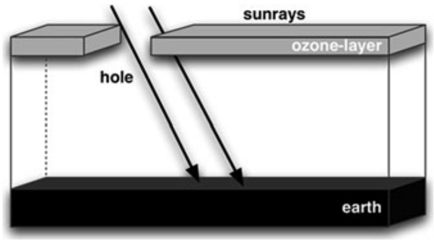
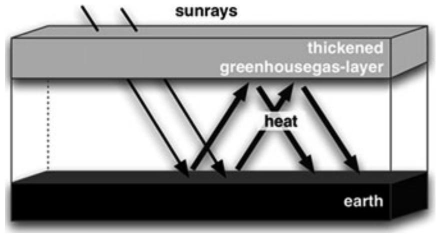
In several interviews, we found that students hold two different conceptions in parallel, using different terms in connection with these conceptions. While in the students' expressions the term *"warmth"* is connected to positive attitudes and convenient anticipations of the impacts of global warming like a warmer climate (*"I like it..."*, *"...would be very nice..."*), the term *"heat"* is connected to negative emotions and dramatic consequences (*"...would be dramatic"*, *"stop ... immediately"*).

Even in the scientific literature, the terms *"warmth"* and *"heat"* are used in different contexts: the IPCC used the term *"warmth"* to describe the causes of global warming in a neutral way, while the use of *"heat"* can be found in the description of the (mostly negative) impacts of global warming.

These different conceptions connected to global warming can be ascribed to the different receptions of the terms in everyday life: the term *"warm"* has a positive connotation which expresses in different metaphorical and literal wordings as "*warm*-hearted", "to grow *warm*", "to feel *warm* and fuzzy" or "I feel *warm*". On the other hand the term *"heat"* has negative connotations like "scorching *heat*", "to beat the *heat*", "to swelter in *heat*".

Bibliographies describe the term heat as a *"very strong and unpleasant warmth"* (Duden 2002). Thus, the term heat is a concretizing, strengthening comparison of the term warming, which is used literally to describe an uncomfortable, very strong warming in everyday issues like the weather, and metaphorically for abstract issues like emotions or the climate which cannot be experienced directly.

Table 37.3 Conceptions of the mechanisms of global warming

Warming blanket	Ozone hole	Greenhouse effect
Frequency: Scientists	Frequency: 16 of 28 students[a]	Frequency: 12 of 28 students[a]
		
Earth warms up in a dynamic equilibrium.	Earth warms up because more heat gets in	Earth warms up because less heat gets out

[a]Due to the research design not all students argued on all topics discussed in this paper; 28 of the 40 students elaborated their conceptions of the mechanism on global warming

Discussion and Implications for Communication of Climate Change

In this investigation, different conceptions of climate change were found and interpreted using the theory of experientialism. While the nature of the samples studied here limits their generalizability, by allowing respondents to structure and define their own responses, we can offer a clearer perspective on how people conceptualize and describe these issues than is possible with a conventional large-scale study, with a uniform wording of potentially unfamiliar questions and responses. Different studies show that the everyday conceptions analysed in this article can be found in samples ranging from school students in the US and Europe (Koulaidis and Christidou 1998; Lee et al. 2007), university students (Jeffries et al. 2001), and adult laypeople (Bostrom et al. 1994; Sterman and Sweeney 2007). Additionally, the analysis of the conceptions in this study showed a saturation of data: no new conceptions were found. These two findings indicate the ability to generalize our findings to a wider population of laypeople.

Analysis of the conceptions regarding the *causes of global warming* reveals the use of container-flow schemata to explain the exchange of carbon between different spheres. A detailed analysis of the schemata shows differences in the number of the containers and the content of the containers. The thinking pattern *man-made carbon dioxide* shows that some students do not count carbon dioxide as a natural component of the atmosphere, while the thinking pattern *natural vs. man-made carbon dioxide* implies that different containers contain different kinds of carbon dioxide. In the latter conception, students are not able to draw a connection between their physiological and ecological knowledge of the emission and fixation of carbon dioxide. Metaphor analysis shows the conceptions *man-made carbon dioxide* and *natural vs. man-made carbon dioxide* emerging from the schema *natural is good – man-made is bad*. In this deeply rooted cultural schema, nature and its natural processes are perceived as something natural and good, while man-made, artificial processes lead to negatively perceived impacts (Niebert 2008). This resembles the fallacy of the *appeal to nature*. Based on this schema the *man-made* CO_2 is considered to possess devastating and detrimental properties, while an atmosphere without CO_2 (in the conception *man-made carbon dioxide*) or only with natural CO_2 (in the conception *natural vs. man-made carbon dioxide*) is in an undisturbed, healthy state.

From the perspective of a moderate constructivism, these everyday conceptions can be used as a starting point to communicate more science-oriented conceptions. By uncovering the – mostly unconsciously – used schemata for our thinking on global warming, communication strategies which focus on the following scheme might be fruitful: (1) Give students access to their conceptions, i.e. *uncovering the used schema*; (2) discuss the consequences of the domain specific use of the schema, i.e. *what is man made:* CO_2 *itself or the flow?* (3) Help students to reconstruct their conceptions, i.e. from *man-made and natural* CO_2 to the scientific

Table 37.4 Terms of global warming

Warmth	Heat
"I like it, that the earth is warming by 2–6°C." (Emma, 18)	"[. . .] a heating of the atmosphere by 3°C would be dramatic." (Emma, 18)
"A warmer climate would be very nice." (Jacob, 18)	"We have to stop emitting CO_2 immediately, because it heats up the earth." (Jacob, 18)
"Main cause of global warming is the anthropogenic emission of greenhouse gases." (IPCC 2007)	"Drought catastrophes will be one consequence of heating of the climate." (IPCC 2007)

concept *man-made and natural cause of carbon flow* by reflecting on and experiencing their mental model.

The aim of learning activities for the global carbon cycle should be (a) to communicate CO_2 as a natural component of the atmosphere, (b) to emphasize the equal structure of CO_2 from burning processes and physiological processes, (c) to discuss the conception of the global carbon cycle in a container-flow schema and (d) to discuss the increasing CO_2 concentration in the container atmosphere as an interaction with the other carbon containers. Teaching the global carbon cycle on the level of carbon and not on the level of different carbon compounds (CO_2, CO_3^{2-}, HCO, etc.) seems to be a fruitful basis for the guidelines discussed above. Thus the concept *burning is emitting* would be more appropriate to explain the carbon flows leading to global warming than the concept *burning is producing*.

The analysis of the thinking patterns about *mechanisms of global warming* reveals that students already have science-orientated conceptions. These are either hybrids of different ideas about atmospheric phenomena (*depletion of ozone vs. greenhouse effect*) or a simplified description of atmospheric processes (*reflection of radiation, greenhouse gas layer)*. Ekborg and Areskoug (2006) described five thinking patterns laypeople use to describe the mechanism of global warming in their relation to a climatologist's point of view. From the perspective of experientialism we were able to reduce these five thinking patterns to two: *warming by more input* and *warming by less output*. Life-world experiences can be linked to either of the two following conceptions. *warming by more input* means turning the heater up to warm a room or to heat an oven to cook some food. *Warming by less output* is more difficult to understand, because one needs to understand that there is already heat inside a container (room, bed, etc.), which has to be captured by insulating the container (insulation layer for house, warming blanket for bed). To understand the idea of an insulating layer, one has to understand the container-flow schema, because warming by less output needs a continuous flow of energy into a container, thus producing an imbalance in the equilibrium by keeping the energy from going out again.

Based on our study we can supplement the recommendations Koulaidis and Christidou (1998) described with a set of experiences students need in order to understand the greenhouse effect. The aim of teaching sequences about global warming should be (a) to arrange a conceptual change from *"The earth is warming because more heat gets in"* via *"The earth is warming because less heat gets out"* to *"The earth is warming in a dynamic equilibrium"*; (b) to show that absorption and emission are the elementary processes of the greenhouse effect and not reflection; (c) ozone depletion and the greenhouse effect are two phenomena that differ regionally, temporally, and structurally; and (d) to show that sunlight consists of different forms of radiation (e.g. visible and heat radiation).

In many school books, popular science magazines, and in the media, the greenhouse effect is communicated with a *greenhouse gas layer* and a *reflection of heat between the layer and earth's surface*. These scientifically incorrect and misleading representations can lead students to confound the *"greenhouse gas layer"* with the *"ozone layer"*. Additionally, the linguistic analysis of the terms used in communicating atmospheric phenomena shows the linguistic closeness of the German term *Treibgas* (e.g. CFCs), meaning propellant gases, and *Treibhausgas* (e.g. CO_2, CH_4, N_2O), meaning greenhouse gas. The use of *klimaaktive Gase* (climate active gases) instead of *Treibhausgas* is clearer.

The different terms *"warmth"* and *"heat"* can be used for the communication of global warming: a *heating* of the atmosphere is described as something negative by all students –even the ones who anticipate the *warming* of the atmosphere as something positive. Thus, using the term heat instead of warmth can convince students that global warming – or better, global heating – is a problem. This will not automatically lead to a better understanding of the atmospheric processes or motivate action against climate change. But following the three-step model of action described by Andrey et al. (2000), which begins with the first step "waking an interest" in global warming, provides an important precondition for moving to the second step, "understanding the principles" of global warming, to develop strategies to fight global warming and thus to the third step "motivate for action" against global warming. Recommendations for the communication of climate change ideas will be evaluated in teaching experiments during the second part of our study.

References

Andrey J, Kay P, Fook IF, Mortsch L, Gibson R, Scott D et al (2000) Introduction. In: Scott D, Jones B, Andrey J et al (eds) Climate Change communication. Proceedings from an international conference. University of Waterloo and Environment Canada, Kitcher-Waterloo, pp iii–iv

Bord RJ, Fisher A, O'Connor RE (1998) Public perceptions of global warming: United States and international perspectives. Clim Res 11:75–84

Bord RJ, O'Connor R, Fisher A (2000) In what sense does the public need to understand global climate change? Public Underst Sci 9:205–218

Bostrom A, Morgan GM, Fischhoff B, Read D (1994) What do People Know about Global Climate Change? – 1. Mental Models. Risk Anal 14(6):959–970

Boyes E, Stanisstreet M (1992) Student's Perceptions of Global Warming. Int J Environ Stud 42:287–300

Boyes E, Stanisstreet M (1997) Children's Models of Understanding of Two Major Global Environmental Issues (Ozone Layer and Greenhouse Effect). Res Sci Technol Educ 15 (1):19–28

Boyes E, Stanisstreet M (1993) The 'Greenhouse Effect': children's perceptions of causes, consequences and cures. Int J Sci Educ 15(5):531–552

Boyes E, Stanisstreet M, Papantoniou VS (1999) The ideas of Greek high school students about 'ozone layer'. Sci Educ 83(6):724–737

Campbell NA, Reece JB (2002) Biology. San Francisco, Benjamin Cummings

Christidou V, Koulaidis V (1996) Children's models of the ozone layer and ozone depletion. Res Sci Educ 26(4):421–436

Cohen L, Manion L, Morrison K (2007) Research Methods in Education. Routledge, New York

Duden (2002) Das Bedeutungswörterbuch. Dudenverlag, Mannheim

Duit R, Gropengießer H, Kattmann U (2005) Towards science education research that is relevant for improving practice: The Model of Educational Reconstruction. In: Fischer H (ed) Developing standards in research on science education. The ESERA Summer School 2004. Taylor & Francis, London, pp 1–9

Duit R, Treagust D (1998) Learning in science: From behaviourisms towards social constructivism and beyond. In: Fraser BJ, Tobin KG (eds) International Handbook of Science Education. Kluwer, London, pp 3–25

Ekborg M, Areskoug M (2006) How students teacher's understanding of the greenhouse effect develops during a teacher education programme. NorDiNa 5:17–29

Gore A (2006) An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It. Rodale Books, New York

Gropengießer H (2007) Theorie des erfahrungsbasierten Verstehens. In: Krüger D, Vogt H (eds) Theorien in der biologiedidaktischen Forschung. Berlin, Springer

Hansen PJK (2005) The greenhouse effect and the effects of the ozone layer: Norwegian teacher students' development of knowledge and teaching skills. Eur Meteorol Soc 2:33–40

Hildebrandt K (2006) Die Wirkung systemischer Darstellungsformen und multiperspektivischer Wissensrepräsentationen auf das Verständnis des globalen Kohlenstoffkreislaufs. Kiel

Houghton J (2002) Physics of the Atmospheres. Cambridge University Press, Cambridge

IPCC (2007) Climate Change 2007: The Physical Science Basis. Cambridge University Press, Geneva

Jeffries H, Boyes E, Stanisstreet M (2001) Knowledge about the Greenhouse Effect: Have college students improved? Res Sci Technol Educ 19(2):205–221

Kattmann U (2008) Learning biology by means of anthropomorphic conceptions. In: Hammann M, Reiss M, Boulter C et al (eds) Biology in Context – Learning and teaching for the 21st century. A selection of papers presented at the VIth Conference of ERIDOB. Routledge, London, pp 7–17

Koulaidis V, Christidou V (1998) Models of Students' Thinking Concerning the Greenhouse Effect and Teaching Implications. Learning 83:559–576

Lakoff G (1987) Women, fire and dangerous things: What categories reveal about the mind. London, The University of Chicago Press, Chicago

Lakoff G (1991) Metaphor in politics

Lakoff G, Johnson M (1980) Metaphors We Live By. The University of Chicago, Chicago, London

Lakoff G, Johnson M (1999) Philosophy in the Flesh. The Embodied Mind and Its Challenge To Western Thought. Basic Books, New York

Lee O, Lester BT, Ma L, Lambert J, Jean-Baptiste M (2007) Conceptions of the Greenhouse Effect and Global Warming among Elementary Students from Diverse Languages and Cultures. J Geosci Educ 55(2):117–125

Mayring P (2002) Qualitative Content Analysis – Research Instrument or Mode of Interpretation? In: Kiegelmann M (ed) The Role of the Researcher in Qualitative Psychology. Huber, Tübingen, pp 139–148

Niebert K (2008) „Ich finde es gut, wenn es bei uns ein bisschen wärmer wird." Die Folgen der globalen Erwärmung in den Vorstellungen von Wissenschaftlern und Lernern. In: Krüger D, z Belzen AU, Riemeier T et al (eds) Erkenntnisweg Biologiedidaktik, vol 7. Kassel, pp 22–36

Österlind K (2005) Concept formation in environmental education: 14-year olds' work on the intensified greenhouse effect and the depletion of the ozone layer. Int J Sci Educ 27(8):891–908
Read D, Bostrom A, Morgan GM, Fischhoff B, Smuts T (1994) What do People Know about Global Climate Change? – 2. Survey Studies of Educated Lay People. Risk Anal 14(6):971–982
Riemeier T, Gropengießer H (2008) On the Roots of Difficulties in Learning about Cell Division. Int J Sci Educ 30(7):923–939
Schmitt R (2005) Systematic Metaphor Analysis as a Method of Qualitative Research. Qual Rep 10(2):358–394
Schönwiese C-D (2003) Klimatologie. Stuttgart, UTB
Smith TM, Smith RL (2006) Elements of Ecology. San Francisco, Pearson
Sterman J, Sweeney LB (2007) Understanding Public Complacency About Climate Change: Adults' Mental Models of Climate Change Violate Conservation of Matter. Clim Change 80 (3):213–238
UNCED (1992) Agenda 21. Paper presented on the UN Conference on Environment and Development, Rio de Janeirio, Brazil

Chapter 38
Integrating Environmental, Sociopolitical, Economic, and Technological Dimensions for the Assessment of Climate Policy Instruments

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Abstract Climate policy assessments often appear to lack a multi-analytical approach capable of considering different dimensions of sustainability during policy design. This paper presents an integrated assessment framework of climate policy instrument interactions by reconciling environmental, socio-economic, political, and institutional aspects for the initial stage of policy development. Selected interacting policy instruments are categorized into their policy design characteristics, referring to parameters that describe the institutional context of each instrument. Criteria covering specific environmental, sociopolitical, macroeconomic, financial, and technological objectives for assessing the policy instruments are identified and selected. Complementarities and overlaps between different combinations of instruments are identified. These affect subsequently the likely values (scores) of policy instruments against the evaluation criteria. By applying an interactive weighting method, policy makers are able to assign weighting factors on the criteria expressing their perceptions and objectives. An overall assessment of combined instruments from these steps is therefore determined based on the input from policy makers. We found that the developed framework provides a transparent tool to stakeholders capable of highlighting potential synergies and conflicts between environmental, socio-economic, political, and technological criteria during the stage of climate policies design. The method merits further attention in group decision-making for mapping stakeholders' preferences with diverse objectives.

Keywords Climate policy aspects · Climate policy interactions · Criteria weights · Evaluation criteria · Integrated approach · Stakeholders' perspectives

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Introduction

The energy and climate policy framework of the European Union (EU) consists of a series of regulations and initiatives that aim at different objectives and affect various actors in the energy and climate field. These policies aim to achieve specific objectives set by the United Nations Framework on Climate Change Convention, which assigns greenhouse gas (GHG) emissions reduction targets for all member states. In December 2008, EU leaders reached agreement over an energy and climate change "package" to deliver the bloc's ambitious objectives of slashing greenhouse gas emissions by 20%, boosting renewable energies by 20%, and increasing energy efficiency to 20% of the primary energy consumption by 2020. The package has multiple objectives and is designed to increase the EU's share to combat climate change, reduce the Union's dependency on imported fuels, promote green technologies, and create new jobs.

Policy instruments addressing such targets are present at EU-wide level and on a national basis. As far as the latter case is concerned, many instruments are currently incorporated into regulations, economic instruments, voluntary agreements, and market-based mechanisms. In the EU-wide context, a unified emissions trading scheme (EU ETS) was established as from 2005, based on an EU Emissions Trading Directive (CEC 2003b), followed up by an additional Directive (CEC 2004) that enables direct links of the EU ETS with the Kyoto Protocol project mechanisms (namely Joint Implementation and Clean Development Mechanism). The climate and energy package lays down certain conditions and requirements for further improvement and amendment of EU ETS specifically for its third phase, which starts in 2013. In addition, EU policy focuses also on the promotion of renewable energy sources by adopting various directives, such as the directive on the promotion of electricity produced from renewable energy sources (CEC 2001), the biofuels directive (CEC 2003a) and the recently agreed energy and climate package, which includes new targets for renewable energy sources for Member States.

Numerous policy instruments are applied simultaneously at an EU, national and regional level, aiming at often contradictory energy, environmental, and economic targets. Given this complex policy environment, it is clear that various objectives are pursued in terms of environmental and energy effectiveness, alongside economic efficiency. As these policies are designed and implemented in an already policy-crowded environment, interactions of their measures are taking place. These interactions can take different forms and shapes and in general can be complementary, overlapping, or indifferent. This raises the issue of compatibility of the different policy schemes, which is of crucial importance for further policy design. In this sense, policy interactions can affect the result of the overall targets of climate policy either in a positive or negative way. In addition, policy interactions could be beneficial towards certain policy objectives, but on the other hand they might affect negatively other objectives, which consequently would undermine the effectiveness of the overall policy. Thus, during the ex ante assessment of policy interactions, a systematic way to highlight and analyse trade-offs and synergies between policy objectives is indispensable. The most common practice in climate policy assessment is the use of quantified tools, models, and neoclassical economic approaches to measure the extent of climate mitigation and economic efficiency simultaneously. Therefore, the majority of researchers and practitioners in climate policy evaluation use approaches such as cost benefit analysis (CBA) and cost effectiveness analysis (CEA), which normally can capture the economic and environmental (in terms of greenhouse gas emissions reduction) dimensions of climate policy. In order to complement these approaches and consider other aspects of climate policy, specific studies are being conducted separately, targeting other dimensions and policy objectives such as competitiveness, employment, energy security of supply, and technological innovation. There is a lack of a unified method that aims to capture the different climate policy objectives in a systematic way and thus reconcile environmental, economic, sociopolitical, and technological aspects.

In order to reconcile the various aspects of climate and energy policy into the evaluation of policy instruments interactions, a Multi Criteria Analysis (MCA) approach is deemed appropriate for the following reasons:

- Multiple instruments and thus multiple combinations of instruments (policy options) for evaluation can be considered and evaluated by MCA
- Climate and energy policy have various aspects and objectives that should all be considered while evaluating policy instruments, where MCA is capable to deal with multiple, often conflicting, criteria and objectives
- Climate policy interaction is a high complex issue, whereas MCA has the ability to deal with complex policy issues by decomposing, analysing, and structuring them in a transparent way
- MCA can consider and combine objective (facts or likely performances) and subjective type of information (expression of judgments and preferences)
- MCA can incorporate different stakeholders' perspectives and preferences by the application of a weight elicitation technique
- MCA is an aid to decision-making that assists stakeholders to organize the available information, think of the consequences, explore their own objectives and tolerances, and thus provide a widely acceptable policy decision

However, despite the recent interest in participatory and MCA methods, MCA assessments are absent from most of the actual climate policy evaluations for various reasons. Time constraints, data availability problems, lack of guidelines and general tradition in monetized and cost benefit analysis methods, misconceptions, and a large variety of MCA methods comprise some of the main reasons that MCA methods are neglected most of the time in climate policy evaluation (Borges and Villavicencio 2004).

MCA methods should be used as decision aid tools rather than techniques for making decisions. Their outcomes are the result of stakeholders' evaluations and thus are sensitive to their judgments. Therefore, stakeholders should be informed about the tools they use and comprehend their functions and outcome.

MCA, although appropriate for the evaluation of policy interactions, should have a properly modelled preference system in order to facilitate the decision-making process. In this respect, special attention is paid to distinct stakeholders who tend to weight differently the employed criteria according to their policy objectives and preferences. Therefore, capturing this essential information could be of significant use, especially if it will appropriately feed into the decision-making process.

To this extent, we have developed an integrated assessment tool to evaluate energy and climate policy interactions during the policy design phase, which is able to assess combined policies using multiple criteria and parameters. This decision support tool is qualitative and in an interactive way provides a useful insight into several aspects of policy interactions. It addresses policymakers, policy analysts, and stakeholders, who can use it in order to identify policy interactions and effects of various policies.

Considering the above and following this introduction, we describe in Sect. 2 the methodology employed in the tool alongside with its basic characteristics and the parts that focus mainly on the selection of evaluation criteria and the weighting factors determination. In Sect. 3, we present an illustrative example of the tool in order to demonstrate its actual function, whereas Sect. 4 is dedicated to the presentation and analysis of results obtained from the illustrative case study. Finally, conclusions are drawn and future research areas are identified in Sect. 5.

Methodology

The developed multi-criteria decision support tool, the Energy and Climate Policy Interactions (ECPI), provides a qualitative framework for analysing interactions among policy instruments in various policy mixes during the phase of policy design. The key concept is that policymakers and stakeholders are able to examine selected policy instruments for interaction and express their preferences towards certain criteria when assessing options of integrating various instruments. In the ECPI tool, a traditional policy condition is assumed that an optimal policy solution preconditions the relationship one policy instrument for one policy target (Tinbergen's rule).

ECPI consists of certain features and steps that are described in detail by Oikonomou et al. (2010). In this paper, we focus on the preference system modelling and more specifically on the elicitation of criteria weights from various stakeholders and the investigation of potential trends according to their specific preferences and objectives.

Design Characteristics and Areas of Policy Interaction

Design characteristics refer to parameters that describe several functions of a policy instrument in terms of a measure identification, objectives pursued, scope, market creation, financing, timing, and institutional setup. A detailed explanation of these characteristics is provided in Oikonomou and Jepma (2008). The most important characteristics taken into consideration at this stage are briefly explained in Table 38.1.

EUA stands for Emission Unit Allowance (under the EU emissions trading scheme), WhC for White Certificates, TGC for Tradable Green Certificates and CHP for Co-Heat and Power

Design characteristics of standalone policies are combined and provide options for the formation of unified policy instruments with areas of design interaction. In a combined option of policy instruments A and B, a design characteristic X is compared in pairs and an area of policy interaction is extracted.

Design characteristics and areas of policy interaction are practically the same, but we distinguish them in the tool since they belong to different processes. Design characteristics refer to parameters of individual policy instruments, while areas of policy interaction to shared characteristics of combined policy instruments. In the options of combined policy instruments, based on our selection of design characteristics and on formulation of areas of policy interaction, we classify areas of policy

Table 38.1 Design characteristics of policy instruments (Adapted from Oikonomou and Jepma 2008)

Characteristic	Explanation
Application	The option for a policy target group to participate or not in the instrument's objective accomplishment (mandatory or voluntary)
Level and kind of target	General objective of a policy translated into targets in different ambient levels (GHG reduction, RE, energy efficiency, etc.) and level of target expressed in terms of high or low stringency
Energy target	Targeting sources of energy (e.g. oil, fossil fuels) leads to substitution effect between them and hence to cleaner production, while targeting final energy use stimulates energy efficiency and reduction of energy use
Obligated entities	Entities that comprise the target group that undertakes the fulfilment of the target, distinguished in: energy producers, industry, energy suppliers, and end users
Market flexibility	The optional choice of excluding or including some entities or sectors or technologies in the course of time of the policy cycle
Linking commodities	Type of commodity generated, exchanged, and traded in parallel to product market, distinguished in: EUA, WhC, TGC, emissions allowance, CHP certificate
Commodity liquidity	Trading participants can be allowed to bank the commodity and use it in the next compliance period. Trading participants can be allowed to borrow or lend a commodity in order to fulfil their target for the current compliance period
Cost recovery	The way that the target group recovers induced policy costs. There is partial, full, or no cost recovery and it is determined by market structure and market's degree of liberalization
Technologies	Technologies addressed and eligible for the target fulfilment, distinguished in: fossil fuel, renewable energy, nuclear, all, energy efficiency products
Additionality	Effect of policy if the target group would take actions independently of other policies and measures, and these investments would not have taken place in the absence of the specific policy
Institutional setup	Entities that design, set the rules for the implementation, monitor, verify the eligibility for target fulfilment, register all actions of a policy instrument

interaction as complementary, overlapping, or indifferent. This principle of redundancy of design characteristics is in accordance with our core assumption of Tinbergen's rule as stated above. Complementary means that a design characteristic of policy A enforces the same characteristic of policy B. Overlapping means that a design characteristic of policy A reduces the value of the same characteristic of policy B. Indifferent means that a design characteristic of A and B do not meet or reinforce each other.

Climate and Energy Policy Objectives and Criteria

Policy and decision-makers implement policies and measures to achieve specific objectives, taking into account different aspects, that they believe will not be achieved in the absence of government intervention, possibly because of the existence of non-internalized externalities and/or public goods supplies. There are various aspects deriving from climate and energy policies that policymakers aim to take into account. The evaluation of climate and energy policies first defines evaluation criteria and second categorizes them into main policy aspect categories. The evaluation criteria are used to measure the extent of the fulfilment of the policy aspects and objectives taken into account. Evaluation criteria are indispensable for both the choice of instruments during the policy design phase and the ex post assessment of implementation of policy instruments. The main EU climate and energy policy objectives which the EU climate and energy package aim to achieve are the following:

- To combat climate change and reduce GHG emissions
- To secure energy of supply and diversify the energy fuels
- To reduce the energy consumption by increasing energy efficiency within the economy
- To boost technological innovation and competitiveness
- To create new jobs

In this context, different studies have also identified criteria for the evaluation of climate and energy policy instruments (IPCC 2001; 2007; OECD 1997; 2001; Bondansky 2003; Oikonomou and Jepma 2008; Gaiza-Carmenates et al. 2010) addressing the different dimensions of climate and energy policy evaluation. Following a bottom-up process of selection of criteria and based on a review of these studies, we have selected the most relevant criteria and clustered them in the following five main categories, trying to capture all possible aspects of climate and energy policy interaction evaluation:

1. Environmental category

Environmental effectiveness has been widely emphasized in the environmental and climate change literature as the main criterion able to capture the extent that a policy instrument achieves the environmental goal, such as a GHG emissions reduction target (IPCC 2001; 2007; Bondansky 2003; Oikonomou and Jepma

2008). How reliable is the instrument in achieving that objective? In addition, does the instrument create continual incentives to improve products or processes in ways that reduce GHG emissions? Furthermore, OECD (1997) and Bondansky (2003) identify "soft" effects, which relate to the impact of environmental policy instruments on changes in attitudes and awareness. Thus "environmental awareness" is another environmental criterion which complements the criterion of "reduction of GHG emissions" in environmental category.

2. Sociopolitical category

Considering sociopolitical aspects is often an important issue of climate and energy policies. Blyth and Lefevre (2004) carried out a quantitative study on the interactions between energy security and climate policies, highlighting the significance of "security of energy supply" as an evaluation criterion. Decoupling economic growth and energy use is one of the main EU objectives and thus "reduction of energy intensity" has been added as a criterion in this category.

3. Financial category

The second assessment report (IPCC 2001) identifies cost effectiveness as one of the main criteria for the evaluation of climate policies. Does the policy instrument achieve the environmental objective (e.g. reduction of GHG emissions) at the lowest cost, taking transaction, information, and enforcement costs into account? "Administration" and "compliance" costs have been defined as separate evaluation criteria of climate and energy policy interactions by Oikonomou and Jepma (2008) additional to "transaction" costs. OECD (1997) identifies "governmental revenues" raised in the case of market mechanisms, for instance, may constitute a second source of benefits from their use, over and above their direct environmental impact, depending on if and how the revenues are recycled.

4. Macroeconomic category

Administrative and political feasibility includes considerations such as flexibility in the face of new knowledge, understandability to the general public, impacts on the "competitiveness" of different industries, and other government objectives. "Wider" economic effects include potential effects on variables such as inflation, competitiveness, "employment", trade, and growth (OECD 1997). One of the priorities of EC energy policy is the enhancement of energy market liberalization (e.g. Directive 2003b) which can be captured by the "market competition" criterion (Oikonomou and Jepma 2008).

5. Technological category

OECD (1997) identifies dynamic effects, which relate to the impact on learning, innovation, technical progress, and dissemination and transfer of technology. Stimulating technological change is stressed also by Bondansky (2003) as one of the main criteria for evaluating climate policies. In the long run, the development and widespread adoption of new technologies can greatly ameliorate what, in the short run, sometimes appear to be overwhelming conflicts between economic wellbeing and environmental quality. Therefore, the effect of public policies on the development and spread of new technologies may be among the most important determinants of success or failure in climate policy.

Criteria must fulfil some qualitative attributes as described by Hajkowicz et al. (2000), and Belton and Stewart (2002), while a few more have been added by Grafakos et al. (2010):

- *Value relevance* – Linking the concept of each criterion to the objectives it is meant to represent
- *Operationality* – Evaluation criteria should be able to identify how well each option of policy interaction meets the objectives expressed by the criteria
- *Reliability* – A malfunctioning criterion should not render the whole set of criteria unworkable
- *Measurability* – Degree of measurement of the performance of alternatives against specified criteria
- *Decomposability* – Possibility to break down an objective into specific means
- *Non-redundancy* – Limiting the number of criteria addressing the same objective, meaning avoidance of duplication of information in criteria
- *Minimum size* – The number of criteria employed should be only the absolute necessary to provide representation of policy objectives
- *Preferential independence* – Preferences associated with the performances of each option should be independent of each other from one criterion to the next
- *Completeness* – The selected criteria should cover all the key elements of the evaluation problem
- *Understandability* – The selected criteria should be understandable not only by specialists but by non-technical people too

The selection of evaluation criteria as described is based on a bottom-up approach. By reviewing the relevant literature and assuring that the selected set of criteria meets the above conditions the criteria are categorized according to their association with the climate and energy policy aspects discussed above. At the final stage, stakeholders and experts were asked to approve and refine the set of criteria. Figure 38.1 illustrates the main climate and energy policy aspects and criteria categories, whereas Table 38.2 provides a brief explanation of each selected criterion employed within the tool.

It is unavoidable that some overlaps between the criteria might exist within a category and between the different categories of criteria. They are not necessarily consistent, but give room for synergies and conflicts. This leads us to the necessity not to see the criteria or groups as separate formulas, but as parts of the overall aim, and to incorporate them whenever possible into the integrated climate and energy policy concept. Coming from the overall aim to the criteria is one step of operationalizing, whereas the next would be to measure the criteria through quantitative – if possible – otherwise qualitative measurement scales.

Assessment of Policy Mixes (Scoring of Policy Options)

The criteria selected in the ECPI tool receive specific values that range from −2 to +2 and reflect the positive or negative effect of each policy instrument on the

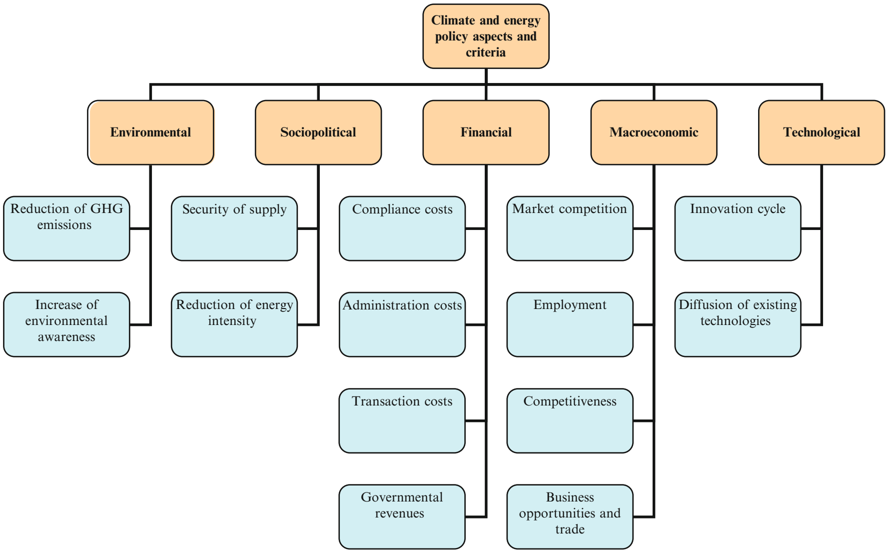

Fig. 38.1 Major criteria categories and selected criteria

specific criterion. A zero value reflects that there is no influence on the criterion, which could also illustrate that a policy instrument is not related to targets that the specific criterion represents. As the numbers −2 to 2 are taken as mathematical numbers and as ordinal ones (having a meaning), the distance between the numbers must be the same as between the associated answers (see Table 38.3). This overcomes the problem of using an ordinal scale (answer possibilities) for a weighted sum aggregation.

A positive or negative effect does not always mean an increase of a positive or negative value of a criterion. The effect of the value is in accordance with the interpretation of criteria as explained in Table 38.2.

The tool provides the user with performance values of policy instruments towards the evaluation criteria, as they are assessed from various literature studies and experts' judgements. The performance values for the option of integrating the policy instruments result from the design areas of integrated policy instruments and the degree of influence of areas of policy interaction on the criteria. The measurement scale is the same as of the scale of standalone policy instruments (−2/+2). We should stress here that these performance values cannot give more than a preliminary idea about the direction and the probable range of the impact on all criteria.

Weighting of Criteria

Each policymaker and stakeholder may apply different weights to the evaluation criteria according to policy objectives and preferences while evaluating climate and

Table 38.2 Explanation of selected criteria

	Criterion	Explanation	Comments	Objective
Environmental category	Reductio of GHG emissions	Reduction of emissions through policy	A positive sign refers to an *increase* in reduction of GHG emissions	Max
	Increase of environmental awareness	All economic actors become more environmental aware through policy	A positive sign refers to an *increase* in environmental awareness	Max
Socio-political category	Security of supply	Non interruption and security of energy supply through policy	A positive sign refers to an *increase* in security of supply	Max
	Reduction of energy intensity	Reduction of energy use as input for a given output in total economy due to	A positive sign refers to an *increase* of reduction in energy intensity	Max
Financial category	Compliance costs	Direct costs for obligated parties that need to fulfill policy goals	A positive sign refers to a *decrease* in compliance costs	Min
	Administration costs	Costs required from public bodies for implementing a policy based on the institutional set up	A positive sign refers to a *decrease* in administration costs	Min
	Transaction costs	Search, information, negotiation, approval, monitoring, insurance costs undertaken by obligated parties due to	A positive sign refers to a *decrease* in transaction costs	Min
	Governmental revenues	Revenues generated through policy that can be redistributed for an environmental or other cause	A positive sign refers to an *increase* in governmental revenues	Max
Macro – economic category	Market competition	Compatibility with market liberalization and transparency that enhance competition through policy	A positive sign refers to an *increase* in market competition	Max
	Employment	New positions in sectors through policy	A positive sign refers to an *increase* in employment opportunities	Max
	Competitiveness	Effects on market prices of domestic industrial products due to policy	A positive sign refers to an *increase* in competitiveness	Max
	Business opportunities and trade	Enhancement of trade (national or international) and of investment opportunities (beyond the direct policy goals) due to policy	A positive sign refers to an *increase* in business opportunities and trade	Max
Technological category	Innovation cycle	Innovation, Invention and Diffusion of new technologies can be enhanced	A positive sign refers to an *increase* in innovation activity	Max
	Diffusion of existing technologies	Besides innovation, diffusion of existing efficient technologies in stock due to	A positive sign refers to an *increase* in diffusion of existing technologies	Max

Table 38.3 Measurement scale of criteria performance

Measurement scale of criteria performance	Explanation[a]
−2	Significant decrease of criterion performance
−1	Moderate decrease of criterion performance
0	No change of criterion performance
1	Moderate increase of criterion performance
2	Significant increase of criterion performance

[a]This refers to max. criteria and the opposite stands for the min. criteria

energy policy options. There are numerous methods to determine criteria weights which can be used in various ways for different policy evaluation purposes according to different interpretations of weights (Grafakos et al. 2008). Weights can have different meanings, they can either be perceived as relative importance coefficients stating importance of the criteria, or as scaling factors reflecting impact trade-offs between criteria. The weighting method that has been developed to derive factors of relative importance of criteria is a combination of pair-wise comparisons with an initial ranking technique.

Ranking of Criteria

The methodology combines an initial simple ranking criteria exercise and a pair-wise comparison technique which results in criteria weights determination and a new criteria ranking. The former is a direct ranking whereas the latter one is indirect, determined by the weights derived by the pair-wise comparisons of criteria. The introduction of the initial holistic ranking technique has a twofold meaning and use. It is introduced first to help stakeholders to comprehend the concept of criteria importance and second to provide the means to respondents to resolve any conflicts and discrepancies that may be detected between the two rankings.

Pair-Wise Comparisons of Criteria

Respondents' weighting judgments regarding the criteria are derived by comparing the criteria in pairs in a structured and constructive manner. We use the abbreviated pair-wise comparison format and thus $n-1$ pair wise comparisons are performed. Pairs are sequentially assigned (as *a*-*b*, *b*-*c*, *c*-*d*, etc.), where the initial criterion *a* is the first ranked criterion by the respondent, criterion *b* is the second ranked criterion, *c* is the third ranked criterion and sequentially the order of pairs of criteria is according to the initial criteria ranking. This means that first, randomness is assured in the sense that each subsequent pair is selected differently according to respondents' initial ranking and thus problems with path dependency are being minimized (Saaty 1987) and second, the ranking consistency of stakeholders' preferences is being maximized.

The criteria weights are derived in a constructive way after completing certain judgmental steps. Firstly, respondents' preferences between pairs of criteria are expressed verbally. Secondly, the verbal expression of preferences is being assigned with ratios on a 10-point scale between 0 and 1. Thirdly, one criterion is assumed to have relative score of 1, to be used for the calculation of the relative scores of the rest of the criteria. Then, the obtained relative scores of criteria are translated into normalized weighting factors *Wi* by the following formula:

$$Wi = \frac{RSi}{\sum_{n-1} RS} \tag{38.1}$$

where *RSi* is the relative score of criterion *i* compared to criterion *j* during the pair-wise comparison and Σ(*RS*) is the sum of relative scores of all criteria (*n*) after completing the whole set of abbreviated pair wise comparisons ($n-1$).

It is possible to assign weights both to the criteria (third level), and to the categories (second level), both indicating relative importance. This can be done in different ways. Firstly, we can elicit weights for the criteria one by one (whose sum is 1) and then add the criteria weights according to the category they belong to derive categories' weights. Secondly, we can assign weighting factors on criteria categories (whose sum is 1) and then further divide each category's weight across category's criteria. In both cases, we run the risk of being subject to splitting bias, which leads to the problem that within categories with many criteria, one criterion has less importance than within categories with few criteria or inversely, categories with more criteria have more importance than categories with less criteria (Weber et al. 1988; Pöyhönen et al. 2001). We are aware of this bias and we avoided assigning weights to categories since the focus of the paper is on the particular selected criteria. However, in order to get an idea of interpretable results between the categories, and being aware of the risk of splitting bias, we can just add the weights on the third level in order to derive some indicative weight values for the second, the category level. It should be stressed that the development and application of this weighting methodology proved to overcome the major weighting difficulties, biases, and risks that normally arise during the applications of the weighting process, namely impact range effect, splitting bias, inconsistency, and numerical evaluation scale (Hayashi 2000; Hamalainen and Alaja 2008; Grafakos et al. 2010).

Transitivity and Consistency Test

A complete ranking of criteria is based on the actual choices assuming transitive preferences. For further discussion on transitivity of preferences in pair wise comparisons see Keeney (1982); Peterson and Brown (1998); Strager and Rosenberger (2006); and Grafakos et al. (2008). Despite the assumption of transitivity, a ranking consistency index is introduced, based on Spearman's Rank Order Correlation Coefficient (SROCC), to explore the degree of consistency between the initial ranking and the ranking based on pair wise comparisons. The formula of the Spearman rank order correlation coefficient (ρ) is:

$$\rho = \frac{6 * (\sum D^2)}{N(N^2 - 1)} \tag{38.2}$$

where 6 is a constant that is always used in the formula. D refers to the difference between a criterion's ranks on the two methods (simple ranking and pair wise) and N is the number of criteria.

Weighted Summation

The main focus of the current study is rather on the underlying stakeholders' views and preferences towards the different aspects of climate and energy policy instruments than on the final overall ranking of alternatives, and thus a weighted summation is based on the simple, straightforward and transparent aggregation additive rule,

$$V(p) = \sum_j w_j * v_j (p) \tag{38.3}$$

the value of the overall effect of each policy option, v_j, to each criterion is multiplied with its respective criterion weight, w_j, whereas the summation of these products determines the overall value of each policy option, in our case of each policy instrument and their combination $V(p)$. This overall value indicates whether two policy instruments should be integrated or not.

Application

Description

An illustrative application of the methodology is presented in this section by comparing the option of implementing two standalone policy instruments to the option of their combined application. The policy options are evaluated by the weighted summation of each option based on their scores and criteria weights that have been assigned by the stakeholders. We compare the option of applying feed-in tariffs for renewable energy (feed-in RE) to energy suppliers in combination with the application of EU ETS to energy producers for CO_2 emissions reduction with the option to keep them as standalone policy instruments. The main characteristics of the policy instruments and policy options are illustrated in Table 38.4 as presented to stakeholders.

As was described at the methodology section, the policy instruments are compared to their combined application based on the selected evaluation criteria. The performance values (scores) of the policy options have been determined from literature studies and experts' judgments. The measurement scale of the performance values is common for all criteria and ranges from −2 to 2 as discussed above. Table 38.5 depicts the evaluation impact matrix which contains the scores of policy options towards the evaluation criteria.

It can be noticed from Table 38.5 that none of the policy options is superior to others with respect to all evaluation criteria. EU ETS and the interaction policy options have negative scores at the criteria of "administration costs" and "transaction costs". On the other hand, these two options achieve the best performance (score 2) at the criterion of "business opportunities". Feed-in tariff for RE policy option also has a negative score at the "governmental revenues" criterion whereas it performs best (score 2) at the criterion of "security of supply". Therefore, the weighting factors that stakeholders assign to criteria would determine the most desirable policy option with the highest score.

The tool was distributed to various stakeholders to elicit their preferences on criteria weights. The tool includes specific instructions to assist the stakeholders to use it in an easy way and minimize the cognitive burden to users and time to be spent by them. The sample was small and the response rate judged as moderate

Table 38.4 Areas of policy interaction

Areas of policy interaction	Feed-in tariffs for renewable energy	EU ETS	Status of interaction
Application in market (Mandatory (M) or Voluntary (V))	Voluntary	Mantadory	Complementary
Level of targets (High or Low)	Low	High	Complementary
Energy (primary or final)	Final	Final	Overlapping
Obligated entities (energy producers, energy suppliers, industry, consumers)	Suppliers	Producers	Complementary
Market flexibility for entities (Optional in/ Optional out)	Optional out	Optional out	Indifferent
Linking commodities (EU allowance, Tradable Green Certificate (TGC), White Certificate (WhC))		EUA	Indifferent
Commodity liquidilty (Banking and Borrowing (Y/N))		Yes	Indifferent
Cost recovery (Full tariff, Limited tariff)	Limited tariff	Full tariff	Complementary
Technologies (Fossil Fuels, Renewable Energy (RE), Nuclear)	RE	Fossil fuel	Complementary
Additionality (no, baseline)	No	No	Overlapping
Institutional setup (number of bodies required)	6	3	Overlapping

Table 38.5 Evaluation impact matrix

	Environmental category		Socio-political category		Financial category				Macroeconomic category				Technological category	
Criteria policies	Reduction GHG emissions	Increase of environ -mental awareness	Security of supply	Reduction Energy intensity	Compliance costs	Adminis-tration costs	Transaction costs	Governmental revenues	Market competition	Employ-ment	Competitive-ness	Business opportunities and trade	Innovation cycle	Diffusion of existing technologies
Feed-in tariff for RE	1	1	2	0	1	0	0	−1	1	0	1	0	1	2
EU ETS	1	1	0	0	−1	−1	−1	1	1	1	−1	2	0	2
Result of Interaction	2.0	2.0	2.0	0.0	0.3	−1.0	−1.0	0.1	2.0	1.0	0.2	2.0	1.0	2.0

(50%). The tool was sent to 38 stakeholders, while 19 of them responded. The sample was divided into two main categories: academics (9) and market players (10) (e.g. energy and climate experts, consultants) in the climate and energy policy field. The completion of the tool was performed individually in an interactive way in the sense that each respondent could see and revise the output of his preferences.

Assigning Criteria Weights

First Step: Initial Ranking

The respondent is required to rank criteria according to his preferences, from the most preferred to the least preferred criterion. The initial ranking is also used for a consistency test of the user's preferences by being compared to the ranking determined by the pair-wise comparisons of criteria.

Second Step: Pair-Wise Comparisons

The respondent is required to express his preferences in three consecutive step-requests: (a) which criterion he prefers at each pair wise comparison, (b) how much he prefers a criterion to the other verbally, and (c) how much preference intensity he assigns arithmetically to the most preferred criterion against the other. Five levels of preferences have been defined in verbal expressions. The five levels of preferences verbally expressed are associated to 10 levels of numerical preference values (Table 38.6).

The user is assisted by a developed computer aided Excel tool. A graph automatically reflects his preferences, providing him with the visual representation of the resulted relative importance between the pair of compared criteria. When the respondent completes the whole series of pair-wise comparisons across criteria, then relative scores, weighting factors, and ranking of criteria are determined automatically by the tool.

Table 38.6 Verbal and ratio numerical intensity of preferences

Verbal expressions	Ratio – numerical intensity of preferences
Equally preferred	1
Almost equally preferred	0.9
Moderately preferred	0.6, 0.7, and 0.8
Strongly preferred	0.3, 0.4, and 0.5
Very strongly preferred	0.1 and 0.2

Final Step: Consistency Test and Revision of Preferences

During the final stage, the respondent can observe the derived weights and ranking of criteria, and revise his preferences if necessary. The obtained ranking of criteria during the pair-wise comparisons is compared with the initial ranking. The consistency indicator, which is calculated automatically by the tool, suggests whether or not the respondent needs to revise his preferences.

Results and Discussion

The analysis of results focuses mainly on how different stakeholders weight various objectives and criteria during the climate policy interactions evaluation. Figure 38.2 illustrates the spread of criteria weights for confidence level 95%. It can be clearly noticed from Figs. 38.2 and 38.3 that the criterion which has been assigned with the highest average weighting value is the "reduction of GHG emissions". "Reduction of energy intensity" and "security of supply" follow as second and third most significant criteria respectively. The least significant criteria according to stakeholders are "governmental revenues", "transaction costs", and "administration costs". This could be expected since there were no representatives from governmental institutions that returned the tool within the sample and thus their views are not represented in these results.

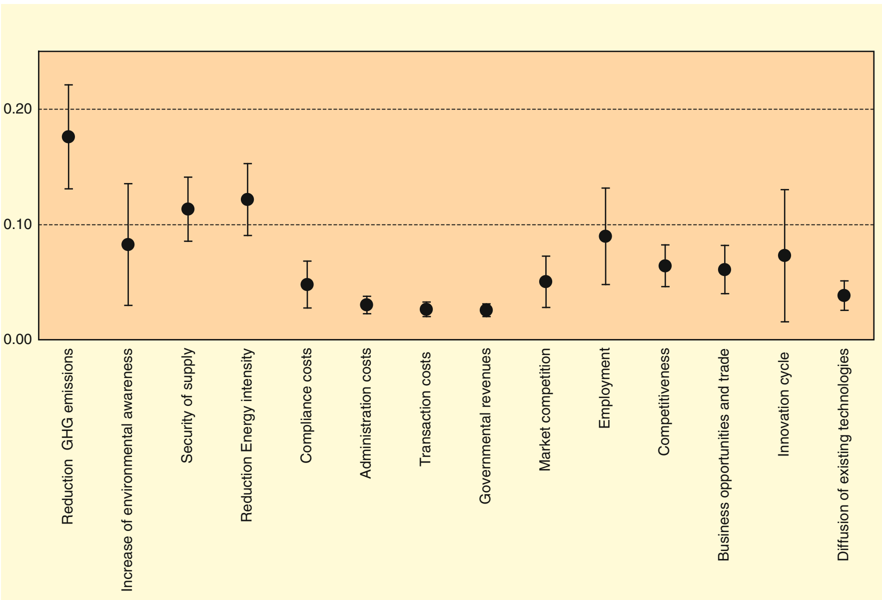

Fig. 38.2 Spread of criteria weights (95% confidence level)

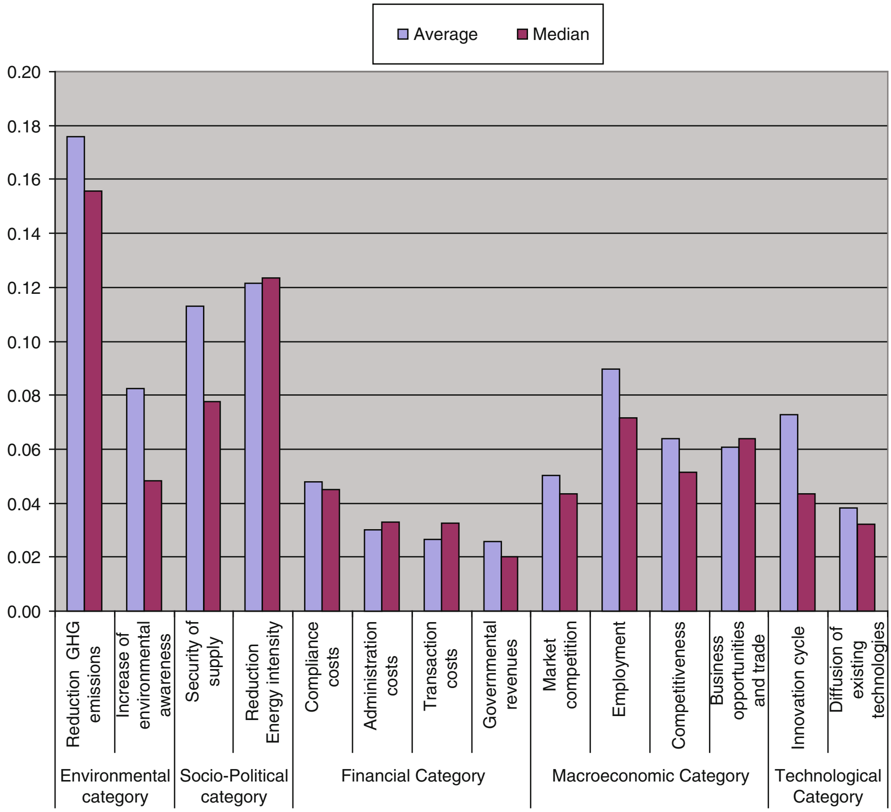

Fig. 38.3 Average and median criteria weights

It can be observed from Fig. 38.3 that there is significant deviation between average and median value of some criteria weights. In particular, the criteria of "increase of environmental awareness", "security of supply", and "innovation cycle" obtain the highest deviation between average and median, which means that few respondents assigned high weights and force the average values upwards. On the contrary, the criteria with less variation of the assigned weights by the stakeholders are those of "reduction of energy intensity", "business opportunities" and "compliance costs".

In case we would like to explore how stakeholders value and weight different criteria categories, we can simply add the criteria weights for each specific category (see Fig. 38.4). However, we should be aware of the risk of splitting bias that exists, while there is a tendency to weight more the categories with more criteria than the categories with fewer criteria. Therefore, we should interpret this data with care and be cautious about the conclusions that can be drawn. Nevertheless, we can observe that the financial category is being weighted with the second lowest value factor even if it includes four criteria. In addition, environmental and sociopolitical

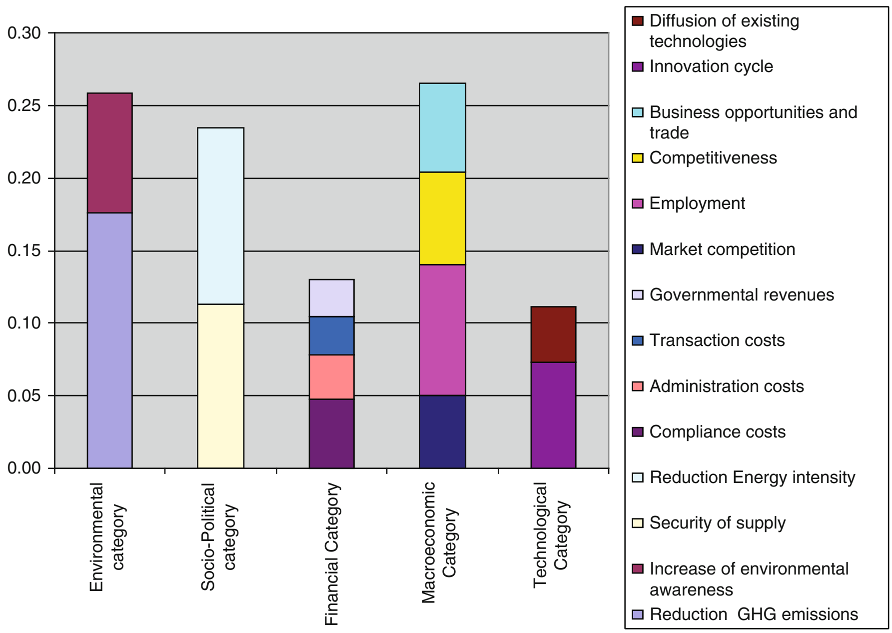

Fig. 38.4 Criteria categories' weights

categories have been weighted with high values and much higher than the technological category (which also includes two criteria).

Figure 38.5 shows the differences of criteria weights that have been assigned between different stakeholder groups. In our application we have distinguished two stakeholder groups: (1) academics and (2) market players (energy experts, consultants, etc.). It can be observed from Fig. 38.5 that the group of market players perceives some criteria to be much more significant than the group of academics do.

In particular, "reduction of GHG emissions", "reduction of energy intensity", "compliance costs", "competitiveness", and "business opportunities and trade" assigned with much higher weights by market players than by academics. On the contrary, "market competition", "employment", and "innovation cycle" have been considered with more significance by the group of academics than by the group of market players. In order to have more robust results or to explore the views and preferences of other type of stakeholders, a bigger sample of respondents would be essential to be involved in the study.

It can be observed from Fig. 38.6 that some average and median values of criteria weights had significant differences within the group of academics.

On the other hand, the differences between average and median weights were mainly insignificant within the group of market players, as shown in Fig. 38.7.

This probably could be explained by the fact that market players represent more unified preferences than the group of academics. In particular, the median weight of

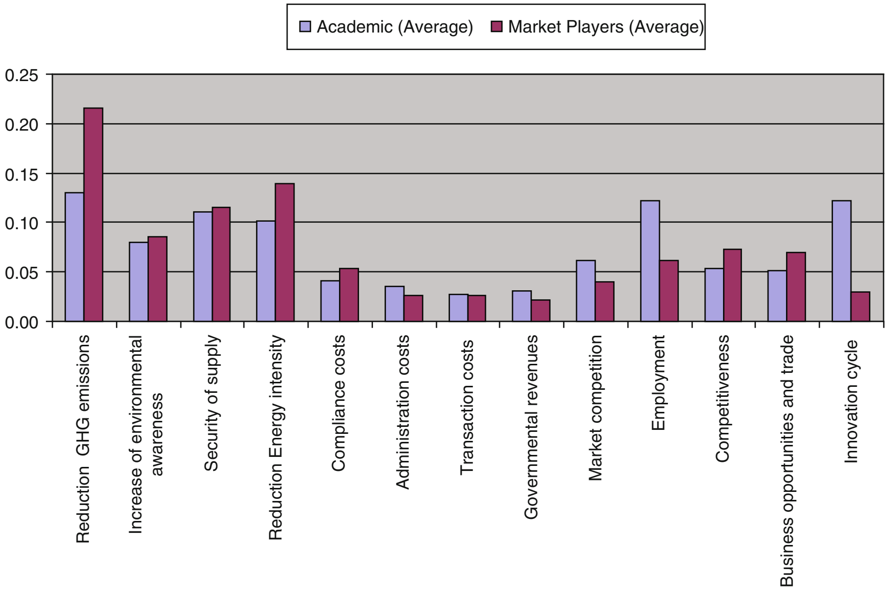

Fig. 38.5 Criteria weights of different stakeholder groups

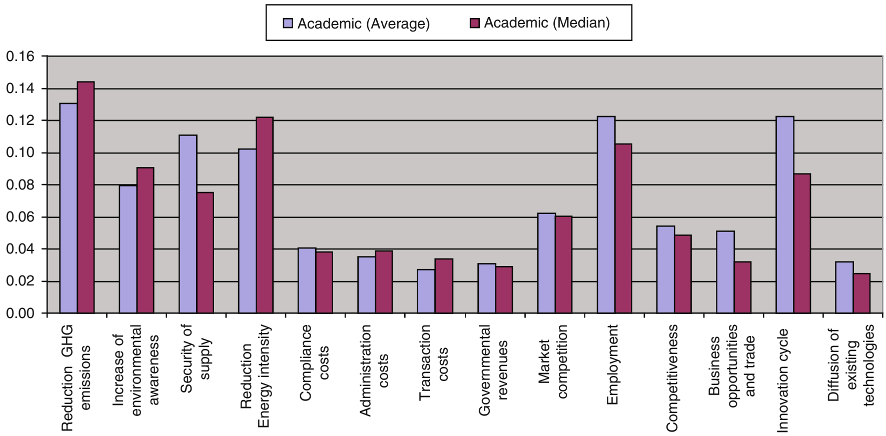

Fig. 38.6 Average and median weights of group of academics

the "reduction of GHG emissions" is estimated higher than the average weight, which means that few academics assign very low values to this criterion and consequently drive the average value downwards. Therefore, this may also explain the major difference between the average weighting values of the two groups for the criterion of "reduction of GHG emissions".

Regarding the policy options' final scores and ranking, the policy option of combining the policy instruments (interaction) performed best for all stakeholders

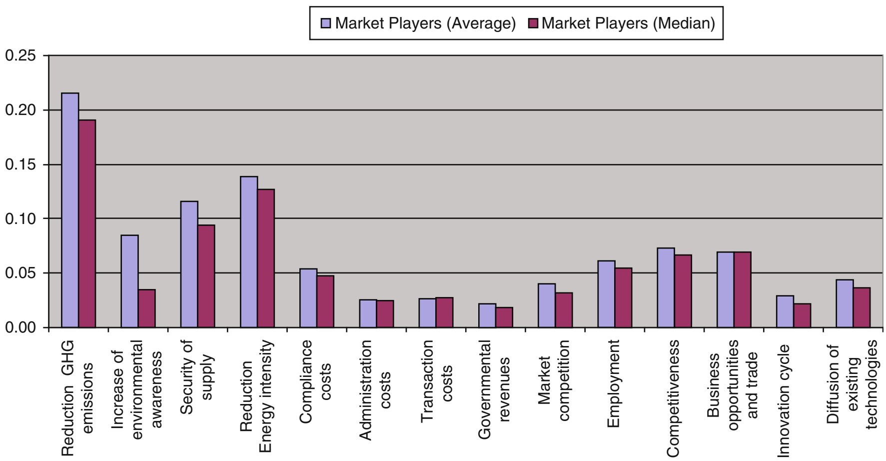

Fig. 38.7 Average and median weights of group of market players

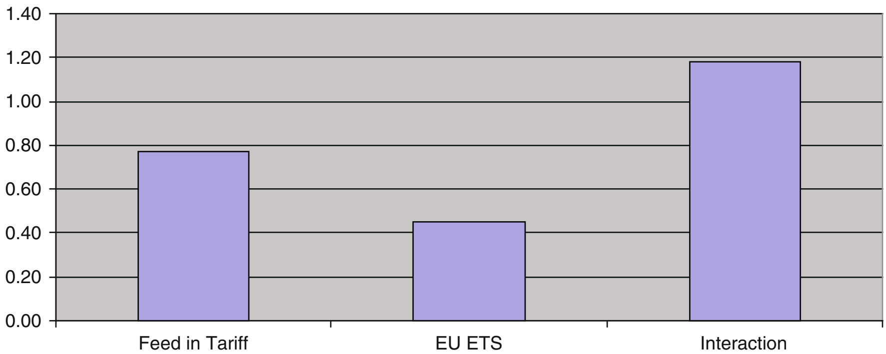

Fig. 38.8 Average weighted scores of policy options

irrespective their background and the particular group they belong (see Fig. 38.8). This result coincides with many practices in EU countries, where EU ETS has been complemented by the feed-in tariff for renewables.

Figure 38.9 demonstrates how different criteria contributed to the final score of the most desirable policy option, taking into account their weighted scores. It can be noticed that the criterion of "reduction of GHG emissions" has the highest contribution to the final average score of the interaction policy option. This figure can also illustrate the main synergies and conflicts between certain criteria concerning the particular examined policy option. For instance, we can clearly observe that this policy option performs high score simultaneously on specific criteria (synergies), such as "reduction of GHG emissions", "security of supply", "increase of environmental awareness", and "business opportunities and trade". On the contrary, this achievement is being realized at the expense of other criteria (e.g. administration and transaction costs), highlighting conflicts between criteria.

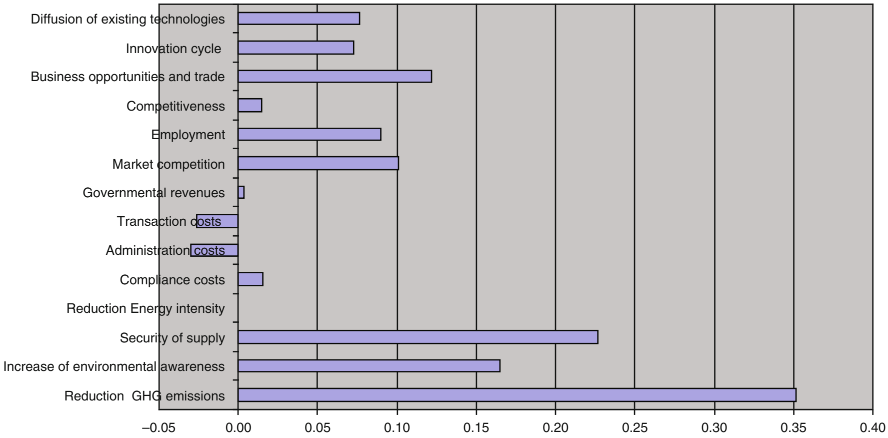

Fig. 38.9 Contribution of criteria to the final score of the interaction policy option

The share of each criterion to the final score can be further analysed and categorized into individual components of criteria weights and scores and thus indicate the main policy drivers of the policy design process and the different perspectives affecting the policy outcome.

The development and application of this weighting methodology contributed also to the improvement of weighting methods for mapping stakeholders' preferences in climate and energy policy evaluation:

- It has the capability to consider a high number of criteria
- It is a user-friendly weighting procedure (structured, simple, transparent), it does not require a lot of time and effort from stakeholders, and it therefore reduces the cognitive burden required by them
- The weighing method has been applied by the use of an Excel tool which has been developed for this purpose and provides the appropriate automated modules
- It provides the ability to respondents to interact with the results and revise their initial preferences, while a ranking consistency index gives them the opportunity to check the consistency of their rank order preferences
- It can be used by many and different individuals simultaneously, either in the form of individual interview or by electronic communication
- It can be used within groups to identify trends, preference differences, and conflicts, and raise discussion for the evaluation problem at hand

Conclusions

In a policy environment where EU ETS has been introduced since 2005 and renewable energy targets have been set for all EU member states as laid down within the recently agreed climate and energy package, the assessment of interactions between energy and climate policy instruments is essential. ECPI can serve these needs in a quite satisfactory way by considering different aspects and objectives within the analysis and, furthermore, with the ability to embed stakeholders' preferences and weights towards certain policy objectives. Our analysis of ECPI characteristics and the testing applications are illustrative of the following aspects:

Integration of Different Aspects

ECPI includes specific parts to break down the issue of assessing policy instruments' interactions into structural elements of the climate policy problem and then to integrate and synthesize them within one unified policy analysis framework. We have distinguished five main aspects as main criteria categories: (1) environmental, (2) sociopolitical, (3) financial, (4) macroeconomic, and (5) technological, which are taken into account and have been further broken down into 18 evaluation criteria. Apart from the integration of various aspects of climate policy, the tool incorporates stakeholders' preferences as well. In addition, one of its greatest strengths is the ability to integrate normative judgements (e.g. stakeholders' preferences) and technical expertise (e.g. experts' judgements).

Transparency

Transparency of the impacts, the preferences, and the conflicts between the criteria is extremely important for every decision maker. The policymakers and stakeholders need insight into the nature of these parameters in order to make the decision. Transparency in the decision process is again important for the acceptance of the decision and the implemented climate and energy policy strategies by the affected people. As MCDA improves this transparency, it can improve the decision process and the design of climate and energy policies. The result of MCDA is usually a ranking or a set of rankings of policy options. This ranking is not unequivocal; it is dependent among others on the preference structure of the stakeholders involved. In our case study, MCDA does not provide only one exact ranking, but it provides the background for the ranking and the information about its formation.

Learning and Awareness Process for Stakeholders

The tool comprises certain interactive elements that keep the respondent aware about the specific characteristics and areas of policy instruments interactions, the likely impacts of interactions towards certain evaluation criteria, his or her own preferences, and how these preferences affect the final outcome.

Identification of Synergies and Conflicts

By the application of the tool, synergies and conflicts between criteria can be identified and therefore areas for further improvement can be highlighted. By categorizing the policy problem into structural elements, we can observe which elements and parts function as potential conflicts and thus try to improve them for optimizing the policy design.

The stakeholders who have tested ECPI and its weighting module have expressed positive opinions about its usefulness, especially with regard to its characteristic of identifying policy instrument interactions that should be further analysed and the improvement of the decision-making process transparency.

Some conclusions can be drawn also based on the application of the tool:

- Based on the application of the tool, the criteria of “GHG emissions reduction”, “reduction of energy intensity”, “security of energy supply” performed as the most significant, whereas “transaction costs”, “governmental revenues”, and “administration costs” performed as less significant.
- Different groups of stakeholders, namely academics and market players weight differently the evaluation criteria. Furthermore, market players’ preferences, regarding the criteria, proved to be more unified and less dispersed as was the case with the group of academics where significant variations observed between their responds.
- The policy option of interaction of the examined policy instruments (EU ETS and feed in tariff) performed best for each one of the respondents.

ECPI tool and its weighting technique should not be considered as static. On the contrary, it is a dynamic instrument that is open to changes, improvements, adaptations. It has an evolutionary character, which lies in the concept of integrated climate and energy policy. Being aware of certain limitations of the current version of the tool, we can draw specific directions for further improvement.

- In the current version of the tool the selected list of criteria is based on the analysis of climate and energy policy aspects by the research team, whereas stakeholders’ involvement is limited to the final refinement of the set of criteria. The possibility of including stakeholders more actively in the process of selection of criteria could also be explored, where criteria can be discussed, added, changed, or removed. This prospect could also minimize the risk of any personal or institutional bias that might arise during the predefined selection of the criteria.
- This case study was limited in terms of the number of respondents contacted and who answered. More robust results could be derived by engaging a wider range

of stakeholders and forming more groups of stakeholders, and then mapping their perceptions based on the elicitation of criteria weights.

- Furthermore, the tool can be examined in a group decision-making context and serve stakeholders as a communication and mapping tool. Then, participants can shape and share information in order to reach a reciprocal understanding, highlight differences, identify potential conflicts, and strive towards building upon a communicative consensus. Thus, it could be used as a communication and dialogue tool which should improve the negotiation process through better understanding and more transparent dialogue, which consequently enhances the overall policy design.

Although we have received positive comments about ECPI applicability, it is in our plans to continue working towards its further improvement.

Acknowledgments This paper was based on research conducted within the framework of a bilateral cooperation of the University of Groningen with the National Technical University of Athens. The authors would like to acknowledge the significant help provided by stakeholders who have tested ECPI and the weighting tool and provided their fruitful comments for the current application and suggestions for its further improvement.

References

Belton V, Stewart T (2002) Multiple criteria decision analysis: An integrated approach. Kluwer, Dordrecht

Blyth W, Lefevre N (2004) Energy security and climate change interactions: an assessment framework. OECD/International Energy Agency, Paris, France

Borges P, Villavicencio A (2004) Avoiding academic and decorative planning in GHG emission abatement studies with MCDA: The Peruvian case. Eur J Oper Res 152:641–654

Bondansky D (2003) Climate Commitments – Assessing the Options. Advancing the international effort against climate change, Technical Report, Pew Center on Global Climate Change, Beyond Kyoto

Commission of the European Communities (2001) Directive COM 2001/77/EC, On Electricity Production from Renewable Energy Sources, Brussels

Commission of the European Communities (2003a) Directive 2003/30/EC, On the promotion of the use of biofuels or other renewable fuels for transport, Brussels

Commission of the European Communities (2003b) Directive 2003/54/EC, Common rules for the internal market of electricity, Brussels

Commission of the European Communities (2003c) Directive 2003/87/EC, Establishing a scheme for greenhouse gas emission allowance trading within the Community, European Communities, Brussels

Commission of the European Communities (2004) Directive 2004/101/EC, Establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, Brussels

Gaiza-Carmenates R, Altamirano-Cabrera C, Thalmann P, Drouet L (2010) Trade-offs and performances of a range of alternative climate architectures for post-2012. Environ Sci Policy 13:63–71

Grafakos S, Zevgolis D, Oikonomou V (2010) Towards a process for eliciting criteria weights and enhancing capacity of stakeholders in ex-ante evaluation of climate policies. In: Hardi P, Martinuzzi A (eds) Evaluating sustainable development, vol 3. Edward Elgar, Northampton, MA

Hajkowicz S, Young M, Wheeler S, MacDonald DH (2000) and Young, D. Supporting Decisions, Understanding Natural Resource Management Assessment Techniques, CSIRO Land and Water, Canberra

Hamalainen R, Alaja S (2008) The threat of weighting biases in environmental decision analysis. Ecol Econ 68:556–569

Hayashi K (2000) Multi criteria analysis for agricultural resource management: A critical survey and future perspectives. Eur J Oper Res 122:486–500

IPCC (2001) Climate Change 2001: Mitigation, Contribution of Working Group III to the third assessment report of the Intergovernmental Panel of Climate Change

IPCC (2007) Climate Change 2007: Mitigation, Contribution of Working Group III to the fourth assessment report of the Intergovernmental Panel of Climate Change

Keeney R (1982) Decision analysis: An overview. Oper Res 30:803–838

OECD (1997) Evaluating economic instruments for environmental policy. OECD, Paris

OECD (2001) Environmentally related taxes in OECD countries: issues and strategies. OECD, Paris

Oikonomou V, Flamos A, Zevgolis D, Grafakos S (2010) A qualitative assessment of EU policy interactions. Energy Sources Part B: Economics, Planning and Policy (in press)

Oikonomou V, Jepma C (2008) A framework on interactions of climate and energy policy instruments. Mitig Adapt Strateg Glob Change 13(2):131–156

Peterson G, Brown T (1998) Economic valuation by the method of paired comparison, with emphasis on evaluation of the transitivity axiom. Land Econ 74(2):240–261

Poyhonen M, Vrolijk H, Hamalainen P (2001) Behavioural and procedural consequences of structural variation in value trees. Eur J Oper Res 134:216–227

Saaty TL (1987) Concepts, theory, and techniques rank generation, preservation and reversal in the analytic hierarchy decision process. Decis Sci 18:157–177

Strager M, Rosenberger R (2006) Incorporating stakeholder preferences for land conservation: weights and measures in spatial MCA. Ecol Econ 58:79–92

Weber M, Eisenfuhr F, von Winterfeldt D (1988) The effects of splitting attributes on weights in multiattribute utility measurement. Manage Sci 34(4):431–445

Chapter 39
Mitigating the Climate Impact of Aviation: What Does Hydrogen Hold in Prospect?

Kolja Seeckt, Philip Krammer, Malte Schwarze and Dieter Scholz

Abstract This article discusses the impacts of aviation on global climate change, and shows attempts by the aviation industry to mitigate those impacts by means of alternative fuels. Special respect in this paper is given to the use of hydrogen as aviation fuel. Examples of practical and theoretical research projects on the application of hydrogen are presented and the current outlook towards an introduction of hydrogen into practice is presented. From a technological point of view, hydrogen as an aircraft fuel is feasible. However, in the current attempts by the aviation industry to improve environmental friendliness, hydrogen is not included as a measure within the foreseeable timeframe due to large financial and technical efforts.

Keywords Aircraft · Alternative fuels · Aviation · Climate change · Climate impact · Fuel cell · Hydrogen

Introduction

"Gliders use the energy of up-currents, while solar powered vehicles use the energy from the sun. Human-powered flight has also been demonstrated. Propulsive power for any other 'down to earth' flying depends on fuel. This fuel is used in the aircraft main engines." Scholz (2003)

The Meaning of Aviation for Economy and Society

International air traffic and logistics are key factors for today's global community, economy, and trade relations. The fast and safe transport of people and cargo allows

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for business and leisure flights and enables the intercontinental transport of perishable goods and express freight. Furthermore, aviation creates millions of jobs in aviation directly but also in related industries and service sectors. In detail, the Air Transport Action Group (ATAG), a coalition of several organizations and companies throughout the global air transport industry, states that 32 million jobs are generated globally by the air transport industry, of which:

- 17% are directly linked (airports, airlines, manufacturing industry)
- 20% are indirect jobs through purchases of goods and services (supply chain)
- 9% are induced jobs through spending of industry employees, and
- A remarkable 54%, i.e. 17 million jobs are created through air transport's catalytic impact on tourism (ATAG 2009)

With special respect to developing countries, "Tourism is one of the main export earners for 83% of developing countries and it is the principal export earner for one third of them. It is also a significant generator of employment: in twelve countries, employing one in five, and, in two instances (Maldives and Anguilla), employing over one half of the country's population..." (RGS-IBG 2006). Consequently, these countries are especially dependant on air traffic as well. In total (direct, indirect, induced, and catalytic), aviation's global economic impact is estimated as 7.5% of the world Gross Domestic Product (GDP) (ATAG 2009). Moreover, worldwide air traffic of passengers and cargo is still expected to continue expanding even in the light of the current world economic crisis (Embraer 2009). Annual growth rates over the next two decades are estimated at 4.9% for passenger transport and as much as 5.8% for cargo transport (Airbus 2007; Boeing 2008). This means that air traffic doubles roughly every 14 years.

The Environmental Effects and Efforts of Aviation

The global climate is warming, and there is very high confidence that human activities have been contributing to this (Penner et al. 1999). Carbon dioxide and other emissions from aircraft also add to this – especially because these emissions are produced in high altitudes. In its special report, "Aviation and the Global Atmosphere", the International Panel on Climate Change (IPCC) stated in 1999 that it is estimated that 3.5% of all anthropogenic contribution to climate change, expressed as "radiative forcing", is due to air traffic (Penner et al. 1999). Figure 39.1 shows the estimated contribution of air traffic to climate change, under different future scenarios. These scenarios range from the low-growth scenario Fc1 (2.2% annual traffic growth and broad technology improvements), to the high-growth scenario Edh with 4.7% average annual traffic growth and technology improvements mostly concentrated on nitrogen oxides emissions. All scenarios predict rising radiative forcing; however, none of these scenarios include the use of hydrogen or other alternative fuels.

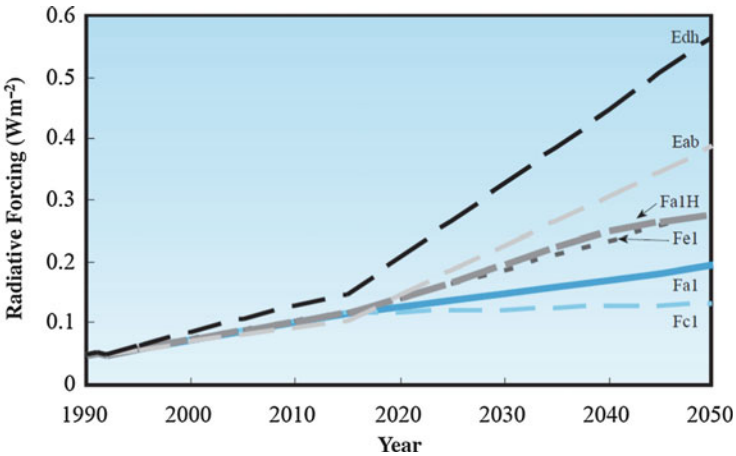

Fig. 39.1 Estimates of the globally and annually averaged total radiative forcing (without cirrus clouds) associated with aviation emissions under different scenarios to 2050 (Penner et al. 1999), with Fa1 as the reference scenario that assumes improvement in fuel efficiency and mid-range economic growth

From an industry perspective, the International Air Transport Association (IATA), the international industry trade group of airlines, states in its leaflet, “Debunking Some Persistent Myths about Air Transport and the Environment” (IATA 2009a), that air transport is responsible for only 2% of all global man-made CO_2 emissions but supports 8% of the global economic activity. On its website, IATA writes that “The best estimate of aviation’s climate change impact is about 3% of the total contribution by human activities. This may grow to 5% by 2050.” (IATA 2009b). With a full passenger load, a modern jet consumes about 3.5 l/100 km per passengers. This is only one-third the consumption of a jet in the 1950s.

However, a return trip from Frankfurt to Sydney for a family of four amounts to 10 times their annual electrical energy consumption. A compact car consumes about 1.5 l/100 km per passenger, which is still considerably less than a modern jet. On a social level, aviation is facing increasing challenges: in recent years, an increase in public awareness of climate change has been noticeable. Also, the general environmental consciousness has increased, and the public perception of aviation is becoming more critical. On a political level, the European Parliament decided in 2008 to include aviation into the emissions trading scheme of the European Union for carbon dioxide from 2012 on (European Parliament, 2009). Further environmental effects, besides global warming, that are linked to air traffic are noise, local air quality, and land use, due to an increase in the number of airports and airport growth. Regarding noise, numerous airports have introduced noise surcharges through individual sets of measures according to their specific needs (Krammer et al. 2009). Consequently, much effort is also spent on noise abatement procedures and the reduction of noise at the source, especially at the engine. Particularly logistic companies are affected by night-time operational restrictions, as their aircraft are most often operated during the night in order to deliver express freight during the office hours.

In the light of these enormous challenges, the Advisory Council for Aeronautics Research in Europe (ACARE) in 2001 set up the “Agenda for the European Aeronautics’ Ambition” referred to as “Vision 2020”. In this agenda, the two European top-level goals of “meeting society’s needs” and “winning global leadership” are addressed through a series of goals, such as:

- Reduction of the number of accidents in air transport by 80%
- Reduction of noise emissions by 50%
- Reduction of carbon dioxide emissions by 50%
- Reduction of nitrogen oxide emissions by 80% in reference to year 2000 standards (ACARE 2001)

These challenging goals put very high demands on future aircraft designs. Moreover, improvements in parameters such as fuel burn and noise, as well as fuel burn and nitrogen oxides emissions, are conflicting. Thus, the outcome can only be a compromise. However, current developments in technology do not show the potential to achieve the ACARE percentages. Furthermore, the total amount of emissions is expected to increase as the rapid growth of air traffic outpaces the achievements of new technologies to safe fuel. In order to meet future fuel demands and lower the environmental impact of transport, the consequences have to be a combination of three aspects:

- Higher fuel efficiency of current and future aircraft
- Alternatives to kerosene that are sustainable and cause a smaller carbon footprint (IATA 2009b), and
- Reducing the need to fly, e.g. by means of internet communication

Fuel: Kerosene and Its Alternatives

The world’s crude oil resources are limited. In the foreseeable future, crude oil will no longer be able to accommodate demand, as the worldwide energy consumption is permanently rising due to a growing world economy. The consequences are increasing fuel and energy prices in general and depleting resources. Thus, the time has already come to search for alternatives that can replace crude oil (BGR 2007).

Figure 39.2 shows a comparison of the energy densities of different fuels and batteries with respect to their energy-specific volume and mass on a double logarithmic scale. It becomes apparent how high the energy contents of crude oil-based fuels are. Their volumetric energy density, for example, is more than thirty times higher than the ones of batteries, which in return means that for the storage of the same energy content, batteries need more than thirty times the volume that e.g. kerosene (Jet A/Jet A-1) needs. Moreover, between kerosene and liquid hydrogen there is still a factor of about four – again in favour of kerosene. With respect to

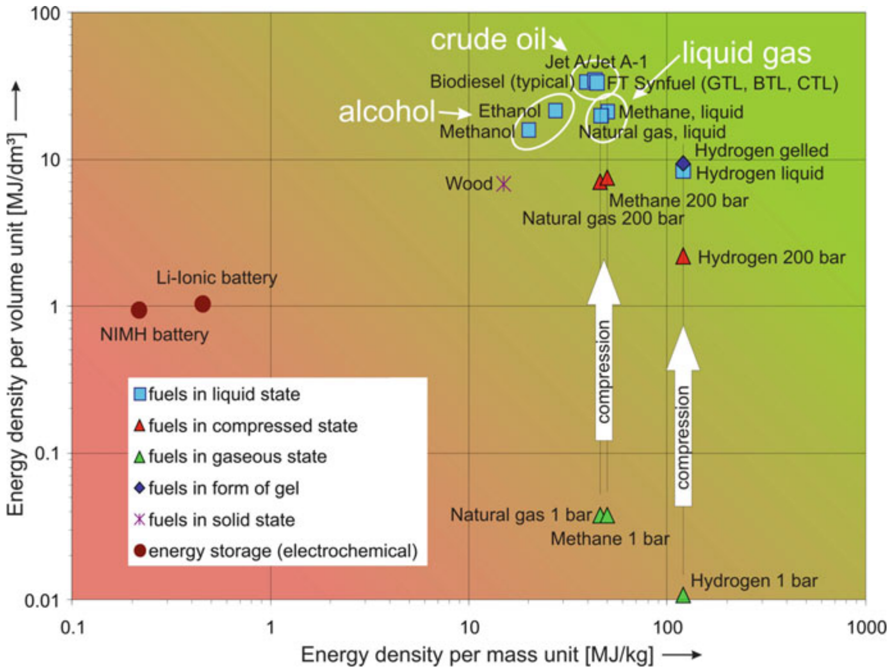

Fig. 39.2 Volumetric and gravimetric energy contents of different fuels and batteries on a double logarithmic scale (based on Sieber 2009)

mass, the factor between kerosene and liquid hydrogen is three; this time to the advantage of liquid hydrogen. This means that the same energy content has one third the mass of kerosene when stored in the form of liquid hydrogen. These numbers illustrate the very high demands posed to the alternatives that compete with current crude-oil based fuels. Energy storages in these forms become very voluminous and/or very heavy.

Hydrocarbons

Today's aviation fuel kerosene (Jet A/Jet A-1) has an energy content of 42.8 MJ/kg, and the combustion of 1 kg of kerosene requires 3.4 kg of air oxygen. Combustion products are 3.15 kg of carbon dioxide (CO_2), 1.25 kg of water vapour (H_2O), as well as further reaction by-products such as nitrogen oxides, sulphur oxides, and soot. The exact amounts of these by-products are highly subject to engine technology.

Synthetic fuels are very often produced by means of a chemical process named after its inventors, Fischer and Tropsch. Thus, they are also referred to as FT fuels. They mark an interesting alternative to conventional kerosene, as their volumetric and gravimetric energy densities lie in the same region as those of conventional kerosene.

Their handling qualities are also widely the same as those of the actual fuel. The most important synthetic fuels today are called GTL (gas-to-liquid), CTL (coal-to-liquid), and BTL (bio-to-liquid), depending on their raw material. However, only the latter one may be judged “climate-neutral”, since GTL and CTL still rely on fossil fuels.

The challenge today is to develop a fuel that is sustainable and exhibits low pollutant emissions over its whole life cycle from production to combustion (well to wing). Besides different feedstocks, there are also different production processes under investigation in several laboratories or relatively small production facilities, especially in the United States (Decker 2008). However, it will still take some time to ramp up production rates from laboratory size to industrial application. According to IATA’s Report on Alternative Fuels (IATA 2008), it does not appear possible at this time that a 100% sustainable fuel source will be available for the aviation industry.

Hydrogen

The production of hydrogen is significantly different from that of conventional kerosene or other crude oil-based fuels. In nature, hydrogen does not exist in a pure form. Consequently, hydrogen has to be separated from a feedstock first, and only parts of the invested energy for this purpose can be recovered during its use afterwards. Hence, hydrogen must not be regarded as an energy source like e.g. crude oil or wood, but must be considered an energy carrier like a battery.

Hydrogen has an energy content of 122.8 MJ/kg. The combustion of 1 kg of hydrogen produces 9 kg of water vapour and up to 90% fewer nitrogen oxides compared to the combustion of fossil fuels (NO_x, dependent on engine technology) (Funke 2009). Thus, the combustion of hydrogen generates a multiple of water vapour but significantly less NO_x than the combustion of an energy-equivalent amount of kerosene. The development of nitrogen oxides cannot be avoided completely, since the surrounding air with 78% nitrogen, which is a reactive gas, is involved in the combustion process. In total, the use of hydrogen as a future fuel for aviation offers the advantage of being an unlimited resource that, furthermore, contributes to much more environmentally friendly aircraft operation. However, today more than 90% of hydrogen is produced by reforming natural gas. The end products of the reforming process are hydrogen and carbon dioxide. Therefore, although the combustion of hydrogen generates no carbon dioxide, the reforming process itself produces a lot of this greenhouse gas. A more promising method for obtaining pure hydrogen is called electrolysis. In this process, water is split up into hydrogen and oxygen by means of electricity. Thus, if the electricity is generated from renewable energy, the production of hydrogen shows very low emissions.

With respect to safety, “Safe handling of hydrogen is no longer a problem in the industrial and commercial area” (LTH 2008). It has been used for decades in various applications such as space flight or chemical industry. Nevertheless, it is important to stress the cryogenic character of liquid hydrogen. Contact with liquid hydrogen, e.g. caused by a leakage, causes severe damage to the skin. Hydrogen has to be stored below 22 K (−251°C) to be available in liquid state (Brewer 1991).

Batteries

Figure 39.2 illustrates that batteries do not have sufficient energy densities to lend themselves as energy stores for airborne applications, although there has been significant progress in recent years. Current and foreseeable energy densities are too low to compete with kerosene. Moreover, there are still a number of unanswered questions concerning aspects such as pollutants and non-recyclable materials in their production process and disposal, as well as lifetime and charging time.

Comparison of Environmental Impacts

For an overall environmental assessment of alternative fuels, the resulting effects of industrial production have also to be taken into account. Feared effects of otherwise very promising biofuels are, for example, the conversion of cropland for food production or rainforest into cropland for the production of energy crops. This could cause deforestation and biodiversity loss as well as competition between these plants for freshwater. Concerning algae, the implications of mass production on sea flora and fauna are not yet known (Kuhlmann 2009).

Figure 39.3 compares the carbon dioxide emissions of different fuels over their whole life cycle in relation to conventional kerosene. It becomes apparent that particularly coal as a raw material for the production of different fuels leads to significantly larger carbon dioxide emissions than today's kerosene, when regarding the whole life cycle. Biofuel and liquid hydrogen produced from water and nuclear power by means of electrolysis, show significantly lower CO_2 emissions. The emission level of liquid hydrogen from water and nuclear power is even close to CO_2-neutral. However, the use of nuclear power is highly controversial.

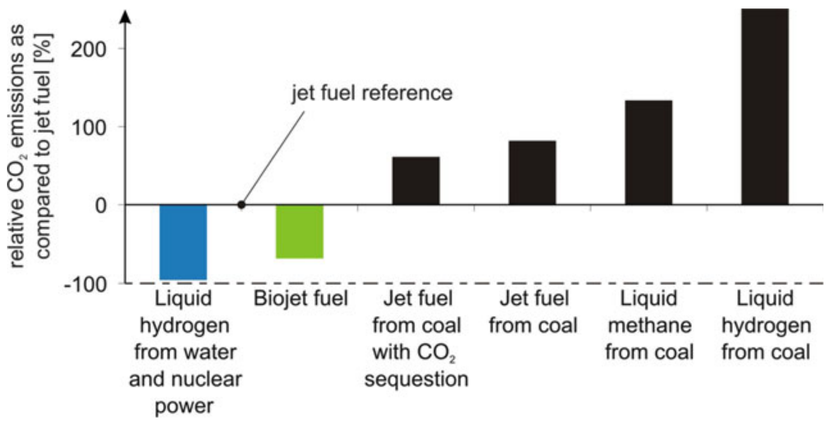

Fig. 39.3 Relative carbon dioxide emissions of different alternative fuels over their whole life cycle compared to conventional kerosene (based on IATA 2008)

Alternatives for the generation of the required electrical energy would be e.g. solar energy and wind energy.

The climate impact of condensation trails, in short contrails, which form behind aircraft under certain atmospheric conditions at altitudes greater than 8 km is not yet very well understood. The aforementioned IPCC special report stated in 1999 that "Contrails tend to warm the Earth's surface, similar to thin high clouds" (Penner et al. 1999). More recent investigations support this tendency (Schumann 2008). Due to their significantly larger emissions of water vapour, this is especially important for hydrogen-powered aircraft, as it has effects on their climate impact and/or operational conditions if such aircraft have to stay out of the critical atmospheric conditions.

Hydrogen-Driven Aircraft

The increased environmental awareness in society has also reached aircraft manufacturers. While in the last century the aircraft design process was mainly driven by purely economic factors, which focused on low operational and ground handling costs, now there is also a priority on the environmental impacts of an aircraft. Ideally, the task is to provide society in the future with the same standards of mobility as today, but to achieve the environmental objectives in parallel. From the present technical perspective, hydrogen-powered aircraft appear to have the potential of fulfilling both requirements.

The integration of a hydrogen propulsion system into an aircraft is not a trivial matter. The large storage volume for the low-density fuel can be placed on the outside of the aircraft e.g. on top of the fuselage (see Fig. 39.4) with a significant

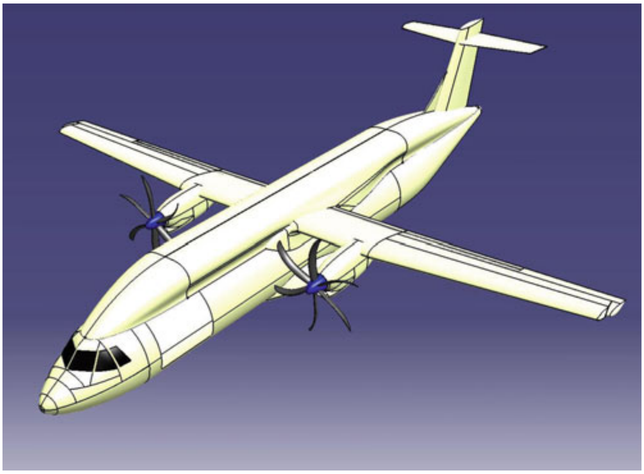

Fig. 39.4 Regional cargo aircraft with fuel stores mounted on top of the fuselage

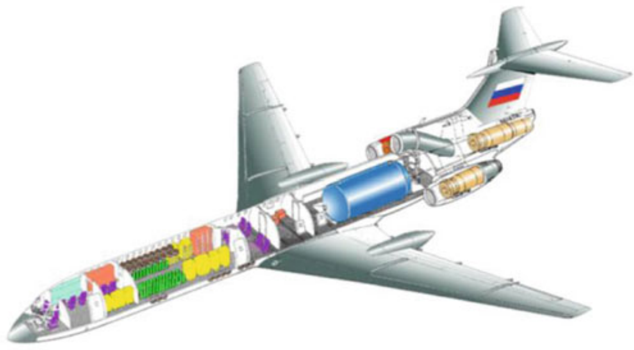

Fig. 39.5 Russian Tupolev TU-155 (Tupolev 2009)

increase in drag and fuel consumption. Alternatively, the storage volume can be placed inside the aircraft's fuselage (see Fig. 39.5), which decreases the available space for passengers or cargo.

Flying Aircraft

One approach towards hydrogen-powered demonstrator aircraft was the Russian Tupolev TU-155 (see Fig. 39.5). It first flew in 1988 as a test and demonstrator vehicle, and one of the three engines could be run on liquid hydrogen or alternatively on liquefied natural gas. In the 1990s, the idea was continued theoretically by a Russian–German research collaboration.

Theoretical Aircraft Studies

Cryoplane

From 2000 to 2002, 36 universities, research agencies and industrial partners from various nations all over Europe participated in the so-called "Cryoplane" project (see Fig. 39.6) under the leadership of Airbus. Its objective was the theoretical investigation and redesign of several hydrogen aircraft types of different size (Westenberger 2003). A real aircraft or mock-up has not been built.

Green Freighter

The Green Freighter project is a joint research project with a focus on the design and investigation of hydrogen-powered freighter aircraft. The project partners are

Fig. 39.6 Hydrogen-powered medium-range aircraft (Forschungszentrum Jülich, 2006)

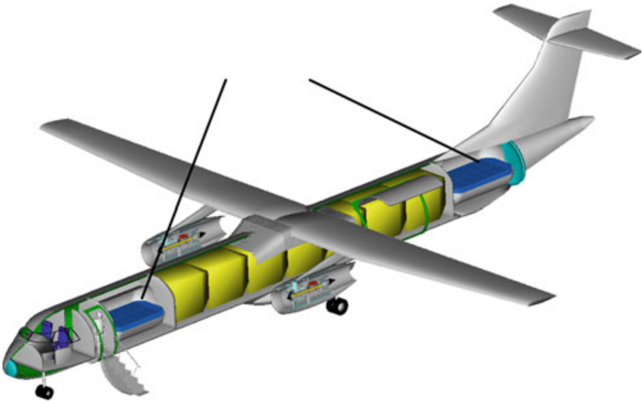

Fig. 39.7 Hydrogen-powered regional cargo aircraft with fuel tanks inside the fuselage

the Hamburg University of Applied Sciences (HAW), the Institute of Aircraft Design and Lightweight Structures (IFL) of the Technical University of Braunschweig, Airbus, and the engineering office Bishop GmbH. As the air cargo chain includes different types and sizes of freighter aircraft, the investigations include freighter aircraft from small regional, so-called feeders, to large long-range freighters. The ATR 72 full freighter version was chosen as the regional and the Boeing B777F as the large reference aircraft (Seeckt et al. 2008; Scholz 2009a).

Figure 39.7 shows an example of a short-range aircraft that has been converted from kerosene to hydrogen as the fuel. Investigations indicate that, based on current kerosene and an energy equivalent hydrogen price, such aircraft are not economically favourable (Seeckt and Scholz 2009).

Besides the investigation of hydrogen only on conventionally shaped aircraft, the Green Freighter project also comprises unconventional aircraft configurations, namely the Blended Wing Body (BWB) configuration (see Fig. 39.8). In combination with the new aircraft layout, the aeroplanes will then be even more fuel-efficient and environmentally friendly.

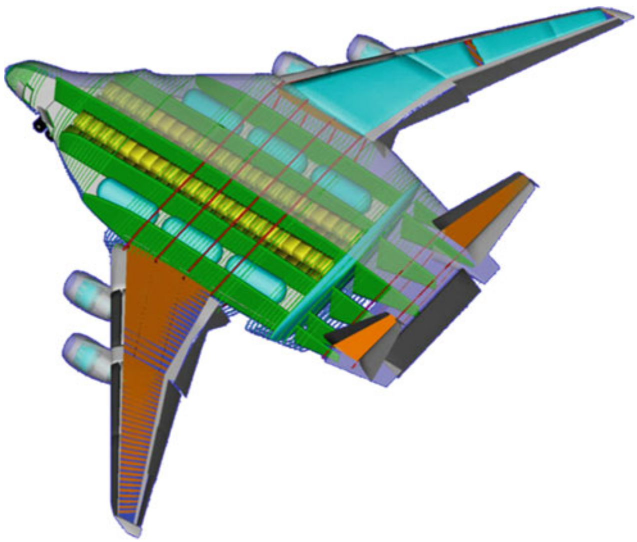

Fig. 39.8 Blended Wing Body with (hybrid) hydrogen-propulsion technology

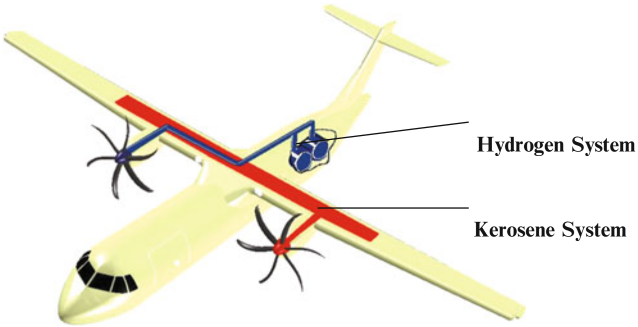

Fig. 39.9 Hybrid-powered demonstrator aircraft

Hybrid-Powered Experimental Freighter

The overall concept of a demonstrator aircraft has to be technically effective and at the same time simple in order to avoid extra spending on time and money. This leads to a hybrid propulsion concept which means that the right engine is powered by liquid hydrogen, while the left engine remains unchanged and is operated on conventional kerosene. This special architecture decreases emissions during cruise by 50% (Fig. 39.9).

As with normal aircraft, during taxi, only one engine is operated. In this architecture, the active engine is the hydrogen-powered one. The hydrogen engine is also used for the power supply of the aircraft on the parking position. The propeller is decoupled from the engine in this mode and does not rotate. Thus, ground operation without CO_2 emissions becomes possible and local air quality within the vicinity of airports is improved.

The demonstrator aircraft is set up on the basis of the regional cargo aircraft ATR 72. The turboprop concept in combination with a moderate cruise speed is well known to be generally very fuel-efficient (Snijders and Slingerland 2007), which further decreases the fuel that is needed to fly a certain reference mission.

This aircraft operates at cruising altitudes below 8 km, where the formation of contrails is very unlikely. The hydrogen engine is fed from two identical liquid hydrogen tanks, mounted in the rear of the aircraft. These tanks and the supply ducts have to be specially insulated due to the fuel's low storage temperature. In general, cargo aircraft offer a good possibility for demonstrating experience in the application of hydrogen, because psychological concerns of passengers do not need to be taken into account.

After the demonstration of reliability and safety by a liquid hydrogen-powered demonstrator aircraft, the next step could be to establish this technology in the commercial air cargo operation.

Aircraft Systems

Tasks and Impact of Aircraft Systems

Broadly speaking, an aircraft can be subdivided into three categories:

1. The airframe (the aircraft structure)
2. The power plant (the engines)
3. The aircraft systems (the equipment)

Aircraft systems comprise all the many mechanical, electrical, and electronic items, devices, and components which are installed in an aircraft for the various purposes.

Aircraft systems are needed to steer the aircraft (*flight controls*) and to handle it on the ground (*landing gear*). A *fuel system* is necessary for powered flight. Aircraft flying longer distances need *navigation* and *communication systems*; aircraft flying higher and taking passengers on board need cabin systems like *air conditioning* and *oxygen systems*. All these systems consume energy during their operation (Scholz 2003).

The engines on an aircraft produce thrust in order to overcome aerodynamic drag and to accelerate the aircraft to the desired speed. The power required to achieve this is referred to as *propulsive power*. Power that does not contribute to the propulsion of the aircraft but is nevertheless needed during flight to operate the various aircraft systems is referred to as *secondary power*.

The *consumption of secondary power* is about 5% of the total fuel consumed during the flight (Scholz 2009b). 5% is not much, but if we consider the absolute amount of fuel being burned on aircraft it definitely makes sense to consider also the impact of aircraft systems.

Energy *types of secondary power* systems are:

- Electric
- Hydraulic (special hydraulic fluid under pressure)
- Pneumatic (air under pressure)

Aircraft engines normally (i.e. during taxiing and in flight) provide all secondary power requirements onboard through electricity comes from generators attached to the aircraft engines, hydraulic power comes from engine driven hydraulic pumps, and pressurized air is taken directly from the engine compressor ("bleed air").

On the ground with engines shut off or in certain failure cases in flight, secondary power comes from an auxiliary power unit (APU). Traditionally the APU is a gas turbine providing electric and pneumatic power. Hydraulic power is produced from electric motor-driven pumps. Major airports provide secondary power to the aircraft so that there is mostly no need to run the APU once the aircraft is taken care of by the airport.

Greening of Aircraft Systems

As for the aircraft as a whole, the approach to greening of aircraft systems was and is to *improve efficiency*. Measures for improving the efficiency of aircraft systems are: better efficiency of consumers, fewer steps of energy conversions, better efficiency in power generation, improved/less/no bleed air usage, reduced system mass, reduced ram air, reduced amount of added drag. Aircraft technology is today already quite mature. For this reason, it has become difficult to achieve further savings. A recent EU research programme "Power Optimised Aircraft" (EU 2004) claims that fuel savings in aircraft systems of 5% would be achievable (Faleiro 2006), i.e. 4.75% instead of 5%, hence saving (only) 0.25% of total aircraft fuel burn. This saving potential is not much, but will have to be considered because every effort helps.

Since most of the time (during cruise) secondary power for aircraft systems comes from the engines, an important statement is: "Aircraft systems are green if the engines are green". That means, if e.g. engines run on environmentally compatible hydrogen or biofuels then automatically all power on board is also produced from these green fuels. It would be possible to achieve sustainable aircraft systems operation in this way without the need for changing aircraft systems technologies. Even old aircraft running on biofuel would have the benefit of green systems.

Another vision (Heinrich 2007) is to decouple secondary power production from the engines. In all phases of flight, secondary power would come from a *fuel cell*. The fuel cell directly converts fuel into electricity without burning the fuel. This totally different conversion principle from fuel into electrical energy has an efficiency that could save up to 20 – 30% of fuel (Heinrich 2007) in aircraft systems, hence saving about 1% of total aircraft fuel burn. The fuel cell runs on hydrogen. This means that a fuel cell could be well integrated into a hydrogen powered aircraft that already stores hydrogen in large quantities for engine operation. If no hydrogen is available on board, kerosene could be converted into hydrogen (reforming) for fuel cell operation.

If the new fuel cell technology could be *combined* with using environmentally compatible hydrogen or biofuels, than aircraft systems would be sustainably saving considerable extra amounts of energy compared with aircraft systems using today's technology.

The fuel cell has some "by-products" that make it especially interesting to integrate such a multifunctional fuel cell.

Multifunctional Fuel Cell

The application of the fuel cell in aviation is often referred to as a multifunctional fuel cell because of additional advantages that are indirectly linked to fuel efficiency.

A continuously running fuel cell produces:

- *Oxygen-depleted exhaust gas* that can be used for fuel-tank inerting (Doyle 2008), decreasing the explosion risk, and
- *Water* that can be used for
  - Flushing toilets or for tap water (after thorough purification and enrichment with minerals) (EADS Innovation 2009) and hence reducing aircraft weight of water otherwise carried in tanks
  - Passenger amenities such as water for showers
  - Cabin humidification, or
  - Water injection into the engines with the aim of increasing engine life and reducing costs and NO_X emissions (Snyder 2009)
- *Rejected heat* could be used in heat exchangers to e.g.
  - Heat up the fuel to required temperature, or
  - To heat the wing leading edge for wing anti-icing.

With electricity from a fuel cell, the aircraft could taxi on ground by an electric motor operated nose gear (autonomous taxiing) without engines running. This would improve overall fuel efficiency and would reduce emissions and noise in the airport vicinity.

In all cases where the hydrogen must be extracted from kerosene or other fuels, a reforming process is needed. There is still a great deal of research to be done on fuel reforming. Today, the mass-to-power ratio of fuel cells is still too high. Fuel cells have to show a considerable weight reduction (Turner 2006) and reduction of purchase costs before it will be feasible to integrate them into aircraft in the way discussed here. Furthermore, the introduction of the fuel cell technology on board aircraft will only be successful if maintenance costs are low. Modern health monitoring techniques will have to be applied to achieve low maintenance costs of fuel cells (Scholz 2009c).

Fuel Cell Demonstrator

For commercial wide-body aircraft, a fuel cell demonstrator was successfully demonstrated at the Berlin International Aerospace Exposition in 2008. The German Aerospace Centre (DLR) presented an Airbus A320 with an experimental 20 kW fuel cell in the rear cargo hold that replaces the Ram Air Turbine (RAT). The RAT is a little turbine that drops out if the aircraft encounters a loss of electrical power. The turbine is driven by ram air that drives an electrical generator to produce electricity for the cockpit and the primary flight controls. While the weight of fuel cell is comparable to that of RAT, the fuel cell may still supply sufficient power to extend the aircraft's flaps during a glide-approach at lower altitudes. Additionally, the fuel cell is easier to test, though it can be tested without really powering up the system (Doyle 2008).

Future Trends

Figure 39.10 shows the road map towards more environmentally friendly air traffic, as prospected by IATA. Its timeline consists of four major steps from retrofits today or in the very near future to new aircraft designs after 2020. It becomes apparent that the measures mentioned in this road map concentrate on improvements of details of current aircraft such as aerodynamics, materials and especially engines. Hydrogen is not yet listed in this outlook. This shows that from a current airline perspective, hydrogen as a fuel is not seen as a measure for improving the environmental friendliness of future air traffic.

The reason for this is not technological issues concerning the use of hydrogen. "Technologies for production, storage, and transport are available, technologically mature, and scalable" (Albrecht 2009). The main reasons are the high financial risk and technical effort of its introduction, since production and handling of hydrogen require a new airport infrastructure. Such large changes to the current airport and aircraft technology take time and are avoided. The effort to develop and introduce sustainable drop-in fuel replacements is much lower, cheaper and, therefore, more favourable for industry. Aircraft design takes decades from the preliminary studies via design, development and manufacturing until flight testing and delivery. That is why "IATA recognises that aircraft are long-lived assets and will be using kerosene or kerosene type fuels for many years to come." (IATA 2009b).

In order to justify the large efforts required to build up a hydrogen infrastructure, the exact environmental benefits of using hydrogen must first be numeralized.

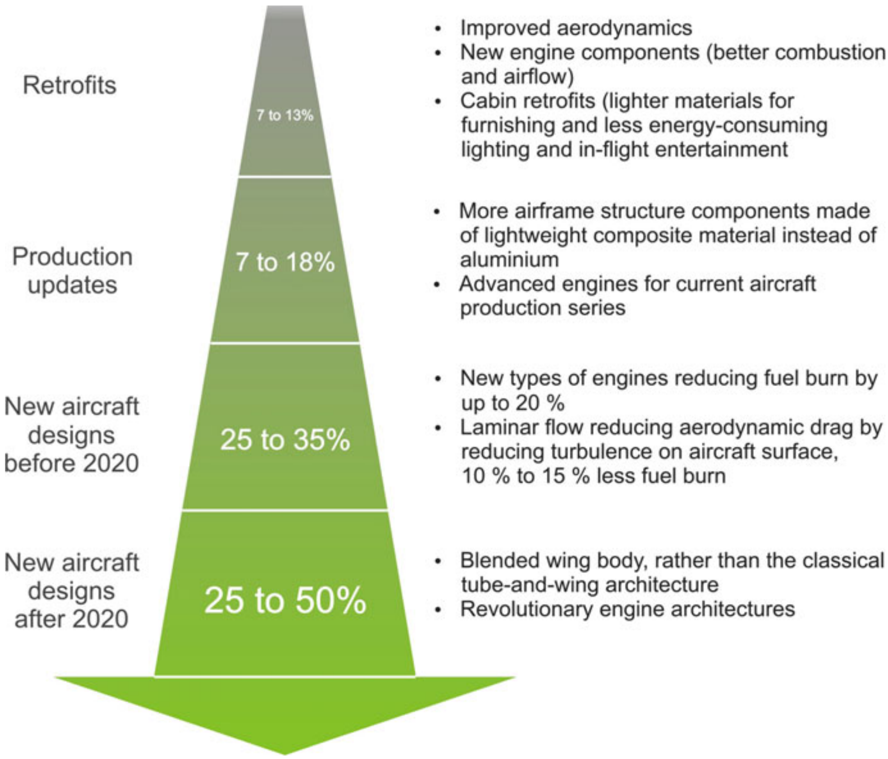

Fig. 39.10 Road map for environmental improvement (based on IATA 2009b)

Summary

Worldwide air traffic of passengers and cargo is expected to grow, and it is estimated that air traffic doubles every 14 years. The global impact of aviation amounts to 7.5% of the world Gross Domestic Product (GDP). Globally, 32 million jobs are generated by air traffic, of which a remarkable 54% are related to air transport's catalytic impact on tourism. These jobs are also found in developing countries. In summary, air traffic is very important to global business and society, and a total ban on all air travel today would have disastrous consequences on the global economy.

However, as a consumer of fossil fuel, air traffic contributes to global climate change. The emissions of aviation produced at high altitudes cause concern. Estimations of the fraction of air traffic in the total anthropogenic "radiative forcing" range from 2.2% to 4.7%. Because these numbers may still appear low in comparison to the contributions of other industries and in order to get a better idea of the influences related to flying, they have to be set against the right background of energy consumption. A return trip from Frankfurt to Sydney for a family of four, for example, amounts to 10 times their annual electric energy consumption. Furthermore, in the future, the total quantity of emissions is expected to increase due to the rapid growth of air traffic.

Future fuel demands will have to be met even though the world's crude oil and, thus, aviation's kerosene resources are limited. Therefore, in order to lower the environmental impact of aviation and to ensure the availability of future air traffic, a combination of (1) higher fuel efficiency, (2) alternatives to kerosene such as hydrogen, and (3) a reduction of the need to fly has to be found.

The examples of aircraft studies, first and foremost, the built and flown Tupolev Tu-155, show the technical feasibility of hydrogen-driven aircraft. However, the financial and technical effort to introduce hydrogen as an aviation fuel would be enormous. Consequently, the current efforts from the aviation industry to develop sustainable air traffic favour alternative drop-in replacements of conventional kerosene, due to the lower financial and technical effort and risk. Moreover, the current search for alternatives to crude oil-based kerosene also includes fuels that are based on other fossil feedstocks, such as coal or natural gas. Consequently, the timeline for the introduction of hydrogen as an aviation fuel is still unclear.

German universities have contributed to the question of introducing hydrogen as a fuel in aviation. This paper has given the examples of: hydrogen-driven regional cargo aircraft, Blended Wing Body (BWB) aircraft, and hybrid-powered demonstrator aircraft. All three projects are considering freighter aircraft because the introduction of hydrogen technology into cargo aircraft seems to be reasonably free from obstacles. Furthermore, the Hamburg University of Applied Sciences is working on the aspect of greening aircraft systems. It was recognized that the simplest way of greening aircraft systems is by using hydrogen or biofuels for the engines. In addition, the integration of the fuel cell to continuously supply power to the aircraft system during all phases of flight could result in considerable fuel savings.

Conclusion

Hydrogen as a fuel for aviation is feasible. It offers the possibility to eliminate carbon dioxide emissions and to largely reduce other emissions such as nitrogen oxides that form during combustion of hydrocarbon fuels. In order to achieve these overall environmental benefits, hydrogen has to be produced in an environmentally friendly way from renewable energy. The storage of hydrogen, even in liquid form at below $-251^{\circ}C$, requires very large tanks and additional mass of tank and insulation.

Today, the circumstances do not justify taking the massive risk of introducing hydrogen. Before hydrogen becomes a real fuel alternative, its benefits must be pointed out clearly: its environmental friendliness and the possibility to have a sustainable energy carrier produced from renewable energies.

References

ACARE (2001) A Vision for 2020 – meeting society's needs and winning global leadership, Advisory Council for Aeronautics Research in Europe, Luxembourg, Office for Official Publications of the European Communities), ISBN: 92-894-0559-7. http://www.acare4europe.com

Airbus (2007) Global market forecast 2007–2026, Airbus Corporate Information. http://www.airbus.com/en/corporate/gmf/. Accessed 3 Mar 2009

Albrecht U (2009) Hydrogen Technology and Systems – An Overview, SWAFEA – 1st European Stakeholder Meeting Workshop III: Other Renewable Energy Sources for Aviation, Brussels, 24 April 2009

ATAG (2009) The economic and social benefits of air transport 2008, Air Transport Action Group. http://www.atag.org/. Accessed 24 Jun 2009

BGR (2007) Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 2007, Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover. http://www.bgr.bund.de/. Accessed 11 Mar 2009

Boeing (2008) Current market outlook 2008–2027, Boeing Corporate Information. http://www.boeing.com. Accessed 3 Mar 2009

Brewer GD (1991) Hydrogen aircraft technology. CRC Press, Boca Raton, Florida

Decker J (2008) Alternative Fuels Power Players. Flight International. Accessed 17 Jun 2008

Doyle A (2008) Fuel cell could replace ram air turbine on next Airbus narrowbody. Flight International (Article ID 224309). http://www.flightglobal.com. Accessed 21 Jun 2009

EADS Innovation (2009) Saving energy with hydrogen – Fuel cells to replace auxiliary power units for supplying electricity in aircraft. *EADS Innovation* (Aviation Articles). http://www.eads.com/. Accessed 21 Jun 2009

Embraer (2009) Market Outlook 2009–2028, Embraer Corporate Information. http://www.embraercommercialjets.com/. Accessed 3 Mar 2009

EU (2004) 'POA' – research project works to optimise aircraft power use", European Commission Research. http://ec.europa.eu/research/transport/news/article_1599_en.html. Accessed 30 Jun 2009

European Parliament (2009) Emissionshandel im Luftverkehr ab 2012, Europäisches Parlament – Informationsbüro für Deutschland. http://www.europarl.de/presse/pressemitteilungen/. Accessed 11 Mar 2009

Faleiro L (2006) Power Optimised Aircraft (POA) – a Keystone in European Research in More Electric Aircraft Equipment Systems. Aeronautics Days, Wien (Session E.6: Improving Cost Efficiency: Onboard Systems). http://www.aerodays2006.org/sessions/E_Sessions/E6/E61.pdf

Forschungszentrum Jülich (2006) HyCare, Hydrogen Energy, Chances and Risks for the Environment, Forschungszentrum Jülich, Institute of Chemistry and Dynamics of the Geosphere ICG. http://www.fz-juelich.de/icg/icg-2/datapool/page/750/cryo1.jpg. Accessed 30 Jun 2009

Funke H (2009) Status and Perspectives of Hydrogen Gas Turbine Systems in Aviation. SWAFEA – 1st European Stakeholder Meeting Workshop III: Other Renewable Energy Sources for Aviation, Brussels, 23 Apr 2009

Heinrich HJ (2007) Fuel Cell Systems for Aeronautic Applications – A Clean Way from Kerosene to Energy, Airbus Deutschland GmbH (Presentation at DGLR-Bezirksgruppe Hamburg 2007). http://www.fzt.haw-hamburg.de/pers/Scholz/dglr/hh/poster_2007_05_10_Brennstoffzelle.pdf

IATA (2008) IATA 2007 Report on Alternative Fuels, IATA – International Air Transport Association (Montreal, Geneva). http://www.iata.org/whatwedo/environment/climate_change.htm. Accessed 25 Jun 2009

IATA (2009a) Some Debunking Persistent Myths about Air Transport and the Environment, IATA – International Air Transport Association. http://www.iata.org/whatwedo/environment/climate_change.htm. Accessed 25 Jun 2009

IATA (2009b) Fact Sheet: IATA Technology Roadmap for Environmental Improvement, IATA – International Air Transport Association. http://www.iata.org/pressroom/facts_figures/. Accessed 25 Jun 2009

Krammer P, Bertsch L, Werner-Spatz C (2009) Multidisciplinary Preliminary Aircraft Design with Integrated Noise Analysis Capabilites. In: *Deutsche Gesellschaft für Luft- und Raumfahrt, Tagungsband – Ausgewählte Manuskripte: Deutscher Luft- und Raumfahrtkongress* (Paper: DLRK 2009-1177, ISBN: 978-3-932182-63-4)

Kuhlmann A (2009) Luftfahrt und Klimawandel – Relevanz alternativer Kraftstoffe und des EU Emissionshandels, Bauhaus Luftfahrt e.V. München (Presentation at DGLR-Bezirksgruppe Hamburg 2009). http://www.fzt.haw-hamburg.de/pers/Scholz/dglr/hh/text_2009_06_25_BioFuel.pdf

LTH (2008) Triebwerkstechnologie – Wasserstofftechnologie, Luftfahrttechnisches Handbuch (AT 01 900-00). LTH Koordinierungsstelle, Ottobrunn, IABG

Penner JE, Lister DH, Griggs DJ et al. (eds) (1999) Aviation and the Global Atmosphere – Summary for Policy Makers, IPCC International Panel on Climate Change, Geneva, ISBN: 92-9169. http://www.ipcc.ch/ipccreports/

RGS-IBG (2006) The changing face of tourism in developing countries, Royal Geographical Society with the Institute of British Geographers. http://www.qca.org.uk/geography/innovating/. Accessed 25 Jun 2009

Scholz D (2003) Aircraft Systems. In: Davies M (ed) The Standard Handbook for Aeronautical and Astronautical Engineers. McGraw-Hill, New York

Scholz D (2009a) Forschungsprojekt GF – Grüner Fracher, Hamburg University of Applied Sciences. http://www.fzt.haw-hamburg.de/pers/Scholz/GF.html. Accessed 25 Jun 2009

Scholz D (2009b) Aircraft Systems Overview – Greening of Secondary Power Systems, SWAFEA – 1st European Stakeholder Meeting Workshop III: Other Renewable Energy Sources for Aviation, Brussels, 24 April. http://www.fzt.haw-hamburg.de/pers/Scholz/Aero/Reports_at_Aero.html

Scholz D (2009c) Forschungsprojekt – MOZART Health Monitoring of Fuel Cell Systems in Aviation, Hamburg University of Applied Sciences. http://MOZART.ProfScholz.de. Accessed 30 Jun 2009

Schumann U (2008) Globale Verkehrsemissionen in der freien Troposphäre und unteren Stratosphäre und ihre Klimawirkung. In: Metz N (publ.) Im Spannungsfeld zwischen CO_2-Einsparung und Abgasemissionsabsenkung. Expert Verlag, Renningen, pp 247–263, ISBN: 978-3-8169-2806-5

Seeckt K, Heinze W, Scholz D (2008) The Green Freighter Project – Objectives and First Results. In: CD Proceedings, ICAS 2008 – 26th International Congress of the Aeronautical Sciences, Edinburgh, UK, Optimage Ltd (Paper: ICAS 2008-4.10.3, ISBN: 0-9533991-9-2)

Seeckt K, Scholz D (2009) Jet versus prop, hydrogen versus kerosene for a regional freighter aircraft. In: Deutsche Gesellschaft für Luft- und Raumfahrt, Tagungsband – Ausgewählte Manuskripte: Deutscher Luft- und Raumfahrtkongress 2009 (Paper: DLRK 2009-1195, ISBN: 978-3-932182-63-4)

Sieber J (2009) Neue Triebwerkskonzepte und alternative Brennstoffe, Forum Ökoeffizientes Fliegen (Luftfahrtcluster Hamburg), MTU Aero Engines. http://www.mtu.de/de/technologies/engineering_news

Snijders TA, Slingerland R (2007) Design and analysis of a hydrogen fuelled turboprop airliner, 7th AIAA Aviation Technology, Integration and Operations Conference ATIO (Belfast), AIAA 2007-7752

Snyder CA (2009) Water Injection in Commercial Aircraft Investigated for Increasing Engine Life and Reducing Costs and Emissions, NASA Future Propulsion Systems Research. http://www.grc.nasa.gov/WWW/RT/2005/PB/PBA-snyder.html. Accessed 30 Jun 2009

Tupolev (2009) Cryogenic Aircraft – Development of Cryogenic Fuel Aircraft. http://www.tupolev.ru/English/Show.asp?SectionID=82. Accessed 22 Jun 2009

Turner A (2006) Fuel cell team targets certification. Flight, International (Article ID 207639). http://www.flightglobal.com. Accessed 21 Jun 2009

Westenberger A (2003) Cryoplane – Hydrogen Aircraft, H2 Expo, Hamburg, 11 Oct 2003. http://www.h2hh.de/downloads/Westenberger.pdf

Chapter 40
Opportunities and Constraints for Climate Adaptation in Regional Water and Land Use Planning

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Abstract Whereas the literature on adaptation is rich in detail on the impacts of, vulnerability to, and constraints of climate adaptation, less is known about the conditions that facilitate adaptation in practice. We examined the constraints and opportunities for adaptation in water and land use planning in three regions: the Guadiana River Basin in Spain and Portugal, the Tisza River Basin in Hungary and western Inner Mongolia in China. We analysed the conditions that either facilitate or constrain adaptation in relation to (1) adaptation actors, (2) adaptation strategies, and (3) adaptation objectives. Many adaptation assessments concentrate on climate impacts and the potential of adaptation strategies. The conditions that enable people to act on adaptation are less studied. Yet these have been identified as particularly important for successfully implementing adaptation. We find that adaptation is enhanced by pilot projects that test and debate new ideas through collaboration between recognized actors from civil society, policy, and science. Promising for adaptation is the integration of (traditional) agro-environmental land use systems that regulate regional climate impacts with new technologies, organizational responsibilities and financial instruments. A key challenge is to create flexible and equitable financial instruments that facilitate benefit and burden sharing, social learning, and that support a diverse set of potentially better adapted new activities rather than compensate for climate impacts on existing activities.

Keywords Adaptation assessment · China · Climate adaptation · Europe · Hungary · Land use management · Portugal · Regional water and land use planning · Spain · Water management

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Introduction

Since initial work for the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) demonstrated that adaptation to climate change is both important and complex, there has been growing attention for documenting adaptations as they happen and explaining the processes by which adaptation can occur (Adger et al. 2005; Adger et al. 2007). Whereas the literature on adaptation is rich in detail on impacts, vulnerability and constraints to adaptation (e.g. Smit and Pilifosova 2001; Adger et al. 2007), less is known about the conditions that facilitate adaptation in practice. The latter is, however, of paramount importance for developing guidance on how to cope with climate change in the long term.

This paper applies the definitions and concepts of impacts, vulnerability, and adaptation as outlined by the Fourth Assessment Report of the IPCC (Adger et al. 2007). Adaptation to climate change takes place through adjustments in human and natural systems to reduce vulnerability in response to observed or expected climate change, including extreme weather events. It involves changes in perceptions of climate risk, in social practices, and environmental functions to reduce potential damages or to take advantage of new opportunities. It includes anticipatory and reactive actions, as well as private and public initiatives. In practice, adaptation is an ongoing process, reflecting many stresses and cross-sectoral concerns, including discrete actions to address climate change specifically. Isoard and Swart (2008) conclude that human adaptation occurs mainly at sub-national and local levels but involves many other levels of decision-making from municipalities to international organizations. Adaptation is a cross-sectoral, multi-scale, and often transboundary issue, requiring comprehensive and integrated responses. We conceptualize and assess adaptation as the process of actors developing and implementing adaptation strategies to reach adaptation objectives (see Fig. 40.1).

Societies have always had to respond to climate variability and extreme weather events. Many have developed ways of coping with floods, fires, and droughts (for instance, the vernacular architecture of Mediterranean countries). Recent experience of weather extremes has given these efforts new impetus within countries and at the

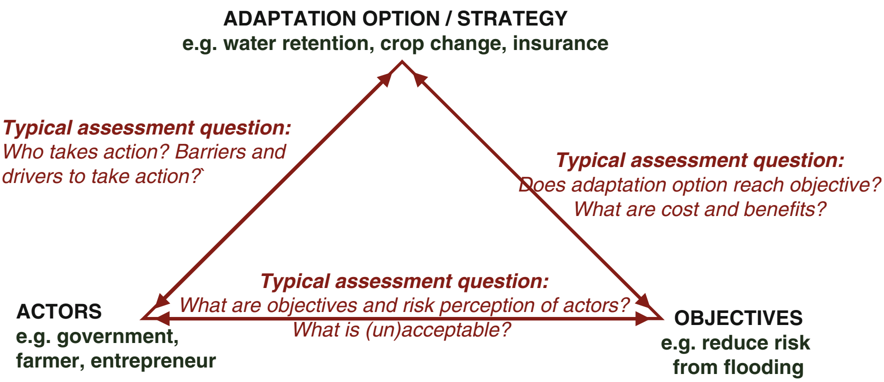

Fig. 40.1 Elements of adaptation (modified from Grothmann et al. (2009))

European level. Whilst projected climate change is a new driver for action, government actors will in many cases instigate adaptation by regulatory modifications of the existing policy frameworks for floods, droughts, and the management of water quality. Step-wise advances in action, coordination, and engagement of actors at the local and regional level will be needed to handle the expected level of accumulated incremental change over time, and to address the increased possibility of new extreme events (Footitt and McKenzie Hedger 2007).

Land and water resources are directly impacted by climate change, and decisions regarding these resources affect ecosystems and human vulnerability. As such, water and land use planning are expected to play an increasingly central role in adaptation. Stern (2007) identifies land use planning as a key area for adaptation. Yet, although changing land use planning is a promising adaptation strategy to cope with climate change impacts, this strategy is not practised extensively (Footitt and McKenzie Hedger 2007). The multitude of land uses and stakeholders means that water and land use planning are complex sectors in the climate change arena that deserve special attention. So far, climate change analyses and climate policy formulations have not adequately addressed the integration of water resource issues and climate change response options, including associated synergies and trade-offs between different policy domains and scales of action (Bates et al. 2008).

This paper examines the challenges and opportunities for climate adaptation in ongoing water and land use planning in three study regions of the European research project ADAM (Adaptation and Mitigation Strategies: Supporting European Climate Policy, www.adamproject.eu): the Guadiana River Basin in Spain and Portugal, the Tisza River Basin in Hungary and the Alxa region in western Inner Mongolia, China. The three regions have in common that they increasingly struggle with climate impacts on land use and water resources, including desertification and the occurrence of extreme events such as floods and droughts. However, the institutional contexts and governance traditions upon which societal responses and adaptation practices have developed differ greatly in the three regions. We describe adaptation practices in the study regions from a comparative, empirical, and analytical perspective, and synthesize our findings by discussing the lessons learned for adaptation in water and land use planning.

Adaptation in Three Regions

In order to analyse the conditions that facilitate or constrain adaptation in the study regions, we first briefly introduce the context in which adaptation is taking place or needs to take place. In particular, we look at the potential impacts of climate change in relation to water and land use planning. Secondly, we describe adaptation practices in each region as identified through workshops, interviews with stakeholders, modelling studies, and the review of secondary sources. Finally, we discuss the constraints and opportunities to adaptation. Table 40.1 summarizes the main characteristics of the three study regions.

Table 40.1 Characteristics of the three study regions

	Guadiana region, Spain & Portugal	Alxa region, Inner Mongolia, China	Tisza region, Hungary
			
Biophysical, land-use	Semi-arid climate, forest, agriculture	Arid climate, (semi-) desert, livestock herding and intensive agriculture	Continental climate, grassland, agriculture
Climate projection	Significant temperature increase, rainfall decline	Temperature increase, rainfall trend uncertain	Temperature increase, rainfall more irregular
Area/Arable land	66,800 km^2/ 20 million ha	72,000 km^2 (study area)/30,000 ha arable land + 9 million ha steppe	46,000 km^2 (Hungarian part river basin)/ 2.6 million ha
Technical	2,000 dams. Reservoir and irrigation system	Irrigation, groundwater and river water transfers	2,800 km river dike, drainage system
Economic	Participation in EU and global market. Tourism. GDP 20,000 euros per capita. Below EU average	Increasing market forces and rapid industrialization. GDP 2,000 euros per capita	Transition economy. GDP: 4,500 euros per capita. Below country average
Institutional	EU member since 1986. EU regulation. Regional competences defined in Spain and Portugal	Communist party-led state; well defined limited regional autonomy	EU member since 2004. Implementation national and EU regulations
Social	4 million people. Aging	200,000 people.Mongol minority	4.1 million people. Roma minority

Guadiana River Basin

Climate Change and Impacts on Water and Land Use Planning

The Guadiana is a transboundary river between Spain and Portugal. Its basin is one of the three main drainage units of the Iberian Peninsula. Eighty-three per cent of the basin is located in Spain and 17% in Portugal. The river basin has the typical semi-arid climate of southern Europe with low and irregular precipitation

(440 mm/year). Rainfall peaks in the central-north, decreasing westwards towards the mouth of the river (Orioli et al. 2008). Average seasonal temperature ranges from 14.5°C (winter) to 31.9°C (summer). Temperature rarely drops below zero. Climate scenarios projects a temperature rise in spring and summer of four to seven degrees by 2100 (Santos et al. 2002), with temperature variation increasing towards the north east of the basin. At the same time, rainfall is expected to decrease in spring and in summer. Figure 40.2 illustrates this for the SRES A2 Scenario results from the HIRHAM model (Extra High Resolution: 12.5 × 12.5 km) (Orioli et al. 2008). The Guadiana River typically has low flows during summer and confined high flow events in winter. Using the HadCM3 model's climate scenarios, annual runoff is estimated to fall by 60% by 2100 (Santos et al. 2002).

In the last four decades, the river basin has undergone major modifications through the building of dams, tourism developments, (illegal) wells, and increasing urbanization pressures. On the Portuguese side of the basin, the Alqueva dam has been built, creating the largest artificial lake in Europe for which water use is still to be allocated. Whilst groundwater development has substantially increased people's livelihoods, groundwater use is not sustainable and groundwater tables are falling. The main problems associated with water and land use planning are overexploitation of aquifers for agricultural use, agricultural contamination, and river fragmentation by dams (WWF 2003; Tàbara et al. 2009). The combination of these developments and the semi-arid climatic conditions has intensified water scarcity along the Portuguese–Spanish border. Climate change potentially increases the pressure on available resources and conflicts between agriculture, irrigation, tourism, nature conservation, and the development of large urban areas. Furthermore, climate change impact assessments show a worsening of the current situation of desertification, particularly through the impact of forest fires (Moriondo et al. 2006) and the loss of soil fertility (ECCE Project 2005).

Land use and agricultural practice differ considerably in the region. Going from the southwest to the northeast, three main zones can be distinguished. The first zone is the coastal zone with mainly tourism on the Portuguese side (Algarve) and a

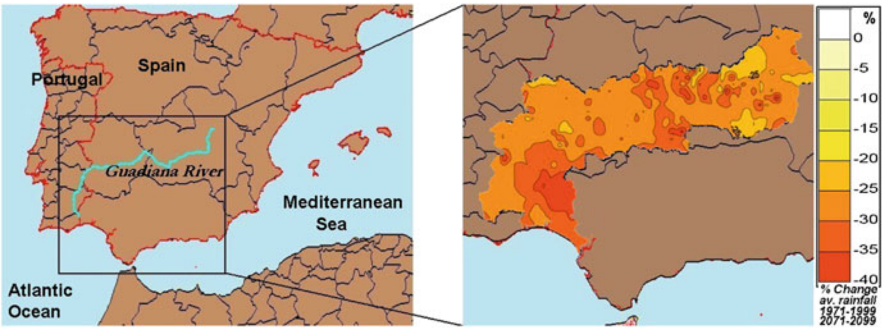

Fig. 40.2 Guadiana River Basin and projected change in average summer precipitation between 1971–1999 and 2071–2099 in SRES Scenario A2 using regional climate model HIRHAM (adapted from Orioli et al. 2008)

combination of intensive agriculture (mostly citrus and fruits) and tourism on the Spanish side. Moving inland, the next zone is hilly and forested, and supports a unique ecosystem called *dehesa* (Spanish) or *montado* (Portuguese). Dehesa farmers combine cork oak (*Quercus suber*) and common oak (*Quercus robur*) with different types of tree crops (olives, figs, almond, oranges, carobs), ground vegetation (cereal, herbs, grass) and cattle breeding (cows, sheep, red swine) (Joffre et al. 1999). Dehesa has a high landscape value and is protected as cultural heritage. The third zone is dominated by large-scale agriculture (Beja region in Portugal and Extremadura in Spain). Crops include cereals, wine, olives, and citrus. Crops are grown both irrigated and non-irrigated. The share of irrigated land is expected to change in part due to the new Alqueva reservoir.

The impacts of climate change depend strongly on the cropping system. Dehesa is well adapted to the regional climatic conditions, although its economical feasibility is questioned (Joffre et al. 1999). With respect to intensive agriculture, the impacts differ for summer and winter crops. Whereas climate change is not expected to significantly impact winter wheat and spring wheat, the summer crops sunflower, soybean, and corn are projected to be significantly affected with yield reduction in almost the whole basin (Orioli et al. 2008).

Adaptation Options and Strategies

During interviews and a workshop, stakeholders proposed the following adaptation options in relation to water and land use planning (Tàbara 2007): agricultural and economic diversification, changing farm size, reuse of grey water, promotion of rural tourism and local produce, and protecting as well as modernizing the "dehesa" agro-ecological production system, using (new) drought and heat resistant crops (e.g. dates), and (changing) irrigation systems. Reforestation was welcomed as an adaptation option, although criticism was voiced with respect to the current use of fire-prone pine species. Besides biophysical interventions, stakeholders emphasized the need for building adaptive capacity at the farm and regional institutional level, through awareness raising, better coordination between actors and policies, and financial support for promoting alternative sustainable activities (often linked to small-scale rural tourism and businesses).

With agriculture an important economic sector in the region, the ADAM project assessed different agro-technical adaptation measures for field crops. Irrigation and changing crop variety for a shorter growth cycle were found to be the most promising for reducing climate impacts on crop yields. This concurs with opinions held by stakeholders. At the same time, the assessment showed that the effectiveness of each adaptation measure depends strongly on crop type and that some measures could even be counter-productive with respect to crop yield. Together with the potential pressure of irrigation on the already strained water resources, this highlights the potential for mal-adaptation.

Tourism is another important sector in the Guadiana region that is closely connected to other sectors, such as agriculture and water supply. Many of the regional landscapes that appeal to visitors are currently managed by traditional agricultural practice, and a greater emphasis on the multi-functionality of the land (bringing together tourism, nature and agricultural concerns) could be of significant benefit to the adaptation agenda. It would help strengthening long-term sustainable development objectives for the region, as well as reducing over-dependence on one economic activity (Fig. 40.3).

A constraining factor to the analysis of adaptation in water and land use planning is the sectoral and disciplinary perspective with which adaptation measures are often assessed. Adaptation requires an understanding of economic aspects, such as market trends, cost of inputs and new incentives for agriculture, as well as institutional and plant specific physiological aspects. More complex production systems such as dehesa and diverse cropping patterns offer opportunities to reduce climate risks. These multiple dimensions of the adaptation challenge have yet to be addressed comprehensively.

Adaptation Actors

Changes in involved actors and institutional arrangements can be observed in both countries and in particular at the river basin scale, although this is still at an early

Fig. 40.3 Guadiana River Basin: (**a**) Guadiana River at Mertola, Portugal, (**b**) Extensive agro-environmental production system dehesa, (**c**) Intensive irrigated agriculture, (**d**) Tourism development in the estuary (Photos: Werners, December 2006)

stage (McEvoy et al. 2007). Arrangements that affect the Guadiana River Basin include the Portuguese National Climate Change Programme (2001) and the Spanish National Adaptation Plan (2006). Implementation of these programmes is the responsibility of several newly created national bodies, such as the Portuguese Climate Change Commission, the Spanish Inter-ministerial Group on Climate Change and the National Council on Climate Change. Among their duties is to promote climate change policy across government and to ensure integration of climate considerations into sectoral and regional policies in accordance with national and European regulation. These new bodies are also required to ensure the participation of public and private actors in the policy-making process.

To implement adaptation actions, stakeholders underlined the importance of cooperation between administrative agencies of both countries to ensure integrated socio-ecological planning in the Guadiana River Basin. According to Cots et al. (2009), a promising administrative vehicle for integrating climate concern into the existing regulatory transboundary cooperation is the "Convention on Cooperation for the Protection and Sustainable Use of the Portuguese-Spanish River Basins" (1998) and its Commission for the Convention Development and Application (CDAC). The Convention defines the regulatory framework for cooperation between the two countries to protect inland waters (surface waters and groundwater). A transboundary organization like the CDAC can break down regional or national divisions while at the same time foster new cooperation and collaboration because (1) it works on the scale of the transboundary river basin, (2) it provides a space for exchange between actors on both sides of the border, and (3) it intervenes in a broad set of activities and regulatory areas. However, major obstacles remain: explicit climate change considerations are absent in the convention, its implementation lacks transparency and participation, and both the Convention itself and the work of the Commission for the Implementation and Development of the Convention are almost unknown to the general public and even to the local administrative bodies in the Guadiana basin (Timmerman and Doze 2005).

An important opportunity for adaptation in the Guadiana basin is the harmonization and implementation of the European regulatory framework. The implementation of the Water Framework Directive (Commission of the European Communities 2000) and the new EU regulatory processes in the field of river basin and water resources – such as the White Paper on Adaptation and the EC communication on Water Scarcity and Drought – provide added stimulus for new transboundary governance structures. Regions have gradually developed a more important role both in the European and the national arena (Jones and Keating 1995). Today, regions interact directly with EU bodies to obtain resources from the distributive policies and further their interests.

Changes in policies and institutional designs are not only motivated by European policies. The study region also shows a gradual increase in the involvement of local actors who were typically excluded from the policy-making process. The wide range of policies and actors that directly or indirectly influence adaptation in the Guadiana River Basin indicate the importance of building capacity among local, regional and national actors – both public and private – for adaptation.

Inner Mongolia Alxa Region

Climate Change and Impacts on Water and Land Use Planning

The Alxa region in Inner Mongolia covers more than 270,000 km^2 of Northern China and has a continental arid to semi-arid temperate desert to steppe ecosystem. The average temperature is 7°C with extremely cold winters and very hot summers. Precipitation ranges from 50 mm in the Northwest to 200 mm in the Southeast with high spatial and interannual variability. Hence, water availability is a critical environmental factor. Temperature has risen since the 1950s, and regional climate models project a further rise, ranging from 3 to 5°C above pre-industrial values by 2100, depending on the scenario (Xu et al. 2006). As a result, surface evapotranspiration will increase, placing extra pressure on water availability. Projected precipitation changes are more uncertain and differ largely between climate models as rainfall is scarce and small absolute changes may correspond with large relative changes (Xu et al. 2005) (Fig. 40.4). In addition, some models suggest an increase in precipitation and a cooling trend for some areas (Dai et al. 2008) adding to the uncertainty adaptation policy has to cope with.

Traditionally, the Mongol lifestyle was one of nomadic pastoralism (Dickinson and Webber 2007). Immigration brought farming practice from outside Inner Mongolia to the region. Government policy that promoted the economic rationalization of herding, desertification, immigration, and population growth made many

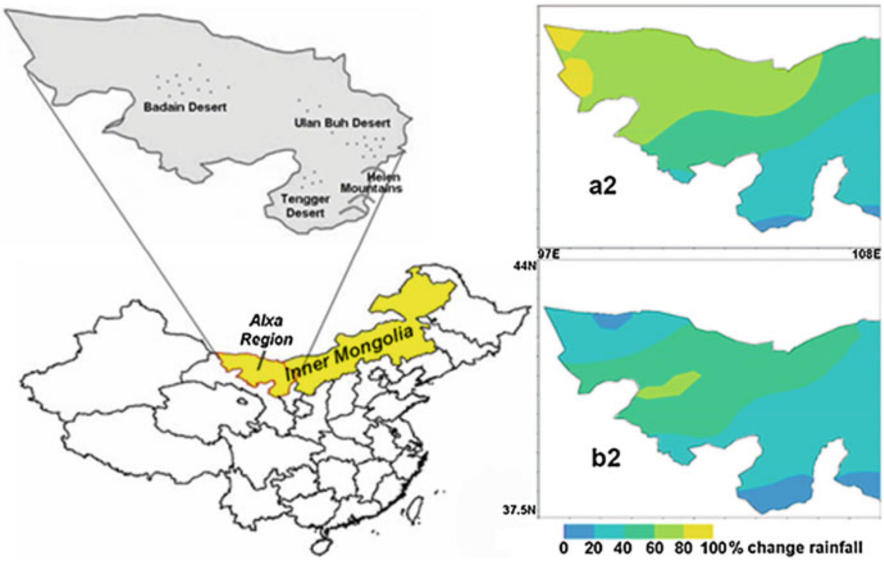

Fig. 40.4 Alxa region in Inner Mongolia, China and projected change in average precipitation between current and SRES scenario *A2* and *B2* (2071–2100) using regional climate model PRECIS (after Xu et al. 2005)

herders give up their nomadic lifestyles and establish permanent dwellings. As a result, pastures were no longer grazed in rotation as previously, but are used intensively all year round (Brogaard and Zhao 2002).

Nowadays, most of Alxa's nearly 200,000 inhabitants live in small towns in close proximity to the hundreds of desert oases. Water availability is low (110 m^3/capita year). The main land use is irrigated agriculture and extensive rangeland. Currently, rangeland covers one-third of Alxa with an official livestock population of 2,200,000, managed by 30,000 herdsmen. Primarily due to the economic value of cashmere, the composition of herds has shifted from a mix of horses, camels, cattle, sheep, and goats to predominantly sheep and goats. While having lower water requirements, their grazing exposes or pulls out roots and is more destructive to the grassland. Use of lands at the margin of deserts, conversion of rangeland to farmland, increasing animal numbers in the 1980s and 1990s, and changing herd composition are officially cited as the key human driving forces of recent desertification (Dickinson and Webber 2007). More than 65% of the rangeland in Alxa is currently classified as degraded, resulting in productivity reduction. Although the key drivers of the desertification problem are disputed, it is acknowledged that climate change can amplify existing problems (Reynolds et al. 2007). Over 80% of the farmers and herdsmen interviewed in the Alxa region have noticed a decline in water quantity and quality as well as an increase of severe droughts and heat waves. Interestingly, only a few of those interviewed associated these changes with global climate change (Dai et al. 2008). Desertification has connected formerly distinct deserts, resulting in more intense sandstorm events and the abandonment of human settlements (Du and Huang 2005). The sandstorms cause serious economic loss in China, as well as countries as far away as Japan and South Korea, giving the problem an international dimension (ADB 2005).

Adaptation Options and Strategies

Analysis of measures and policies to deal with desertification and environmental degradation can provide useful insights into the constraints and opportunities for adaptation in China. Policies aimed at rangeland rehabilitation have sought to address the biophysical, as well as the social and economic aspects of desertification. Examples of land use policies are grassland enclosure, grazing bans, promotion of land conversion on sloped lands (the so-called "Grain for Green" policy (Du 2006)), logging bans, and tree planting. Socio-economic policies include general poverty alleviation strategies (for example the "Eight-Seven" Poverty Alleviation Reinforcement Plan (1994–2000)) and herdsmen resettlement programmes, in China referred to as ecological migration (Du 2006). Ecological migration in Alxa has resulted in the migration of 6,624 households (approximately 25,000 peasants and herders) in 5 years (Du and Huang 2005). The Alxa development plan aims to reduce by 2010 the population living on extensive livestock grazing by two-thirds. It is intended that this goal will mainly be achieved by providing job opportunities in the coal mining and chemical industry sectors that have developed rapidly in northeast

Alxa in recent years under the Grand Development in West China programme (Yan and Quian 2004). Since the introduction of rangeland rehabilitation in 2001, about 20% of the rangeland has been closed throughout the year and another 30% has been put under rotational or seasonal grazing. In the areas under protection, there is localized evidence of vegetation recovery (Dai et al. 2008) (Fig. 40.5).

At the farm or household level, farmers apply different water-saving techniques and many have experimented with more drought-resistant crops. Other adaptation options that are considered include the introduction of greenhouses, more widespread use of drip-irrigation or no-till cropping, and integration of fruit trees with annual crops in oasis settings in order to reduce denudation, raise water use and nutrient efficiency, and support economic diversification. The climatic and other challenges associated with herding and farming in marginal areas have led some families to abandon these activities to find another living in industry or the larger urban centres as a type of livelihood adaptation, resulting in ghost towns throughout the region. With few exceptions, migrants see the policy of ecological migration as a successful adaptation to what they themselves described as a situation in which vegetation and grasslands had degraded to a point where livelihoods could no longer be sustained (West 2009).

Illicit economic activities, such as the extraction of native medicinal plants for local and regional markets and collection of firewood, have added to landscape degradation. However, cultivation of high-value medicinal plants has become a

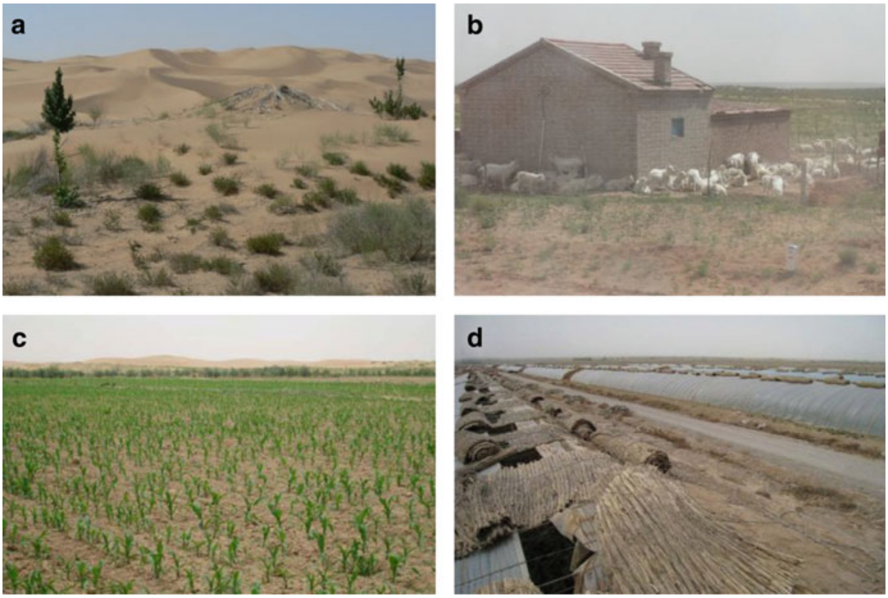

Fig. 40.5 Alxa Region in Inner Mongolia: (**a**) Landscape of sand dunes and steppe desert along edge of desert, (**b**) Enclosed herd at house, (**c**) Oasis agriculture with shelterbelt woodland, (**d**) Local style greenhouses developed by governments for migrants, (Photos: **a**, **b**: Werners, 2007; **c**, **d**: Jiong 2007)

new focus mandated by government, and creates opportunities for alternative livelihoods and is seen as a promising measure to raise the resilience of the local population and reduce pressure on vulnerable ecosystems. Future policies therefore need to build on successful experiments, such as public–private partnerships in which marketable products obtain additional public funding in exchange for providing environmental services and maintaining social and environmental standards (China Council Task Force on Forest and Grasslands 2001).

Adaptation depends on the implementation of policies to deal with socio-economic and environmental change in the region. The rangeland rehabilitation policies in Inner Mongolia in particular have the potential to create new opportunities, as well as constraints. One key challenge is to create balanced and flexible policies that can – if necessary – be altered after evaluation of longer-term effects. An example of this challenge is the widely implemented grazing ban. With the recovery of the rangelands, the accumulation of dry material adds to bushfire risk. This suggests that a certain amount of grazing might be necessary to keep dry material levels low while maintaining sufficient plant cover. Moreover, while the grazing ban has reduced human-induced pressure on the rangelands, it has indirectly increased pressure on the scarce water resources as migrants have been moved to villages located in or beside the few oases remaining in the Alxa region. The continuing conversion of oases into settlements and farmland will have major long-term consequences for the regional climate and hydrology, now regulated by oasis ecosystems. Modification of the grazing ban could allow some herdsmen to return to their trade, combining use and protection of grassland.

Adaptation Actors

Recently, climate change adaptation has been recognized by the central government, as expressed in its “Eleventh Five-Year Plan” (NDRC 2006) and the launch of a national climate change programme in 2007. Adaptations are promoted by a combination of government-endorsed agricultural extension projects, regional associations such as the Alxa Association of Science and Technology, bilateral research and development projects, and local NGOs. Although the Alxa development plan makes no reference to changes in temperature, precipitation, or severity of extreme weather events (Dai et al. 2008), the regional government has responded to climate change by providing more specified weather forecasts and by subsidizing agricultural insurance in two pilot programmes.

If planned carefully, ecological migration will continue to provide alternative livelihoods for the rural poor as well as release direct pressure on marginal land. While many interviewed migrants express the view that their lives have improved in key areas such as access to healthcare, goods and services, and schooling for their children, challenges remain to ensure that the move is sustainable. These include ensuring adequate and affordable access to clean forms of electricity, providing water adequate for irrigation, drinking and household use, promotion of new cultivation techniques, alternative or additional income opportunities, and culturally appropriate training to facilitate sustainable transitions from herding to farming. Another challenge is the equity and long-term financial sustainability of existing compensation programmes for ecological migrants. While continuation of compensation programmes for rehabilitating grasslands is desirable from the perspective of the beneficiaries – individual herdsmen and farmers – it would arguably require more central government funds than is politically feasible (China Council Task Force on Forest and Grasslands 2001). Beneficiaries will reconsider their activities when the compensation programme ends (cf. Runhong 2001).

Perhaps the most pervasive constraint to successful adaptation is related to local people's perceptions of the government as the main actor responsible for adaptation. While government policies are important and can provide stimulus and support for successful adaptation at the local level, local people are found to be ill-informed of the goals of grassland policies that have been conceived, implemented and scaled up rapidly (cf. Runhong 2001). In addition, there was very little awareness among those interviewed about what they themselves, either as individuals or communities, could do to adapt to long-term climate and environmental change (West 2009). This highlights the importance of informing and including the perspective of local people in the development of adaptation policies, so that people feel they have a role and responsibility in the adaptation process. Experience in Alxa also suggests that local adaptive capacity can be built through environmental education, training, and livelihood projects that explicitly link environmental protection and use, and livelihoods are made explicit, and that rely on cooperation and financial input from a mix of local actor groups, NGOs, the government, the private sector, and international donors.

Tisza river Basin

Climate Change and Impacts on Water and Land Use Planning

The Tisza river is the largest tributary of the Danube, receiving water from the Carpathian Mountains in Romania, Slovakia and Ukraine. Climate change projections suggest more irregular rainfall and a warmer climate in the Carpathian basin (Láng 2006; Bartholy et al. 2007), aggravating the three main water-related problems of the Tisza region: floods, inland water stagnation, and droughts (Barta et al. 2000). Between 1998 and 2006, there has been at least one severe flood each year, of a magnitude that was previously associated with the 100-year flood. Paradoxically, the plains between Danube and Tisza are especially drought-prone, and Hungarian agriculture and forestry has suffered from extensive droughts in successive years.

Until the eighteenth century, socio-economic activities in the Tisza valley were predominantly organized around the operation of a system of creeks and channels regulating the water flow between the main river bed and the floodplain (Balogh 2002). Inundation frequency determined land use. The Tisza floodplain provided a secure income for communities along the river, with a floodplain production system that combined plough land, forest, floodplain orchards, meadows, fish, and cattle (Bellon 2004). Since then, the Tisza river has been heavily modified to cater for large-scale mono-agriculture and river transport. Dykes were built, one third of the river length was regulated and the floodplain was drained, decreasing the total naturally flooded area by over 80%. These changes put an end to the traditional water management system and the related production systems (Bellon 2004).

At present, the main land uses are intensive agriculture, wetlands, and meadows (the famous Hungarian grasslands or *puszta*). Vulnerability of rural production systems has increased through the loss of local flood and drought resistant crop varieties and processing techniques (Sendzimir et al. 2008). Flood damages are expected to increase under climate change (Koncsos and Balogh 2007). Socio-economic problems that add to vulnerability include a high unemployment rate, an ageing population, migration, and minority issues (Linnerooth-Bayer et al. 2006). More promisingly, the region has a large undeveloped potential for recreation and nature conservation (Csete 2007) (Fig. 40.6).

Adaptation Options and Strategies

Adaptation options have been developed in the frame of the national research project VAHAVA (VAltozas-HAtas-VAlaszadas: change-impact-response), launched by

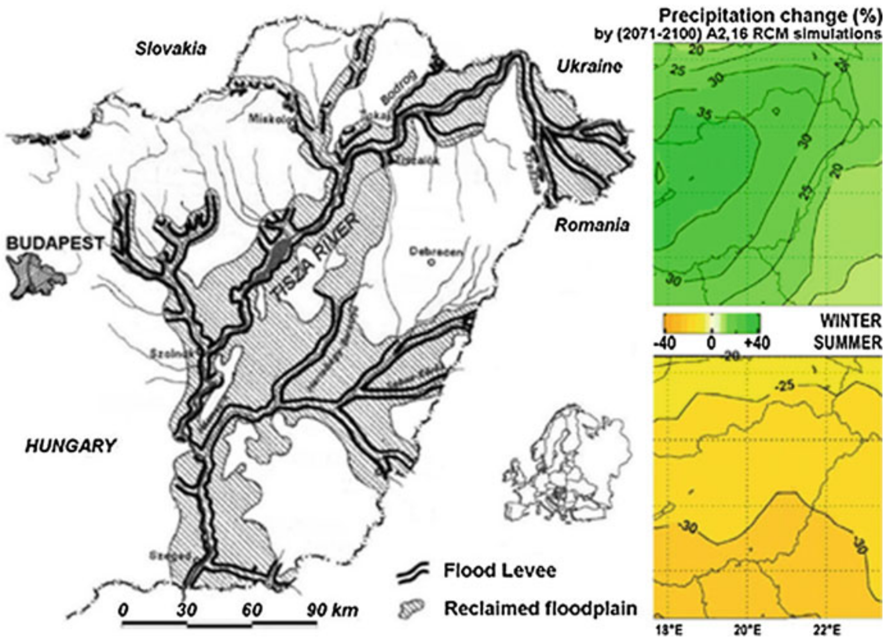

Fig. 40.6 Hungarian Tisza river basin and projected change in average precipitation by 2071–2100 in SRES Scenario A2 using 16 regional climate models, (after Szlávik and Ijjas 2003; Bartholy et al. 2007)

the Ministry of Environment and Water and the Hungarian Academy of Sciences in 2003 (Láng 2006). A major outcome of the programme was the development of the National Climate Change Strategy approved by the Hungarian parliament in 2008 (www.klima.kvvm.hu). The follow-up project KLIMAKKT pays more attention to the assessment of adaptation options, especially for agriculture.

Recurring flooding events and the recent predictions of an increased incidence of floods and droughts have been a driving force behind a new water plan for the Hungarian Tisza river: the New Vásárhelyi Plan (VTT – www.kvvm.hu/vizeink). The key innovation of the plan is the combination of water retention, floodplain rehabilitation, and rural development as a strategy to replace or complement prevailing engineering approaches, favouring flood levee construction (Fig. 40.7). The implementation of the new water plan holds many lessons for adaptation. At present, water infrastructure is in the planning stage, with the first retention area constructed. However, measures that focus on social adaptation, such as rural development and support of floodplain production systems (e.g. extensive fishing, utilizing biomass of water related areas, floodplain orchards), are subject to significant delays. The causes for the delays were discussed in a series of interviews and workshops (Werners et al. 2009a). Direct obstacles to implementation were said to be the required land acquisition and institutional fragmentation of responsibilities. EU accession adds to the complexity of organizational responsibilities and financial flows, as it offers access to new funds as well as spurring the Hungarian government

Fig. 40.7 Hungarian Tisza river basin: (**a**) Tisza River at Tiszadada; (**b**) Oxbow lake: traditional water management used oxbows and creeks for water regulation, which inspired the new water plan; (**c**) Bicycle lane on retention reservoir dike for rural development; and (**d**) Construction of first retention reservoir. (Photos: Werners 2007)

to cut budgets in order to reduce overall budget deficits. Given the shortage of financial resources, actors suggested integrating adaptation, the new water plan, and the Hungarian regional development programmes. A re-evaluation of resource allocation is crucial for floodplain management and includes the clarification of property rights and the use of EU funds in various sectors of the Hungarian economy (such as common agricultural policy schemes, cohesion funds, support for "less favoured areas" and Natura2000).

Locally the development of adaptation options is supported through the UNDP-GEF-funded project "Living Tisza" (Élő Tisza – SZÖVET project, 2005–2008, www.elotisza.hu). In 2007, it introduced a micro-grant scheme for – amongst others – climate adaptation. Granted projects include facilities for village tourism that aim to reduce climate dependency in agriculture and increase income security (Kajner et al. 2008). Another initiative of the Living Tisza Alliance, together with other NGOs, is the marketing of regional products though the introduction of the "Élő Tisza" eco-label and online retail that can help producers to change production as a response to climate change.

Adaptation Actors

Stakeholders value the regional water plan for its participatory development. After initial criticism, regional and national actors collaboratively prepared the implementation plan, with key objectives being to establish improved socio-economic and environmental security through water and land use planning (Werners et al. 2009b). While the implementation of the water plan stimulates the national debate on climate adaptation, many issues remain unresolved. These include harmonization with other policies and clarification of the role of different actors and agencies. Regional public local action groups and NGO initiatives (such as the Living Tisza Alliance) can carry the adaptation debate forward. Its "Tisza völgy" magazine has facilitated outreach and social involvement, in which local stakeholders emphasized the need to link climate change adaptation, the new water plan and agricultural subsidies in the region. It is intended that raising local income from floodplain production systems will help to reduce vulnerability of local communities.

The costs and benefits of adaptation and floodplain management have to be shared between many parties. Actors in the Tisza region are keen for a clarification of the roles of different parties involved in the new water plan and expressed a strong interest in establishing a multi-stakeholder implementing agency with national government and other stakeholder representatives. In addition to formal coordination, actors identified options to strengthen informal relations and cooperation between non-governmental agencies. This includes awareness raising about – amongst others – the impacts of climate change and the associated flood and drought risks.

Socio-economic constraints for adaptation in the Tisza valley are the economic vulnerability of local production systems, social problems such as poverty, migration, segregation of minorities (Gypsy minority), and inequalities within the educational system. The level of education is low, both in general and in vocational training, contributing to high unemployment rate and high social vulnerability (cf. Fekete 2006). The initiatives of the Tisza Alliance show that the informal networks and local production systems have degraded, but are capable of recovery.

Discussion and Conclusions for Adaptation Planning

In its assessment of adaptation practices, Chap. 17 of the IPCC's Fourth Assessment Report (Adger et al. 2007) concludes that: (1) adaptation measures are seldom undertaken in response to climate change alone, (2) adaptation to climate change is already taking place, but on a limited basis, (3) adaptation and adaptive capacity are uneven across and within societies, and (4) there are substantial limits and barriers to adaptation. Our results support these insights. In addition to constraints, we observe opportunities for advancing adaptation in water and land use planning. We elaborate on the commonalities and contrasts in the three regions between adaptation objectives, actors and strategies.

Adaptation Objectives

In all three regions, people are experiencing impacts of a changing climate. Yet, in the Alxa and Guadiana regions in particular, people struggle to connect regional trends to global climate change. The causes of trends in desertification and reduced water availability are heavily contested. Adaptation policy so far does not address the diverse perceptions of risks and their causes. Although climate change impacts have encouraged dialogue between different actors and policy communities (for example water and agriculture), actual adaptation planning and implementation remain largely sectoral.

Although the role of context-based science is increasingly being recognized and supported by national and regional institutes (cf. Weaver et al. 2006), there is no clear connection between regional climate impact studies and adaptation objectives. Adaptation planning typically accounts for general climate trends and scenarios, partly because detailed climate projections and assessments of climate impacts have only recently become available.

Adaptation Options and Strategies

At present, proactive adaptation options are developed for future climate change, yet on a limited basis. Adaptation is mostly in the planning stage or implemented through pilot projects. Existing technical solutions, such as building dykes, run into limits or are being challenged for adding to undesirable downstream or longer-term effects. Pilot projects and demonstration activities have started to test the feasibility of new technologies and policies for climate-sensitive land use and natural resources management.

In all three regions, opportunities arise from integrating traditional agro-environmental land use systems with new technologies and institutional designs to preserve diversity in landscape and livelihoods, and to promote adaptive capacity. Traditional land use systems, such as the *dehesa* in Spain and Portugal, floodplain management in the Tisza, and extensive livestock keeping in Inner Mongolia had an active role in regulating climate extremes and seem to be better prepared to respond to climate change. The climate regulating service provides an important opportunity for climate change adaptation. Our research in the Tisza and Guadiana river basins show that preserving and managing diversification of land uses has great potential for reducing climate related risks. In the Tisza region, diversification of land use in relation to the hydrological conditions is explicitly supported by the current water plan.

A gap remains between scientific adaptation assessment and adaptation practice on the ground. So far, the primary focus of climate projections has been on temperature. Improved projections, especially of precipitation and secondary climate impacts, such as water shortage, remain important challenges. In addition, there is a mismatch between model assessments of impacts and adaptation on one hand and “real” adaptation practices and options as discussed by people in the region or in the policy plans on the other. Regional relevance of assessments depends critically on the scale and the resolution of the data used as well as on integration of socio-economic and political aspects in the evaluation of potential adaptation strategies. Currently available integrated assessment models are not parameterized for assessing new technologies and more complex and innovative adaptation strategies, and forego social aspects of adaptation, creating a barrier for the appraisal of adaptation. For example, existing models in the Tisza and Guadiana basin do not include resource conflicts resulting from multi-stressors or win-win opportunities resulting from the integration of adaptation and longer-term sustainable land and water use planning. There is an observable tension between the information demands of the adaptation process and the support that scientific modelling frameworks offer (cf. Vogel et al. 2007).

Financial instruments and resources are limited in each of the study regions and adaptation is often considered too costly and uncertain compared to expected benefits. Whereas there is a pressure on existing financial services (for example, insurance) to become more expensive, new financial instruments are also emerging (such as micro-grants). In all study regions, European and/or national government financial support is sought for the implementation. However, the integration of adaptation options in water and land use planning adds another level of complexity (and potentially bureaucracy) to existing relations with donors or subsidies. The European agro-environmental schemes for instance are not designed for inter-annual land use change depending on water availability.

Creating markets for adaptation is a key challenge for the Tisza region (for example, encouraging cities and industries to buy in on upstream flood water storage and floodplain management) as well as for national and international adaptation to climate change. All three regions identified opportunities for public–private partnerships in which marketable products obtain additional support in exchange for providing social and environmental services that support adaptation. Agro-tourism is promoted in all three regions as a means to diversify the economy, reduce climate related risks and create opportunities for both tourism and traditional land use practise. Adaptations include the promotion of festivals and fairs in periods that are attractive and comfortable for tourism. There is scope for more sustainable technologies and information systems, including early warning systems (for example the mobile phone-based warning service in Inner Mongolia). Small-scale techniques to provide shade, break wind, or harvest rainwater are an opportunity for adaptation in local planning and design.

Adaptation Actors

Opportunities for using water and land use planning to support adaptation and climate-proof regional development have started to emerge. In all three regions, we identified the capacity to participate in adaptation planning and the distribution of that capacity across different actors and governance levels as crucial for implementing adaptation successfully. This includes, for example, access to information, governance, and financial services.

Divided and unclear responsibilities of actors are key constraints for adaptation action in the Guadiana and the Tisza river basin. By contrast, in Inner Mongolia, the top-down implementation of environmental policy and strictly defined roles of different organizations is considered a constraint. In all three regions, we saw a lack of coordination between agencies and tensions between actors at different scales. To achieve more adaptive governance structures capable of dealing with projected climate related risks and uncertainties, different actors will need to work together to make policies, plans, roles, and activities more coherent. Stable adaptive governance is a complicated paradox. Adaptive governance is a relatively new concept that needs to be demonstrated to gain in appreciation. Inspiring examples are the emerging coalitions of government and non-government actors that are helping to put adaptation in the regional context and encouraging action. Successful coalitions often have close connections to academics who act as brokers in the communication of climate risk and adaptation information. Our analysis in the Tisza region shows the importance of recognizing adaptation at an abstract level by responsible civil servants and backing of an adaptation strategy by a credible regional coalition. Opposition is inherent to implementing more fundamental policy change and engaging with (potential) opponents is an important activity in adaptation planning.

Adaptation can fail or be counterproductive because social processes and structures are imperfectly understood. Some adaptation options have consequences that are socially unacceptable. In the Tisza basin, for example, proposed sites for water retention were rejected. In the Alxa region, the enclosure of livestock conflicts with traditional herding lifestyles. The Tisza study region shows that informal social networks around local production systems have degraded, but are remediable. Local populations hold a wealth of knowledge on how to cope with climate variability, which deserves to be taken into account while developing adaptation policies and measures. In addition, strengthening diverse local capacities offers opportunities for income diversification though, for example, agriculture and culture-related tourism. The Tisza region in particular shows benefits of debating climate related risks and how best to respond. After various discussions on adaptation options, actors were quick to take advantage of a micro-grant scheme for implementing local solutions. This supports the notion of adaptation as a social learning process.

The implementation of adaptation strategies is constrained by unequal distribution of costs and benefits among actors. For instance, water retention can reduce overall risks in a river basin while increasing the risks for those who store the water. Likewise, measures taken to reduce sandstorms and land degradation can negatively affect local incomes in the absence of retraining and sustainable compensation. At a smaller scale, the difference between those who are, and are not, included in adaptation pilots or support programmes can increase tensions among residents. The perception of fair sharing of costs and benefits between actors, – locally, nationally and internationally – is central to the successful implementation of adaptation and has to be addressed in adaptation planning.

Adaptation Planning: Linking Actors, Objectives, and Strategies

Adaptation to regional climate variability has always taken place. Traditional agro-environmental land use systems reflect the way local populations adapted to the region's climate variability. These traditional systems have subsided under competition from the global economy and changing institutional and societal contexts. New global market production systems tend to be less adapted to regional climate variability. Thus, climate impacts cannot be dealt with separately from the increase of scale of economic human activities. Together, these aggravate existing challenges for sustainable land and water use. Water shortages in particular highlight the interdependence of water users and the need for interaction of different sets of actors, their objectives, and actions. The emerging interaction can also stimulate new cooperation, as in the case of linking sustainable tourism with agricultural diversification in the Guadiana and Tisza region.

Embedding adaptation in existing national policy and institutional frameworks allows for addressing trade-offs and synergies that are crucial for "selling" adaptation. Yet it may complicate the implementation of the original policy and diffuses the responsibility for implementing the adaptation agenda. There is a clear call on central governments to delineate and communicate the roles and responsibilities for implementation of adaptation strategies at national, regional, and local levels. At the same time, our study suggests that it is important to balance formal regulatory rules and informal social factors in planning and implementation. Informal networks are crucial for social learning and adaptive capacity and may be particularly useful in times of crisis; whereas formal rules are required to include adaptation in longer-term planning, investment, and financial support of experimentation and adaptation.

With respect to adaptation planning, we observe a gap between ambitious adaptation policy goals and adaptation planning. Whereas adaptation policy goals often refer to transitions to adaptive systems, the measures selected in the European study regions focus on gradual change and well-established existing practices (dykes, dams, irrigation, risk management, setting targets). In Inner Mongolia, where transitions are rapid and pervasive, it remains to be seen whether new systems are adaptive. All three regions suffer from a lack of (access to) information about new adaptation options and policies. Knowledge integration can take place through “issue linking” in adaptation planning (for example in the case of linking climate change to desertification). Newly emerging forums for debating adaptation strategies may prove to be valuable in this regard. At the regional level, these are often associated with internationally funded projects, experimenting with new forms of engagement between scientists, policymakers, and the wider stakeholder community, allowing for the integrated appraisal of adaptation. A major opportunity for planning is to focus on the transfer of knowledge relevant for adaptation decisions including early warning systems. Another lesson is to implement cost-effective and flexible adaptation frameworks, which can be modified as personal and scientific understanding changes.

In summary, opportunities and constraints for adaptation in water and land use planning can be analysed in relation to adaptation options, objectives, and actors. Most adaptation assessments concentrate on climate impacts and the potential of adaptation strategies. The conditions that enable people to act on adaptation are less studied, yet have been identified as particularly important for successfully planning and implementing adaptation. These include institutional, social, and financial conditions. Our research conveys that consideration of actors and their objectives in relation to adaptation options discloses opportunities for planning and implementing adaptation successfully. Furthermore, our study regions suggest that besides advancing adaptation through existing policies, there is a need for a comprehensive and systemic adaptation agenda, reaching across non-climate policies and actor groups.

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References

ADB (2005) Regional master plan for the prevention and control of dust and sandstorms in Northeast Asia

Adger WN, Agrawala S, Mirza MMQ, Conde C, O’Brien K, Pulhin J, Pulwarty R, Smit B, Takahashi K (2007) Assessment of adaptation practices, options, constraints and capacity. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change

2007: Impacts, adaptation and vulnerability. Contribution of Working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK, pp 717–743

Adger WN, Arnell NW, Tompkins EL (2005) Adapting to climate change: perspectives across scales. Global Environmental Change, Part A 15(2):75–76

Balogh P (2002) Basics and method of floodplain management on middle-Tisza valley. VATI Kht, Budapest

Barta K, Bódis K, Boga TL, Kiss T, Kiss R, Mezősi G, Pálfai I, Rakonczai J, Szlávik L, Török IG (2000) The hydrological risks influencing the development of the Tisza country; resources and opportunities (in Hungarian). University of Szeged, Natural Geography Department, Szeged, HU

Bartholy J, Pongrácz R, Gelybó G (2007) Regional climate change expected in Hungary for 2071–2100. Appl Ecol Environ Res 5(1):1–17

Bates BC, Kundzewicz ZW, Wu S, Palutikof JP (eds) (2008) Climate change and water. IPCC Secretariat, Geneva

Bellon T (2004) Living together with nature. Farming on the river flats in the valley of the Tisza. Acta Ethnographica Hungarica 49(3):243–256

Brogaard S, Zhao X (2002) Rural reforms and changes in land management and attitudes: a case study from inner Mongolia, China. Ambio 31(3):219–225

China Council Task Force on Forest and Grasslands (2001) Report to CCICED Annual Meeting 2001. China Council for International Cooperation on Environment and Development (CCICED), Beijing, China

Commission of the European Communities (2000) Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (EU Water Framework Directive)

Cots F, Tàbara JD, Werners SE, McEvoy D, Roca E (2009) Policy entrepreneurship as an adaptive management response to climate change in a transboundary context. The case of the Guadiana River Basin. Environmental and Planning C (in press)

Csete M (2007) Climate change and local sustainability. CEMEPE/SECOTOX Conference, Skiathos island, GR

Dai X, Xu Y, Jia G, Fu C, You L, Xiong Z, Yuan J, Hu Yn, Yang H, Wang H, Hu Y, Zhang Y, Liu H, Liu Z, Sun Y, Chou J, Werners SE, Nabuurs G-J (2008) Climate change impacts and adaptation strategies in Inner Mongolia. Mid-term report. Project Report. ADAM Project (EU Project no. 018476-GOCE). www.adamproject.info, Norwich, UK

Dickinson D, Webber M (2007) "Environmental resettlement and development on the Steppes of Inner Mongolia, PRC. J Dev Stud 43(3):537–561

Du F (2006) Grain for green and poverty alleviation. The policy and practice of eological migration in China. Horizons 9(2):45–48

Du F, Huang W (2005) Approach on ecological environment problems in Alxa area (in Chinese). Inner Mongolia Environment Protection 17:5–9

ECCE Project (2005) A preliminary assessment of the impacts in Spain due to the effects of climate change. Impacts on the agrarian sector – Final report (Evaluación preliminar de los impactos del cambio climático en España (ECCE)). Ministério de Medio Ambiente, Madrid, ES

Fekete ÉG (2006) A situation of disadvantage turned into an advantage? Convergence opportunities for backward small regions in the region of Northern Hungary. European Integration Studies 5(1):71–89

Footitt A, McKenzie Hedger M (2007) Climate change and water adaptation issues, No. 2/2007. EEA Technical report, European Environment Agency, Copenhagen, Denmark

Grothmann T, Schauser I, Nenz D, Hain B, McCallum S, Prutsch A, Zebisch M, Pütz M (2009) Climate change adaptation assessment, Lessons learnt from six regional case studies in the European Alps. IHDP Open Meeting, Bonn, DE

Isoard S, Swart R (2008) Adaptation to climate change. In: Jol A, Šťastný P, Raes F et al (eds) Impacts of Europe's changing climate – 2008 indicator-based assessment, vol 4. European Environment Agency, Copenhagen, Denmark, pp 161–166

Joffre R, Rambal S, Ratte P (1999) The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. Agroforest Syst 45:57–79

Jones B, Keating M (eds) (1995) The European union and the regions. Oxford University Press, UK, Oxford

Kajner P, Farkas G, Nagy R (eds) (2008) A chance along the River Tisza. Biodiversity Micro Grant Find – Report and prospects, Violet Bt., Hungary

Koncsos L, Balogh E (2007) Flood damage calculation supported by inundation model in the Tisza Valley. In 32nd Congress of the International Association of Hydrolic Engineering and Research (IAHR), Venice, Italy

Láng I (2006) The project 'VAHAVA', Executive summary. Ministry for the Environment and Water Management (KvVM) and the Hungarian Academy of Sciences (MTA), Budapest

Linnerooth-Bayer J, Vári A, Thompson M (2006) Floods and fairness and Hungary. In: Verweij M, Thompson M (eds) Clumsy solutions for a complex world: Governance, Politics and Plural Perceptions. Palgrave-Macmillian, Houndmills, Basingstoke, UK, pp 181–204

McEvoy D, Cots F, Lonsdale K, Tàbara JD, Werners SE (2007) The role of institutional capacity in enabling climate change adaptation: the case of the Guadiana River Basin. In Proceedings International Symposium on Transborder Environmental and Natural Resource Management, Kyoto, Japan

Moriondo M, Good P, Durao R, Bindi M, Giannakopoulus C, Corte-Real J (2006) Potential impact of climate change on fire risk in the Mediterranean area. Clim Res 31:85–95

NDRC (2006) The outline of the Eleven Five-year plan for National Economic & Social Development of The People's Republic of China, National Development and Reform Commission (NDRC). Chinese Market Press, Beijing, CN

Orioli L, Moriondo M, Brandani G, Bindi M (2008) Combining climate change, land use and some economic aspects for an adaptation strategy in Guadiana river basin, Iberian Peninsula, ADAM project. Tyndall, Norwich

Reynolds JF, Stafford-Smith DM, Lambin EF, Turner BL II, Mortimore M, Batterbury SPJ, Downing TE, Dowlatabadi H, Fernandez RJ, Herrick JE, Huber-Sannwald E, Jiang H, Leemans R, Lynam T, Maestre FT, Ayarza M, Walker B (2007) Global desertification: Building a science for Dryland development. Science 316:847–851

Runhong G (2001) Case study on conversion of farmland to forest and grass in Zhuozi County, Inner Mongolia – Prepared for CCICED Western China Forest Grasslands Task Force, Institute of Forestry, Inner Mongolia Agricultural University, Hohhot, CN

Santos FD, Forbes K, Moita R (eds) (2002) Climate Change in Portugal. Scenarios, Impacts and Adaptation Measures. Gradiva, Lisbon, Portugal

Sendzimir J, Magnuszewski P, Flachner Z, Balogh P, Molnar G, Sarvari A, Nagy Z (2008) Assessing the resilience of a river management regime: informal learning in a shadow network in the Tisza river basin. Ecol Soc 13(1):11

Smit B, Pilifosova O (2001) Adaptation to climate change in the context of sustainable development and equity. In: McCarthy JJ, Canziani O, Leary NA, Dokken DJ, White KS (eds) Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC Working Group II. Cambridge University Press, Cambridge, UK, pp 877–912

Stern NH (2007) The Economics of Climate Change: The Stern Review. Cambridge University Press, Cambridge, UK

Szlávik L, Ijjas I (2003) Action plan on flood prevention for the Tisza River, in Precautionary Flood Protection in Europe, International Workshop, 5–6 February 2003, Bonn

Tàbara JD (2007) A new climate for Spain: A late accommodation of environmental foreign policy in a federal state. In: Harris P (ed) Europe and global climate change: Politics, foreign policy, and regional cooperation. Edward Elgar, Cheltenham, UK; Northampton, MA, pp 161–184

Tàbara JD, Cots F, Dai X, Falaleeva M, Flachner Z, McEvoy D, Werners S (2009) Social learning on climate change among regional agent – insights from China, Eastern Europe and Iberia. In: Leal Filho W, Mannke F (eds) Interdisciplinary aspects of climate change. Peter Lang Scientific Publishers, Frankfurt, DE, pp 121–150

Timmerman JG, Doze J (2005) Transboundary river basin management regimes: the Guadiana basin case study – Background report to Deliverable 1.3.1. In Report of the NeWater project – New Approaches to Adaptive Water Management under Uncertainty, Institute for Inland Water Management and Waste Water Treatment (RIZA), Osnabrück/Lelystad. www.newater.info

Vogel C, Moser SC, Kasperson RE, Dabelko GD (2007) Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships. Global Environmental Change 17(3–4):349–364

Weaver PM, Haxeltine A, van de Kerkhof M, Tàbara JD (2006) Mainstreaming action on climate change through participatory appraisal. Int J Innov Sustain Dev 1(3):238–259

Werners SE, Flachner Z, Matczak P, Falaleeva M, Leemans R (2009a) Exploring earth system governance: a case study of floodplain management along the Tisza River in Hungary. Global Environmental Change 19(4):503–511

Werners SE, Matczak P, Flachner Z (2009b) The introduction of floodplain rehabilitation and rural development into the water policy for the Tisza River in Hungary. In: Huitema D, Meijerink S (eds) Water policy entrepreneurs: A research companion to water transitions around the globe. Edward Elgar Publishing, Camberley, UK; Northampton, MA

West J (2009) Report on fieldwork in Bantanjing village and Luanjingtan town, Alxa League, Inner Mongolia, China, November 13–19, 2008. Center for International Climate and Environmental Research – Oslo (CICERO), Oslo, NO

WWF (2003) Results overview for the Guadiana River Basin (Spain), WWF Water and Wetland Index – Critical issues in water policy across Europe. www.assets.panda.org

Xu Y, Huang X, Zhang Y (2005) Statistical analyses of climate change scenarios over China in the 21st century (in Chinese). Adv Clim Change Res 1:80–83

Xu Y, Zhang Y, Lin E, Lin W, Dong W, Jones R, Hassell D, Wilson S (2006) Analyses on the climate change responses over China under SRES B2 scenario using PRECIS. Chin Sci Bull 51(18):2260–2267

Yan T, Quian WY (2004) environmental migration and sustainable development in the upper reaches of the Yangtze River. Popul Environ 25(6):613–636

Chapter 41
Path to the Future for Climate Change Education: University Project Approach

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Abstract The university system can be conceived as an institution that nurtures, trains, educates, and monitors students in the understanding of myriad bodies of knowledge about the Earth system and all other natural and human activities. With particular reference to climate change education, it also engages students in research activities as a way of learning science, understanding climate change, contributing to climate change studies and participating in several local and international workshops, seminars, and conferences. This paper focuses on how climate change projects within the university system can be used to develop and build capacities in the field of climate science. The study develops a triadic model of capacity building built around training, mentoring, and networking. A case of Assessments of Impacts and Adaptations to Climate Change (AIACC) project in sub-Saharan West Africa is used to illustrate this model. Considering the fact that many developed and developing countries are vulnerable to the impacts of climate change, albeit with different intensities, it is recommended that these countries adopt this triadic model so as to increase capacity, as well as reduce their levels of vulnerabilities to climate change impacts.

Keywords Adaptation · AIACC · Climate change · Nigeria · Obafemi Awolowo University · Vulnerability

Introduction

Climate change is an issue of global importance and it is fast becoming a subject that permeates every aspect of human lives. Increases in CO_2 emissions and global economic meltdown in both the developed and developing countries are creating serious problems, as energy use and CO_2 emissions continue to increase in countries

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such as the United States (US), China, and India through their heavy reliance on coal and energy needs (Sheehan 2008). The information from the US Department of Energy's Energy Information Agency for the USA puts the projection of energy use and CO_2 emission from fuel combustion at 1.1% and 1.2% per annum from 2005–2030 respectively, with energy use and emissions from coal use both growing at 1.6% per annum (DOE 2007). A similar trend is noticed in key developing countries such as China and India where coal constituted 71% and 55% of their total primary energy supply (excluding biomass and waste) in 2004 (IEA 2006). The big coal plants, which are currently being built in Germany, can only add to the present challenges of climate protection (Meinshausen and Hare 2008). However, research efforts over the years and new commitment by the Group of Eight (G8) may help improve our understanding of some of the complexities and technicalities involved in the science of climate change in the near future. The improvements made with respect to the strategies to adapt and mitigate climate change impacts on social, political, and economic developments would also be useful. As a result of these highly focused research activities and new initiatives, we have been able to reduce many uncertainties. Interdisciplinary research projects have also enabled us to identify the most cost-effective measures to mitigate climate change (European Commission 2005). For instance, research focusing on science, technology and innovation has improved the future for low-carbon society and initiated several climate-friendly technologies. Moreover, the approval of economic stimulus packages that incorporate environmentally friendly research activities in some developed countries could cause an increase in the number of green jobs created in these countries. Issues such as these have contributed to global arguments about climate change studies as one of the most important environmental challenges of the twenty-first century.

This paper examines how university projects can contribute to climate change education development by strengthening the capacity to comprehend the complex relationship between the Earth, atmosphere, ocean, and the cryosphere. The university system can be conceived as an institution that nurtures, trains, educates, and monitors students in their understanding of the Earth system and all other natural and human activities. Moreover, with particular reference to climate change education, it also engages students in research activities as a way of learning science, understanding climate change, contributing to climate change studies, and participating in several local and international workshops, seminars, and conferences. However, as important as study of climate change is, very few universities in the world have climate change as a distinct course of study at the undergraduate level.

It is now becoming increasingly clear that the primary factor responsible for the development and wealth of countries and individuals is intellectual capital (Pawowski 2004). The development of countries such as Hong Kong, Japan, and Singapore with little or no natural resources and the astronomical growth of giant corporations such as Google, Microsoft, Cisco, and Nokia give credence to this fact. The rallying point for these nations and corporations is scientific research and generations of new knowledge, which the university system readily provides. This study elucidates the role of universities within the wider context of learning. It looks at a range of programme activities that support university project goals, including increasing students' participation in regional and international gatherings focused on the issues of climate change. Consistent with the aim of capacity development, the paper intends to explore new ways of strengthening students' capacity to contribute to climate change studies both at the local and international levels.

Central to most international conventions such as the United Nations Framework Convention on Climate Change is capacity building, especially among developing countries. Capacity transcends the availability of potentials in a particular area of expertise. It involves the ability of the individual, institution, or society to be able to solve a particular problem. Capacity can be regarded as the ability (of an individual, institution, or society as whole) to identify and solve a problem or problems, while capacity development has been described as the processes of creating, mobilizing, utilizing, enhancing or upgrading, and converting skills/expertise, institutions, and contexts for greater good (Mugabe et al. 2000).

This study emphasizes that it is important to teach students to carry out systematic assessment of evidence of climate change around their local environment, as well as within the global community. Students must also learn the process and steps of carrying out scientific research so as to generate evidence-based explanations and to understand human influences on the environment. It is within this context that we propose the use of university projects on climate change as an educational programme for university students at all levels (undergraduates and postgraduates). It is also important for the teacher to understand the basic interrelationship between Earth's systems. This will allow students to understand concepts about climate change, how they were arrived at, and the necessity to reduce the impacts. This paper examines the case of the Assessments of Impacts and Adaptations to Climate Change (AIACC) project in sub-Saharan West Africa to illustrate the model that can be used to achieve this goal.

Climate Change Education: The AIACC Project

AIACC was developed as a global initiative in collaboration with the United Nations Environment Programme (UNEP)/World Meteorological Organization (WMO), Intergovernmental Panel on Climate Change (IPCC), and funded by the Global Environment Facility (GEF) to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. This initiative intends to achieve this by giving collaborative research grants, training, and technical support to developing countries. The focus of this initiative is to enhance the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations, and generate and communicate information useful for adaptation planning and action. The implementation of the programme rests on the shoulders of UNEP and is executed jointly by SysTem for Analysis, Research and Training (START) and the Third World Academy of Sciences (TWAS). There is also a synergy between the GEF, the United States Agency for International Development, the Canadian International Development Agency, the United States Environmental Protection Agency, and the World Bank in terms of collateral funding. AIACC

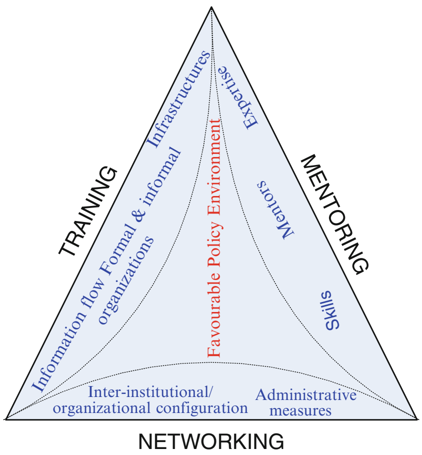

Fig. 41.1 A triadic model of capacity building

intends to fill the gaps that exist in understanding the nature of the vulnerability and opportunities for adaptation in developing countries. A further aim of the organization is to improve scientific and technical capacity to conduct multi-disciplinary regional research in the area of climate change. One of the most critical components of the AIACC capacity building programme is the expertise that scientists will gain through participation in multidisciplinary research teams. The major components of this capacity building are training, mentoring, and networking. The paper intends to situate the proposed approach for climate change education on these three cardinal components, which form a triadic model of capacity building (see Fig. 41.1).

Training

This component comprises the combination of formal and informal organizations, non-governmental organizations, information flow, financial incentives, and infrastructures. It is within the institution that the training of future experts will be done. In order for the training to have the desired impact, each of these elements must be properly structured. Under this component, seminars, workshops, and conferences should be organized to teach the students the basic concepts of climate change. The institutions should invite international experts from international organizations such as IPCC, GEF, UNEP, and other non-governmental organizations to provide training in the methods and tools for assessing vulnerability and adaptation and constructing scenarios of climate and associated socio-economic conditions. This training is best located in the third year for the undergraduate students and after the completion of courses for postgraduate students. The success of this training should be assessed by the level of understanding of students in the basic concepts of climate change and the quality of potential projects that students are able to propose, including the scientific design of their proposed projects. Group structures should also provide opportunities for participants to learn from each other. Another approach to training students could include active participation of the students in the field, which could be achieved by introducing students to local farmers who are most vulnerable to the impact of climate change. Students should be encouraged to engage the farmers in discussions about issues related to climate change with the intention of building the adaptive capabilities and resilience of the local farmers. During these discussions, the local, conventional, and emerging technologies in terms of adaptation and mitigation techniques should be documented, while experimental farms may be set up where the documented techniques would be tested. However, it is important that the experimental farms are selected using parameters such as income of the farmers, social status, age, etc. It is important at this stage to also include other stakeholders (such as governments, agricultural input companies) in this process. The stakeholders are very important because they provide both knowledge and hardware supports for the farmers. For instance, government agencies such as the agricultural extension workers will update farmers' knowledge and keep them abreast of the latest information on farming systems. They also pass across farm inputs such as new seedlings. At the same time, agricultural input companies could provide farm inputs such as fertilizers and farm implements. They could also provide small grants for the farmer to acquire farms' implements.

Mentoring

Another approach in strengthening capacity building in climate change studies is mentoring. This section involves the expertise in climate change studies that could identify problems and provide solutions. The point of focus for this expertise is to stimulate interest of students in the study of climate change. This can be achieved by inviting or linking students with reputable scientists or policymakers who have an interest in the area of climate change. These mentors could also help the students plan and initiate their projects. The university should also make available a database of notable scientists in the field of climate change to the students, which they can choose from. The mentors should be drawn from both developing and developed countries and assist the students throughout the course of their projects. The mentors should guide students in the selection and application of data, sample size, methodology, models, and scenarios for climate change studies, as well as attending to any other problems that may arise while the students are working on their projects. Mentors should also teach the students about publishing, especially in peer-reviewed journals, and support students in publishing their projects in reputable journals. Mentors should be able to inform students of both local and international conferences and workshops where they can enhance their capacities.

Networking

Capacity development is time-dependent. Some societies may posses skills to solve a particular problem, while those skills may be inadequate to overcome emerging and future challenges. As a result of this, there is the need to create a conducive policy environment where students may interact with the experts. This environment provides the condition to enable economic, political, sociocultural, general infrastructure, inter-institutional/organizational configuration, adequate policies, laws, and administrative measures (Mugabe et al. 2000). In order for students to have interactions with experts and other students from different locations with similar or diverse experiences, it is important to organize regional workshops in various locations such as Africa, Asia/Pacific and Latin America/Caribbean, United Kingdom, and USA. These regional workshops could also bring together the project mentors, researchers, and stakeholders from developing and developed countries to discuss current issues, techniques and methodology on climate change studies. Participants and students may present papers from their research activities, while mentors advise students and collaborate across study teams to solve common problems and plan for joint publications with the students. For sustainability of networking, there should be dedicated online discussion groups where further interaction can take place. The dedicated online discussion group would bring together and strengthened regional networks of scientists and students who can collaborate and develop effective teams in investigations of climate change.

A good example of this approach is that of the Asia-Pacific Network for Global Change Research (APN). The APN is an inter-governmental network for the promotion of global change research and linking science and policy making in the Asia-Pacific Region. Members of this network include Australia, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Japan, Lao People's Democratic Republic, Malaysia, Mongolia, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Russian Federation, Sri Lanka, Thailand, United States of America, and Vietnam. However, what is lacking within this network is dedicated online group discussion (where researchers can interact with students) and students' active participation. Another example of this model is the Climate Change Research Network at Vanderbilt. This network is very close to the model suggested in this study. It includes a team of faculty lecturers and graduate students who are conducting theoretical and applied research on climate change studies. The Climate Change Knowledge Network is another centre that brings together expertise, experience, and perspectives from research institutes in developing and developed countries that are active in the area of climate change. It also provides a forum for rigorous research on issues in climate change and provides a means for furthering dialogue between countries as they undertake efforts to address climate change. Again, active participation of both graduates and undergraduates is lacking.

Capacity-Building Operations of the AIACC

There are several initiatives that examine impacts and vulnerabilities of the Earth's response systems to climate change. One such initiative is the AIACC. This global initiative was developed in collaboration with the UNEP/WMO IPCC and funded by the GEF to advance scientific understanding of climate change vulnerabilities and adaptation. It focuses mainly on developing countries. The initiative provides funding for collaborative research, training, and technical support. By so doing, it enhances the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations, and generate and communicate information useful for adaptation planning and action (Adejuwon 2006). Its main contribution to the global body of knowledge is filling the gaps in scientific knowledge and capacity by funding, training, and mentoring researchers in developing countries to carry out multi-sector, multi-country research of their own designs (Leary and Kulkarni 2007).

The AIACC project is one of the focal climate change activities of the GEF. The GEF was the primary source of funding for the AIACC project with a grant of US $7,500,000. Other grants came from the Canadian International Development Agency (US $100,000), the Rockefeller Foundation (US $25,000), the United States Agency for International Development (US $300,000), the United States Environmental Protection Agency (US $50,000), and the participating developing country institutions (valued at US $1,800,000) (Leary and Kulkarni 2007).

The organization has provided financial support to 24 regional study teams, 46 developing countries, 235 developing country scientists, and more than 60 graduate and undergraduate students to conduct 3-year investigations of climate change impacts, adaptation, and vulnerability. More than 25 Master's and PhD theses that received support through participation in AIACC regional assessments were completed (Leary and Kulkarni 2007). The focus of the research activities in these countries are vulnerabilities to climate change, stresses, their implications for human development, and policy options for mitigating the adverse impacts. The array of information, knowledge, tools, and skills generated by these research activities has enhanced the ability of the scientists to assess many countries' vulnerabilities and adaptation options. This model of capacity building is close to the model suggested in this study. However, in terms of students' participation, students' share ratio and level of active participation is very low. Addressing this issue will make this model one of the most appropriate methods for capacity building for students with focus on climate change studies. This research-driven capacity building can be complemented by the other three components of capacity building: training, mentoring, and networking. The engagement of stakeholders in the vulnerability assessment process has further strengthened the information base for policymakers to make informed decisions about adaptation to climate change in these countries.

The success of these assessments projects has produced over 60 papers in peer-reviewed journals and books and over 40 papers in the online peer-reviewed *AIACC Working Papers* series. In terms of student participation, there were more than 25 student theses (Leary and Kulkarni 2007). Another indicator of success is the number of citations in the recent IPCC 4th Assessment Reports and contribution to the national communications to the United Nations Framework Convention on Climate Change (UNFCCC).

Due to the multi-disciplinary nature of the AIACC projects, many scientists have been able to create networks across disciplines, institutions and countries. These networks have resulted in collaboration that could yield further research investigations. Since most of the AIACC workshops engage stakeholders, their involvements have resulted in important inter-country collaborations in the area of climate change studies, such as the ones we have among Kenya, Uganda and Tanzania; Mozambique, Malawi, and Zambia; Egypt and Tunisia; Thailand, Cambodia, Lao PDR, and Vietnam; and Argentina and Uruguay. These stakeholders from various sectors of the economy are being brought together to assess climate change vulnerabilities and cost effective adaptation options. It is therefore not surprising that AIACC was able to select top scientists in the developing countries in 2002 to participate in the IPCC's 4th Assessment Report through the established network of AIACC scientists. The nomination of these scientists in developing countries also broadened their horizons and enhanced their perceived level of professionalism among their counterparts across the globe. Both local and international activities have assisted most of the AIACC participants to be key actors in international activities that relate to climate change. Also, some of the participants have gained international grants from organizations such as GEF, the MacArthur Foundation, the Inter-American Institute for Global Change Research, the Asia-Pacific Network, and others (Leary and Kulkarni 2007).

Model of Climate Change Education: The AIACC Project at Obafemi Awolowo University, Nigeria

This section describes the capacity building activities of the AIACC project at the Obafemi Awolowo University, Ile-Ife, Nigeria. It is suggested that this model be used in other universities to build and strengthen internal capacity in similar disciplines, as the project combined the three components of capacity building in the execution of the projects.

The title of the project is "Climate Change, Climate Variability and Food Security in Sub-Saharan West Africa". This final title was arrived at after several interactions with the AIACC Science Director and his team. Obafemi Awolowo University, Ile-Ife, Nigeria is the administering institution. Other institutions that participated in the project are the University of Lagos, Lagos and the University of Maiduguri, Maiduguri, Nigeria. Although the main area of focus is sensitivity analysis and impact assessment, the analysis in the project also extends to assessment of the human development of peasant farmers.

The country of primary focus is Nigeria. The country was adopted as a sample area for sub-Saharan West Africa because the country represents the climatic profile from the humid to the semi-arid ends of the project region. All the indicator vegetation types of the various climate types are present in the country. Thus, northwards from the very humid, eastern, coastal locations, to the boundary with the desert, the vegetation profile includes Moist Evergreen Rain Forests, Dry Semi-Evergreen Rain Forests, Derived Savannah, Southern Guinea Savannah, Northern Guinea Savannah, Sudan Savannah, and Sahel Savannah (Adejuwon 2007).

One of the most important aspects of the project is capacity building. It was observed that the research culture at the university was at a low ebb when the project was approved for funding. There was a need to increase research activities of scientists at the University. The fact that the country was yet to submit its first communication to the UNFCCC 10 years after the Rio Earth Summit is an indication of the status of research activities at the time. After examining the present situation at the university, it was observed that resident capacity for research on climate change has increased considerably compared with what obtained 3 years ago when the project was approved for funding (Adejuwon 2007). An indicator of this improvement is the increase in the number of participating researchers from seven to seventeen. The project was approved with only six core research staff apart from the Principal Investigator at inception.

In addition, the AIACC-organized workshops; the in-house project seminars; the 2-day stakeholders' workshop held from 20 to 21 September 2004; the stock of equipment including four desktop computers, one laptop computer, and one Powerpoint projector; participation by students, especially at the undergraduate level; the visit of Professor C.G. Knight from Pennsylvania State University; and the study visits of one of the students to the University of Cape Town, South Africa demonstrated the use of the three concepts of capacity building suggested in this study. One of the students who worked as a research assistant also presented a paper at the stakeholders' workshop. Three examples of success stories in capacity building can be cited. First is the generally high level of performance by the undergraduate students who opted for climate change as a specialty. One of them was awarded the third first class honours in the 43-year history of the Department of Geography at Obafemi Awolowo University (Adejuwon 2007). Second, a member of the Research Team was awarded a START Fellowship based on a proposal that was derived from the AF23 Project and his experience when he attended the AIACC Workshop in Trieste, Italy in 2002. Third, another member of the research team who was the most junior member is the sole author of three of the publications submitted with this report and a joint author of a fourth (Adejuwon 2007).

Conclusion

The focus of this paper is to examine how climate change projects within university systems can be used to develop and build capacities in the field of climate science. A case of the AIACC project in sub-Saharan West Africa situated at Obafemi Awolowo University was used to illustrate the model that can be used to achieve this goal.

It was found that the project incorporated all three components of capacity building suggested in the study. Assessment of the present situation in the university community of Obafemi Awolowo University, Nigeria in general, and the Department of Geography in particular indicates that resident capacity for research on climate change has increased considerably compared with what obtained before the project was approved for funding. We propose that the strategies used in this project to promote and build capacities in the area of climate change could be duplicated for projects in similar areas. Considering the fact that many developed and developing countries are vulnerable to the impacts of climate change, albeit with different intensities, it is recommended that these countries adopt this triadic model so as to increase capacity, as well as reduce their levels of vulnerabilities to climate change impacts.

References

Adejuwon JO (2006) Food security, climate variability and climate change in Sub-Saharan West Africa. Assessments of impacts and adaptations to climate change. Working Paper Series, Project No. AF 23, International START Secretariat

Department of Energy US (DOE) (2001/2007) International energy outlook. Department of Energy US, Washington DC

European Commission (2005) EU action against climate change. Research and development to stimulate climate-friendly technologies. European Commission Publication Office, Luxembourg

International Energy Agency (IEA) (2006) World energy statistics and balances, and CO_2 emissions from fuel combustion. IEA, Paris. http://data.iea.org/ieastore/statslisting.asp (cited 23 Jul 2007)

Leary N, Kulkarni J (2007) Climate change vulnerability and adaptation in developing country regions. Assessments of impacts and adaptations to climate change. Working Paper series, Assessments of impacts and adaptations to climate change, International START Secretariat

Meinshausen M, Hare B (2008) Missing the turn towards a low-emission path? Climate Change 91:233–236

Mugabe J, Maya S, Tata T, Imbamba S, Muyungi R, Gwage P (2000) Africa's capacity needs in Global Environmental Governance. GEF-UNDP Strategic Partnership

Pawowski K (2004) Rediscovering higher education in Europe. Studies on Higher Education Series, Conley Barrows L (ed) UNESCO

Sheehan P (2008) The new global growth path: implications for climate change analysis and policy. Climate Change 91:211–231

Chapter 42
Predicted Impact of Climate Change on Coffee Supply Chains

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Abstract Global circulation models all forecast that climate change will increase mean temperatures and change precipitation regimes. As a result, traditional coffee growing regions may disappear and new regions may appear. At the same time, demand for high quality, responsibly sourced coffee continues to grow globally. For sustainable sources of coffee, participants in the global coffee supply chain need to know where coffee will grow in the future and how the suitability of these areas will change over time. With this information, the supply chain then needs to develop appropriate site-specific mitigation and adaptation strategies for both the short and the long term, to guarantee coffee supply as well as to support improved livelihoods for rural communities. In this paper, we firstly quantify the impact of climate change on the suitability of land to grow coffee in a case study in Nicaragua and on acidity content of beverage coffee in a case study in the Veracruz Department of Mexico. Secondly, we propose site-specific adaptation strategies and finally identify critical potential impacts of climate change on the overall supply chain and the implications for all actors in the system. We conclude the paper by identifying key directions for future research to seek mitigation and adaptation strategies at both the community and the supply-chain level.

Keywords Adaptation · Climate change · Coffee · Spatial modelling · Supply chains

Introduction

The global climate has changed over the past century and is predicted to continue changing throughout the twenty-first century. Global circulation models (GCMs) all point in the direction of higher mean temperatures and changes in precipitation

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regimes. Both indicate that there will be a drastic shift in current land use and crop suitability, in addition to general increases vulnerability to climate variability. Climate change, including changes in the baseline and increased variability and frequency of extreme events, will affect agricultural productivity, farm incomes, and food security (Fischer et al. 2002; Mata and Nobre 2006; Busuioc et al. 2007; Lobell et al. 2008; Battisti and Naylor 2009; UNFCCC 2007). The predicted changes in future climates have the potential to expose agricultural systems to conditions and extremes not experienced before. The impacts are likely to vary across geographical regions and between different agricultural systems. Some of the climate changes could have beneficial effects, while others are likely to be detrimental.

Many farmers continuously vary their annual crops, selecting them based on criteria including sustenance, market dynamics, productivity, and cultural preferences. In view of the short growth cycle of annual crops, in many cases substitutions can be made with a minimum of cost. Farmers therefore have the capacity to make changes that will likely outstrip the speed of climate change. It is noteworthy that market factors alone drive changes in cropping systems at a considerable rate, which in itself is both a problem and an opportunity. Whilst attention needs to be paid to adapting annual cropping systems to future changes in climate, we believe that more urgent action is required to address these issues as they apply to high-value perennial cropping systems. Cash crops such as coffee may also have large impacts on national economies: for example, they are the largest contributors to agricultural GDP in Latin America. In Nicaragua, coffee produces 14.3% (MAG-FOR 2006) of agricultural GDP. In Mexico, coffee production is considered as a strategic activity, since it is grown on 664,800 ha, giving labour to 700,000 families (ICO 2005). Coffee systems are characterized by requiring longer-lead times for both farmers and business partners to make changes. In these cases, decisions made today come to fruition in 8–15 years, when the climate is likely to have changed.

Laderach et al. (2008) predicted that climate change will shift the altitude range for coffee to higher elevations over time, with the optimal altitude shifting from 1,200 m at present to 1,400 m in 2020 and 1,600 m in 2050 in Central America. This scenario generates different impacts at different altitudes, with the winners being smallholders at altitudes currently too high for the production of speciality grade coffees and the losers those farmers currently at the lower viable bounds for production of speciality coffee. As part of this process, the viability of some of the most celebrated origins in the speciality coffee market today, including Antigua, Guatemala, and Las Segovias, Nicaragua, will be put at risk.

It is essential for vulnerable smallholder farmers, whose livelihoods will be most affected by climate change, to understand its likely impacts and develop strategies to adapt. Understanding the implications of these changes is also critically important to all stakeholders in the value chain. To ensure the livelihoods of millions of smallholder farmers and related rural industries, it is crucial to identify adaptation pathways for these production systems or identify opportunities for diversification into other high-value crops.

In this paper, we firstly quantify the impact of climate change on the suitability of land to produce coffee in a case study in Nicaragua, and on the acidity content of coffee in a case study in the Veracruz Department of Mexico. Secondly, we propose site-specific adaptation strategies, and finally, we identify critical potential impacts of climate on the overall supply chain and their implications for all actors in the system. We conclude the paper by identifying key directions for future research seeking mitigation and adaptation strategies at both the community and the supply-chain level.

Methodology

Evidence Data and Sampling Design

All the current coffee-growing areas in Nicaragua were mapped by Valerio-Hernandez (2002) using aerial and satellite imagery. The map shows that the coffee-producing areas range from altitudes of 100–2,000 masl. According to experts of CAFENICA, the principal regions that produce *Coffea arabica* lie between 500 and 1,400 masl. Below 500 masl, growers usually produce *Coffea robusta* and there are few coffee farms above 1,400 masl. We extracted the geographical coordinates of coffee farms in the 3,155 polygons that represent the Nicaraguan coffee zone, at 30 arc-sec spatial resolution (approximately 1 km). We obtained a total of 6,192 coordinates, of which 1,129 were for farms below 500 masl and 144 for farms above 1,400 masl. To avoid the introduction of noise due to *Coffea robusta* species or farms whose altitudes were not representative, we only used sites in the range 500–1,400 masl, a total of 4,919 coordinates.

In Veracruz, we used the data of the denomination of origin project conducted by the University of Chapingo (Pérez-Portilla et al. 2005). The sampling design was based on a selection of a statistical subset of the total population of farms. The coffee-producing regions of de Atzalan, Misantla, Coatepec, Huatusco, Córdoba, Tezonapa, and Zongolica, which represent 93% of the total producers of the state of Veracruz, were taken as the entire population of farms. Considering the number of farms per municipality and the project's limited budget, approximately one-thousandth part of the farms were sampled, a total of 73. A panel of seven cuppers in the cupping laboratory of Café-Veracruz, A.C., assessed the quality of the samples of coffee from each farm according to the Specialty Coffee Association of America SCAA standards.

Historical Climate Data Collation

Historical climate data were obtained from the WorldClim database (Hijmans et al. 2005a, www.worldclim.org). WorldClim data were generated at a 30 arc-sec spatial resolution (1 km) through an interpolation algorithm using long-term average

Table 42.1 Bioclimatic variables with their coefficients of variation (CV) of 16 GCM models for Nicaragua and 17 GCM models for Veracruz. The CV indicates the variation between models (i.e. the greater the CV the more variability between GCMs)

ID	Variable	CV % Nicaragua	CV % Veracruz
Bio1	Annual mean temperature	2	2
Bio2	Mean diurnal range (Mean of monthly (max temp–min temp))	3	7
Bio3	Isothermality (Bio2/Bio7) (×100)	3	4
Bio4	Temperature seasonality (standard deviation × 100)	11	8
Bio5	Maximum temperature of warmest month	2	3
Bio6	Minimum temperature of coldest month	4	5
Bio7	Temperature annual range (Bio5–Bio6)	3	6
Bio8	Mean temperature of wettest quarter	3	2
Bio9	Mean temperature of driest quarter	2	4
Bio10	Mean temperature of warmest quarter	2	2
Bio11	Mean temperature of coldest quarter	3	3
Bio12	Annual precipitation	17	5
Bio13	Precipitation of wettest month	7	5
Bio14	Precipitation of driest month	55	53
Bio15	Precipitation seasonality (coefficient of variation)	8	7
Bio16	Precipitation of wettest quarter	10	5
Bio17	Precipitation of driest quarter	33	35
Bio18	Precipitation of warmest quarter	23	26
Bio19	Precipitation of coldest quarter	45	26

monthly climate data from weather stations. Variables included are monthly total precipitation, and mean monthly minimum and maximum temperatures. Hijmans et al. (2005a, b) used data from stations for which there were long-standing records, calculating means of the 1960–1990 period, and included only weather stations with more than 10 years' data. The database consists of precipitation records from 47,554 locations, mean temperature from 24,542 locations, and minimum and maximum temperature for 14,835 locations.

The data on which WorldClim is based in Nicaragua come from 277 stations with precipitation data, 218 stations with mean temperature data, and two stations with minimum and maximum temperatures. In the Department of Veracruz the analyses are based on 332 stations with precipitation data, 65 stations with mean temperature data, and 49 stations with minimum and maximum temperature.

The WorldClim database also includes 19 bioclimatic variables (Table 42.1) that are derived from monthly temperature and rainfall values to generate more biologically meaningful variables (Busby 1991). These variables are often used in ecological niche modelling (e.g. BIOCLIM, GARP). They represent annual trends (e.g. mean annual temperature, annual precipitation), seasonality (e.g. annual range in temperature and precipitation), and extreme or limiting environmental factors (e.g. temperature of the coldest and warmest month, and precipitation during the wettest and driest quarters).

We generated climate surfaces for each bioclimatic variable of Nicaragua and Veracruz from the original WorldClim dataset, and from them we used Arc/Info (ESRI, 9.2) to extract the data corresponding to each of the study farms.

Future Climate

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) was based on the results of 21 global climate models (GCMs), data of which are partially available through the IPCC website (www.ipcc-data.org.ch). The spatial resolution of the GCM results is, however, inappropriate for analysing the impacts on agriculture as in almost all cases the grid cells are 1 arc-degree (more than 100 km a side). This is especially a problem in heterogeneous landscapes such as those of the Andes, where, in some places, one cell can cover the entire width of the range.

Downscaling is therefore needed to provide higher-resolution surfaces of expected future climates if we are to forecast the likely impacts of climate change on agriculture. Two approaches are available for downscaling (1) re-modelling climate change impacts using regional climate models (RCMs) based on boundary conditions provided by the GCMs; or (2) statistical downscaling whereby resolution is reduced using interpolation and explicit knowledge of the distribution of climate at a fine-scale. Whilst the use of RCMs is more robust from the perspective of climate science, it requires a large amount of re-processing. Moreover, RCMs are only available for a limited number of GCM models, which makes it realistic to include only one or two RCMs in any analysis. In the context of this project, the use of RCMs for only one or two GCMs would make it impossible for us to quantify uncertainty in the analysis, which we believe makes them inappropriate. We have therefore used statistically-downscaled data derived from the larger set of GCMs to produce 10-km, 5-km and 1-km resolution surfaces of the mean monthly maximum and minimum temperature and monthly precipitation. In all cases, we used the IPCC scenario SRES-A2a ("business as usual").

Specifically, the centroid of each GCM grid cell was calculated and the anomaly in climate was assigned to that point. The statistical downscaling was then applied by interpolating between the points to the desired resolution using the same spline interpolation method used to produce the WorldClim dataset for current climates (Hijmans et al. 2005a, b). The anomaly for the higher resolution was then added to the current distribution of climate (derived from WorldClim) to produce a surface of future climate. This method assumes that the current meso-distribution of climate will remain the same, but that regionally there will be a change in the baseline. Whilst in some specific cases this assumption may not hold true, for the great majority of sites it is unlikely that there will be a fundamental change in meso-scale climate variability.

Suitability Prediction

We reviewed several prediction models such as ECOCROP, DOMAIN, BIOCLIM, MAXENT and CaNaSTA to select the most appropriate model to use in the analysis. ECOCROP (Hijmans et al. 2005b) is a crop database, with a description of the growing environment for various crops. There is also a crop prediction model with the same name (Hijmans et al. 2005b), which uses parameters in the FAO database to predict areas suitable for specific crops. ECOCROP is a very useful model for situations where there is no evidence data available for specific crops and one is forced to use environmental ranges instead. The results, however, are very general in nature and they can only be used to describe overall trends.

DOMAIN (Carpenter et al. 1993; Hijmans et al. 2005b) and BIOCLIM (Busby 1991) are fairly good models for conditions where evidence data are available. The algorithms used for both models are simple and tend to reduce and average the evidence information. The results are much more specific than the results for ECOCROP but are still rather general.

Maximum entropy (MAXENT) is a general-purpose method for making predictions or inferences from incomplete information. The idea is to estimate a target probability distribution by finding the probability distribution of maximum entropy, subject to a set of constraints that represent (one's) incomplete information about the target distribution. The information available about the target distribution often presents itself as a set of real-valued variables, called "features", and the constraints are that the expected value of each feature should match its empirical average ("average value for a set of sample points taken from the target distribution", Phillips et al. 2006). Similar to logistic regression, MAXENT weights each environmental variable by a constant. The probability distribution is the sum of each weighed variable divided by a scaling constant to ensure that the probability value ranges from 0 to 1. The programme starts with a uniform probability distribution and iteratively alters one weight at a time to maximize the likelihood of reaching the optimum probability distribution.

Crop Niche Selection in Tropical Agriculture, CaNaSTA (O'Brien 2004), employs Bayesian statistics. Bayesian methods provide a "formalism for reasoning under conditions of uncertainty, with degrees of belief coded as numerical parameters, which are then combined according to rules of probability theory" (Pearl 1990). A simple Bayesian model defines prior and conditional probability distributions and combines these to calculate posterior probabilities for each possible outcome. The probability distributions may be derived from data, be set by experts, or defined from a combination of data and expert opinion. The CaNaSTA algorithm, in addition to predicting presence or absence of a specific crop, also appraises its performance, and in the case of coffee, it predicts specific beverage attributes.

MAXENT is generally considered to be the most accurate model (Elith et al. 2006; Hijmans and Graham 2006) and we selected it for the analyses of the Nicaragua study after an initial iteration analysis in the study region using the other four niche models (ECOCROP, DOMAIN, BIOCLIM, MAXENT). We used CaNaSTA for the analyses in Veracruz to predict the impact of climate change on coffee quality. CaNaSTA had been used previously in many agricultural applications including for coffee (Atzmanstorfer et al. 2006; Laderach et al. 2006a, b).

Projected climate conditions for the period 2040 to 2069 ("2050s") were initially derived from the 18 most reputable Global Circulation Models (GCM) used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007; http://www.ipcc-data.org). As explained below, (NCAR-PCM1 and BCCR-BCM2.0) were excluded in Nicaragua and one model (NCAR-PCM1) in Veracruz after initial runs showed that their predictions diverged strongly from those of the other models and the analysis was repeated based on the remaining models.

Future suitability predictions were then assessed through each of the GCM models via the software MAXENT (Phillips et al. 2006) and two measurements of uncertainty were computed (1) the agreement among models calculated as percentage of models predicting changes in the same direction as the average of all models at a given location, and (2) the coefficient of variation (CV) among models.

As mentioned, the initial analysis using 18 GCMs revealed that the predictions of NCAR-PCM1 differed strongly in Nicaragua and Veracruz and BCCR-BCM2.0 differed strongly in Nicaragua from those of the other models. According to these models, the suitability of coffee would increase by the 2050s. These predictions were significantly different from those of the other models according to Tukey's (1977) outlier test. Based on these tests, the two models in Nicaragua and one model in Veracruz were removed from the final analysis.

In MAXENT, we applied the logistic function, which gave us estimates between 0 and 1 of the probability of the presence in the climate change scenario. In CaNaSTA, we applied the score analysis, which gives an estimate between 0 and 1 probability of producing high quality coffee for the acidity indicator, which is important to the denomination of origin for specialty coffees in Veracruz. The results were overlaid with a filter of certainty of 80%, so that only results where CaNaSTA predicted over 80% probability were used.

Driving Environmental Variable Analysis

To determine the environmental variables that directly drive suitability, we conducted a step-wise forward regression. First, we calculated the change in climate and suitability for each of the coordinates. We calculated the change (difference) by subtracting the future climate (2050) from the current climate for each of the bioclimatic variables, and the suitability predictions. Applying a step-wise forward regression, each variable was added one at a time to the analyses to determine its importance in the change in suitability.

Results and Discussion

Predicted Climate Change in the Coffee Zones of Nicaragua and Veracruz (Mexico)

The most representative GCMs (16 in Nicaragua and 17 in Veracruz) of AR4 for the SRES-A2a (business as usual) emission scenario drew a trend of decreasing precipitation and increasing temperature for coffee-producing regions both in Nicaragua and in Veracruz by 2050 (Fig. 42.1). Total annual precipitation is predicted to decrease from 1,740 to 1,610 mm in Nicaragua and from 1,990 to 1,870 mm in Veracruz, while the maximum number of dry months stay constant at 5 months in Nicaragua and increase from 5 to 6 months in Veracruz. The mean annual temperature increases by 2.2°C in Nicaragua and Veracruz, while the mean daily temperature range rises from 10.4°C to 10.6°C in Nicaragua and from 10.8°C to 11.4°C in Veracruz.

With regard to extreme conditions, maximum temperature of the hottest month is predicted to increase from 28.8°C to 31°C in Nicaragua and from 29.1°C to 31.9°C in Veracruz, while the warmest quarter will get hotter by 2.3°C in Nicaragua and by 2.4°C in Veracruz. The minimum temperature of the coldest month is predicted to increase from 14.4°C to 16.4°C in Nicaragua and from 11.5°C to 13°C in Veracruz, and the coldest quarter will be 2.1°C hotter in Nicaragua and 1.8°C in Veracruz. The wettest month is predicted to be somewhat drier with 270mm instead of 280 mm in Nicaragua and with 360 mm instead of 370 mm in Veracruz, while in the wettest quarter the precipitation decreases by 60 mm in Nicaragua and by 42 mm in Veracruz. The driest month will be drier with 18 mm instead of 24 mm in Nicaragua and drier with 35 mm instead of 54 mm in Veracruz, while the driest quarter will be drier by 7 mm in Nicaragua and by 42 mm in Veracruz.

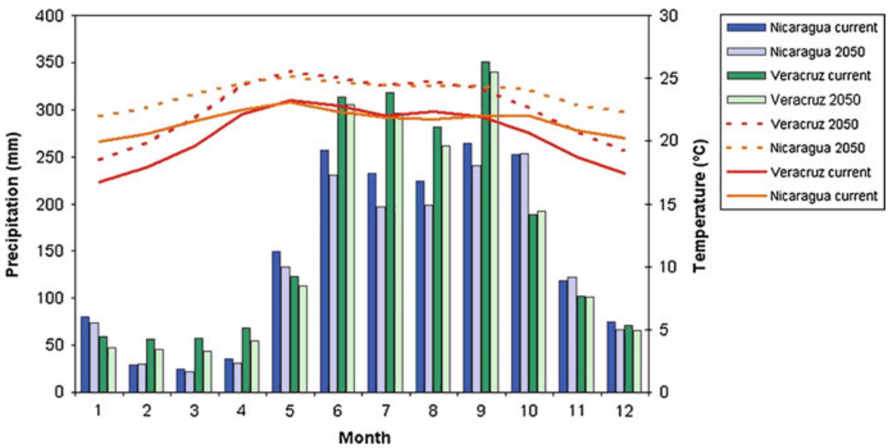

Fig. 42.1 Climate trend summary for current and future (2050) climate in Nicaragua and Veracruz

Overall, the climate will become more seasonal in terms of both variability through the year in temperature and in precipitation both in Nicaragua and in Veracruz. The predictions of the GCM models show a coefficient of variation (CV) of temperature of only 2.5% in Nicaragua and 3.8% in Veracruz, indicating uniform predictions between models with no outliers. The predictions of precipitation predictions have somewhat higher CVs, 9.9% for Nicaragua and 6.0% for Veracruz.

Impact of Climate Change on Coffee Suitability in Nicaragua

According to the MAXENT model, the most suitable coffee-producing areas in Nicaragua are currently Nueva Segovia, Jinotega, Madriz, Estelí, Matagalpa, Boaco, and smaller regions on the border of Masaya, Carazo, and Managua (Fig. 42.2). Their suitability is always between 50 and 80%. There are other areas in the same departments and in the departments of Atlántico Norte, Chinandega, León, and Chontales that are also suitable but at a lower degree (around 30–50%).

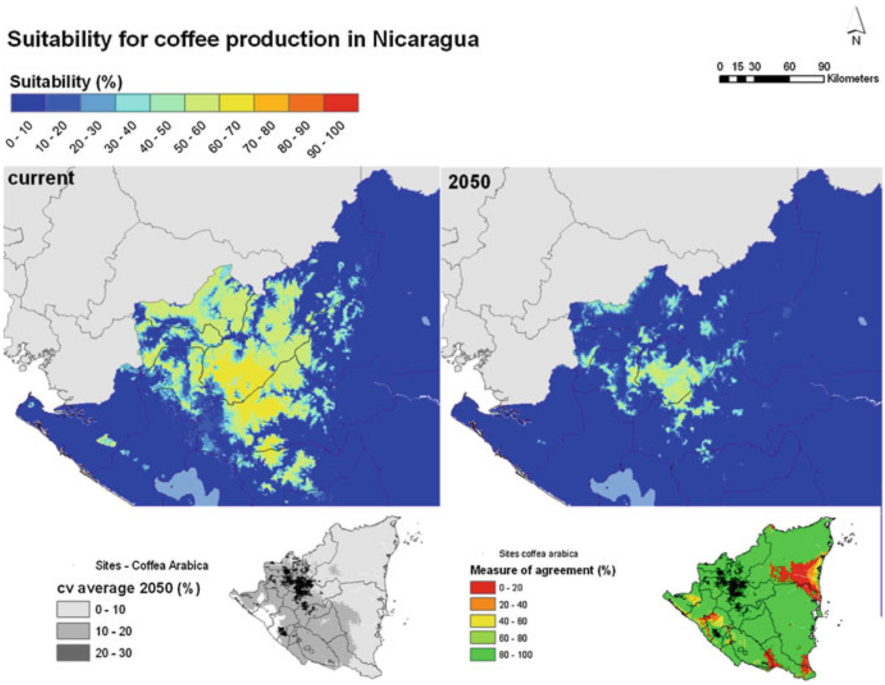

Fig. 42.2 Predicted (according to MAXENT) suitability for coffee production in the Nicaragua coffee-producing area today and in 2050 (*large maps*) and the coefficient of variation (CV) for the study area with the points representing the sampled *Coffea arabica* farms (*small map*)

MAXENT results indicate an important decrease in the suitability of coffee-producing areas in Nicaragua by 2050, equally distributed in areas that are highly and relatively suitable (Fig. 42.2). There is a general pattern of decreases in the area suitable for coffee and a decrease in suitability within these areas. Suitability for coffee will move upwards on the altitudinal gradient with climate change, with lower-altitude areas losing suitability the most. The areas that in 2050 will still be suitable for coffee production are mainly areas that currently show particularly high suitability. In 2050, the dominant area with suitability between 50 and 60% is in southern Jinotega, northern Matagalpa, and some other small areas in these departments. Areas with suitability between 30 and 50% will be in Nueva Segovia, on the border to Honduras, in Madriz, Atlántico Norte, and Boaco. The areas that will suffer the greatest loss of suitability loss (loss of 40–60%) are located in the departments of Nueva Segovia, Jinotega, Matagalpa, Boaco, and on the border of Carazo, Masaya, and Managua. The areas that lose least suitability (loss of 20–40%) are located in Estelí and Madriz. Some small areas that until 2050 will likely have an increase in suitability between 20 and 30% are located in Atlantico Norte, Estelí, Jinotega, and Madriz.

The coefficient of variation (CV) is a measure of the agreement between the bioclimatic variables produced by the different GCMs. CVs less than 20% are considered low. The mean CV of all bioclimatic variables for the 2050 predictions varies between 10 and 20% depending on the geographic location (Fig. 42.2, small grey map).

Currently 80% of the areas of the coffee producing departments in Nicaragua have a suitability of 0–40% to produce *Coffea arabica*, while 20% of the area shows a suitability of 40–100%. This means that only a fifth of the area is suitable for coffee production. By 2050, 96% of the area of the coffee producing departments in Nicaragua will have suitability of 0–40% and only the remaining 4% will have suitabilities of 40–100%. This means that the areas suitable for coffee production (suitability between 40 and 100%) will decrease by 16% and the areas no longer suitable for coffee production (suitability between 0 and 40%) increase by 16%. In other words, there will be substantial decreases in the total area suitable for coffee production.

According to MAXENT, with progressive climate change, areas at higher altitudes become more suitable for producing coffee (Fig. 42.3). We did not consider altitude as such in the suitability modelling so that we can consider it independently to forecast where coffee might migrate with climate change. Altitude and temperature have a fixed relation, called the lapse rate (0.6° per 100 m). The optimum coffee-producing zone in Nicaragua is currently at an altitude of elevation between 800 and 1,400 masl; by 2050, the optimum elevation will increase to 1,200 and 1,600 masl, which is consistent with the predicted temperature increase and the lapse rate. Between today and 2050, areas at altitudes around between 500 masl and 1,500 masl will suffer the greatest decrease in suitability and the areas above 1,500 masl the greatest increase in suitability. As the suitable altitude increases less and less land area to produce coffee will be available (Fig. 42.3, green line).

To develop adaptation strategies, it is important to know the most decisive climatic variables. Applying a step-forward regression analysis, we identified the

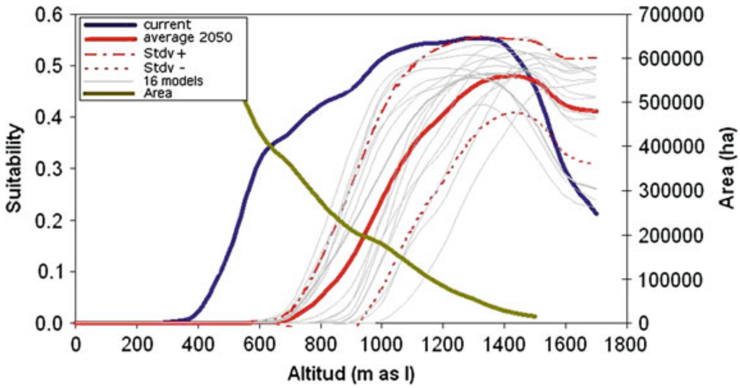

Fig. 42.3 Relation between current and future (2050) coffee suitability and altitude of coffee (*Coffea arabica*)

contribution of each of the 18 bioclimatic variables for the change in climate in the coffee-producing area. We analysed the sites predicted to increase in suitability separately from those predicted to decrease in suitability (Table 42.2). There were insufficient points predicted to increase in suitability to meet the requirements of the statistical tests, so it was not possible to determine the climatic variables for those sites. The most decisive climatic variable for the predicted decrease in suitability is the precipitation of the wettest month with a contribution of 42.8%, followed by the mean temperature of the warmest quarter with a contribution of 22%, the mean annual precipitation with a contribution of 8.8%, and the precipitation of the coldest quarter with a contribution of 6%.

Approximately 65% of the predicted decrease in suitability is due to precipitation-related variables. Overall, there is predicted to be less precipitation in the coffee-producing areas in Nicaragua by 2050. In the case of precipitation in the coldest and warmest quarters, there is not an absolute decrease predicted, which probably indicates an increase in evapotranspiration due to the increase in temperature and somewhat more water stress. Mean temperature of the warmest quarter contributes 22% of the variation. The remaining 35% contribution to the decrease in suitability is due to increasing temperature. The temperature variable that makes the highest contribution is mean temperature of the warmest quarter, which in Nicaragua is second quarter and falls together with the end of the dry season. This suggests that increased temperature and decreased precipitation imposes additional physiological stress on the plant, which it cannot resist.

Impact of Climate Change on Acidity Content in Veracruz

In Veracruz, the analyses focused on the sensorial attribute of acidity of the brewed coffee, which, together with aroma, is the most important attribute that distinguishes Veracruz coffee. The denomination of origin of Veracruz coffee is built on these two

Table 42.2 Contribution of the different bioclimatic variables to the predicted change in suitability of *Coffea arabica* in the Nicaragua coffee-producing area

Variable	R^2 adjusted	R^2 due to variable	Percentage of total variability	Current mean	Change by 2050
Locations with decrease in suitability (n = 4902, 99.8% of total observations)					
BIO13 – Precipitation of wettest month	0.2591	0.2591	42.8	279 mm	−10 mm
BIO10 – Mean temperature of warmest quarter	0.3924	0.1333	22.0	22.6°C	+2.3°C
BIO12 – Annual precipitation −132 mm	0.5862	0.0532	8.8		1,742 mm
BIO19 – Precipitation of coldest quarter	0.4287	0.0363	6.0	192 mm	+23 mm
BIO4 – Temperature seasonality	0.5123	0.0326	5.4	935	+111
BIO16 – Precipitation of wettest quarter	0.4797	0.0192	3.2	759 mm	−55 mm
BIO18 – Precipitation of warmest quarter	0.4605	0.0184	3.0	428 mm	+21 mm
BIO6 – Minimum temperature of coldest month	0.4421	0.0134	2.2	14.4°C	+1.9°C
BIO17 – Precipitation of driest quarter	0.5330	0.0119	2.0	88 mm	−7 mm
BIO5 – Maximum temperature of warmest month	0.5971	0.0109	1.8	28.8°C	+2.2°C
BIO8 – Mean temperature of wettest quarter	0.5211	0.0088	1.5	21.9°C	+2.4°C
BIO9 – Mean temperature of driest quarter	0.6001	0.0030	0.5	21.4°C	+2.1°C
Others	0.6054	0.0002	0.8		
Total variability explained		0.6054	100.0		

characteristics. According to the CaNaSTA analysis, the areas currently suitable to produce coffee berries with high acidity in Veracruz are located northward along the mountain chain from Zongolica in the south through Córdoba and in the regions of Tlaltetela to Atzalan in the north (Fig. 42.4). At higher altitudes towards the west lie the areas with the highest suitability (70–100%) running from Córdoba in the south up to Coatepec in the north. Descending the altitudinal gradient to the east towards Gulf of Mexico, suitability for producing coffee with high acidity falls to low to medium (20–40%). Between Tlaltetela in the centre and Atzalan in the north, there is the same east-to-west pattern of increasing suitability towards higher altitudes. Overall, the southern parts of Veracruz are less suitable for the acidity characteristic.

CaNaSTA predicts that by 2050 the areas with higher suitability will decrease drastically and the highly suitable areas for the acidity characteristic will move towards higher altitudes. Between Tlaltetela in the centre and Atzalan in the north, areas that are currently suitable to produce coffee with high acidity will become limited, although areas at higher altitudes may become more suitable by 2050. In the southern part, between Zongolica and Tlaltetela, the areas that are highly

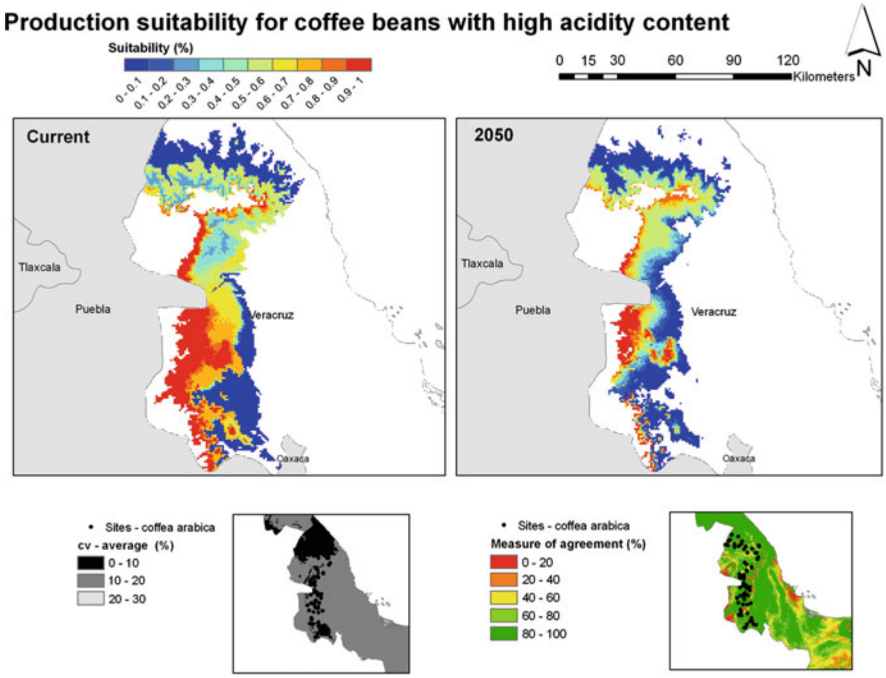

Fig. 42.4 Predicted (>80% certainty according to CaNaSTA) production suitability for coffee beans with high acidity content in Veracruz for current and 2050 conditions (*large maps*) and the coefficient of variation (CV) for the study area with the coordinates of the sampled *Coffea arabica* farms (*small map*)

suitable are predicted to decrease and move to higher altitudes. The north will maintain areas of high, medium, and low suitability, whereas in the south, areas of both high and low suitability will predominate.

The mean CV for all bioclimatic variables for the 2050 predictions varies between 0 and 10% (Fig. 42.4, grey map). This indicates that there is very little variability between the GCMs for Veracruz and one can be confident in the predictions.

Currently, CaNaSTA predicts, with a certainty above 80%, that 45% of the coffee areas in Veracruz have a suitability of only 0–40% to produce *Coffea arabica* with high acidity contents, while 55% of them will have a suitability of 40–100%. This means that rather less than half of the area is suitable to produce of high-acidity coffee. By 2050, 77% of the area of the coffee producing departments in Veracruz will have suitability between 0 and 40% and only the remaining 23% will have a suitability of 40–100%. This means that the areas suitable for high-acidity coffee will decrease by 32% and the unsuitable areas will increase by 32%. That is, there will be a substantial decrease in the areas suitable areas to produce high-acidity coffee.

As climate change progresses, areas at higher altitudes will become suitable for producing high-acidity coffee (Fig. 42.5). The optimum coffee-producing elevation for high-acidity beans is currently above 1,100 masl, but by 2050, the optimum elevation will increase to above 1,600 masl. Between today and 2050, areas at altitudes between 900 masl and 1,500 masl will suffer the highest decrease in suitability while the areas above 1,800 masl will have the highest increase in suitability. As the suitable altitude increases less and less land area to produce coffee will be available (Fig. 42.5, green line) (Table 42.3).

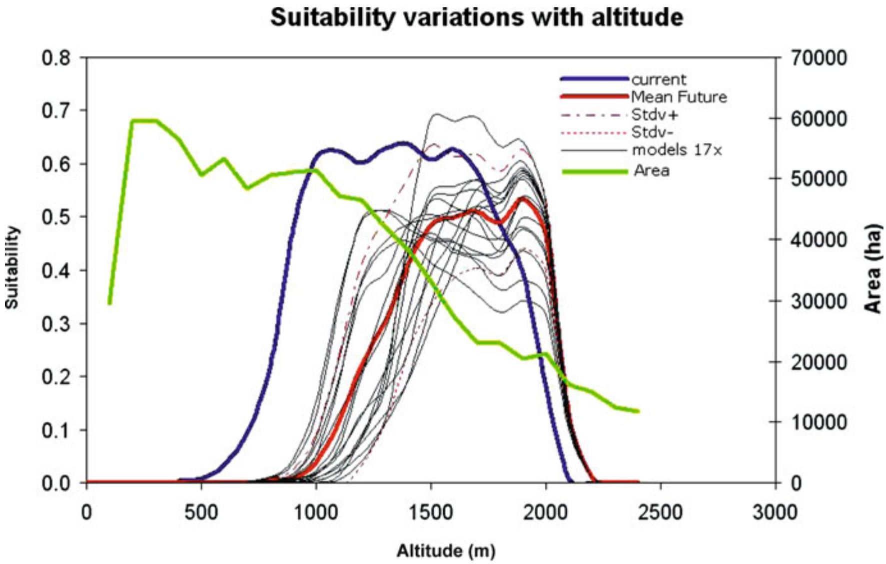

Fig. 42.5 Relation between current and future (2050) coffee acidity and altitude of the coffee

Table 42.3 Contribution of the different bioclimatic variables to the predicted change in production for *Coffea arabica* beans with high acidity content in the Veracruz coffee-producing area

Variable	R^2 adjusted	R^2 due to variable	% of total variability	Current mean	Change by 2050
Locations with decrease in suitability (n = 73, 100% of observations)					
BIO9 – Mean temperature of driest quarter	0.4400	0.4400	68	18.2°C	2.5
BIO8 – Mean temperature of wettest quarter	0.5436	0.1036	16	21.9°C	2.3°C
BIO5 – Max temperature of warmest month	0.6025	0.0589	9.1	29°C	2.8°C
BIO2 – Mean diurnal range	0.6229	0.0204	3.2	10.8°C	5.7°C
BIO6 – Min temperature of coldest month	0.6470	0.0158	2.4	11.4°C	1.4°C
BIO19 – Precipitation of coldest quarter	0.6312	0.0083	1.3	187 mm	−20 mm
Total variability explained		0.6470	100.0		

Close to 100% of the decrease in suitability is due to variables related to temperature. According to the climate predictions, temperature will increase in the coffee-producing areas in Veracruz by 2050. Mean temperature of driest quarter is the major driving variable accounting to 68% of the total variation and precipitation of coldest quarter the only precipitation related factor. The coldest quarter coincidences with the main harvest period. We therefore conclude that increasing temperature and decreasing precipitation have an overall negative impact on acidity content of coffee beverage. A statistically significant relation between elevation – which is a proxy for temperature – and acidity had been observed previously in the Orosi coffee-producing area in Costa Rica (Avellino et al. 2005).

Implications for Coffee Supply Chains and Possible Adaptation Strategies

Thus far we have focused on the impact of climate change at the farm level. From a livelihood and rural development perspective, this is critical. However, coffee farmers in Nicaragua and Veracruz do not operate in isolation, but rather as participants in multi-actor supply chains that link tropical countries with global coffee markets. A full assessment of the implication of climate change to implement effective mitigation strategies needs to include both on- and off-farm actors and the often substantial investments they have made.

At a supply-chain level, two general areas of climate effects emerge (a) the absolute capacity of the regions to produce coffee and (b) the quality of the coffee produced. Both topics have important implications in terms of infrastructure investments, the role of specific actors, the selection of target market niches, and the identification of key areas for research, investment, and policies in the future. The changes in the suitability of a particular area to grow coffee are site-specific because each site or area has its own very specific environmental conditions. In Nicaragua, according to the MAXENT prediction, by 2050 there will be areas that lose 40–60% of their suitability (e.g. the departments of Nueva Segovia, Jinotega, Matagalpa, Boaco), while others only lose 20–40% of their suitability (e.g. areas in the departments of Estelí and Madriz), and there are some small areas that may even become more suitable (e.g. areas in Atlántico Norte, Jinotega, and Madriz).

The first step in adaptation is to reduce the vulnerability of the coffee farmers to climate change. In this regard, use of technical "no regret" measures that strengthen the resilience of the system (e.g. sound agronomy, sustainable management of natural resources) will be beneficial to growers and their livelihoods and may also minimize the effects of climate change.

The solution to site-specific changes is site-specific management. In areas that will become unsuitable to grow coffee, farmers will need to identify alternative crops. In areas that will remain suitable for coffee but with some reductions in suitability, agronomic management might be adapted to buffer the impacts of climate change. Drought resistant varieties, irrigation, and shade cover, which can decrease average temperatures by up to 4°C (Vaast et al. 2006), are all useful practices that can be implemented. Areas where coffee is not grown today, but which in the future will become suitable for coffee, need strategic investments to develop coffee production. Environmental viability needs to be taken into account, since higher altitudes are often forest reserves that provide environmental services to the lowland population and to agriculture.

In regions that may be forced to abandon coffee, existing supply-chain actors need to think carefully about what their role in this transition may be. There are substantial investments in coffee processing and drying facilities but it might be possible to use some of these facilities for other, non-coffee, crops that are better adapted to projected future climates. In addition to physical infrastructure, many coffee-growing regions boast a highly qualified and specialized group of business services focused on coffee. If they continue to specialize in coffee, they will need to adapt and move to other regions, or, if they choose not to move, they will need to begin to work on other crops. This combination of physical and human capacity is a current strength of coffee-growing areas and may well be leveraged to help identify and promote a planned transition to other income sources.

A second major area of climate change impact is coffee quality. Coffee quality is assessed by what is known as "cup quality", where coffee samples are scored by tasters on a 0 to 100 point index based on taste and aroma characteristics (Lingle 2001). For example, the denomination of origin, which provides a price premium for Veracruz coffee, is built on the high acidity content and the distinct aroma of the coffees produced there. As climate changes, the areas in which coffee of this quality can be produced are projected to decline. This, too, has implications for market actors. Some actors may decide to leave the region altogether while others may struggle to find ways to continue to differentiate the Veracruz product on other factors. Taking a long-term view, the strategic challenges for the entire coffee supply chain with regard to climate change are:

- If possible, how best to shift infrastructure, knowledge, andkey capacities from current growing areas towards emerging growing areas
- How to identify and strategically develop alternative crops and livelihood opportunities for producer communities, regions, and countries that provide a viable option to increasingly marginal coffee production
- How to adapt marketing strategies and niche selection currently based on quality differentiation to other characteristics or find other suitable coffee areas
- How to make these transitions work in terms of logistics and processing capacities

None of these questions can be answered easily, and all will require effective collaboration among chain actors as the climate changes and coffee markets continue to evolve.

Successful adaptation of the coffee chain in the face of climate change will require more investment in building collaborative networks, sharing knowledge more widely and making shared strategic investments merely to stay in business. The current structure of the conventional coffee chain is not conducive to these kinds of decisions with the notable exceptions of examples of transparency in small, specific differentiated niches or high-quality niches. In the future, the use of methods such as farmer field schools and other collective learning vehicles focused on multi-actor climate adaptation around specific issues of productivity or quality will be needed. Recent collaboration between the Kenya Tea Development Agency, Unilever, and the Rainforest Alliance on how to promote sustainable tea production with more than 500,000 tea farmers provides one potential model from which to build (Hiller et al. 2009).

Despite the potential to establish successful adaptation strategies between specific buyers and producer organizations, the major challenge is how to generate collective action across the chain to find lasting solutions to these global issues in the coming years. The coffee chain as such needs to become more aware of the potential effects of climate change on the entire system and find ways to encourage strategic research and adaptation strategies at different scales. The data presented in Nicaragua and Mexico show that time is relatively short and the stakes are high.

Determine Risk and Opportunities at Farm Community Level

The AdapCC initiative has developed a participatory methodology of risk and opportunity analysis (ROA) to identify site-specific vulnerabilities of smallholders and possible adaptation pathways (Schepp et al. 2008). The methodology used the climate scenarios of the present study and estimated possible losses and damage for smallholder families as a consequence of climate variability.

The ROA process seeks to identify adaptation strategies at local level. In so doing, the approach aims to develop, test, and implement these site-specific adaptation strategies to support small-scale farmers' future production and their livelihoods.

We have shown that by 2050, Nicaragua will lose between 20 and 60% of the areas that are currently suitable to grow coffee. The ROA process identified the climate risks that smallholder producers already perceive as threats are extreme weather events, increasing temperatures and less rainfall causing droughts, and increased pressure from pests and diseases. All these factors subsequently lead to declining yields and fruit quality, and lower incomes (Schepp et al. 2008). Through the ROA analysis, farmers identified immediate no-regret measures such as (1) improved agro-forestry management to reduce the effect of higher temperatures and water scarcity; (2) capacity building to increase coffee growers' awareness of climate change and promote improved management, (3) foster the compilation and evaluation of climate data to monitor the impact of climate change on coffee in their specific region.

Key Future Research Directions for Community and Chain-Level Mitigation and Adaptation Strategies

The results we present here show potentially drastic changes in the suitability for coffee production in the study regions in Mexico and Nicaragua. Thousands of smallholder farmers depend on coffee for their income, and the likely societal impacts in these regions are particularly worrying as the coffee industry (from production, including the support of a large labour market, through to rural service providers and local and regional buyers and exporters) is an important component of the local economy. Outside of the region, this will have implications on coffee prices, and the global supply of beans, especially for the gourmet market.

This study suggests that there are a number of actions required, on both research and in terms of enabling the affected communities to adapt. In terms of research, we suggest a number of further refinements and additional research components that require attention:

- Our models only take into account the climate; research should also include constraints of soils, pests, and diseases
- Analyses need to be expanded to include economic impact analyses, using general equilibrium models, which take into account possible substitute crops, and incorporate livelihood components including also analysis of the impacts on gender and diversity
- Besides climate, there are many other important factors that drive change such as markets, social and cultural preferences, and policies that should be incorporated into the modelling
- Regional climate models (RCMs) could be used to improve the certainty of future climate scenarios and
- The use of multi-stakeholder learning mechanisms to identify, test and scale up appropriate adaptation strategies in coffee growing regions tied to a greater sector-wide understanding of the potential impacts of climate change

Despite a number of research questions that remain unresolved in our analysis, the results nevertheless suggest the need to use these results to establish adaptation measures for the communities that will be affected. The impacts demonstrate that areas suitable for coffee will decrease substantially by as soon as 2020. Production investments in coffee have a 10–15 year time horizon, hence farmers and other chain actors today should be making decisions based on long-term scenarios of change, such as those demonstrated here.

In areas that will be negatively affected, the first stage of adaptation will involve agronomic interventions that buffer the negative impacts, including change of varieties and the establishment of shade trees (including fruit trees, other tree crops, and timber species). The latter may form the basis for a transition towards crop substitution in areas where particularly severe negative impacts are predicted within the next 15 years, thus providing a seamless adaptation strategy that moves producers out of coffee. National and sub-national policies should be put in place to provide site-specific recommendations, and incentives for enabling adaptation. These may include provision of shade planting material, and promotion of agronomic practices through technical extension services. Attention should also be paid to the entire supply chain rather than focusing only on the production system. Coffee provides multiple employment and secondary income opportunities in rural areas, and hence entire societies must adapt. Despite uncertainties attached to the analyses, the results merit careful consideration, and action in the region to address the challenges we have identified.

Conclusions

This paper predicts severe impacts of climate change on both overall suitability for coffee production in Nicaragua, and coffee beverage quality in the Mexican department of Veracruz by 2050. Due to the long lead-time of perennial cropping systems and the complexity of global supply chains for coffee, it is urgent to identify appropriate adaptation strategies. These strategies must operate locally but be connected with the global supply chain. Farmers will need to develop site-specific adaptation strategies tailored to their environments, while other supply chain actors will need to invest more in building collaborative networks, sharing knowledge more widely and making shared strategic investments merely to stay in business. Researchers must better integrate climate science with analyses of economic, environmental and social impact. These will be needed on regional, national, and local scales to quantify the impact of climate change on relevant social, economic and environmental variables that lead to the development of appropriate adaptation pathways.

References

Atzmanstorfer K, Oberthür T, Läderach P, O'Brien R, Quiñonez GE, Collet L (2006) Probability modeling to reduce decision uncertainty in environmental niche identification and driving factor analysis, CaNaSTA Case Studies. In: Conference and Exhibition on Applied Geoinformatics – AGIT, GeoInformation for Development – gi4dev AgitSPECIAL, Salzburg, Austria, 7 July 2006, p 11

Battisti DS, Naylor RL (2009) Historical warnings of future food insecurity with unprecedented seasonal heat. Science 323:240–244

Brus DJ, De Gruijter JJ (1997) Random sampling or geostatistical modelling? Choosing between design-based and model-based sampling strategies for soil (with discussion). Geoderma 80:1–44

Busby JR (1991) BIOCLIM: a bioclimatic analysis and prediction system. Plant Prot Q 6:8–9

Busuioc A, Chen Z, Gao X, Held I, Jones R, Kolli RK, Kwon W-T, Laprise R, Magana Rueda V, Mearns LC, Menendez G, Raisanen J, Rinke A, Sarr A, Whetton P, Hewitson B (2007) Regional climate projections. In: Climate Change 2007: The Physical Science Basis. Cambridge University Press, Cambridge, pp 847–940

Elith J, Graham CH, Anderson RP, Dudík M, Ferrier S, Guisan A, Hijmans RJ, Huettmann F, Leathwick R, Lehmann A, Li J, Lohmann LG, Loiselle BA, Manion G, Moritz C, Nakazawa M, Nakamura Y, Overton J McC, Peterson AT, Phillips J, Richardson K, Scachetti-Pereira R, Schapire E, Soberon J, Williams S, Wisz M, Zimmermann E (2006) Novel methods improve prediction of species' distributions from occurrence data. Ecography 29:129–151

Fischer G, Shah M, van Velthuizen H (2002) Climate change and agricultural vulnerability. International Institute for Applied Systems Analysis (IIASA), Vienna

Hijmans RJ, Graham CH (2006) The ability of climate envelope models to predict the effect of climate change on species distributions. Glob Change Biol 12:2272–2281

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A (2005a) Very high resolution interpolated climate surfaces for global land areas. Int J Climatol 25:1965

Hijmans RJ, Guarino L, Jarvis A, O'Brien R, Mathur P, Bussink C, Cruz M, Barrantes I, Rojas E (2005b) DIVA-GIS Version 5.2, Manual

Hiller S, Onduru DD, de Jager A (2009) Sustainable tea production: an assessment of Farmer Field Schools in Kenya, Report 2008–078. LEI Wageningen UR, The Hague, Netherlands

International Coffee Organization (ICO) (2005) Fortalecimiento de la capacidad comercial, financiera, gerencial y empresarial de los pequeños productores y exportadores de café de México y Nicaragua. Informe sobre los avances realizados en el proyecto hasta marzo de 2005. http://dev.ico.org/documents/icc934c.pdf. Accessed 23 Feb 2008

Jarvis A, Rubiano J, Nelson A, Farrow A, Mulligan M (2004) Practical use of SRTM data in the tropics – Comparisons with digital elevation models generated from cartographic data 198. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia

Jarvis A, Reuter HI, Nelson A, Guevara E (2006) Hole-filled SRTM for the globe Version 3. CGIAR-CSI SRTM 90m Database. http://srtm.csi.cgiar.org

Jones PG, Thornton PK, Diaz W, Wilkens PW, Jones AL (2002) MarkSim: a computer tool that generates simulated weather data for crop modeling and risk assessment. Centro Internacional de Agricultura Tropical, Cali, Colombia

Laderach P, Oberthür T, Niederhauser N, Usma H, Collet L, Pohlan J (2006a) Café Especial: Factores, dimensiones e interacciones. In: Pohlan J et al (eds) El Cafetal del Futuro: Realidades y Visiones. Shaker Verlag, Aachen, Germany, pp 141–160

Laderach P, Vaast P, Oberthür T, O'Brien R, Nelson A, Estrada LDL (2006b) Geographical analyses to explore interactions between inherent coffee quality and production environment. In: 21st International Conference of Coffee Science, ASIC 2006, September 2006, Montpellier

Laderach P, Jarvis A, Ramirez J (2008) The impact of climate change in coffe-growing regions. In: Taller de Adaptacion al Cambio Climatico en las Comunidades Cafetaleras de la Sierra Madre de Chiapas, Tuxtla Gutierrez, Chiapas, 17–18 Nov 2008

Lingle TR (2001) The Coffee Cuppers' Handbook – a systematic guide to the sensory evaluation of coffee's flavour. Long Beach, California, USA

Lobell DB, Burke MB, Tebaldi C, Mastrandrea MD, Falcon WP, Naylor RL (2008) Prioritizing climate change adaptation needs for food security in 2030. Science 319:607–610

Mata LJ, Nobre C (2006) Background paper: Impacts, vulnerability and adaptation to climate change in Latin America. Paper commissioned by the Secretariat of the United Nations Framework Convention on Climate change. UNFCCC, Bonn, Germany

O'Brien RA (2004) Spatial decision support for selecting tropical crops and forages in uncertain environments. Department of Spatial Science, Curtin University of Technology, Perth, Western Australia

Pearl J (1990) Bayesian decision methods. In: Shafer G, Pearl J (eds) Readings in uncertain reasoning. Morgan Kaufmann, San Mateo, CA, pp 345–352

Pérez-Portilla E, Partida-Sedas JG, Martines-Pérez D (2005) Determinación de las Subdenominaciones de origen del Café-Veracruz. Revista de Geografía Agrícola, Universidad de Chapingo, Texcoco, Mexico 35:23–38

Phillips SJ, Anderson RP, Schapire RE (2006) Maximum entropy modeling of species geographic distributions. Ecol Modell 190:231–259

Ramírez J, Jarvis A (2008) High resolution downscaled climate change surfaces for global land areas. International Centre for Tropical Agriculture CIAT, Cali, Colombia

Schepp K, Lau I, Rizo L, Suárez G (2008) Sistematización de los Análisis de Riesgos y Oportunidades (ARO) en Nicaragua. AdapCC, Eschborn, Germany

Tukey JW (1977) Exploratory data análisis. Addison-Wesley, Reading, MA

UNFCCC (2007) Climate change: impacts, vulnerabilities and adaptation in developing countries, Climate Change Secretariat (UNFCCC). Bonn, Germany

Vaast P, Bertrand B, Perriot J-J, Guyot B, Genard M (2006) Fruit thinning and shade improve bean characteristics and beverage quality of coffee (Coffea arabica L.) under optimal conditions. J Sci Food Agric 86:197

Valerio-Hernandez L (2002) Elaboracion del Mapa del Cultivo de Café de Nicaragua: Informe Final. Dirección General de Estrategias Territoriales, Minsiterio de Agropecuario y Forestal, Managua, Nicaragua

Chapter 43
Preparing Communities for the Impacts of Climate Change in Oregon, USA

Bob Doppelt, Roger Hamilton, and Stacy Vynne

Abstract No matter how fast society reduces greenhouse gases, rising temperatures will produce significant ecological, social, health, and economic consequences. Few public or private organizations in the US, however, have the capacity to effectively prepare for or adapt to these inevitable changes. Unless the public and private sectors begin now to prepare for these impacts, great harm and high costs will result. The Climate Leadership Initiative at the University of Oregon, with partners, instituted a multi-year programme to develop a model that can be replicated nationwide for (a) analysing potential climate impacts at the basin scale; (b) engaging government agencies and stakeholders involved with natural (e.g. landscapes, streams, and biodiversity), human (e.g. emergency response, health care, education), built (e.g. transport, irrigation, communications infrastructure and buildings), and economic (e.g. forestry, agriculture, manufacturing, tourism) systems in assessing what those likely impacts mean for their sectors; (c) helping the agencies and stakeholders develop strategies and policies to prepare their systems to withstand and adapt to climate change through methods that enhance, and not undermine, climate preparation efforts in the other sectors.

We began with pilot programmes in the Rogue and Upper Willamette river basins of Oregon. We are now working in the Klamath Basin of Oregon and California and will soon move to the national level with model programmes in three to four locations across the country. Our goal is to dramatically increase climate preparation and adaptation literacy and to build and deliver the tools and resources needed to assist all levels of governments, institutions and non-profits across the nation to proactively prepare for climate change.

Keywords Adaptation · Climate change · Community empowerment · Planning · Preparation · Stakeholder engagement

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Introduction

Even if global carbon emissions are rapidly cut, Oregon and the Northwest will likely experience up to a 3.6°F temperature increase in the coming years. Aquatic and terrestrial ecosystems and species, along with human health, the built environment, and the economy will be severely stressed. Our recent economic analysis found that climate change will cost Oregon at least $3.3 billion annually by 2020, $5.1 billion annually by 2040, and $9.8 billion annually by 2080 (CLI & EcoNorthwest 2009). In addition to temperature increase, Oregon is already beginning to experience the impacts of climate change, such as extreme weather events, increased plant disease outbreaks, reduced stream flow, and impacts on biodiversity. Even if greenhouse gas emissions are reduced today, these impacts will become more severe over time because of the build-up of emissions in the atmosphere. In addition, these impacts will disproportionately affect our most vulnerable species (e.g. organisms already at risk), as well as human populations (e.g. low income, elderly, minorities, infirm, and children).

The severe consequences of climate change underscore the urgent need to reduce locally and globally generated carbon emissions to control the problem. Equally urgent, however, is the need for a concentrated effort to help all levels of government, private companies, community groups, and others develop the methods and tools needed to prepare for the consequences of climate change that now cannot be prevented. Lack of preparation will lead to crisis management, which will be extremely costly for ecosystems and people.

Climate change is a symptom of maladaptive individual and organizational behaviours, practices, and public policies. Solutions require fundamental changes in our way of thinking and doing business. New governance structures and new analysis, planning, and decision-making tools will be needed to help government, the private sector, and communities prepare for and withstand climate change. Most of these entities, however, do not have the information or tools needed to prepare for these challenges. Nor do they have the training or tools to communicate the urgency of climate change mitigation and preparation in a way that leads to changes in behaviour within their organization or with the public. Given the current economic crisis and pressures they are under, few will develop these tools or pursue training on their own.

Systems Thinking Model

Our approach to climate change preparation uses a systems dynamics or systems thinking model. Climate change is a multidimensional dynamic issue. Multiple factors affecting each other in sometimes random ways produce cascading changes in the structure and composition of the climate and hence ecological, social, economic and human systems. Quantitative change in climatic systems beyond a certain point (e.g. more carbon emissions) results in qualitative change leading to a new set of relationships within the whole system. Yet most organizations, whether government, industry or nonprofit, use "linear" (and numbers-based) approaches in planning, management and policy development. In the systems thinking approach, the learning and adaptation model used is called "single loop" learning: people see an event (e.g. flood, fire) and respond with a quick fix that – usually temporarily – solves the problem (e.g. put out the fire, build a dam to prevent future floods). Linear, single loop learning almost always fails as soon as a slight change in the current system occurs and will not enable society to effectively respond to climate change.

The climate change preparation programme supports organizations and institutions in becoming "climate learning systems". This begins with learning how to "see" and comprehend the multidimensionality of climate change (recognizing how one factor affects another, which feeds back and effects still more non-linear change, as opposed to managing by numbers) and then to help them learn how to employ "double and triple loop learning". This type of learning involves (a) seeing an event (e.g. potential or actual flood, fires, a disease, etc.) and developing a proposed response; (b) analysing a proposed response to determine likely short and long term consequences; and (c) analysing the consequences of those consequences. The ultimate goal is to enable organizations and institutions to alter their means (practices, programmes, policies) and their ends (goals) under conditions of constant change.

A passive and reactive response to a deteriorating environment (in any business, government, or society at large) is a road to disaster. By the time people or organizations realize the severity of the problem, their capacity to respond has often been undermined to the point that they have lost the capacity to cope with the change. In contrast, developing the capacity to purposefully understand and prepare for climate change provides the potential for all levels of society to withstand the impacts and capture the opportunities presented by change.

Localizing Data to Identify Risks and Develop Recommendations

In 2007, the Climate Leadership Initiative (CLI), with partners such as National Center for Conservation Science & Policy (National Center) and the United States Forest Service Pacific Northwest Lab Mapped-Atmosphere-Plant-Soil-System (MAPSS) Team, launched a climate change preparation programme in Oregon. The purpose of the programme was to develop model, replicable projects (called Climate Future Forums) in river basins across Oregon to understand the likely local consequences of climate change and design appropriate preparation strategies for natural, built, human, cultural, and economic systems.

Three Intergovernmental Panel on Climate Change (IPCC) models, Hadley, MIROC, and CSIRO, (Randall et al. 2007) as well as a global vegetation model, MC1, (Bachelet et al. 2001) were downscaled to the basin or sub-basin level for the

Klamath, Upper Willamette and Rogue basins and projections were made using the A2 "business as usual" scenario.

[1](Projections are currently underway for the Lower Willamette and Umatilla river basins.) We looked at ten-year periods of 2035–2045 and 2075–2085. Local watershed data was also incorporated into the scenarios and time series maps, other visuals, and narrative descriptions were generated. A series of Climate Future Forums (CFFs) were then held in each of the chosen sub-regions of the Klamath, Rogue, and Willamette basins. In each region, the first forum was conducted with natural systems scientists to analyse the ecological implications of the downscaled climate models. The next forum included people responsible for cultural, built, human and economic systems (also referred to as "community systems") in the selected basins/sub-basins, who analysed the risks to their resources and proposed strategies and policies to prepare them to withstand and adapt to climate change.

Findings

The Rogue river basin, located in southwest Oregon, consists of a diverse array of communities, economic sectors, and ecological systems. The Basin's rich history, beautiful setting, and recreational and employment opportunities, attract visitors and residents to the region year-round. Climate change projections for the Basin include (CLI & National Center for Conservation Science & Policy 2008):

- Summer temperatures may increase dramatically reaching 7–15°F (3.8–8.3°C) above baseline by 2080, while winter temperatures may increase 3–8°F (1.6–3.3°C)
- Rising temperatures will cause snow to turn to rain in lower elevations and decrease average January snowpack significantly, with a corresponding decline in runoff and streamflows. Snowpack may be reduced 75% from the baseline by 2040, and by up to 95% from baseline by the end of the century
- The basin is likely to experience more severe storm events, variable weather, higher and flashier winter and spring runoff events, and increased flooding

[1]Climate models are systems of differential equations based on the basic laws of physics, fluid motion, and chemistry. The IPCC uses a minimum of 19 different models from around the world to make global climate projections. The models are developed by different institutions and countries and have slightly different inputs or assumptions. CLI and the National Center selected models that seemed to perform best in the Pacific Northwest.

The Hadley model comes out of the United Kingdom's Met Office Hadley Centre. The Met plays a key role on the international stage, representing the UK in many global organizations.

Japan's MIROC model, is the Model for Interdisciplinary Research on Climate (MIROC). The CSIRO model comes from The Commonwealth Scientific and Industrial Research Organisation, Australia's national science agency. MC1, developed by the United States Forest Service, is a dynamic global vegetation model created to assess potential impacts of global climate change on ecosystem structure and function at a wide range of spatial scales from landscape to global.

Risks that were identified by the participants include:

- Young native fish will be threatened by increased storm events and sediment load
- Changes in timing of stream flow could result in disconnect between food availability and fish life stages
- High elevation wildlife and plant species may not be able to make the shift to new areas due to a lack of available habitat and rapidity of changes
- Expansion of invasive species may occur as conditions become more favourable for exotics and less favourable for some natives
- Power lines are likely to face increased stress due to rising fires and temperatures
- Rising summer temperatures will likely increase the incidence and intensity of heat-related illnesses and vector- and water-borne diseases such as Lyme disease and West Nile virus
- Agriculture will face increased competition with in-stream and municipal users for available water supplies while rising temperatures are likely to require the use of more water and/or a shift in crop types and farming practices

Recommendations from participants for preparation planning include:

- Reduce existing stressors for aquatic and terrestrial species
- Move permanent structures out of high-risk floodplains, riparian areas and steep forested canyons when damaged by floods or fires and new development constrained in these critical landscape areas
- Expand the use of on-site renewable energy systems to provide protection against blackouts and provide stability to energy prices

The Upper Willamette River Basin, in west-central Oregon, is home to 6% of Oregon's population and is 90% forested. Projections for the Basin include (CLI & National Center for Conservation Science & Policy 2009):

- Annual average temperatures are likely to increase from 2 to 4°F (1–2°C) by around 2040, and 6–8°F (3–4°C) by around 2080
- Snowpack across the Pacific Northwest is likely to decline by 60% by 2040 and 90% by the end of the century
- Storm events could increase in intensity, resulting in more flooding in all rivers in the Basin
- Vegetation will shift from softwoods such as coastal spruce and fir, to mixed pine, hardwoods, and oaks

Risks identified by the participants include:

- Increasing temperature is likely to benefit warm water native and nonnative species, while harming cold-dependent native species, resulting in the decline of Chinook salmon, steelhead, and Oregon chub
- Non-native invasive plants such as blackberry and black locust as well as native "weeds" will become more common across the landscape as CO_2 levels rise
- Reduced snowpack and summer water storage in reservoirs behind generation facilities are likely to diminish hydroelectric generation

- Higher temperatures likely will lead to increased heat stroke and cardiovascular disease, particularly for those without air conditioning
- Crops sensitive to higher day and night-time temperatures, such as certain wine grape varieties, will lose viability, while other crops may benefit from a longer growing season
- Disturbances to transport systems due to increased storm activity could threaten local food security

Recommendations from participants for preparation planning include:

- Early detection and rapid response efforts to identify, manage, and control invasive species should be increased
- A shift should be made to protecting and restoring key parts of the landscape that can allow ecological systems and species to withstand and adapt to increased stress
- Planning agencies should limit expansion of residential development into forested areas or floodplains
- Agricultural agencies should research and develop new crop varieties suitable for a warmer climate that may be wetter in the winter and drier in the summer
- Local governments should encourage local food production to build resistance to transportation disruptions

Developing Tools to Build Capacity for Implementing Preparation Plans

Proceedings from the Climate Future Forums were incorporated into a report, which was widely distributed and presented to local decision-makers. One year post Climate Future Forums, we are returning to the communities to identify strategies for incorporating climate change preparation planning into existing planning efforts. We have also identified the need to develop an online decision support tool that would empower local communities and governments to conduct their own climate change projections, risk and vulnerability assessments, and understand the costs and benefits of different preparation strategies. This tool, the Climate Preparation Analyst (CPA™), which is currently under development and testing, is being designed for multiple uses, enabling people within any public or non-profit organization to: (a) educate themselves or others about climate change and the need for preparation/adaptation; (b) identify and access key sources of information, financial resources, and state and federal policies to support preparation, including links to key databases and resources; (d) identify gaps in governance including information needs (e.g. climate impact projections, monitoring), resource allocations (e.g. funding, staffing, technologies), and decision-making mechanisms (e.g. who needs to be involved, how fast do decisions need to be made); (e) design an anticipatory climate preparation plan; (f) make a decision about implementing a particular preparation project, plan, or policy, including a cost – benefit analysis; and (g) monitor and evaluate plans. The tool will provide an integrated approach to preparing natural, built, human, cultural, and economic systems to ensure that a strategy for one system does not detract from preparation strategies for another system.

CLI is also developing in-person and online trainings on mitigation, preparation and climate change communication. These trainings will be piloted in Oregon and eventually available to everyone.

Recommendations

Few communities or local governments in Oregon, the United States, or across the globe, have the information, tools, human or financial resources needed to prepare for the challenges posed by climate change. In addition, few recognize that climate change impacts are already being felt and that they will affect every place, community and individual on earth. By localizing climate change projections and convening local experts from a variety of sectors, we are building awareness of the impacts of climate change that are specific to a particular community, supporting the development of preparation plans that best meet the risks the face and the resources they have on hand, and empowering communities to be proactive in their planning efforts. We envision that the Climate Future Forum pilot programme in Oregon will eventually be replicable across the country and globe.

References

Bachelet D, Lenihan JM, Daly C, Neilson RP, Ojima DS, Parton WJ (2001) "MC1: a dynamic vegetation model for estimating the distribution of vegetation and associated carbon, nutrients, and water – a technical documentation", Version 1.0. en. Tech. Rep. PNW-GTR-508. Portland, OR, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. vol 95

Climate Leadership Initiative & EcoNorthwest (February 2009) "An overview of potential economic costs to Oregon of a business-as-usual approach to climate change"

Climate Leadership Initiative & National Center for Conservation Science & Policy (December 2008) "Preparing for Climate Change in the Rogue River Basin of Southwest Oregon"

Climate Leadership Initiative & National Center for Conservation Science & Policy (March 2009) "Preparing for Climate Change in the Upper Willamette Basin of Western Oregon: Co-beneficial planning for communities and ecosystems"

Randall DA, Wood RA, Bony S, Colman R, Fichefet T, Fyfe J, Kattsov V, Pitman A, Shukla J, Srinivasan J, Stouffer RJ, Sumi A, Taylor KE (2007) "Climate Models and Their Evaluation." In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) Climate change 2007: the physical science basis. contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Chapter 44
Prioritizing Climatic Change Adaptation Investment at Local Government Levels

Supriya Mathew, Ann Henderson-Sellers, and Ros Taplin

Abstract The Intergovernmental Panel on Climate Change (IPCC (2007), "Climate change 2007: impacts, adaptation and vulnerability", Working Group II contribution to the fourth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, UK) describes warming of the climate system as "unequivocal". In future, global warming will influence the frequency and severity of extreme events and in response, local councils around the world must take adaptive measures. In this paper we focus on an investment tool that relates adaptation strategies to climatic extremes for the local government jurisdiction, Ku-ring-gai Council, Australia. The impacts of climatic extremes cannot be solely viewed in terms of economic losses, but should also be considered with regard to their social and environmental implications. Bayesian inference, a method usually used in operational risk analysis is used to assess the economic cost and benefit of adaptation options. The use of this method helps in accounting for the uncertainties and absence of observations for extreme events. Economic modelling is done with selected discount rates considering the economic constraints of local councils. Social and environmental ranks for adaptation options are obtained by drawing ideas from the Delphi approach that elicits expert opinion and tries to obtain consensus in a number of iterative steps. Through this paper we introduce a method to obtain a prioritized set of adaptation options for local scale climate extreme events.

Keywords Adaptation · Bayesian inference · Borda counts · Climate change · Delphi method · Local scale · Options · Prioritization · Ranking

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Introduction

The Intergovernmental Panel on Climate Change (IPCC 2007) describes warming of the climate system as “unequivocal”. Climate change is already happening in terms of temperature rise. A warmer earth may result in changes in sea level, rainfall patterns, frequency and severity of extreme events, and a number of other social, environmental, and economic impacts. Climate response actions: mitigation and adaptation are to be taken seriously, as the time for action is now. Mitigation measures at national levels, such as carbon taxes, can have a larger impact on greenhouse emission reductions than local efforts. The focus of local efforts can thus be on location specific adaptation, to mitigate the impacts of irreducible climatic changes. The varying impact of climate change and climate extremes across locations makes it necessary to act according to the varying needs. Each local government needs to foresee the risks, prioritize adaptation options and take necessary actions. The main problem local governments face is the uncertainty and unavailability of climate predictions at local scales. This research focuses on how to integrate climate change adaptation knowledge at the local scale in policy and planning decisions and investment prioritizations. The case study reported here is for a local government jurisdiction, Ku-ring-gai Council, Sydney, Australia.

Ku-ring-gai LGA (Local Government Area) (see Fig. 44.1) is predominantly a residential area, with significant areas of parkland and bushland. Ku-ring-gai LGA encompasses a total land area of 8,446 ha, of which a large proportion is National Parks, public parks, bushland or reserves. The Bureau of Meteorology (BoM 2009) climate online data from a weather station close to the Ku-ring-gai LGA shows an average annual rainfall of 1,140 mm, average annual temperature maximum of 22.8°C and an average minimum annual temperature of 11.4°C.

Based on the Australian Bureau of Statistics data from the census of population and housing (ABS 2006), the population in Ku-ring-gai LGA was 100,460 with almost 17% of the population above the age of 65. According to a 2007 consultation with the residents of Ku-ring-gai (Ku-ring-gai Council 2007), the five key environmental strengths of the local area are biodiversity, lower density development, access to public transport, health and clean environment, and bushland and open space. Their top five environmental concerns were limited public transport, climate change, traffic congestion, loss of bushland and wildlife, and urban development. Oddly, access to public transport was raised in both categories, but more people mentioned it in the former category.

Method

The method described below illustrates how an example Council of a hypothetical place called “Colour Land” can choose its best investment strategy for funds

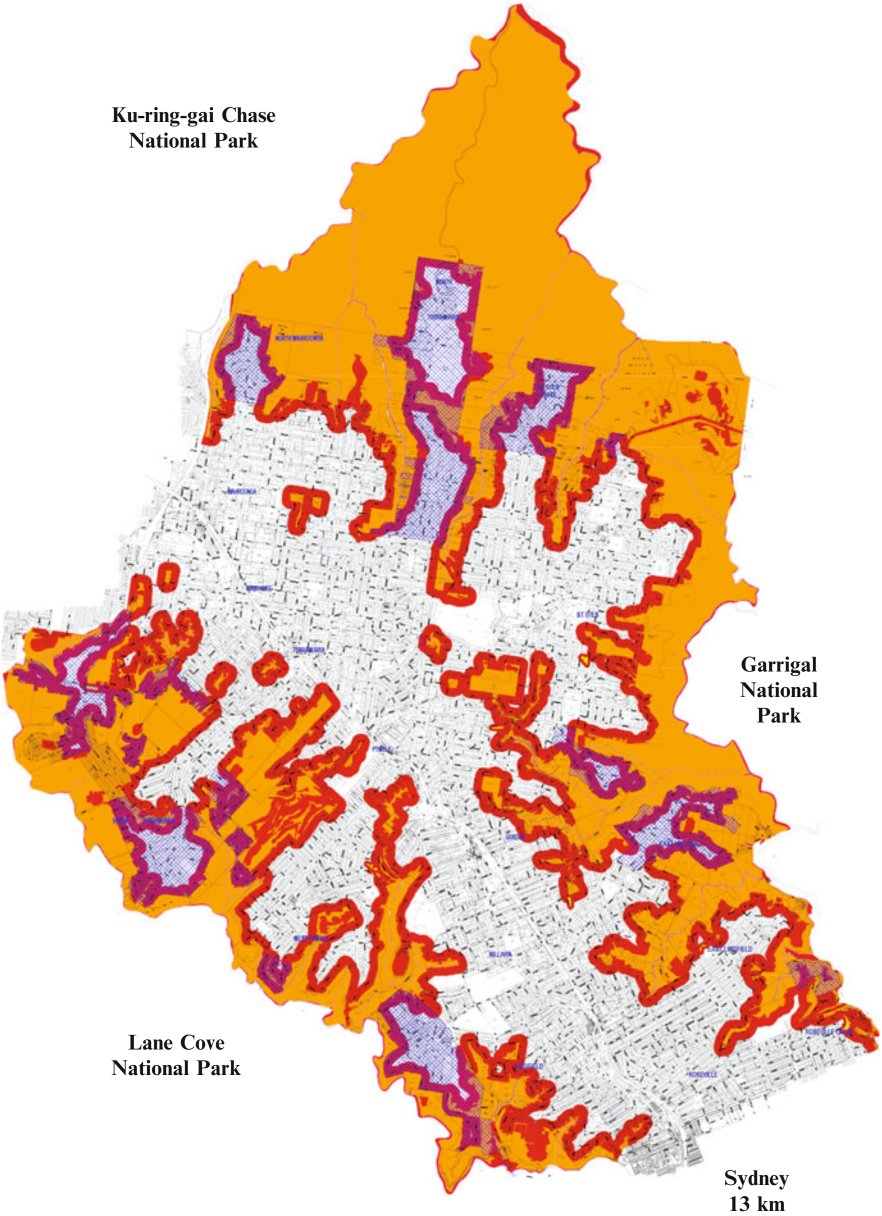

Fig. 44.1 Map showing Ku-ring-gai Local Government Area (LGA) surrounded by National Parks (*orange shaded regions*): Ku-ring-gai Chase National Park, Garrigal National Park and Lane Cove National Park. Source: Copy of bushfire prone land map and bushfire evacuation risk map certified by the Commissioner of New South Wales Rural fire Service on 2 January 2008

designated for adaptation to climate change. There are four parts to the overall method we describe. These are:

1. Identification of extreme climate-related weather hazards important for Colour Land
2. Proposal of hazard and/or impact reduction options for each selected extreme
3. Review of the net benefits of all these proposed measures in terms of three aspects
   - Economic
   - Environmental
   - Social
4. Combining all proposed measures into a single list of options for Colour Land's Council to consider

It is important to note that prioritization is complicated and so we encourage councils to tightly restrict the degrees of freedom with which they have to contend:

1. Choosing only three or four weather hazards
2. Restricting hazard/impact reduction proposals to no more than five for each extreme (in the first instance)
3. Selecting a time-horizon of importance to them (e.g., 20 years from now)
4. Choosing at most three (preferably only two) discount rates in the economic analysis

Step 1: Extremes

This method considers the impacts of climatic change in terms of extreme location specific weather events. Every location has extreme weather events that are a matter of concern to the local community, e.g., bushfires in Ku-ring-gai LGA, Australia, as this location is surrounded by bushlands; and floods in Cochin Municipal Corporation, Southern India, where two monsoons each year cause disruption.

First, we consider a case in which there are four imaginary extreme events (red, blue, yellow, and violet extremes) of importance to the hypothetical place Colour Land.

Step 2: Management Options

The number of adaptation management options for the Colour Land Council is restricted to only very relevant options. Consequently, we allow only four options per extreme in Table 44.1.

Table 44.1 Possible adaptation options for four climate extremes: red, blue, yellow, and violet for the hypothetical place Colour Land

Adaptation options	Red extreme	Yellow extreme	Blue extreme	Violet extreme
	R1	Y1	B1	V1
	R2	Y2	B2	V2
	R3	Y3	B3	V3
	R4	Y4	B4	V4

R1, R2, R3, and R4 are adaptation options for the Red extreme. Y1, Y2, Y3, and Y4 are adaptation options for the yellow extreme. B1, B2, B3, and B4 are adaptation options for the blue extreme. V1, V2, V3, and V4 are adaptation options for the violet extreme

Step 3: Aspects

We consider three aspects of climate change adaptation measures:

(a) Economic
(b) Environmental
(c) Social

Other aspects such as governance while important are not explicitly considered here. The council objectives for climate investments and the options suggested take into consideration legal obligations and constraints at local government levels. So, the approach we use lies somewhere between a triple bottom line (social, environmental, and economic) and a quadruple bottom line (social, environmental, economic, and governance), as shown in Fig. 44.2. Once the options have been selected, we rank separately by aspect (economic, environmental, and social) the net benefit of proposed measures to reduce the impact of selected severe weather events (this could be by reducing the hazards or by reducing their effects) against well defined objectives.

The aim of the method explained below is to choose some options that will be economically beneficial considering the limited funds of the councils and are socially and environmentally beneficial to some degree. (N.B. balancing the economic, social, and environmental benefits will be part of the Council's ultimate selection process.)

Step 3a: Economic

To simplify the situation, the method starts with economic net benefit rankings, as it is relatively easy to find an economically beneficial strategy from among all the different options for the four different extremes. For social and environmental

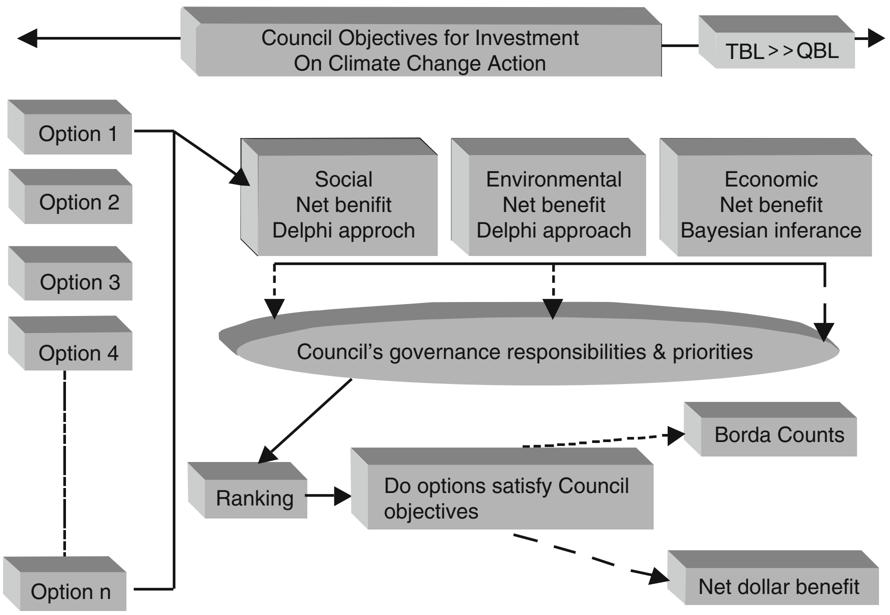

Fig. 44.2 Block diagram showing the method used to prioritize adaptation options. The *dotted arrows* represent social and environmental aspects, while the *dashed arrows* represent economic aspects of the adaptation options

aspects, comparison of ranks between the extreme events is difficult, as these are not in monetary units. For instance, rating a social rank 1 for an option for red extreme compared to a social rank 1 in blue extreme requires experts well versed in both events, which is difficult, especially at local scales, hence it is easy to start with economic impacts. The economic objective in this study is to obtain better net dollar benefits over a time horizon by implementing the options.

The main advantage in ranking the economic impacts is that all are in dollars. It is easy to combine all the options into a single list and rank them accordingly as seen in Tables 44.2 and 44.3. The option with the maximum net benefit is ranked 1. In this particular example, option Y1 has rank 1.

Steps 3b and 3c: Environmental and Social

Ranking of social and environmental aspects (Tables 44.4–44.7) is done in a slightly different way, without allocating dollar values to their net benefits. Putting dollar values to social and environmental impacts is time consuming and at times impossible. Also assigning monetary units to human life can be controversial. Three experts from the council complete this ranking individually and the ranks for each option are converted into Borda votes (e.g., Saari 2006). If there are n options,

Table 44.2 Ranked economic benefits of the adaptation options in 4 columns showing individual ranks within each climate extreme

Adaptation options	Red extreme Ranks	Yellow extreme Ranks	Blue extreme Ranks	Violet extreme Ranks
	R1-1	Y1-1	B1-1	V1-1
	R2-2	Y2-4	B2-4	V2-2
	R3-3	Y3-3	B3-2	V3-3
	R4-4	Y4-2	B4-3	V4-4

Economic aspects ranked separately by extremes using Bayesian inference

Table 44.3 Adaptation options of all four of the climate extremes in the order of net benefit (total cost–benefit)

Options	Y1	Y4	Y3	R1	Y2	B1	B3	R2	B4	R4	R3	V1	V2	V3	B2	V4
Net benefits $s × 10	1.2	1.12	0.8	0.75	0.6	0.3	0.29	0.25	0.22	0.1	0.06	0.03	0.02	0.01	−0.7	−0.9
Ranks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 44.4 Ranked environmental benefit of the adaptation strategies

Adaptation options	Red extreme Ranks	Yellow extreme Ranks	Blue extreme Ranks	Violet extreme Ranks
	R1-2	Y1-3	B1-2	V1-1
	R2-1	Y2-4	B2-4	V2-3
	R3-3	Y3-1	B3-1	V3-2
	R4-4	Y4-2	B4-3	V4-4

Environmental ranks for each extreme event

rank1 gets n − 1 votes, rank 2 n − 2 votes, and so on. These votes can be added, thus combining ranks from three different experts and the option with the greatest number of votes is ranked 1.

Table 44.5 Environmental ranks by three experts are combined using Borda votes for the red extreme event of Colour Land

Options	Expert 1	Expert 2	Expert 3	Borda votes	Overall ranks
R1	2	2	1	7	2
R2	1	1	2	8	1
R3	3	3	4	2	3
R4	4	4	3	1	4

Option R2 gets the highest Borda vote and hence first environmental rank in the list of adaptation options for red extremes

Table 44.6 Ranked social benefit of the adaptation strategies

Adaptation options

Red extreme Ranks	Yellow extreme Ranks	Blue extreme Ranks	Violet extreme Ranks
R1-1	Y1-1	B1-1	V1-3
R2-2	Y2-4	B2-2	V2-1
R3-3	Y3-2	B3-3	V3-2
R4-4	Y4-3	B4-4	V4-4

Social ranks for each extreme event

Table 44.7 Social ranks by three experts are combined using Borda votes for the blue climate extreme event

Options	Expert 1	Expert 2	Expert 3	Borda votes	Overall ranks
B1	2	1	1	8	1
B2	1	1	3	7	2
B3	2	3	4	4	3
B4	4	4	3	1	4

Option B1 gets the highest Borda vote and hence first social rank in the list of adaptation options for blue extremes

Step 4: Combining Three Aspects into a Single Options Table

There are many different ways of combining all the aspects of the various options proposed. Here we describe one way, which we believe will work for most local councils. In Table 44.8, the first ten options are considered, removing the bottom six ranks. Options Y2, B4, and R4 have very high ranks (bad outcomes) for social and environmental benefits and may be excluded from the list without much loss of management choice.

This table can now be used to rank as a function of each of the columns as desired or preferred. For example, Table 44.9 illustrates that there can be slight

Table 44.8 Options arranged according to the net economic benefits

Options	Net benefit A$ 10^6	Ranks	Capital cost A$ 10^6	Total cost A$ 10^6	Environmental ranking	Social ranking
Y1	1.2	1	0.01	0.01	3	1
Y4	1.12	2	0	5.8	2	3
Y3	0.8	3	0	0	1	2
R1	0.75	4	0	1	2	1
Y2	0.6	5	0	0.5	4	4
B1	0.3	6	0.2	6	2	1
B3	0.29	7	0.3	9	1	3
R2	0.25	8	0	0	1	2
B4	0.22	9	1.25	6.25	3	4
R4	0.1	10	1.5	7.5	4	4
R3	0.06	11	1.3	1.3	3	3
V1	0.03	12	0	5	1	3
V2	0.02	13	1	7	3	1
V3	0.01	14	6	6	2	2
B2	−0.7	15	10	15	4	2
V4	−0.9	16	6	11	4	4

The shaded boxes denote adaptation options within the first ten options that have comparatively poor social and environmental benefit

Table 44.9 Adaptation options arranged according to the capital investments required

Options	Net benefit A$ 10^6	Ranks net benefit	Capital cost A$ 10^6	Total cost A$ 10^6	Environmental ranking	Social ranking
Y4	1.12	2	0	5.8	2	3
Y3	0.8	3	0	0	1	2
R1	0.75	4	0	1	2	1
Y2	0.6	5	0	0.5	4	4
R2	0.25	8	0	0	1	2
V1	0.03	12	0	5	1	3
Y1	1.2	1	0.01	0.01	3	1
B1	0.3	6	0.2	6	2	1
B3	0.29	7	0.3	9	1	3
V2	0.02	13	1	7	3	1
B4	0.22	9	1.25	6.25	3	4
R3	0.06	11	1.3	1.3	3	3
R4	0.1	10	1.5	7.5	4	4
V3	0.01	14	6	6	2	2
V4	−0.9	16	6	11	4	4
B2	−0.7	15	10	15	4	2

The shaded boxes denote adaptation options within the first ten options which have comparatively poor social and environmental benefits, arranged in the order of net economic benefit

differences in the ordering of the options when they are based on capital investments. Capital investment is the initial investment required to implement the strategy in the year of implementation. The total cost includes capital investment, annual maintenance cost, and residual damages even after the adaptation strategy is implemented. It has to be noted clearly that the residual damages, i.e. the damages that can occur even after implementing a strategy, are also included in the total cost. Thus the net benefit (total cost benefit) is usually positive when the time frame is small, capital investment and maintenance cost is high.

Options Y1, Y4, Y3, R1, B1, and R2 appear within the upper ten ranks for all the three tables. Options within the shaded boxes in Tables 44.8–44.10 are ignored because of their poor environmental and social ranks, though they may be repeated within the top ten. There are six options that could be adopted by the council, depending on their funding availability or other particular preferences. Thus, this method aims to present a "best list" of adaptation options for discussion and ultimately for decision by elected officials of Colour Land.

Prioritizing Adaptation Options for Bushfires in Ku-ring-gai LGA

In this section, we try to demonstrate the methodology applied to a real world example for a single climate extreme: bushfires in the Ku-ring-gai LGA. Bushfire impact analysis is very important for the Ku-ring-gai local government area, as it is surrounded by National Parks on three sides. Moreover, studies show that fire weather conditions will worsen in the future, altering the frequency and severity of the events in Australia (see e.g., Lucas et al. 2007; Pitman et al. 2007). A study conducted by Chen (2005) had ranked Ku-ring-gai LGA as the third highest local government having bushfire risk-prone addresses within Greater Sydney. In response to the precautionary principle, the Ku-ring-gai local government authorities

Table 44.10 Adaptation options arranged according to the total costs over a time horizon

Options	Net benefit A$ 10^6	Ranks net benefit	Capital cost A$ 10^6	Total cost A$ 10^6	Environmental ranking	Social ranking
Y3	0.8	3	0	0	1	2
R2	0.25	8	0	0	1	2
Y1	1.2	1	0.01	0.01	3	1
Y2	0.6	5	0	0.5	4	4
R1	0.75	4	0	1	2	1
R3	0.06	11	1.3	1.3	3	3
V1	0.03	12	0	5	1	3
Y4	1.12	2	0	5.8	2	3
B1	0.3	6	0.2	6	2	1
V3	0.01	14	6	6	2	2
B4	0.22	9	1.25	6.25	3	4
V2	0.02	13	1	7	3	1
R4	0.1	10	1.5	7.5	4	4
B3	0.29	7	0.3	9	1	3
V4	−0.9	16	6	11	4	4
B2	−0.7	15	10	15	4	2

The shaded boxes denote adaptation options within the first ten options which have comparatively poor social and environmental benefits, arranged in the order of net economic benefit were very keen about investigating and implementing bushfire adaptation measures. The Council chose four adaptation options: “construction of fire-trails”, “new local fire brigade”, “community awareness through education” and “mid-storey vegetation removal” that has been used in this study. The time horizon considered is 20 years from now and we also assume that the present climatic conditions continue for the next 20 years.

Environmental Ranking

The ranking process adopted for social and environmental aspects, as referred to before, is different from the method used for economic modelling. The method applied here draws insights from the Delphi method (e.g., Geist 2009; Chu and Hwang 2008; Hsu and Sandford 2007) used usually to reach some sort of consensus among a number of expert opinions. As a pilot exercise, three experts from the Council were selected and they interacted indirectly to show convergence or divergence of opinions or ranks. Ranking was done for all the adaptation strategies for a 20-year period in terms of the net environmental and social benefits, based on how closely each option satisfies the objective of reducing the hazard or the impact or both. Each adaptation option is to be ranked in comparison to other options. The option that satisfies the environmental/social objective best was ranked as the top priority. The first round included initial ranking by all three experts without any sort of communication between each other. The experts were asked to specify relevant comments regarding the expected benefits and its importance in the local context against each ranking. In the second round, each expert was given a chance to change his/her position after seeing others’ opinions and comments on their ranks. The ranks from the second round were taken as the final ones and are used here. Interestingly, the experts did not change much in their decisions during the second rounds.

Environmental objective: Adaptation options which reduce the environmental impacts due to bushfires and which do not disrupt the natural habitat are selected.

Table 44.11 shows that the option “building new local fire brigade” has the maximum number of Borda votes in the environmental ranking and is ranked 1 followed by the options “conducting community awareness programmes”, “constructing new fire trails”, and “selective removal of mid-storey vegetation”.

Social Ranking

Social objective: An option that reduces the social impacts due to bushfires and which does not affect the social well being of the community is selected.

The option “conducting community education programs” is ranked first in Table 44.12 as it has the maximum number of Borda votes. The option “selective

Table 44.11 Ranking of the environmental benefits of the adaptation options for bushfire extremes of Ku-ring-gai LGA

Adaptation options	Expert 1 ranks	Expert 2 ranks	Expert 3 ranks	Borda votes	Final ranks
Build new local fire brigade	2	1	1	8	1
Construct new fire trail	3	4	3	2	3
Conduct community awareness programmes	1	2	2	7	2
Selective removal of mid-storey vegetation	4	3	4	1	4

Ranking was done by three experts working in related fields and specifically well versed about the location

Table 44.12 Ranking of the social benefits of the adaptation options for bushfire extremes of Ku-ring-gai LGA

Adaptation options	Expert 1 ranks	Expert 2 ranks	Expert 3 ranks	Borda votes	Final ranks
Build new local fire brigade	2	1	2	7	2
Construct new fire trail	3	3	3	3	3
Conduct community awareness programmes	1	2	1	8	1
Selective removal of mid-storey vegetation	4	4	4	0	4

Ranking was done by three experts working in related fields and specifically well versed about the location

removal of mid-storey vegetation" is at the bottom in both Tables 44.11 and 44.12. The council can decide not to opt for this option at this stage. Thus, we arrive with a list of three adaptation options that can be again prioritized with respect to economic benefit, capital investment and total cost.

Economic Ranking

Historically, a number of houses have been destroyed during many of the extreme bushfire events in Australia. Accordingly, as an easy measure to quantify the economic impacts, the number of houses lost during a bushfire event was considered. The first step here was to collect information on the average number of houses lost in past bushfire events. The problem here is that historical data of local scale extremes is normally not enough to project a future trend. Moreover, collection of observations of past climate extremes, usually one in 100 year events, are very crucial, as they can be misleading if not done properly. For example, if there was an event 50 years ago and data records are only available for the past 49 years, there is a chance of underestimation of the event frequency and its impact. At the same time, if data collection starts very near to the event, then there is a chance of overestimating the frequency of events. So, here we use Bayesian inference, a method that incorporates expert opinions to model the total house loss. Bayesian inference is a method commonly used in operational risk analysis to model the frequency and severity of low probability high impact events (Shevchenko and Wüthrich 2006; Meel et al. 2007).

The following steps are carried out in this method:

1. Selecting appropriate distributions for modelling frequency and severity of events separately
2. Eliciting expert opinion to derive the prior distribution of the parameters required for the distribution
3. Updating the prior distribution with the available observations to get a posterior distribution
4. Once the updated parameters are obtained for the distributions for modelling severity and frequency, the aggregate loss was estimated

To calculate the aggregate loss by combining the frequency and severity distributions, Monte Carlo simulations are done (Lewis 2004):

1. Choose randomly a frequency and a severity from the distributions
2. Simulate the number of events and the individual severity, then calculate the corresponding aggregate loss
3. Repeat 5,000 times to get an empirical aggregate loss

The total loss over a time horizon of 20 years was calculated using discount rates selected by the Council. Discount rates are used to standardize the costs and benefits occurring at different time periods. There has been considerable discussion nationally and internationally regarding the value of the discount rates to be used for climate investments (e.g., Garnaut 2008; Nordhaus 2006; Stern 2006). A high discount rate values the present generation more than future generations, which is seen as unethical by some commentators. The value of discount rate depends on the pure time preference rate and the marginal elasticity of utility with respect to consumption. The rate of pure time of preference is the rate at which future utility is discounted. The Garnaut Review (2008) uses a rate of pure time preference of 0.05%, very similar to the value used in the Stern Review (2007), while Nordhaus (2006) uses a rate of 1.5%. The Garnaut Review comments that the only reason for a positive rate of pure time preference is the risk of human extinction in any 1 year.

The other factor, marginal elasticity of utility, is a measure of the equity in income distribution. The premise here is that people in future may have better incomes compared to people at present. Stern (2006) uses a parameter value of 1, Nordhaus (2006) uses 2 and Garnaut (2008) uses both the values for economic modelling. In this particular local context, we used a discount rate 6% at first that was selected by the local government. Unlike the state or national governments, local councils work under very limited funds making it difficult for them to choose very low discount rates. To a great extent the discount rates chosen at local government levels will depend on funds available from the state or national governments.

Poisson: Gamma (Frequency Modelling)

The Poisson distribution is commonly used to model discrete data such as the number of customers entering a shop in an hour. Here we use the Poisson distribution to model frequency of events. The major advantage of using a Poisson distribution is that an expert's opinion is required only for one parameter, which makes it much easier than asking the expert many statistically significant questions for the distributions. The prior distribution for Poisson parameter is assumed to be Gamma distribution (see Shevchenko and Wüthrich 2006; Buhlamnn and Gisler 2005). The parameter of the Poisson distribution as given by an expert from Ku-ring-gai LGA on bushfire management is then updated with observations as seen in Fig. 44.1. An annual frequency of 0.1 suggested by the expert is updated with the help of historic observations to 0.112.

The major advantage of using Bayesian inference is demonstrated through Fig. 44.3a, b. Assuming that the only source of information is the past observations, then in Fig. 44.3a, for the first 5 years there are no observations, but if we rely on the expert, the probability of an event is still seen, which may be close to a real case. In both Fig. 44.3a, b, the expert opinion is that there is one bushfire every 10 years (0.1 probability), which is updated by the observations. When the expert opinion is almost the same as the observations, the two curves tend to converge. In Fig. 44.3b, the expert opinion and the average of the observations tend to converge, but variations are seen in Fig. 44.3a, where the observations considerably differ from the expert (two events in the first 10 years). This indicates that the expert view needs to be updated, but is a good start as long as a long record of observations are unavailable.

Lognormal: Normal (Severity Modelling)

The number of houses lost was used as a measure of severity and was modelled using the lognormal distribution, which has two parameters. The prior distribution of one parameter was assumed to be a normal distribution and was updated with observations. In this particular example, the other parameter of the lognormal distribution was assumed to be same as the value suggested by experts for simplicity. Frequency and severity distributions were then combined to get the annual loss through Monte Carlo simulations and then, the aggregate loss was estimated over 20 years with a discount rate of 6%.

In Table 44.13, total cost benefit gives three positive values, particularly because of the shorter time horizon of 20 years and the high discount rate used. The cost of adaptive responses generally comes early, and the benefit from reduced costs of climate change later. Even after adopting an adaptation strategy, there can be residual damages, which has been included in the total cost. Analysis of all (in all three aspects) ranks suggests "conducting community awareness

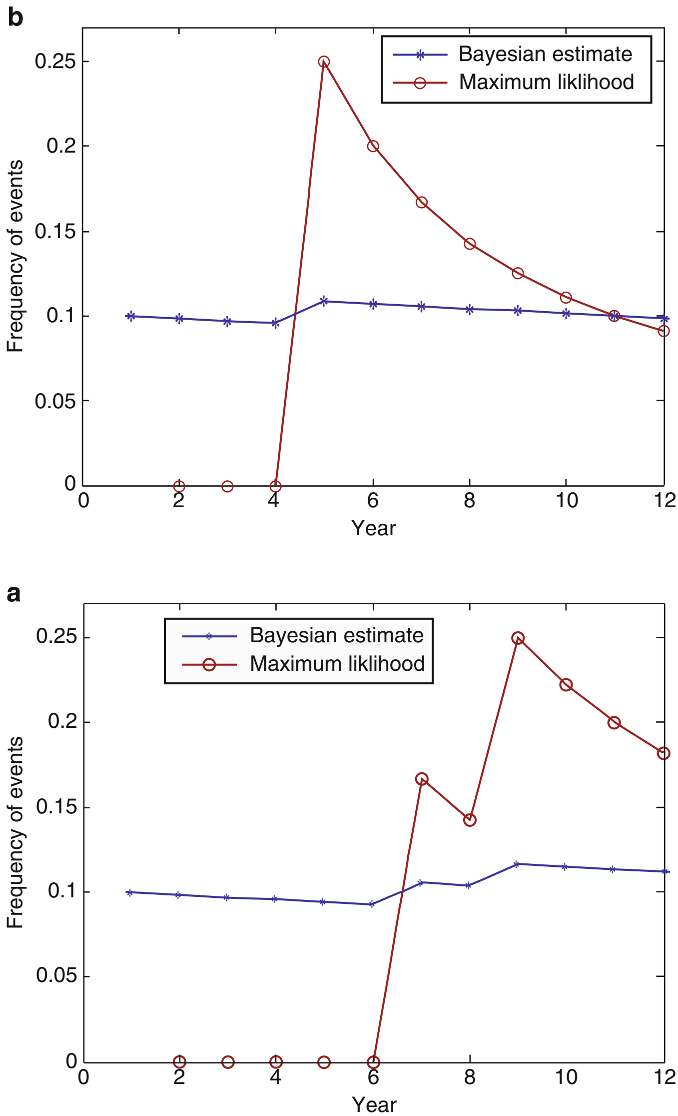

Fig. 44.3 Bayesian and maximum likelihood estimates for the frequency vs. the observation year. The Bayesian estimate is obtained by updating the expert opinion on the average frequency of bushfires (taken as 0.1 here) as observations become available. (**a**) The maximum likelihood estimate is a simple average over the number of observed events (0,0,0,0,0,1,0,1,0,0,0). (**b**)The maximum likelihood estimate is a simple average over the number of observed events (0,0,0,1,0,0,0,0,0,0,0)

programmes" as a strategy that could be adopted. A trial to choose another option proves to be a little difficult as there is no clear winner. The selection of the second option depends on whether the Council is ready for capital investments for

Table 44.13 Economic ranks of the four adaptation options suggested by Ku-ring-gai Council

Adaptation options	Benefit A$ 10^6	Capital investment A$ 10^6	Total cost A$ 10^6	Net benefit A$ 10^6	Ranks net benefit	Ranks capital investment	Ranks total cost
Build new local brigade	0.258	0.600	1.002	0.744	2	3	2
Construct new fire trail	0.499	1.500	3.275	2.776	4	4	4
Conduct community awareness programmes	0.783	0	0.458	−0.325	1	1.5	1
Selective removal of mid-storey vegetation	0.677	0	1.950	1.273	3	1.5	3

The ranks are based on net benefit, capital cost, and total cost. Only one adaptation option has a negative value for the net benefits (total cost benefit). The monetary unit used in this study is Australian dollar

the strategies. If the Council can invest initially, then construction of fire trails and local fire brigade are the next better options. Selective removal of mid-storey vegetation has very poor social and environmental ranks, so in the first ranking step, this option is omitted. This method thus helps councils to prioritize options giving importance to all three aspects (social, environmental, and economic) and at the same time considers the limited fund within which a council may have to work.

Sensitivity of Economic Aspects of Adaptation Measures to the Values of Discount Rates

Selection of a low discount rate, as seen in Fig. 44.4, shows that there is greater loss in future years. The need for timely action will be more emphasized with low discount rates, but at the local level as mentioned before, choice of a discount rate depends on funding availability and/or current interest rates.

A comparison between Tables 44.13 and 44.14 shows that the ranking remains almost the same, but there is considerable difference in the net benefits, when there is less capital investment and maintenance cost. This worked out example indicates that no matter what discount rate is used, there are some adaptive measures beneficial to the community that a council can implement without much capital investment.

Concluding Remarks

Local government authorities, such as Ku-ring-gai Council, the world over are facing the problem of finding and funding climate change adaptation. The method proposed here will help local councils prioritize their investment for climate

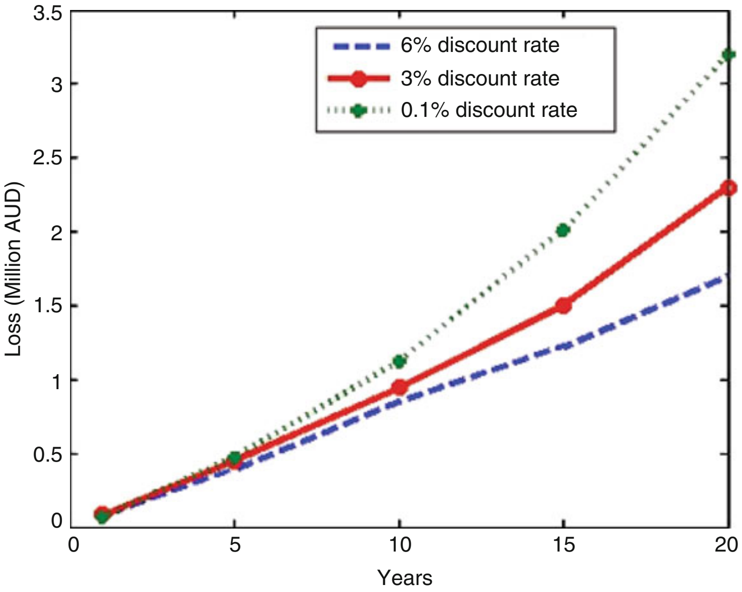

Fig. 44.4 Sensitivity of economic loss to discount rates without any adaptation strategy. The *dashed line* represents the aggregate loss because of bushfires, with a discount rate of 6% if no climate action is implemented. The *dotted line* and *solid line* represents aggregate loss with discount rates 0.1 and 3% respectively

Table 44.14 Economic ranking of the four adaptation options suggested by Ku-ring-gai Council with a very low discount rate of 0.01%

Adaptation options	Benefit A\$ 10^6	Capital investment A\$ 10^6	Total cost A\$ 10^6	Net benefit A\$ 10^6	Ranks net benefit	Ranks capital investment	Ranks total cost
Build new local brigade	0.542	0.600	1.293	0.751	2	3	2
Construct new fire trail	0.896	1.500	2.496	1.590	3	4	3
Conduct community awareness programmes	1.426	0	0.792	−0.634	1	1.5	1
Selective removal of mid-storey vegetation	1.345	0	3.365	2.020	4	1.5	4

The ranks are based on net benefits, capital costs and total costs

adaptation actions. In the real world, where councils have limited funds and an abundance of competing priorities for investment, it is very natural that climate adaptation actions fail to be implemented because of uncertainty and unpredictability. The benefit of this research is that it delivers timely climate action advice: local councils do not have to wait for local climate predictions from scientists to become available at their jurisdictional resolution. The focus of this tool is to help councils consider the benefits and constraints of their most likely, or most preferred, investment options. The prioritized listing of available options tries to balance environmental and social benefits as well economic parameters. We hope to develop a climate decision-making tool of international applicability and hence we plan to try this method on the climate extremes of Cochin Municipality, Kerala, India, in the near future.

References

Australian Bureau of Statistics (2006) Census of population and housing data. Available at: http://www.abs.gov.au. Accessed 11 June 2009

Buhlamnn H, Gisler A (2005) A course in credibility theory and its applications. Springer, Berlin

Bureau of Meteorology (2009) Climate data online. Available at: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=38&p_display_type=dataFile&p_stn_num=066156. Accessed 10 July 2009

Bushfire prone land map and bushfire evacuation risk map for Ku-ring-gai LGA (2008) Certified by the commissioner of New South Wales rural fire service. Available at: http://www.kmc.nsw.gov.au/resources/documents/Certified_Ku-ring-gai_Bushfire_Prone_Land_Map_and_Bushfire_Evacuation_Risk_Map_2-01-08.pdf. Accessed 10 July 2009

Chen K (2005) Counting bushfire-prone addresses in the greater Sydney region. Symposium on planning for natural hazards – how can we mitigate the impacts? Wollongong, NSW. Available at: http://www.riskfrontiers.com/RFfrontimages/FireAUS_NSW_paper.pdf. Accessed 11 June 2009

Chu HN, Hwang GJ (2008) A Delphi based approach to developing expert systems with the cooperation of multiple experts. Expert Syst Appl 34:2826–2840

Garnaut R (2008) The Garnaut climate change review: final report. Cambridge University Press, Cambridge, UK, p 616

Geist MR (2009) Using Delphi method to engage stakeholders: a comparison of two studies. Eval Program Plann 819–827 (in press)

Hsu CC, Sandford BA (2007) The Delphi technique: making sense of consensus. Pract Assess Res Eval 12(10)

IPCC (2007) Climate change 2007: impacts, adaptation and vulnerability. Working Group II contribution to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK

Ku-ring-gai Council (2007) Ku-ring-gai sustainability vision report 2008–2033. Available at: http://www.kmc.nsw.gov.au/resources/documents/Sustainability_Vision_Report_-_Summary.pdf. Accessed 28 June 2009

Lewis NC (2004) Operational risk with excel and VBA – applied statistical methods. Wiley, New Jersey

Lucas C, Hennessy K, Mills G, Bathols J (2007) Bushfire weather in Southeast Australia: recent trends and projected climatic change impacts. Consultancy report prepared for the climate institute of Australia. CSIRO and Bushfire Cooperative Center, Melbourne, VIC

Meel A, Neill LM, Levin JH, Seider WD, Oktem U, Keren N (2007) Operational risk assessment of chemical industries by exploiting accident databases. J Loss Prev Process Ind 20:113–127

Nordhaus W (2006) The stern review on the economics of climate change. National bureau of economic research working paper series, WP12741, December. Available at: http://www.nber.org/papers/w12741. Accessed 10 July 2009

Pitman AJ, Narasimha GT, McAneney J (2007) The impact of climate change on the risk of forest and grassland fires in Australia. Clim Change 84:383–401

Saari DG (2006) Which is better: the Condorcet or Borda winner? Soc Choice Welf 26(1):107–129

Shevchenko PV, Wüthrich MV (2006) The structural modeling of operational risk via Bayesian inference: combining loss data with expert opinions. J Oper Risk 1(3):3–26

Stern N (2006) The economics of climate change: the stern review. Cambridge University Press, Cambridge, UK

Chapter 45
Reducing Vulnerability to Climate Change and Global Market Developments

Capacity Building and Knowledge Transfer for Smallholder Farmers in Small Island Developing States as One Means to Adapt to a Changing Environment: The Case of St Lucia

Franziska Mannke and Kathrin Rath

Abstract As many crops are sensitive to changes in temperature and precipitation, agriculture is especially vulnerable to climate events. This may prove critical in tropical regions where most agriculture is in rain-fed systems and climate change may have a potentially large influence on productivity. By adversely affecting food and water resources, climate change thus threatens progress and efforts made in poverty reduction, economic growth, and achievement of further Millennium Development Goals, such as ending hunger on our planet and achieving environmental sustainability.

The intensification of food production transformed formerly small-scale traditional systems to modern large-scale monocultures, e.g. in Latin America. However, banana monoculture production by smallholders is also found in many parts of the world, for example in countries such as St Lucia, which is a major banana-producing country in the Caribbean Windward Islands.

Mono-cropping farmers increasingly need to deal with the fact that modern intensive agricultural systems which are characterized by increased need for fertilizers and irrigation, i.e. nutrients and water, may become more sensitive to climate change in terms of lower productivity, higher vulnerability, and reduced sustainability in the future. Moreover, food systems in developing countries are currently experiencing enormous organizational changes, reflected in the ongoing reorganization of supply chains, ranging from farm to fork. Being at the end of the chain, particularly the small-scale producers have to cope with global consumers' demands, reflected in the necessity to deliver high-quality products on time and at competitive prices. These high requirements can represent a serious barrier to small farmers' participation in higher value chains, e.g. in the Caribbean Island of St Lucia. St. Lucia's farmers therefore need to diversify their production, e.g. by adopting fair trade production standards, and tap new domestic as well as niche markets by means of improved commercialization to sustain food security and poverty reduction endeavors.

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Considering that small island developing states like St Lucia, where agriculture still represents the backbone of a society increasingly have to face these two global challenges – globalized markets and climate change – and recognize their impacts already today, this paper will explore the future impacts of climate change on the Caribbean region, discuss the potential impacts of climate change for smallholder agriculture in St Lucia, and elaborate on the importance of information, training and capacity building, not only in terms of improved diversification and commercialization of agricultural produce, but also for raising the adaptive capacity of small-scale farmers in St Lucia by providing sustainable adaptation options for farm-level diversification in the light of climate change.

Keywords Adaptation strategy · Agriculture · Capacity building · Climate impacts · SIDS · St Lucia

Introduction

The impact of global warming can already be noticed in many parts of the world. According to the World Bank (2005: 16), given the extent of the impacts and the irreversible character of some of the climate change impacts, the Caribbean region needs to prioritize adaptation in its comprehensive climate strategy. Given that no adaptation takes place, the World Bank (2005: 23) estimates a potential economic impact of climate change on the Caribbean Community (CARICOM) countries[1] to range from US$1.4 to 9.02 billion. It is estimated that the largest category of impacts were loss of land, tourism infrastructure, housing, other buildings, and infrastructure due to sea level rise (Fig. 45.1).

Although the agriculture sector in the Caribbean region only contributes very little to the worldwide increase in greenhouse gases (GHG), agriculture as such is a major source of GHG and has fuelled climate change in many ways, e.g. through the conversion of forests to farmland and the release of greenhouse gases. According to expert opinion, agriculture contributes 14% of global emissions (UNFCCC 2009: 2). Seen from a different angle, climate change threatens to irreversibly damage natural resources on which agriculture depends. Some regions benefit in that moderate warming may slightly increase crop yields. Overall, however, negative impacts will most likely dominate: floods and droughts will become more frequent and severe. This is likely to seriously affect productivity on the farm level, impact the livelihoods of rural communities, as well as increase the risk of conflicts

[1]The Caribbean Community (CARICOM) comprises 15 Caribbean nations and dependencies. The organization promotes the economic integration and cooperation among its members and coordinates foreign policy.

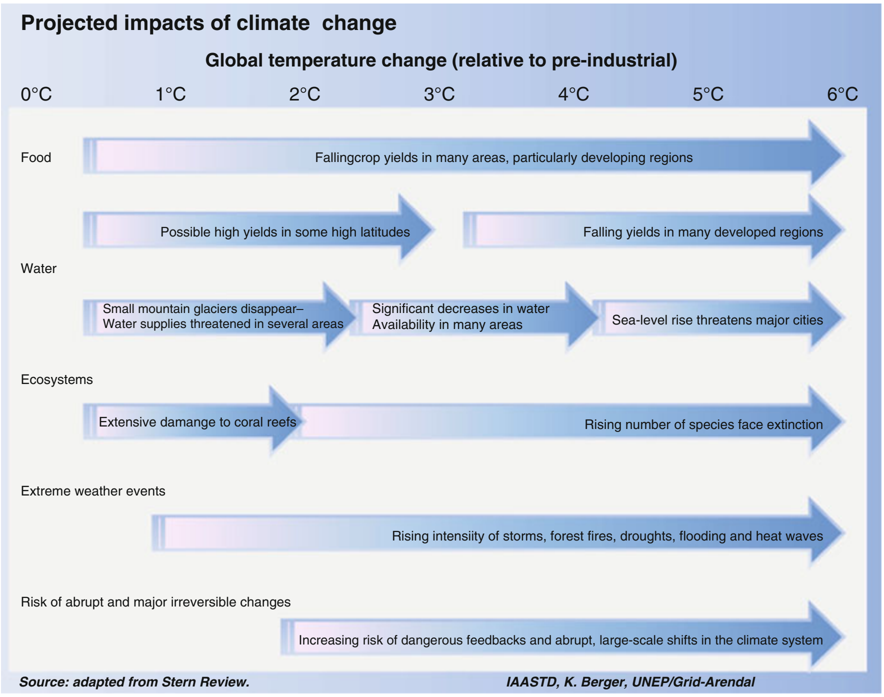

Fig. 45.1 Projected impact of climate change
Source: Stern (2005)

over land use and water resources. Furthermore, climate change contributes to the further spread of pests and invasive species and might contribute to increasing the geographical range of some diseases.

For the small island developing states (SIDS) of the Caribbean region, the impacts of climate change may lead to social impacts, as they are expected to affect all levels of rural poverty, trends in intra-national as well as international migration, the use of marginal lands, national food security, and foreign exchange earnings. As a vast majority of the Caribbean region's population relies on subsistence agriculture to at least a certain extent, the need to adapt to climate change becomes pressing, considering the impact of a changing climate regime on food production and supply (National Symposium on CC, p. 11).

The intensification of food production transformed formerly small-scale traditional systems to modern large-scale monocultures, e.g. in Latin America. However, banana monoculture production by smallholders is also found in many parts of the world, for example in countries such as St Lucia which is a major banana producing country in the Caribbean Windward Islands. In St Lucia as well as elsewhere in the world, mono-cropping farmers increasingly need to deal with the fact that modern intensive agricultural systems, characterized by increased need for fertilizers and irrigation, i.e. nutrients and water, may become more sensitive to climate change in terms of lower productivity, higher vulnerability, and reduced sustainability in the future.

Besides this, major structural changes in the worldwide agricultural industry, albeit mostly taking place in the developed countries, have far-reaching implications and may counteract efforts to develop the agricultural sector in less developed countries and, in particular, SIDS such as St Lucia. Food systems in developing countries are currently experiencing enormous organizational changes, reflected in the ongoing reorganization of supply chains, ranging from farm to fork. Being at the end of the chain, especially the small-scale producers have to cope with global consumers' demands, reflected in the necessity to deliver high-quality products on time and at competitive prices. These high requirements can represent a serious barrier to small farmers' participation in higher value chains, e.g. in St Lucia.

St Lucia's farmers therefore need to diversify their production, e.g. by adopting fair trade production standards, and tap new domestic as well as niche markets by means of improved commercialization to sustain food security and poverty reduction endeavors. In this respect, it is of key importance to consider the future impacts of climate change on agriculture and to develop adaptive capacity among the affected groups of society in order to enable them to cope with the challenges of climate change.

For purposes of this paper, adaptation will solely be viewed in terms of raising the adaptive capacity of social systems with particular attention paid to the agricultural sector. In this context, raising the adaptive capacity of small-scale farmers is therefore concerned with (a) an improved anticipation of future climatic changes, i.e. knowledge transfer and capacity building, and (b) the optimization of production systems to reduce exposure to loss of yields or to exploit new crop growing opportunities, e.g. agricultural diversification and improved commercialization.

Impacts of Climate Change in the Caribbean Region

The impact of global climate change is manifold: heat and droughts as results of global warming in parts of the world, changed rainfall patterns often combined with extreme weather events and natural disasters such as hurricanes and floods, as well as sea level rise due to the melting of polar caps. All regions worldwide are affected by climate change and have to more or less adapt to the situation.

Although only contributing very little to the global greenhouse gas emissions (GHG) which are responsible for global warming, particularly SIDS, such as the island states located in the Caribbean, have to struggle with the effects of climate change. SIDS in general only have a limited spatial size surrounded by large expansion of ocean, they only have limited natural resources as well as limited water resources. SIDS have already been facing high susceptibility to natural hazards and extreme events such as hurricanes and storm surges. The economies of small islands have the problem of extreme openness which makes them highly sensitive to external market shocks. Furthermore, SIDS have only limited financial and human resources (Nurse and Sem 2001: 845).

Due to these characteristics, SIDS, including all Caribbean islands, only have marginal adaptation capacities. This means, they have only little capacity to make "adjustments in (their) ecological, social or economic systems in response to actual or expected climate stimuli, their effects or impacts" (Nurse and Sem 2001, in Ministry of Physical Development Environment and Housing 2005: 11). In addition, they have less capability to recover from extreme events. SIDS are therefore highly vulnerable to the threats caused by the effects of climate change and sea level rise.

The climate in the Caribbean region is characterized by dry winters and wet summers with the dominate influence of the North Atlantic subtropical high (NAH). During winter, the NAH lies further south with strong easterly winds modulating the climate and weather in the region (UNFCCC 2005: 7). Temperatures in the total region vary in from 28°C in the hotter months (July–Aug) to around 24°C in the cooler months (Jan–Feb). The region, like other regions worldwide, faces a general warming. Actual temperature analysis for the Caribbean shows a warming ranging from 0 to 0.5°C per decade for the period from 1971 to 2004. Since the 1950s, the percentage of days having very warm maximum or minimum temperatures has increased considerably, while the percentage of days with cold temperatures has decreased (Mimura et al. 2007: 691). The table below shows the projected increase in air temperature (°C) relative to the 1961–1990 period. The analysis reaffirms previous IPCC projections and makes clear that a general warming up to 4.18°C more compared to temperatures in the last century is projected (Table 45.1).

With regard to precipitation, most of the Caribbean basin is supposed to become up to 25% drier in the annual mean by the 2080s (Taylor et al. 2007). The following table shows the projected change in precipitation (%) relative to the 1961–1990 periods. Regarding precipitation, the range of projections is still large, and even the direction of change is not clear. It is anticipated that similar to the changes reported from global analysis, the maximum number of consecutive dry days is decreasing while the rainfall intensity and the number of heavy rainfall events are increasing (Mimura et al. 2007: 691) (Table 45.2).

Table 45.1 Projected increase in air temperature (°C), relative to the 1961–1990 period (Mimura et al. 2007: 694)

Region	2010–2039	2040–2069	2070–2099
Caribbean	0.48–1.06	0.79–2.45	0.94–4.18

Table 45.2 Projected change in precipitation (%), relative to the 1961–1990 period (Mimura et al. 2007: 694)

Region	2010–2039	2040–2069	2070–2099
Caribbean	−14.2 to +13.7	−36.3 to +34.2	−49.3 to +28.9

Due to the generally projected decline in total rainfalls and the intensification of rainfall variability, most islands in the Caribbean are expected to be exposed to severe water stress in the future. As water resources are limited, these islands depend on surface water catchments for water supply. During the dry season, water shortages already often occur in many areas (Tulsie et al. 2001). With regard to the anticipated reduction in precipitation, it will be most likely that future water demand could not be met to serve all needs (Mimura et al. 2007).

Like other coastal areas, the Caribbean region will be seriously affected by sea level rise. According to the Caribbean Community Climate Change Center, the region experienced a sea level rise of 2 mm per year during the twentieth century (Caribbeannetnews, 19.01.2007). Although there will be regional variation, it is projected that sea level will rise as much as 5 mm per year over the next 100 years as result of GHG-induced global warming (Nurse and Sem 2001: 845). Due to the spatial limit of small islands and due to the fact that most economic activities, infrastructure, and settlements are along the coastlines, sea level rise will be one of the major challenges with the Caribbean nations will have to meet.

Another critical element of climate change, especially in the Caribbean region, is the increase in extreme climate events and natural disasters such as hurricanes and floods with regard to the danger and damage they cause. Impacts of natural hazards to the economies of small islands are disproportionally large. For example, hurricane Ivan hit the island of Grenada in 2004 and caused damages up to 200% of Grenada's GDP (Ratter 2009). One of the major threats of these natural disasters is the time it takes to recover from them. In future, due to more intense and/or more frequent extreme events, the affected islands could have less and less time to recover; the possibility exists that full recovery could never be completed. This may result in long-term deterioration of affected islands (Mimura et al. 2007: 693).

The described impact of climate change in the Caribbean region clearly underlines the vulnerability of SIDS and points to their limited adaptive capacity. Warmer temperatures, changing precipitation patterns, sea level rise, and additional and more severe extreme weather events in this region most likely mean irreversible environmental losses, decline of economies, deterioration of settlements and infrastructure, and danger and adverse health effects for human beings.

With regard to the agricultural sector, which plays a major role in the Caribbean economy, the implications of climate change amongst others are saltwater intrusion and worsening of soil conditions, loss of soil fertility and therefore lower productivity, erosion and land degradation, and an increased crop vulnerability to certain diseases due to higher temperatures and changed rainfall patterns. It is most likely that improved irrigation methods in many places are needed to solve the problem of seasonal water scarcity for water-intensive crop production. These impacts may in future threaten subsistence and commercial agriculture in the Caribbean.

The Impact of Climate Change on the Agricultural Sector: The Case of St Lucia

This chapter explores the effect of a changing climate regime on the agricultural sector of the Small Island Developing State of St Lucia and highlights the national adaptation strategies.

Impacts and Vulnerabilities

With regard to its current climate, accessible data for the island state is more or less in line with climate data for the total Caribbean region. Like agriculture in other Caribbean Islands, St Lucia's agricultural sector has shown a high vulnerability to the existing climate, e.g. to spatially and temporally unevenly distributed rainfall, and especially to some natural disasters which have affected the island during the last years (NN 2001).

To assess St Lucia's vulnerability to the impacts of climate change and in order to be able to develop adaptive strategies also for the island's agriculture sector, St Lucia's Ministry of Planning, Development, Environment, and Housing already started in 1999 to prepare St Lucia's initial national communication on climate change to the UNFCCC. As to the table mentioned below, six climate change scenarios for St Lucia have been developed, each showing a low, medium, and high case scenario with regard to GHG emissions (Table 45.3).

Table 45.3 Six climate change scenarios used in the National Climate Change Vulnerability and Adaptation Assessment

Factor	Period	Scenario	Change
Annual mean temperature change (°C) for 2050	Average	Low	+1.71
		Medium	+2.03
		High	+5.0
Annual mean precipitation change (%) for 2050	Average	Low	−1.3
		Medium	−5.2
		High	+20
Seasonal mean temperature change (°C) for 2050	Dec–Feb	Low	1.68
		High	2.00
	June–Aug	Low	1.71
		High	2.01
Seasonal mean precipitation change (%) for 2050	Dec–Feb	Low	3.4
		High	5.9
	June–Aug	Low	−14.4
		High	−6.9
Projections for sea level rise (cm) for 2050	Average	High emissions	50
		Medium emissions	39
		Low emissions	26
Tropical storms/hurricanes scenario	Average	High	+20
		Low	−20

Source: Tulsie et al. 2001: 43

Regarding the impacts of climate change, the above scenarios show an increase in the annual mean temperature, modifications in rainfall patterns especially in summer, more frequent hurricanes and tropical storms, and a sea level rise of at least 5 mm per year until 2050. Increased annual mean precipitation of 20% in the "high case scenario" and an increase of tropical storm events (+20 events) may lead to the assumption that although drought periods are extended, the surplus of precipitation will come as increased rain intensities. According the "low case scenario" the tropical storm decrease (−20 events) and the annual mean precipitation decrease by some 1.3% is tantamount to higher storm intensities (Reisdorff and Leal 2008: 6–7).

The implications of climate change to St Lucia's agricultural sector are manifold, and basically the same as what has been described for the total Caribbean region. Major challenges for St Lucia are linked to salinization and water shortages, soil erosion and loss of soil fertility, plant diseases, and tropical storm activities, which will lower St Lucia's agricultural productivity:

- *Salinity of coastal agricultural zones and loss of freshwater* due to saltwater intrusion as an impact of sea level rise will most likely destroy crops, ruin soils, or make them unsuitable for agriculture. Furthermore, a lack of freshwater for irrigation is anticipated. An increase in sea level can also result in total physical loss of agricultural lands and pasture for livestock (Tulsie et al. 2001).
- *Periods of low precipitation and extended dry periods* will result in water shortages for irrigation and therefore in a loss of soil moisture; they will weaken the crops prone to insect attack and diseases such as the Black Sigatoka disease; and will be responsible for an increase of agricultural pests due to the alteration of the soil microorganism balance on the one hand (Tulsie et al. 2001).
- *Increased concentrated precipitation due to heavy rainfall and storm surges* will lead to flooding of agricultural lands and to excessive soil erosion and loss of nutrients. Especially on St Lucia, the problem of soil erosion and leaching of nutrients may become a major problem as the banana cultivation was extended to upper catchment areas and steep slopes in recent years (Reisdorff and Leal 2008).
- *Rising intensity of extreme climate events* such as hurricanes may not only lead to the destruction of crops and livestock but also to the destruction or damage of agricultural infrastructure and to the loss of farm lands (Tulsie et al. 2001).

In Aug 2007, hurricane Dean hit St Lucia and caused severe damage to the total country, to the agricultural sector, and especially to the banana industry. Bananas are St Lucia's main cash crop product, and 85% of the banana fields in the Roseau valley and 70% of the fields in the Micoud region were damaged due to overthrown and ripped out banana trees. Furthermore, the Dennery valley was completely flooded. All in all, hurricane Dean caused estimated costs of 13,200,000 ECD to St Lucia's agriculture sector including fisheries (St Lucia National Emergency and Management Organisation 2007). The photo below illustrates the damages

Fig. 45.2 Damaged banana field
Source: IICA 2007: 3

hurricane Dean caused not taking into account the damages to other affected islands which laid in the passage of the hurricane (Fig. 45.2).

All the above mentioned implications underline the high vulnerability of St Lucia's agricultural sector to the impacts of climate change. The serious damage of the island's agriculture, which is crucial for St Lucia's inhabitants and the country's economy, may lead to loss of income, increased unemployed and poverty and it will endanger the country's food security.

Adapting to Climate Change: St Lucia's National Climate Adaptation Policy

The St Lucia National Climate Change Policy and Adaptation Plan points towards the climate-related features of the island: as St Lucia is located within the trade wind belt, winds approach the island from directions between the east–northeast and east–southeast. Stronger, more northerly winds occur from December to May. Average temperatures in St Lucia are around 27°C; the relative humidity is 75%, with little variation. A dry season from January to May and a wet season from June to December are characteristic for St Lucia's climate. During times of heavy rainfall, flooding often occurs in the low-lying areas. The island is vulnerable to tropical storms and hurricanes which occur in the Western Atlantic between the months of July and November each year, and has during the last decades suffered from a number of storms and hurricanes. The high concentration of infrastructure (hotels, ports, roads, settlements) located along the coast, often in low-lying reclaimed areas contributes to an increased vulnerability. In its national climate change policy, the government of St Lucia clearly states that climate change may impact agricultural production which is important for national food security, as well as for the generation of employment and foreign exchange. In the light of these aspects, and given St Lucia's geographic location within the hurricane belt, its small land size and the location of major settlements and infrastructure in low-lying coastal areas prone to flooding and storm damage, the island government regards St Lucia as highly vulnerable to climate change impacts (GOSL 2003: 1–11).

To cope with the threats of climate change, St Lucia is, on the one hand, contributing to several Caribbean-wide programmes and projects such as the Caribbean Planning for Adaptation to Climate Change Project (CPACC) and the Special Programme on Adaptation to Climate Change (SPACC). On the other hand, St Lucia's government has identified country-specific adaptation strategies within its initial national communication on climate change documentation. Adaptation options for agriculture in documentation vary from:

- Changing land topography to reduce water run-off and soil erosion
- The introduction of salt-, heat-, and drought-tolerant crops
- Improved irrigation systems
- Farm relocations and
- An improved pest and disease management

During the National Symposium on Climate Change and Food Production, held in the Cara Suite Hotel, St Lucia, on 21 July 2005, the following specific measures were suggested as options to the implications of climate change (GOSL 2005: 11):

- Production adjustments at the micro-levels
- Income diversification and insurance schemes at the market level
- Pricing policy adjustments
- Income stabilization options at the institutional level
- Development and promotion of new crop varieties at the technological level

Additionally, scientific work such as data collection and analysis and crop research is deemed to be necessary to support adaptive strategies. Major barriers to almost all adaptive options are related to limited technical and financial resources, limited stakeholder awareness and limited technical and institutional capabilities, as well as to existing market arrangements and market constraints (NN 2001).

Agricultural diversification in line with capacity building as one additional adaptive strategy in order to reduce St Lucia's agricultural vulnerability – and especially the vulnerability of banana production – to the impacts of climate change is also required by different stakeholders such as IICA (IICA 2008) and the Ministry of Planning, Development, Environment and Housing (Tulsie et al. 2001). The EU-funded AGIL-project "Banana commercialisation and Agricultural Diversification in St Lucia", which will be elaborated later, acts on this challenge.

The Transformation of Food Systems and the Consequences for Smallholder Banana Production in the Caribbean Region: The Case of St Lucia

The Caribbean island of St Lucia, belonging to the Lesser Antilles, has a population of more than 160,000 people. St Lucia belongs to the category of Small Island Developing State (SIDS) and is characterized by an open, developing economy with limited human and financial resources that is heavily dependent on tourism and agriculture (GOSL 2003: 2–11). The independent small island state is located between the Caribbean Sea and North Atlantic Ocean, north of Trinidad and Tobago. St Lucia is volcanic and mountainous with some broad, fertile valleys. The island is 43 km long and 22.5 km wide; settlements and activities are primarily located along the coasts and in the valleys. With a total land area of approximately 616 km^2, St Lucia has 158 km of coastline. According to the CIA World Fact Book (2009), only 6.45% of the total land is reported to be arable land, with permanent crops being cultivated on 22.58% of the area. In 2003, approximately 30% of the arable land was under irrigation. The major agricultural products grown are bananas, coconuts, vegetables, citrus, root crops, and cocoa. In line with this, its main export commodities are bananas (41%), clothing, cocoa, vegetables, fruits, and coconut oil. History and welfare in St Lucia are closely linked to commodity exports. Banana is still the main agricultural crop, but the banana industry is declining due to the loss of preferential trade regimes as a result of global trade liberalization policies. The economic and social consequences of these changes in the agricultural sector are said to be responsible for a substantial increase in poverty. According to the St Lucia Poverty Assessment (Kairi Consultants 2006: xvi), poverty by headcount increased to 28.8% in 2005; overall, the country is classified as a lower-middle income country.

For St Lucia, tourism and agriculture represent the two main pillars of its economy, with tourism being the island's most important source of foreign exchange. Today, the services industry accounts for almost 80% of the country's gross domestic product (GDP), with tourism contributing approximately 40% of the island's GDP; in contrast, the proportion of agriculture in the GDP fell from an average of 14% during the 1980s to 5.5% in 2004, down to 3% in 2008 (OECD 2006: 94; IMF 2006; WTTC 2008; SEDI 2008). However, in spite of its declining contribution to the small island's gross domestic product and corresponding total area of agricultural holdings, the agricultural sector still plays a significant role in the country's socio-economic development, in terms of food security, employment, and poverty reduction (MAFF/GOSL 2007: 13–15).

Concerning the transformation of food systems, global agriculture is struggling to keep pace with increasing demands for food as human population increases and food preferences alter. The global economic development has resulted in major global shifts in consumption, marketing, production, and trade. McCullough et al. (2008: 4) lists four key driving forces associated with economic development which drive the transformation of global food systems and impact producers in developing countries:

- Rising incomes
- Demographic shifts
- Technology for managing food chains
- Globalization

Moreover, through increasing integration of world markets resulting from multilateral trade liberalization and structural adjustment programmes especially in the developing world, farmers in the developing world are now, more than ever, linked to consumers and companies of the developed world.

The transformation of agricultural production systems can be observed as the level of organization in retail rises, the level of specialization of wholesale increases, and the scope of formalized procurement grows. This implies that production systems not only in developed, but also in developing countries, are becoming more commercialized. These commercialized systems show specialization at the farm level, greater dependence on purchased inputs, and more marketing of outputs (McCullough et al. 2008: 23). Being at the end of the chain, small-scale producers have to deal with global consumers' demands, reflected in the necessity to deliver high-quality products on time in a given volume at competitive prices. These high requirements can represent a serious barrier to small-scale farmers' participation in global food export and local markets, and higher food value chains in particular.

Challenges of Smallholder Windward Islands Banana Production

The specific banana production environment in the Windward Islands is characterized by a number of factors which prevent farmers achieving the high level of production and productivity common in other banana producing regions. In 2000, Reid estimated the total area under cultivation in the Windward Island region at over 30,000 acres, with most of the cultivated land under drought stress during the dry period (January to June). According to Reid (2000: 45), some of the key banana production problems include:

- The *rain-fed nature of banana production* characterized by severe water deficit in the dry season causing crop loss
- The *difficult production environment*, with particular reference to steep slopes and shallow soil depth, high level of soil acidity, and poor native soil fertility
- *Soil acidity* – farmers have to use large amounts of fertilizers and to apply limestone in an effort to ameliorate the adverse effects of the soil acidity
- A relatively *high level of field losses*, estimated at 20–30%, resulting mainly from the ravages of nematodes and the corn borer
- The *high cost of "high quality" inputs* to farmers, who may not be able to use these at the recommended rates

- The *high cost of controlling leaf spot disease* in the rugged terrain and highly variable agro ecological zones in the Windward Islands
- The *shortage and high cost of labour* in banana production (over 60% of the total cost of production)

These factors contribute to the relatively low average yields of 6–8 tonnes per acre obtained on most farms. This relatively low average yield is regarded as a major factor resulting in high unit cost of banana production. Labour is estimated to account for over 50% of the total cost of production, with material inputs representing approximately 30% and management and capital 20% (Reid 2000: 45).

The lower cost of production faced by other banana producers will enable them to operate profitably in a liberalized market for bananas. The relatively higher cost of production by the Windward Islands banana producers requires that they increase their productivity if they are to stay competitive in the banana market. Windward Islands producers are required to narrow the productivity gap between local production and that of other banana producers (Reid 2000: 45).

Growing evidence suggests that it is only access to the Fairtrade markets which allow farmers to receive a premium on top of the market price for their produce that is enabling the Windward Islands industry to survive: According to latest figures for banana shipments from the Windward Islands, the average proportion of Fairtrade bananas grew from 29% in 2005 to 72% in 2006 (Fairtrade, 20 June 2009).

Constraints and Opportunities of Banana Production in St Lucia

In 2007, more than one-fifth of the population lived on agricultural holdings located in rural areas, most of which are nowadays small-scale farms (MAFF 2007: 13).

Constraints

According to the 2007 St Lucia Census of Agriculture, the continuing decline in number and area of agricultural holdings in St Lucia is the most striking result of the overall transformation of food systems. Compared to 51,328 acres in 1996, the total land area in these holdings fell to 30,204 acres in 2007, representing a decline of 41.1%. The largest loss in the number of holdings and area was observed in the largest farms: more than 70% of farms with more than 100 acres disappeared in 2007. Small farms thus dominate St Lucia's agricultural sector (GOSL 2007: 4–6).

Table 45.4 Number of trees in St Lucian agricultural holdings 1986–2007.

Number of selected trees (1986–2007)			
	1986	1996	2007
Banana	11,839,400	11,376,220	5,042,412
Plantain	329,300	606,731	1,103,603
Coconut	846,200	560,880	280,001

Source: GOSL 2007: 12

Moreover, and in line with the decrease in the number of holdings, the dismantling of preferential trading agreements has resulted in the sharp decline in banana production and significant reductions on agricultural export earnings. The apparent abandonment of banana plots has contributed to the decrease in land used for permanent and medium term crops in total land holdings. The following table illustrates this decline of banana production by stating the decline in number of banana trees (Table 45.4).

Between 1992 and 2004, annual export volumes showed a considerable decline, from 135,000 tonnes down to 42,000 tonnes. Accordingly, banana export revenues declined from US$71m to US$31m. Simultaneously, the number of banana farmers fell from 10,000 in the early 1990s to 1,552 in 2007 (Fairtrade, 20 June 2009; AGIL 2009: 4).

In spite of this development, banana production remains central to the agricultural sector in St Lucia, although the impacts of globalization, multi-lateral liberalization and increasingly unfavourable banana trade regimes, especially for small-scale farmers, resulted in a major decline of exports and the number of farmers. Bananas still represent the dominant export crop of the island, contributing over 70% of total agricultural exports between 2002 and 2006 (GOSL/MAFF 2007: 1).

According to Polius (2000: 57), and in line with the problems of banana production mentioned before, the following factors contributed to the apparent movement away from bananas:

- Uncertainty about future market development
- Shortage of available labour
- High cost of production/labour
- High cost of inputs, e.g. fertilizers
- Yield losses due to drought, pests and diseases and
- Declining soil productivity

In St Lucia, banana has dominated performance in the agricultural sector. The fortune of the sector is seen as being closely tied to this commodity. Since the early 1990s, Caribbean banana exporting states such as St Lucia needed to adapt to changes to the banana import regime in Europe. Consequently, the production systems had to be adjusted to increased competition and lower prices. Within these adjustment processes, the government of St Lucia embarked on a strategy to diversify the agricultural sector, focusing on the fresh produce sector, in particular vegetables, fruits, root crops, and horticulture. Underscoring the need to adjust to major global shifts in consumption, marketing, production and trade, the government of St Lucia aims to diversify the agricultural sector, not only to tap new international as well as domestic markets, but also to enhance food security, raise additional foreign exchange earnings, and lower the food import bill (Polius 2000: 55–57).

Opportunities

The increase in land use for non-traditional crops suggests that the St Lucian agricultural diversification strategy had somewhat of an effect as the land use for temporary crops such as tomato, sweet pepper, etc. increased from 4.9% to 10.8% between 1996 and 2007. However, the findings of a recent survey of St Lucian banana farmers point toward some fundamental constraints that hinder diversification:

- Unpredictable, not yet established market for alternative crops
- Established market for bananas, predictable revenue streams
- Lack of land, time, and financial means
- Age level of banana farmers

With reference to the knowledge level of the farming community, Reid (2000: 45) stated that the typical farmer has a general knowledge of the recommended practices in banana production, however fewer than 50% have in-depth knowledge and understanding of the practices. The reluctance of the farmers to diversify becomes even clearer by the result that almost two-thirds of the farmers interviewed in 2008 state that they do neither have access to information about sustainable crop alternatives nor to information about latest technologies (AGIL 2009: 21–23).

That lack of knowledge can pose a serious barrier to diversification is underscored by the findings of a recent desktop study stating that “for the export based agro-economy of St Lucia the potential economic value of a crop is as vital as its ecological value, because the limitations in arable land forces people to grow crops with high cash yields per area” (Reisdorff and Leal 2008: 3).

Two cash crops were identified to play a potential key role with respect to both economic and ecological requirements: sweet potatoes and papaya. In terms of diversification, the study suggests that these cash crops may be considered as functional key elements for the early stages of agro-forestry systems which may be installed on former banana plantations. Furthermore, the study identified peach palm as one of the fruits with the highest economic potential for export and with certain ecologically valuable features. Peach palm can be used for fruit production; it can be consumed locally or be transformed into higher value goods, i.e. processed food for both local and export markets. Key recommendations of the analysis pointed out that export crop revenues may be increased by improvement of production systems, i.e. fair trade and organic certification (e.g. banana, pepper, ginger), by quality improvement (banana, cocoa) and/or by the development of a small local food industry fulfilling EU standards (Reisdorff and Leal 2008: 3).

Strengthening Adaptive Capacity of the Agricultural Sector in St Lucia: The AGIL Project

The Caribbean region, including St Lucia, shows the following general characteristics (GOSL 2006 – Report National Symposium on Climate Change and Food Production 2005, p. 8):

- Tropical and low-lying coastal states
- Very prone to extreme weather events
- Diverse cultures, environments, and food provision systems
- High reliance on imported foods
- Dependency on export crops, tourism, and other non-food sectors for foreign exchange revenues
- Loss of preferential export trade regimes
- Continuing dependency on preferential agricultural markets (bananas, sugar)
- Lack of regional-level institutional connectivity
- Non-traditional agricultural markets (rice, coffee, cocoa, root crops, and vegetables)

Adaptive Capacity Building in the Frame of National Adaptation

A range of limits and barriers exist which need to be addressed for effective adaptation to climate change:

- Physical and ecological limits
- Technological limits
- Financial barriers
- Informational and cognitive barriers
- Social and cultural barriers (Adger et al. 2007: 733–737)

Addressing these aspects relates to the assessment of the so-called adaptive capacity. The International Panel on Climate Change (IPCC) defines the adaptive capacity as "the ability or potential of a system to respond successfully to climate variability and change [including] adjustments in both behavior and in resources and technologies" (IPCC 2007: 21). Adaptive capacity is regarded as a prerequisite for the pursuit of effective adaptation strategies in order to mitigate the harmful impacts of climate change. A positive aspect of adaptive capacity is the fact that, according to the IPCC, it enables sectors and institutions at the same time to take advantage of opportunities and benefits from climate change, for instance longer growing seasons or increased potential for tourism (IPCC 2007: 21). According to the IPCC, the human and social capacities are viewed as key determinants of adaptive capacity on all scales. Furthermore, it is argued that these aspects had the same relevance as income levels and technological capacity (IPCC 2007: 27).

In St Lucia's National Climate Change Policy and Adaptation Plan, three main policy objectives comprise (1) the development of processes, plans, strategies, and approaches to mitigate climate change impacts; (2) the development of a climate-proof regulatory environment; and (3) the design of economic incentives to encourage public and private sector adaptation measures (GOSL 2003: 6). Correspondingly, a range of policy directives for the agricultural sector have been formulated, which also need to be taken into consideration to ensure the sustainability of agricultural projects that deal with knowledge and capacity building (GOSL 2003: 11–12):

1. *Development of a sound basis for decision-making*, by conducting further and more detailed research to assess, inter alia:
   - Risks posed by climate change to the productivity of agricultural crops, and to food security (specific attention placed on potential impacts on banana, cocoa, and other commercially important crops)
   - Impact on water availability for agriculture (specific attention on irrigation)
   - Impact of climate change on soil productivity and soil management (specific attention on salinization, erosion, etc.)
   - Impact of climate change on pest–crop interactions
2. *Development of a national adaptation strategy for the agricultural sector* to address impacts over the short, medium, and long term
3. *Incorporation* of the national agricultural adaptation strategy into national physical and spatial planning process
4. *Inclusion* of adaptation policies into the national policy formulation process
5. *Adoption of appropriate adaptation measures* to address areas of *immediate need* where this does not jeopardize or contradict the development of long-term, sustainable strategies for the agricultural sector. Such measures may include soil conservation measures and construction of water storage and irrigation facilities for crop production
6. *Formulation and implementation of any other such strategies and measures* which may help to ensure food security sustainable food production and sustainability of forest resources

The AGIL Project as a Means of Capacity and Knowledge Building for Human Adaptation

To the disadvantage of St Lucia's banana farmers, the banana exporters from the ACP region, e.g. Costa Rica, have increased their exports to the EU market as they can produce at lower cost (Mather 2008: 3). According to Reid (2000: 45), the relatively higher cost of production by the Windward Islands banana producers does require that they increase their productivity, i.e. build capacity in terms of production knowledge and application of new technology, if they are to successfully stay competitive in the market for bananas. Building this knowledge and capacity involves anticipating future climatic changes and their potential impacts on crop production.

To support the transition of the agricultural sector, St Lucia receives funds from the European Special Framework of Assistance (SFA), which was designed to facilitate economic adjustment and diversification of particularly those groups historically dependent on the banana business. In this respect, St Lucia's banana farmers obtain assistance to adapt to new market conditions and, furthermore, improve their competitiveness in terms of producing high-quality crops through raising the efficiency of production and building capacity for better commercialization, as well as supporting agricultural diversification.

In order to motivate the remaining farmers to remain in the banana industry, grow more competitive and adopt new approaches, the project "Banana Commercialization and Agricultural Diversification in St Lucia (AGIL)" is being conducted in the course of this SFA: the AGIL project aims to assist with the development of rural communities in the Caribbean island of St Lucia by undertaking a set of initiatives related to human resource development and training. The project duration is 1.1.2008 until 31.12.2010.

The set of actions envisaged as part of this project include consultancy, training workshops, and seminars on the one hand, complemented by coaching within businesses as well as a business-friendly system of advice on the other hand, which caters for the needs of small enterprises and the realities of small farmers. The partnership of the EU-funded project entails the Research and Transfer Centre "Applications of Life Sciences" at the Hamburg University of Applied Sciences, Germany (the European partner) and the Sir Arthur Lewis Community College (the St Lucian partner). There is also a network of national and international agencies involved in the project and taking part in its activities.

In methodological terms, the project is organized into five sets of activities:

1. *Project management* involves the overall project management, administration and reporting, as well as the coordination of the partners.
2. *Assessment of needs* entails an assessment of the current state-of-the-art with respect to training and information needs seen in the agricultural sector as a whole and in rural communities in particular, complemented by an overview of the elements that hinder investment and access to capital in the country.
3. *Capacity building* develops and implements a capacity-building programme which enhance the capacity of target beneficiaries (approximately 200 entrepreneurs, 20 agribusinesses, and around 20 agencies such as farmer and other rural organizations) and will involve training workshops and seminars around the island of St Lucia to achieve greater agricultural diversification, inform on technologies, and improve access to capital.
4. *Consultancy, coaching and on-site support* entails the undertaking of consultancy, advice, and coaching within agribusinesses to improve access to technology and the relevant capital, thus helping them in the areas of market strategies to improve domestic and international market penetration. Activity 4 also entails the provision of training to at least 20 agencies (e.g. farmer and rural organizations) for the

improvement of data management and dissemination systems, as well as to provide support to stakeholders in the application of data and information for effective decision-making.

5. *Networking, information and dissemination* is a complementary measure in the execution of the project; a network will be established, linking all relevant stakeholders. In addition, information about the project will be disseminated. By means of these measures, a lively network will be maintained and information about the project will be systematically disseminated.

As illustrated in Fig. 45.3, the project takes a participatory approach, involving multiple stakeholders and beneficiaries to maximize the impact of the activities: farmers and farm workers are at the heart of the capacity-building project. By means of a comprehensive assessment of needs, involving two hundred banana farmers and an additional two hundred non-banana farmers, specific training objectives could be defined. In the following, a capacity-building programme was set up which includes topics such as theory and practice of international trade; trade of perishable products; the adoption of production systems to meet domestic and international trade requirements and standards; awareness raising on aspects of product diversification, presentation, labelling, market packaging, and distribution systems (Fig. 45.4).

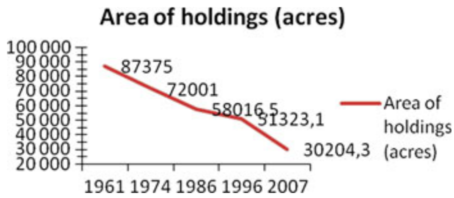

Fig. 45.3 Total area of holdings 1961–2007 (acres)
Source: GOSL 2007: 5

Fig. 45.4 Actors and beneficiaries of the AGIL project
Source: own visualization

A case study of a training session on improved pesticide management may serve as a concrete example of the knowledge and capacity-building activities of the AGIL project.

Case Study: AGIL/BMU Pesticide Training 2009

Rationale

The Musa species, which, besides banana, also includes plantain and highland banana, is prone to pests and diseases. A major constraint to Musa production in lowland tropical humid areas, e.g. in the valleys of St Lucia, is the Black Sigatoka disease. This disease can cause 40% yield loss due to incomplete finger filling. In spite of the still unknown impact of climate change on crop–pest relationships, and as temperature is likely to increase due to global warming, pests are expected to become more damaging.

In St Lucia's banana industry, farmers currently use fungicides to combat these pests; however, theoretical as well as hands on knowledge on appropriate techniques, types, and amounts of fungicides is often lacking or incomplete. With increasing rainfall due to climate change, this spraying strategy might become less effective as higher precipitation will result in greater runoff of the fungicide, requiring either better formulations or more frequent spraying which further reduces profitability of production (Nicholls et al. 2008: 9–11). Consequently, there is a pressing need for alternative control methods (Fig. 45.5).

Fig. 45.5 Pesticide spray worker in protective working outfit
Source: AGIL project

Scope

Within the frame of the AGIL project, a training module on the issue of pesticide management has been designed and implemented by means of a set of training workshops. The three key aims of the training module were:

- To assess and develop candidates in competence of spray operators to meet standards set by the certification authority
- To ensure that candidates are competent in their general knowledge of pesticides, crop protection, hazards, international standards for food production, and good agricultural practices
- To ensure that candidates have basic knowledge and competence in the safe use of pesticides used in commercial banana cultivation

The pesticide workshops were held at different locations of the island over a period of 2 months, since the needs assessment revealed that trainings should be conducted not only in Castries but also in the south and southeast of St Lucia, where most of the banana producers are located (AGIL 2009: 38).

Results

In close cooperation with the Banana Production Management Unit (BPMU) of the State Ministry of Agriculture, Fisheries, and Forestry, the AGIL project conducted a series of workshops for farm workers and spray operators. To reach the objectives of the envisaged training, the following topics were covered in a total of six 2-day training sessions:

- Health and safety management
- GAP/record keeping
- General sanitation on the farm
- Hygiene and safety for fruit farmers (GGP)
- Occupational health and safety
- Leaf spot disease
- Pesticides and other chemicals
- Pesticides and toxicological chemical legislation
- Principles of pest management

In these workshop sessions, a total of 254 farmers benefited from the training, with each training session comprising two full days of formal and informal learning, i.e. lectures were held in classroom and on the field (see pictures below) (Fig. 45.6).

In terms of project relevance, the BPMU training sets contributed to project objectives in the implementation of the capacity-building programme to enhance the capacity of farmers and spray operators to adopt sustainable technologies and skills required for continued compliance to local and global industry standards.

Fig. 45.6 BPMU workshop utilizing formal and informal learning methods
Source: AGIL project

Fig. 45.7 Award ceremony for successful participation in pesticide training
Source: AGIL project

As proof of having achieved the learning target, each participant received a certificate of competence for having been trained in the respective subject area at the end of the workshop. Concerning the further dissemination of key learnings, the training content as well as any other material and studies produced in the framework of the capacity-building project are accessible through the AGIL project website (www.st-lucia-project.eu), fulfilling EU visibility and dissemination criteria (Fig. 45.7).

Conclusion and Recommendations

Owing to limited endowments with land, labour, and capital, St Lucia's banana farmers cannot compete on price with the large-scale Latin American producers who can exploit economies of scale. Furthermore, consumers demand high quality produce throughout the year, posing additional challenges to smallholders who often lack efficient production methods and financial resources. The remaining options for staying in the agricultural business are twofold (a) St Lucia's farmers need to diversify their production, e.g. by adopting fair trade production standards that promise premium prices yet demand compliance to specific production standards as well; and (b) tap new domestic as well as niche markets by means of improved commercialization.

The current constraints St Lucia's banana farmers experience may worsen given the projected changes in climate, unless diversification activities take into account climate change impacts and adaptation options as well.

The coastal agricultural land will suffer from salinity and loss of freshwater due to sea level rise. Consequently, saltwater intrusion may destroy soils or even result in total loss of land and pasture for livestock. Farm relocation could be an adaptation option, if alternative suitable land were available.

The terrain for banana production, with approximately 50% of the area cultivated to bananas on slopes greater than 20°, does not allow for mechanical harvesting, posing not only a natural limit to the maximum productivity of banana production, but also increasing the risk of erosion. Increased concentrated precipitation may lead to flooding, soil erosion, and loss of nutrients. Reducing water runoff and soil erosion through technological means, e.g. wells or storage facilities, as well as agro-forestry measures, could foster the adaptation to this climate impact. However, this requires a certain investment and technological knowhow. At the same time, new ways of financing for agricultural investment should be designed by the government.

Most of the land is subject to drought stress during January to June. Periods of low precipitation and extended dry periods are expected to result in water shortages for irrigation and, consequently, loss of soil moisture. In addition, crops become more vulnerable to insect attack and diseases. Improving water management, e.g. by using irrigation and water storage technology, could prove an effective means of adaptation. However, this also requires a certain financial investment as well as technological expertise.

The current production of bananas in St Lucia is all based on a conventional system that involves a high input of synthetic pesticides and fertilizers. Raising temperatures and declining precipitation, coupled with the depletion of fossil fuels, i.e. anticipated rise oil price, may negatively impact small farmers in particular, who often lack financial resources to purchase additional pesticides and fertilizers to increase crop yields and combat plant diseases. Diversifying the agricultural production through switching production to new cash crops or species with higher heat and drought tolerance is an adaptation option. Correspondingly, more research in crop species should be funded and new ways of financing for agricultural investment should be designed by the government. To provide incentives for raising producers' knowledge level to ensure compliance with new production methods, these credit lines could require proof of adequate further education in sustainable production.

The AGIL project is viewed as a means of adapting sustainable agricultural technologies and efficient practices at a local level. Pretty and Hine (2000: 11) underscore that these arise from new configurations of social capital, e.g. new partnerships between institutional stakeholders, and human capital, e.g. management skills and knowledge. It is argued that agricultural systems that show a high level of social and human capital are able to innovate in the face of uncertainty.

As the impacts of climate change will most likely disadvantage SIDS due to their inherent constraints, more capacity-building projects focusing on climate change implications for the agricultural sector and further climate impact research is needed in this region to raise the adaptive capacity of small tropical islands like St Lucia and foster their sectoral and cross-sectoral mainstreaming of climate adaptation practices.

References

AGIL (2009) Survey of banana farmers training needs, AGIL project report, January 2009. Hamburg University of Applied Sciences, Hamburg

Chakeredza S, Temu AB, Yaye A, Mukingwa S, Saka JDK (2009) Mainstreaming climate change into agricultural education: challenges and perspectives. ICRAF Working Paper No. 82, World Agroforestry Centre, Nairobi, Kenya

GOSL (2003) St Lucia National climate change policy and adaptation plan. Government of St Lucia, Ministry of Physical Development, Environment and Housing, St Lucia

GOSL (2004) National development policy (NEP) and national environmental management strategy (NEMS) for St Lucia. Final draft, Nov 2004. Government of St Lucia, Ministry of Physical Development, Environment and Housing, St Lucia

GOSL (2005) Report on national symposium on climate change and food production, July 2005. Government of St Lucia, Ministry of Physical Development, Environment and Housing, St Lucia

GOSL (2007) 2006 St Lucia Agricultural Survey, Corporate Planning Unit. Government of St Lucia, Ministry of Agriculture, Forestry and Fisheries, St Lucia, unpublished document

IICA (2007) IICA's Contribution to Agriculture and the Development of the Rural Communities in SAINT LUCIA. Annual Report 2007, Mar 2008, Inter-American Institute for Cooperation on Agriculture, St Lucia

IICA (2008) IICA's contribution to agriculture and the development of the rural communities in St Lucia. Annual Report 2008, Inter-American Institute for Cooperation on Agriculture, St Lucia

Kairi Consultants Limited (2006) The assessment of poverty in St. Lucia, vol 2: The macroeconomic and social analysis of St. Lucia, Trinidad and Tobago, Aug 2006. Kairi Consultants, Trinidad

McCullough E, Pingali PL, Stamoulis KG (2008) Small farms and the transformation of food systems: an overview. In: McCullough E, Pingali PL, Stamoulis KG (eds) The transformation of agrifood systems, globalization, supply chains and smallholder farmers. FAO/Earthscan, USA

Mimura N, Nurse L, McLean RF, Agard J, Briguglio L, Lefale P, Payet R, Sem G (2007) Small islands. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp 687–716

Ministry of Physical Development Environment and Housing (2005) Report on national symposium on climate change and food production in St. Lucia, Cara Suite Hotel, St Lucia, 21 July 2005
Nurse L, Sem G (2001) Small islands. In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (eds) Climate change 2001: impacts, adaptation and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp 845–870
OECD (2006) Caribbean Rim, Antigua and Barbuda, Grenada and St. Lucia, OECD investment policy reviews. Organization of Economic Cooperation and Development, Paris
Polius J (2000) Brief overview of banana production in St Lucia. In: Holderness M, Sharrock S, Frison E, Kairo M (eds) Organic banana 2000: towards an organic banana initiative in the Caribbean. Report of the International workshop on the production and marketing of organic bananas by smallholder farmers. International Network for the Improvement of Banana and Plantain, Montpellier, France
Pretty and Hine (2000) Reducing food poverty with sustainable agriculture: A summary of new evidence. Final Report "SAFE-World" Research Project, University of Essex, UK
Ratter BMW (2009) Global climate change and its implication for small islands, presentation in the context of the European Climate Teach-In Day, 5 June 2009
Reisdorff C, Leal W (2008) Diversification of the agro-economy of St. Lucia: identification of cash crops and service plants for cultivation systems adapted to the economic needs and pedoclimatic conditions. A desktop study. Hamburg, July 2008
St Lucia National Emergency and Management Organisation (2007) Damage assessment and needs analysis. Report on the Passage of Hurricane Dean, St Lucia National Emergency and Management Organisation, St Lucia
Taylor MA, Centella A, Charlery J, Borrajero I, Bezanilla A, Campbell J, Rivero R, Stephenson TS, Whyte F, Watson R (2007) Glimpses of the future: a briefing from the PRECIS Caribbean climate change project, Caribbean Community climate change centre, Belmopan, Belize, p. 24
Tulsie B, d'Auvergne C, Barrow D (eds) (2001) Saint Lucia's initial national communication on climate change. In response to its commitments under the United Nations Framework Convention on Climate Change. UNFCCC, USA
UNFCCC (2005), Vulnerability and adaptation to climate change in small island developing States. Background paper for the expert meeting on adaptation for small island developing states. United Nations Framework Convention on Climate Change, USA
WTTC (World Tourism and Travel Council) (2008) The 2008 Travel and Tourism Economic Research – Carribean. TSA Tourism Satellite Accounting, London

Internet Resources

Adger WN, Agrawala S, Mirza MMQ, Conde C, O'Brien K, Pulhin J, Pulwarty R, Smit B, Takahashi K (2007) Assessment of adaptation practices, options, constraints and capacity. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp 717–743. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter17.pdf. Accessed 20 Apr 2009
CARDI (Caribbean Agriculture Research and Development Institute). http://www.cardi.org/default_print.asp?id=25
Caribbeannetnews.com. http://www.caribbeannetnews.com/cgi-scrpit/csArticles
Caribbean Community Climate Change Centre. http://www.caribbeanclimate.bz/page.php?9 http://www.caribbeanclimate.bz/page.php?10 http://www.caribbeanclimate.bz/page.php?12 http://www.caribbeanclimate.bz/page.php?920http://www.montrosetravel.com/cs_cclimate.html

IAASTD (2008) Agriculture and development. A summary of the international assessment on agricultural science and technology for development. www.greenfacts.org/en/agriculture-iaastd/. Accessed 18 Apr 2008

IMF (2006) IMF Country Report No. 06/325, St Lucia. Statistical Appendix, International monetary found. http://www.imf.org/external/pubs/ft/scr/2006/cr06325.pdf. Accessed 15 May 2008

IPCC (2007) Summary for policymakers. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp 7–22. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf. Accessed 19 Jan 2009

Mather C (2008) Value chains and tropical products in a changing global trade regime, ICTSD Issue Paper No. 13. http://ictsd.net/downloads/2008/07/mather_issuepaperno13.pdf. Accessed 12 Oct 2008

NN (2001) Climate change technology needs assessment for St. Lucia. http://ncsp.undp.org/docs/927.PDF

SEDI – Department of Trade and Tourism (2008) OECS investment gateway, Country Profile St Lucia. http://www.sedi.oas.org/dttc/oecs/StLUCIA/CountryProfile.asp. Accessed 16 Jan 2009

Stern N (2005) The economics of climate change. http://www.hm-treasury.gov.uk/stern_review_report.htm. Accessed 16 Jan 2009

The Fairtrade Foundation. http://www.fairtrade.org.uk/producers/bananas/winfa/conrad_james.aspx. Accessed 20 June 2009

UNFCCC (2009) AWG-LCA Report on the workshop on opportunities and challenges for mitigation in the agricultural sector on 4 April 2009. http://unfccc.int/resource/docs/2009/awglca5/eng/crp02.pdf. Accessed 20 June 2009

Chapter 46
Social, Economic, and Political Aspects of Climate Change

Anandi Sharan

Abstract Instead of the notion that "developing countries will be able to use emissions-backed currency units to pay off their debts", we find "developing countries must forgive developed countries their United States of America dollar debts so that the emissions-backed currency unit-based climate regime can be introduced". Looking at foreign debt as it stands, India may not yet have an interest in an emissions-backed currency unit (ebcu), and other developing countries might or might not either, not until the dollar mess is sorted out. Before the introduction of the ebcu, it is important to have the demise of the dollar economies, and their demise cannot be hastened by the introduction of the ebcu because the quantum of ebcu bears no relation at all to the quantum of foreign exchange circulating in the developed country economies today. The data suggests that the old international economy based on dollars is finished. There is no way these countries can ever pay back their debt, nor should they, because they would need fossil fuels to do so. Therefore, all debts in all currencies in all countries must be forgiven. This is the same as saying the economies have to collapse. Once these economies have agreed to collapse, a new climate bank is established. Every person in developing countries gets 8.63 emissions-backed currency units and 8.63 permits (Assigned Amount Units) in the first year, declining to net zero in line with the science. Developed countries must buy their permits by selling renewable energy technology and reduce their demand for permits by eliminating greenhouse gas (GHG) emissions from over-consumption. In this period, the world thus trades gently, prudently, as India has been doing, just to get what we need from the international markets, which are basically renewable energy systems.

Keywords Cancellation of debt · Cap and share · Decline of trade · Emissions-backed currency unit · Gross foreign debt

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Abbreviations

AAUs	Assigned Amount Units (permits issued by the UNFCCC)
AOSIS	Association of Small island States
CDM	Clean Development Mechanism
CoP	Conference of the Parties
Ebcu	Emissions-backed currency unit
ETS	Emission Trading System of the European Union
IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change

Introduction

India is lower on the Global Hunger Index than at any time in its history. Like other developing countries, sustainable development in India depends on the reform of the global financial system to make the poor the engine of demand for the global economy. The demand for lifeline energy services, and adequate food, shelter, and water, as well as adequate resources to adapt to climate change, all require large volumes of public investment. India cannot fix its problems if we go it alone.

In order to achieve an equitable sustainable outcome for India and all developing countries at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties, the post-2012 agreement being negotiated at the next COP16 should consist of three, and ideally four and, for a global economy based on equitable arrangements, five parallel paths of actions.

Five Paths for Achieving Equitable Sustainable Outcomes

1. Cuts

A 50% reduction against 1990 levels by developed countries by 2020, or 80% if the Clean Development Mechanism (CDM) is still in the picture (but is it still needed? See item 4 below).

2. Contraction and Convergence

A global agreement to achieve the objective of the Convention based on the Bali Plan of Action, in which a contraction and convergence scenario will see a global commitment to a reduction to net zero tonnes of carbon dioxide equivalent per person by 2050. This is a global cut of 100% against 1990 levels by 2050. Net zero means that emissions of greenhouse gases per person are no more than the forestry sinks which the country can make available per person. (But is this fixing of cuts and trajectories still needed? See item 4 below.)

3. Country-Specific Trajectories

All countries with emissions above the equitable sustainable emissions level will track their trajectory against the commitment to achieve a reduction of emissions to the global equitable sustainable per capita level of net zero by 2050. If this is agreed, the UNFCCC would have to create country-specific emissions trajectories, to be agreed at COP16, under which each country agrees to finalize its trajectory with the Secretariat and begins implementing it thereafter. (But could this just be replaced by reporting of AAUs bought and sold? See item 4 below.)

4. Cap and Share

This involves monitoring of items 1, 2, and 3, which will be greatly facilitated if the emission reductions under path 1 above for developed countries and levelling off of emissions by developing countries to the equitable sustainable per capita emissions level under paths 2 and 3 are managed through global cap and share, and replace not only CDM, but the Kyoto system, ETS, and the proposed Waxman–Markey forms of emission trading based on "developed country takes all".

Cap and share will replace CDM as the trade relationship between developed and developing countries under the UNFCCC, and has the advantage of avoiding several peculiarities of the CDM system, such as low investment quantum compared to requirements, dependence of investments on emission reduction commitments and trading systems controlled by developed countries, the need for baselines, wrong assumptions about business as usual, and so on.

Cap and share is a simple trade regime for transfer of financial resources for new technologies to the developing countries based on equitable and sustainable per capita allocation of permits in a global regime, taking into account historical emissions, and thus making it more difficult for developed countries to escape their obligations. Under cap and share, the UNFCCC converts the global cap every year into a per capita equal emissions entitlement. It allocates these entitlements to each citizen in developing countries equally (equity based on historical responsibility dictates that developed countries get nothing), and thereafter oil importers and coal producers in all countries must buy such permits (in the UNFCCC language, these are the Assigned Amount Units – AAUs) from the banks and post offices that act as bundling agencies of these permits in each country, as citizens sell them in return for money. The money helps citizens in developing countries to some extent adjust to rising energy prices, but citizens in developed countries must cut their emissions and change their unsustainable lifestyles and sell green technologies to developing countries to earn some emissions-backed currency units with which to buy Assigned Amount Units (permits) (see below).

Developed countries will buy permits from developing countries in order to back the emissions required to build renewable energy systems for export. In any case, no producer anywhere can emit greenhouse gases if they use oil, coal, or gas that was imported or produced without being backed by permits. In this scenario, developed countries will still not be at the equitable sustainable global average very soon because they may be able to trade in green technologies, but this will not matter because developing countries will be policing the cap. On the other hand, developing countries such as India and China that are already at the equitable sustainable global per capita emissions level will continue to grow their renewable energy economy with surplus ebcus traded for green technology and investment in forestry.

The trajectories of all countries may be watched against the global equitable sustainable per capita emission level. But it is the permit system of cap and share by a new UNFCCC bank/fund/COP agency that will ensure that reductions take place. There is no need for promises to be made. Development will take place through financial flows from selling permits from permit-surplus countries (developing countries) to permit-deficit countries (developed countries). Only if a country is above the equitable sustainable per capita emissions level will it have to buy permits from outside the country. If it is below, it gains from selling permits. India will double or triple its GDP overnight and will have much needed money for development. As the permits limit oil, coal, and gas production to within the global sustainable emission reduction trajectory, the price of permits can be left to the market (but see 5). Under cap and share, monitoring of a country's emissions becomes a subset of monitoring coal, oil, and gas production, which must not take place without permits. This is a different type of policing than there has been hitherto (there has not been any) and will require cooperation from governments through their climate and energy ministries. This is not a major problem: if India wants to grow by 8–9% to serve the needs of the poor, it needs to do this with renewable and nuclear energy, as oil, coal, and gas imports will dwindle after 2020.

5. Emissions-Backed Currency Units

Unlike a real currency, the UNFCCC permits (AAUs) cannot be hoarded and they expire at the end of the year of issue. The USD and the euro, the pound sterling, and all other currencies of high emission countries will lose value rapidly as they adjust to their buying power in relation to permits. At present, there is much too much of this consumer money in circulation in developed countries, and on the other hand, money for food and livelihoods and energy equity is not circulating to the developing countries. Thus, there is a need for a new global currency backed by permits. The currency is distributed on the basis of population to developing countries, as are permits, and starts off at the parity value of one emissions-backed currency unit to one permit. Thus, if the USA needs permits, it must sell something to India for which India pays in ebcu, with which the USA in turn can buy permits for its oil or coal requirement, and there may be competition for permits which will see their price rise to 2 or 3 ebcus for one permit. In this case, the UNFCCC money management institution will recognize that there is too much demand for fossil fuels and too much global trade, and it will take these ebcus out of circulation the following year to restore the parity between the ebcu and a permit.

These are the five parallel paths of action needed. Every year, the emissions are reviewed in the context of global and country-level sinks and in the context of the suggested 650 $GtCO_2e$ budget remaining for the century. This suggestion came from an IPCC author, Mr Malte Meinshausen. The UNFCCC will move the world towards a net zero emissions of greenhouse gases regime as quickly as it sees fit. After 2050, most emissions will probably be used for high value internet communication to facilitate the UNFCCC process and so on, and all energy production and use will be based on renewable energy. The sustainable per capita emission level is assumed to be 8.63 tonnes carbon dioxide equivalent in year 1, which is the total global emissions in 2006 less a percentage for the Adaptation Fund divided by the population of developing countries and allocated to them. It is not possible to track the price of permits in ebcu at this stage, but it should never remain very far away from parity given the monetary management expected. You see in Table 46.1 for selected countries that India and other developing countries will have large volumes of emission permits to use or sell. The USA and the other countries shown in Table 46.2 below are at the opposite end of the spectrum. India has a historic interest in achieving agreement on all five paths to meet the objective of the UNFCCC.

The Gold–Dollar System and Its Demise

It is no use getting ahead of oneself and writing about economic ideas that have no bearing on the real world yet. Thus, for our ideas to move to a second stage – where details are worked out – the first stage must be completed. In so far as it is demonstrable, we wish to demonstrate here why an emissions-backed currency unit (ebcu) to replace the USD as the global trading currency will not suffer from the same shortcomings that caused the gold–dollar system of the last few decades to

Table 46.1 Surplus of permits – 8.63 AAUs in year 1

Selected countries	Emissions per person in tCO_2e in 2006	AAUs available or for sale per person
		8.6
China	5.93	2.67
Mexico	5.37	3.23
Turkey	3.46	5.14
Egypt	2.61	5.99
Brazil	2.56	6.04
Congo	1.91	6.69
Colombia	1.83	6.77
Indonesia	1.63	6.97
Angola	1.62	6.98
India	1.49	7.11
Morocco	1.45	7.15
Philippines	1.07	7.53
Sudan	0.41	8.19
Ghana	0.40	8.20
Kenya	0.37	8.23
Bangladesh	0.35	8.25
Tanzania	0.15	8.45
Nepal	0.14	8.46

Table 46.2 Gross foreign debt exceeds by far available ebcus

Country	USD/cap foreign debt	Per capita emissions	Free AAUs and free ebcus in year 1 allocated on the basis of population to developing countries
Ireland	520,956	15.87	No
Switzerland	187,725	6.75	No
United Kingdom	173,602	10.72	No
Netherlands	161,104	12.82	No
Belgium	151,314	12.79	No
Norway	115,038	5.45	No
Denmark	107,409	12.84	No
Austria	95,895	8.77	No
France	81,974	7.72	No
Germany	66,311	11.77	No
Finland	64,611	8.86	No
Spain	53,202	8.92	No
Portugal	46,627	7.41	No
Greece	44,725	11.43	No
United States	42,902	20.46	No
Italy	42,454	7.68	No
Australia	38,992	26.16	No
Slovenia	28,166	7.86	No
Canada	24,058	22.80	No
Hungary	20,947	7.23	No
Estonia	20,169	11.48	No
Latvia	18,958	−2.72	No
Japan	16,253	9.77	No
Israel	12,289	12.18	No
Croatia	11,746	5.26	No
Lithuania	10,235	4.52	No
Slovak Republic	9,801	8.50	No
South Korea	8,765	13.79	No
Czech Republic	8,429	14.01	No
Poland	6,966	9.44	No
Bulgaria	6,832	8.30	No
Kazakhstan	6,694	17.91	Yes
Chile	3,995	5.07	Yes
Russia	3,851	17.44	No
Turkey	3,822	3.46	Yes
Uruguay	3,324	2.48	Yes
Argentina	3,146	5.33	Yes
Malaysia	2,949	8.00	Yes
Ukraine	2,321	8.83	Yes
Tunisia	1,928	2.66	Yes
Mexico	1,915	5.37	Yes
Costa Rica	1,900	1.68	Yes
Georgia	1,681	1.38	Yes
El Salvador	1,674	1.19	Yes
South Africa	1,535	12.04	Yes
Belarus	1,518	8.73	No
Brazil	1,397	2.56	Yes

(*continued*)

Table 46.2 (continued)

Country	USD/cap foreign debt	Per capita emissions	Free AAUs and free ebcus in year 1 allocated on the basis of population to developing countries
Peru	1,197	1.39	Yes
Moldova	1,107	2.57	Yes
Armenia	1,028	4.46	Yes
Colombia	983	1.83	Yes
Thailand	951	4.99	Yes
Indonesia	653	1.60	Yes
Kyrgyz Republic	604	1.23	Yes
Bolivia	570	1.69	Yes
China	501	5.93	Yes
Egypt	385	2.61	Yes
India	185	1.49	Yes

collapse; and this, it is argued here, is because of the specific circumstances that make it necessary for central banks to adopt the new global currency, not as a reserve currency, but as a trading currency. Reserves, under this new system, will be in permits (AAUs) initially, but this will soon switch to reserves in the national currency only. There will be sink capacity and food production capacity, land, and suchlike all in the domestic economy and domestic currency. But it will not be possible to hoard or save the global trading currency, the ebcu, as it is linked to the declining supply of permits. As the supply of permits declines, the national currency and the national economy is absolutely more valuable. Globally it will be interesting, to say the least, whether it will still be possible or advisable, let alone desirable, for the middle class to hold property or investments in second countries. How will they get there to enjoy them, after all? It is apparent that the comparative benefits of holding an emissions-backed currency unit relative to dollars cannot be calculated. In other words, central banks cannot know what reserve policy will make their country better off – and perhaps they cannot even define precisely what "being better off" is. This was said by Milton Gilbert, in 1968, with regard to holding gold or dollars, but applies equally to ebcus. However, today we know that "being better off" at the very least means avoiding the temperature rise associated with excessive anthropogenic greenhouse gas emissions. Thus, the purpose of this section is to provide some arguments for cap and share and for adoption of the Ebcu, and to lay to rest some misgivings that people might have because of their experience of the international gold–dollar system. Ideally, this section will contribute to answering objections there still might be that have kept the nearly 20-year long proposal for a global climate bank first mooted by G77, China, and AOSIS in 1991 out of consideration, and therefore to hurry forward its acceptance at COP15.

Ever since 1898, India has provided the classic instance of the working of an exchange standard (The Gold Standard in Theory and History 1985). For at least 100 years, India has adjusted its currency system to the imperatives of the global economy, first as a colony, and then as an independent state. To understand India's position, we must first understand that the reluctance of all and sundry to criticize America is rooted in this evolution of the colonial system into what we have today. The reason America did not sign the Kyoto Protocol was that there were "few in official circles bold enough to draw the apparently logical conclusion that the dollar was in fundamental disequilibrium" (adapted from Gilbert 1968). No one questioned the value of the economic growth that was made possible by the USA's large balance of trade deficits. With or without the oil–dollar investments and the tortuous commercial banking instruments to get them into circulation of recent months and years, official circles never drew the next logical conclusion of moving to devalue the dollar, and instead they thought up – are continuing to think up – "all sorts of pseudo measures for the long run correction of the deficit". "However, there is not a single successful case of long-run adjustment of a sizeable balance-of-payment deficit – apart from the special cases of reconstruction of war damage to the productive potential of the economy. [. . .] The United States of America in particular has had a long-term programme to restore balance for 7 years and yet the goal is as elusive as ever. Failure to face up to this reflects political attitudes – not economic analysis" (Gilbert 1968). In 1964, Albert Hart, Nicholas Kaldor, and Jan Tinbergen proposed an international commodity reserve currency (ICRC). "The scheme [was] not designed to stabilize national price levels because countries are free to pursue autonomous monetary and exchange rate policies but rather it [was] intended to stabilize the 'real value' of the international unit of account" (Cooper 1982). Gold would be stabilized against the ICRC. Others proposed indexation instead. Underlying all these attempts at reform was thus the hunt for the holy grail of "real value" to control money supply globally. In recent years, several economists have proposed the reform of the international monetary system (Mundell 2009) by introducing a basket of currencies as the "real value". But today we know that the "real value" is climate stability and thus economic policy and monetary policy must adapt to become agencies to limit emissions. This in turn has led to the call for establishing cap and share on the basis of population.

Will the Supply of Emissions-Backed Currency Units be too Tight?

Consideration of the emissions-backed currency unit involves three quantities: the Ebcu, paper money (including demand deposits) called rupees, and some composite of goods and services in which members of the public are directly interested, for example a composite that we can call goods. There are three prices linking these three quantities: the rupee price of goods, the ebcu price of goods, and the rupee price of ebcus, or the other commodity terms of trade between the ebcus and other goods. Because any one of these relative prices can be derived from the other two, only two of them are independent: (Rs/goods) = (ebcu/goods) x (Rs/ebcu) or (Rs/G) = (e/G) x

(Rs/e) where G stands for Goods, e stands for ebcu and Rs stands for rupee. Inflation involves the first of these three prices, Rs/G. Because India will have a large stock of ebcus, officials in attempting to limit inflation would fix the third price, the rupee price of the ebcu. This can be done because the government has a sufficiently large stock of ebcu relative to the stock of rupees outstanding, and it can thus devote control of the supply of the rupee to that objective. Alternatively, if the economy must be managed to fit with the global economy through which ebcus and thus permits to use fossil fuels are available, inflation can be avoided by going to a pure ebcu currency in which "rupees" are ebcu.

If "rupees" are ebcu, India will in effect have the new global trading currency as its national currency. Every year, as the supply of permits tightens, the "rupee/ebcu" should become more valuable, but as its supply is limited by the cap on permits and by the need to limit global growth, the Rs/e remains constant. Economic activity is internal activity which becomes more and more independent of the availability of permits to buy fossil fuels. In India this scenario is possible because of the large ebcu surplus in relation to requirements. If on the other hand "USDs" are ebcus in America, America will also have the new global trading currency as its national currency, but it will have a deficit, as its demand for fossil fuels is much greater than its allocated permits. Thus America must devalue its currency and withdraw large quantities of USDs from circulation in order to manage its balance of payments. This process of adjusting to the ebcu will in effect be the transition to an economy designed to ensure climate stability and equal access to energy that the globe has been waiting for from the USA, but which was not possible to achieve for the USA without the rest of the world figuring out how to control the global money supply, which is the same as saying controlling America's balance of payments deficit (Everyone, incidentally, will be able to pay off their dollar loans with ebcu and thus get out of the dollar).

So whilst India will find it easy for "rupees" to be ebcus, America will find it exceedingly difficult for USDs to be ebcus in direct proportion to its inability to generate wealth without fossil fuels. In the transition, they will earn some ebcus by exporting renewable energy systems. This is because their economy in the transition requires them to demand more permits than their fair share and they thus must trade for a time to earn ebcus with which to buy permits. What will stop this system falling apart due to too tight a regulation of the global money flows and global trade is the fact that permits expire and ebcus are withdrawn from circulation if the ebcu price of a permit rises above 1. As there is no incentive to hoard (save) ebcus, trade is encouraged, until every country has a demand for ebcus that is identical to the equitable sustainable per capita supply, and trade falls off. At this point, trade will be very low, and this will occur at the very latest once caps are at the equitable sustainable level of 1 tonne per person per year in 2050; all people in the USA will be walking and cycling to work just as they do in India. Fossil fuels will hardly be burnt at all, but used for very high value purposes. Only the UNFCCC with some part of the Adaptation Fund ebcus will have some free ebcus to trade for precious oil in case its renewable energy supplies are not enough to run its giant computer. Thus, India and the rest of the developing countries that are under the equitable sustainable level of greenhouse gas emissions today will benefit from global trade in permits allocated on the basis of population; and will benefit from the introduction of the ebcu that ensures that only a recognized global trading currency can be used for buying permits, thus effectively limiting unsustainable purchasing power in developed countries and forcing them to build up their export trade in renewable energy technologies that developing countries will be able to pay for in their ebcus, which are also allocated on the basis of population.

Is There too Much Discretion?

Another objection, other than the objection above that money will be too tight, might be that the ebcu authorities are empowered to vary periodically the official price of permits, and since thus the system would embody discretion rather than automaticity, it would be bereft of its central feature, which is to introduce price stability. But this is to confuse an emissions-backed currency system with other gold–dollar systems of the past. Automaticity in global monetary affairs is an illusion and goes counter to the need to stabilize the "real value" of the international unit of account, which today is the value of the limited global resource, viz. climate stability. Thus, we are not interested in price stability primarily, but rather in the preservation of an underlying "real value". In fact, India will be able to decide as time goes on whether it allows inflation, i.e. rise in the price of goods in rupees, Rs/G. Instead of sticking to the pure ebcu currency in which rupees are ebcus, officials would allow a floating third price, the rupee price of the ebcu. This can be done as we mentioned above if the government has a sufficiently large stock of ebcu relative to the stock of rupees outstanding and if, when necessary, it devotes control of the supply of the rupee to that objective. In India, this is nothing other than what has been going on all this time in relation to the gold–dollar system. This time, however, there is no scarcity of foreign reserve currency as the limiting factor, but the scarcity of permits. Because we have less demand for permits than what we are entitled to, we have a surplus with which to buy what we need and even after the transition, we will never be in a position that is worse than where we are now, i.e. at one tonne carbon dioxide equivalent per person per year – this is provided we control population somewhat and make efforts to improve sinks, which will be easy once we no longer have to contend with the industrial model of development that was patently not suited to our purpose.

Thus, India has nothing to lose whatsoever in agreeing to a global climate regime based on cap and share, with the proviso that a new global emissions-backed currency unit must be introduced to control global trade to within the limit set by the global cap. If India wishes to continue in the global system, it has a responsibility to design a global system that works. Although others might argue that it is incumbent on the USA as the country with the deficit to solve its deficit problem, the fact is that unless the world argues strongly for the viability of an alternative, the USA will remain the de facto provider of global trade and investment capital. This scenario is incompatible with an equitable solution where everyone must have energy equity in the context of global caps to preserve climate stability.

Relationship Between Foreign Debt and Climate Stability

Let us analyse now the interesting relationship between foreign debt and climate stability – the gross foreign debt of some countries is listed in the Reserve Bank of India reports. We will analyse them in relation to their position on the emissions rankings table, with the aim of understanding the effect of introducing an emissions-backed currency unit (ebcu). Remember that the reason we are introducing the ebcu is because we found what economists have been hunting for, the holy grail of "real value" underlying the international economy and that we think they can now be pointed to global climate stability as that holy grail.

What we find is that instead of the notion that "developing countries will be able to use ebcus to pay off their debts", what we are finding is "developing countries must forgive developed countries their USD debts so that the ebcu-based climate regime can be introduced". Looking at foreign debt as it stands, India may not yet have an interest in an emissions-backed currency unit, and other developing countries might or might not either, not until the dollar mess is sorted out. Before the introduction of the emissions-backed currency unit, it is important to have the demise of the dollar economies and their demise cannot be hastened by the introduction of the ebcu because the quantum of ebcu bears no relation at all to the quantum of foreign exchange circulating in the developed country economies today. The table suggests that the old international economy based on dollars is finished. There is no way these countries can ever pay back their debt, nor should they, because they would need fossil fuels to do so. Therefore, all debts in all currencies in all countries must be forgiven. This is the same as saying the countries have to collapse – not the countries, we should say, but their economies. Once these economies have agreed to collapse, a new climate bank is established. Every person in developing countries gets 8.63 emissions-backed currency units and 8.63 permits. Then the world starts trading again – gently, prudently, as India has been doing – just to get what they need from the international market, which is basically renewable energy systems. Governments concentrate much more on doing what is right for the people, and forget about the international rat race they could not keep up with. So now we have the global ebcu economy. If the price of a permit goes above 1 ebcu, the surplus ebcus are taken out of the market the following year.

Are Emissions-Backed Currency Units Really Necessary?

Let us think it through again. We must again look at Table 46.2 below. We must again wonder what would happen if there were only caps and no global emissions-backed currency unit. Well, perhaps the renminbi would step in, and perhaps the rupee. But this transition from the United States dollar to the renminbi is fraught with difficulties because the USA and the rest of the developed countries would not go quietly. The table shows the countries with the biggest per capita foreign debts today with their per capita foreign debts in the first column and the countries with well managed economies (China, India, and Egypt) as comparison. In the second column, the per capita emissions are given. The developed countries who will not be given Assigned Amount Units or emissions-backed currency units must totally reorganize their economies to sell green technologies to earn emissions-backed currency units to be able to buy AAUs. Developing countries such as India and China have surplus ebcus with which to buy more AAUs if they want, and their domestic currency will easily be aligned with the ebcu. A developed country can only get permits by selling something to a developing country that the developing country needs and is willing to pay for in ebcus; so that then the developed countries can then use the ebcus to buy permits for their own needs.

By 2050 or earlier, there will be virtually no trade except between oil and coal producers and oil and coal consumers to the extent that the sinks in any one country allow such imports. This is what is meant by net zero emissions. National currencies will be generating local value through community economic systems, and the countries' governments will be managing the economy to ensure adaptation to climate change.

We can see that by dollar standards, neither China or India has much interest in international currency reform. Both have very low per capita gross foreign debt. But in ebcu standards, India has much to gain, and its trade with China would increase. This would help bring up renewable energy and forestry-based growth in India, perhaps. India could also trade with the USA. In any case, it is seen that the developed country dollar-debtor countries are all also emission debtors – in other words, there is a direct relationship between their profligacy in financial terms and their inability to control their emissions. Checking one, and I believe this is the argument we are making when we suggest introducing the ebcu, checks the other. It must also be remembered that the major part of China's emissions are on account of the lifestyles of these USD-debtor countries with high emissions of their own in addition. But of course checking emissions can be done just with caps. There is in principle no need for global currency reform. Or is there? Looking at the numbers, one simply cannot see the transition occurring in developed countries without total and utter bankruptcy of the countries, after which they submit to a global climate regime run democratically on an equitable basis. Experience at the UNFCCC shows that the so-called Annex 1 countries – the developed countries with high emissions – cannot be forced to cut their emissions, and this is leading to catastrophe. The high-debt countries are resisting managing their foreign debt for the same reason they are resisting limiting their emissions. Of course, ideally India would have found its holy grail earlier, in welfare, or enhancement of freedoms and suchlike, but these were all subsumed within a global economic paradigm shared with all other countries, and so even though economists tried to find something that India could specifically do that was different from what developed countries were doing, because the people were poorer and needed faster growth, in reality they did not do anything much different, but simply deployed technology, education, and monetary and trade measures according to how they were taught to increase output faster and create more jobs, with the result that India's GDP at factor cost at current prices in 2008–2009 is around Rs. 49,89,804 crore, and the average income per person is apparently Rs. 38,084 per person per year, though it is very unevenly distributed. But leaving income inequality aside, India has fallen steadily on the Global Hunger Index, and by any measure it is not eradicating poverty. Thus, a new approach must clearly be tried.

A Reality Check

One may say that economists have failed us, as indeed have politicians and political theorists who observe without prescribing and then laugh because of a sudden realization of a lack of congruence between a concept and the real objects that had somehow been thought of by way of the concept, and thus they laugh to express the incongruence, and this laughter I think is probably happening more and more frequently in the halls of academic learning and indeed in the offices of finance ministries around the world. And of course this incongruence is a laughing matter, but that is not the end of the matter, because we realize that the people of India, each individual person, and indeed each individual person on Earth, is hostage to the collective failure of these leaders to perceive things as they are, a relatively small group of people whom we here call officials, but who include politicians and other decision-makers. If we compare the gross foreign debts of the countries listed above with the emissions-backed currency units these countries may be possibly able to generate, we find that there is absolutely no correlation. In other words, these countries have been spending at the expense of climate stability, and we all stood idly by, and watched, and complained, but joined in; and we will all continue to do so, unless we wake up, and then the "we" becomes "India", and it is India who takes the lead and suggests at the UNFCCC that the global community take all hard currencies out of circulation and collapse these developed country economies and introduce the ebcu. So there we have the interesting relationship between dollars and emissions – an interesting relationship – of course, why would there not be? We are looking at the numbers for the reason that of course it is. And incidentally, it is also interesting that the expected income in the UK from the sale of emission permits through the European Emission Trading scheme as it is today, is being handled by – yes, the UK Debt Management Office, which is managing a debt of no less than US$10.746 trillion. Developed countries may have come up with the idea of emission permits, but it is up to developing countries to place them on the right footing. And in India we have known all along that there have to be equal per capita emission rights taking into account historical responsibility. An eminent professor in China also recently called for a global climate pact that would involve each country being allowed to emit a certain amount, based on their populations. So what we are saying here is nothing other than what any economist who reads and writes in order to present the facts as they are would herself say, except that we must put the whole thing in relation to the massive foreign debts of these developed countries today, and the need to collapse them as soon as possible. There will be welfare impacts of course, as there already are in Ireland. But there is no way these lifestyles can continue. All countries must have simple lifestyles – how many more different ways does this have to be said? There was a rumour that Germany does not like foreign debts because of wartime memories. The figures indicate otherwise.

Conclusion

A radical reform of the international financial system based on the introduction of a new currency has as its purpose the regulation of foreign trade so as to limit its quantum and extent in terms of atmospheric space and at the same time ensuring that renewable energy technologies are traded as intensively as possible. Only around 650 billion tonnes of carbon dioxide equivalent in the period up to 2050 should be emitted until humankind is at net zero emissions. Creating and allocating a new international trading currency based on a finite quantum of underlying emissions permits, and allocating it only to developing countries, will ensure that international purchasing power is in the hands of those who need to develop, whilst those who have technology and power will be forced to sell important technologies in order to earn enough of the new currency to engage in the structural transformation of their own energy base. Forgiving all international and national debt in domestic currencies and the United States of America dollar and other hard currencies both for developed and developing countries creates the blank slate on which to write sustainable and equitable trade relations. Domestic economies based on land, human effort, and natural resources will become the predominant source of wealth, with fossil fuel use in the transition period bringing developing countries up to the required level of renewable energy infrastructure. Outlawing the United States dollar, the yen, and the euro as international trading currencies will force these largest economies in the world to focus on their domestic economies, whilst at the same time ensuring that they engage in export of renewable energy technologies to developing countries on benign terms in the shortest possible time.

References

Cooper RN (1985) The gold standard: historical facts and future prospects. In: Eichengreen B (ed) The Gold standard in theory and history. Methuen, London, pp 251–271, ISBN 0-416-39110-9

Douthwaite R, Foundation for the Economics of Sustainability (Feasta) (2008) Cap & Share: A fair way to cut greenhouse emissions, May 2008. http://www.feasta.org/documents/energy/Cap-and-Share-May08.pdf

Eichengreen B (1985) (ed) The Gold standard in theory and history. Methuen, London, ISBN 0-416-39110-9

Gilbert M (1985) The gold-dollar system: conditions of equilibrium and the price of gold. In: Eichengreen B (ed) The Gold standard in theory and history. Methuen, London, pp 229–250, ISBN 0-416-39110-9

Grainger CA, Kolstad CD (2008) Who pays for a carbon tax? http://stanford.edu/dept/france-stanford/Conferences/Climate/Kolstad.pdf

Joshi V, Patel UR (2009) India and climate change mitigation. (This paper will be published in Helm D and Hepburn C (eds) The economics and politics of climate change. Oxford University Press, Oxford)

Meinshausen M et al (2009) Low mitigation scenarios since the AR4 – Global emission pathways and climate consequences. http://unfccc.int/files/kyoto_protocol/application/pdf/low_mitigation_scenarios_since_the_ar4.pdf

Mundell R (2009) Financial crises and the international monetary system. http://www.normangirvan.info/wp-content/uploads/2009/03/mundell.pdf

Reserve Bank of India (2008) India's external debt for the quarter ended December 2008, Ministry of Finance, Department of Economic Affairs, External Debt Management Unit, March 2009. http://finmin.nic.in/stats_data/nsdp_sdds/index.html

Sharan A (2008) Potential impacts of a global cap and share scheme on India. http://www.feasta.org/documents/energy/Cap_and_Share_India.pdf

Sharan A (2009) The potential impacts of cap and share on the United States of America. http://www.indiaenvironmentportal.org.in/content/the-potential-impacts-a-cap-and-share-united-states-america

USA Energy Information Administration (2006) International Energy Annual 2006, table h1cco2. Table posted: Dec 8, 2008. http://www.eia.doe.gov/emeu/international/carbondioxide.html

Wakeford J (2008) Potential impacts of a global cap and share scheme on South Africa. http://www.feasta.org/documents/energy/Cap_and_Share_South_Africa.pdf

Chapter 47
The IPY Legacy: Better Awareness of International Cooperation as the Basis for Increasing Arctic Navigation

Danilo Comba

Abstract The polar regions, defined as sentries, are a necessary part of scientific experimentation concerning global climate change; they constitute the engine and the archives of climate development. The polar juridical systems have recognized the importance of such research.

This essay deals with some features of the protection of the marine oceanic environment considering three main coordinates: features of the juridical regulation applicable to the polar regions; juridical problems related to Arctic sea navigation; need for strengthening cooperation between scientific research and legal regulations and international law.

The north polar states can best achieve widespread global support for management of their maritime Arctic by acknowledging the international importance of the north pole and then working through the regional framework set out by the Multilateral Agreements and the IMO to develop comprehensive regulations.

Keywords Adaptation · Arctic · Arctic Council · Awareness · Climate change · Cooperation · IMO · Knowledge · Legacy · Mitigation · Navigation · Polar · Polar code

Introduction

The issue of climate change is one of great urgency; efficient political and legal actions must be undertaken, with sustainable development and the precautionary

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principle as the main interpretative key.[1] Towards this goal, the 2007 Bali Conference launched the Bali Road Plan,[2]

> "a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, in order to reach an agreed outcome and adopt a decision at its fifteenth session" (2008)

by addressing the legal system concerning the struggle against global climate change, assuring mitigation[3] and adaptation[4] to the stated changes, based on the principle of common, but differentiated, responsibilities. Scientific research plays an essential and anticipatory role when setting the objectives to pursue.

The polar regions are necessary for scientific experimentation as well; defined as sentries, they constitute the engine and the archives of the climate developments. The polar juridical systems, although with deep differences, have recognized the importance of such research.

The 4th International Polar Year (IPY) is the Programme of the International Council for Science, ICSU, and the World Meteorological Organization, WMO, for the period 2007–2009. IPY is supporting the largest internationally coordinated scientific research effort in 50 years, to

> "initiate a new era in polar science with a stronger emphasis on interdisciplinary research".[5]

According to the most recent reports, the extension of the Arctic polar ice is decreasing at an alarming rate.[6] The cause for alarm is in the important role the sea ice plays in regulating the earth's temperature. The thinning of the ice over the past decade has been correlated with variations in the global climate.[7] In the Arctic, the average temperature has risen at almost twice the rate as the rest of the world.

In addition to ice thinning, other changes at the polar cap can been seen: a change in the greatest and the smallest extension of the polar cap[8]; a constant decreasing of

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[1]Rio Declaration on Environment and Development http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm; New Delhi Declaration of Principles of International Law Relating to Sustainable Development, A/57/329, http://www.ila-hq.org/pdf/Sustainable%20Development/Sus%20Dev%20Resolution%20+%20Declaration%202002%20English.pdf.

[2]http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf.

[3]Non-compliance Mechanism in Kyoto Protocol and International Transaction Log: http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/pressrelease_itl_go-live_english.pdf.

[4]Working Group II Report on Impacts, Adaptation and Vulnerability; Working Group III Report on Mitigation of Climate Change; http://www.ipy.org.

[5]For an IPY projects list link with the Ocean, see the IPY website; http://www.ipy.org.

[6]2007 National Oceanic and Atmospheric Administration Report (NOOA), http://www.arctic.noaa.gov/reportcard/seaice.html; Arctic Climate Impacts Assessment and Key Findings (ACIA, 2004, Synthesis volume, pp. 10–11), http://www.acia.uaf.edu.

[7]Concerning the topic of climate change changing oceans, see the 2009 Manado Declaration: http://cmsdata.iucn.org/downloads/manado_declaration_as_adopted.pdf.

[8]Ayles Ice Shelf, one of six major ice shelves in Canada, broke off from the coast on 2005. http://www.msnbc.msn.com/id/16390346.

the perennial ice; an accelerating rate of sea level rise; future alterations in the circulation of ocean currents; so far unknown rocks or islands becoming visible (Stray Dog West, Hans Island); fish species living in warmer waters moving to the north; new and more intense prospects of trade navigation across the Northwest Passage or the Northern Sea Route (NSR). In this regard, scientists believe that the Arctic region could be ice-free by summer 2030.[9]

The polar (marine) environment is, therefore, going to become more significant. According to scientific knowledge, its management involves the burning question of global climate change and the question of protecting the poles as sensitive regions whose environment and specific socio-economic conditions must be preserved.

In the Report of the XXIII Antarctic Treaty Consultative Meeting (ATCM 1999, § 113), the Parties have already underlined the need to strengthen scientific cooperation between the two regions. Moreover, pending the last ATCM, the ATS and CA Parties met together for the first time and they adopted a joint resolution in which they supported the objective of delivering a "lasting legacy" for the IPY.[10]

In the meantime, problems may include multiple compounding aspects: with the reduction of the sea ice, for example, opportunities for new shipping trade routes and new mineral exploiting activities will increase. With the climate change issue, their juridical analysis requires a comprehensive and a more stringent application of the general principles related to the environment.

On the basis of such factual elements, this essay deals with some features of the protection of the marine oceanic environment considering four main coordinates: rising juridical problems related to polar sea navigation, particularly to the most exposed Arctic Ocean; understanding some features of the juridical regulation effective in the polar regions; analysing the need for strengthening cooperation between scientific research and legal regulations; suggesting a stronger international cooperation as a legal direction.

Cooperation in Polar Region Frameworks

There are very important differences that should be recognized when discussing the two poles. Historical, economic, social, strategic, and legal aspects have contributed to the creation of two deeply different juridical systems. These differences were particularly stressed in the 1996 ATCM's Final Report (pp. 33–37); however,

[9]See "Arctic Marine Shipping Assessment 2009 Report" (Regional Futures to 2020); http://arctic-council.org/filearchive/amsa2009report.pdf.

[10]Antarctic Treaty-Arctic Council Joint Meeting Washington Ministerial Declaration on the International Polar Year and Polar Science: http://www.state.gov/g/oes/rls/other/2009/121340.htm.

See also: XXXII ATCM, Resolution 6 (2009), Ensuring the legacy of the IPY: http://www.ats.aq/devAS/ats_meetings_meeting_measure.aspx?lang=e; VI Arctic Council Meeting, Tromsø Declaration, International Polar Year (IPY) And Its Legacy, p. 3, http://arctic-council.org/filearchive/Tromsoe%20Declaration-1.pdf.

its Final Report of 1999 also stressed important similarities. Concerning the sovereignty dispute, in Antarctica, the problem relates more to claims (who), while in the Arctic, the concerns are more a direct problem of maritime delimitation (where).

In the Antarctic, thanks to the Washington Treaty in 1959 and to its increasing institutionalization, a System of International Management was started, with a list of common rules, binding for all its members and replacing an uncertain sovereignty. The non-militarization of the Antarctic space ("shall be used for peaceful purposes only", Article 1 of the Washington Treaty), or the exclusion of any nuclear activities ("Any nuclear explosions and the disposal there of radioactive waste material shall be prohibited", Article 5) are strongly recognized rules, and their legal significance is certainly more than merely conventional.[11]

The Madrid Protocol designates Antarctica as "a natural reserve, devoted to peace and science". The General Assembly recognized in 1996 (A/RES/51/56), that the Antarctic Treaty is in furtherance of the purposes and principles of the United Nations Charter. Therefore, in Antarctica, the discussions also concern the legal status of this system, for example if it creates an "objective regime", enforceable vis-à-vis third States.

Further factors must be added to this date: if these courses are sensitive to climate change, it will happen over a long period; furthermore, they are essentially used by vessels dedicated to fishing and tourist activities and the density of navigation is the lowest in the world; finally, as said, they are governed in a very peculiar system.[12]

However, tourist activities in Antarctica have assumed a worrying dimension and have put it in a position of contradiction according with the principal purposes of ATS as a place of research, environmental protection and intrinsic value (particularly Resolution 4 of XXX ATCM and XXXII's Final Report).[13] Concerning fishing activities subjected to the CCAMLR's rules, particular importance is assumed by the analysis of its degree of effectiveness. Of great interest is the recent US proposition for extending the OMI Special Statute of Antarctic Ocean until its "natural boundary", for the Enhancement of Environmental Protection up to the Antarctic Convergence, following the CCAMLR approach.[14]

The Arctic region, an ocean surrounded by five States, has submitted to strong pressures of economic, ecological and, last but certainly not least, security-strategic value. Arctic warming, coupled with other environmental stresses such as illegal fishing, over-fishing, natural resources extraction, pollution, and bioprospecting;

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[11] http://www.unep.org/dewa/assessments/EcoSystems/polar/Antarctica/PDF/A_res_51_56.pdf.

[12] On the basis of these features the submission of information to the Commission on the Limits of the Continental Shelf beyond 200 nautical miles by New Zealand, United Kingdom, Australia, France, and Norway takes a different value. See for example Sentinelle, http://www.sfdi.org/actualites/a2007/Sentinelle%20123.htm#antarctique

Furthermore, the Madrid Protocol includes a compulsory dispute settlement similar to the Article 287 UNCLOS model.

[13] http://www.ats.aq/devAS/ats_meetings_meeting.aspx?lang=e.

[14] Resolution 1 (09): http://www.ats.aq/devAS/ats_meetings_meeting_measure.aspx?lang=e.

more generally, with the development of human activities (industrial, touristic, fisheries, or scientific) must underline the need for clearer rules.

There are ecological and geopolitical risks in the Arctic and this is also a consequence of climate change. The Arctic, an environmentally-sensitive region, has been involved for a long time in a number of economic activities with a high environmental risk. For example, marine areas subject to Russian sovereignty are impacted by the disposal of large amounts of nuclear waste, for which difficult and bilateral removal cooperative interventions have already been initiated (Stokke 2000).

In the Arctic, the cooperative process originated in the 1980s. The Arctic Council was created in 1996 and is essentially represented by a High Level Forum among the eight Arctic States (and six international organizations representing many Arctic indigenous communities as Permanent Participants[15]); the latter, therefore, is a merely intergovernmental process, basically at a regional level (with primary security purposes) and has a mainly consultative character.

Cooperation within the Arctic Council establishes a common knowledge base, spreads information on best practices and lessons learned, and has an important role in the development of policy recommendations for national, regional, and local leaders. The scientific work of the Arctic Council is carried out in five expert working groups focusing on such issues as monitoring, assessing, and preventing pollution in the Arctic, climate change, biodiversity conservation and sustainable use, emergency preparedness and prevention, in addition to the living conditions of the Arctic residents.[16]

From this pertinent point, several important developments follow. The basic responsibility for the implementation of regional policies lies with the Arctic State administrations. They have, as in any other sea area, individual sovereignty, which, even being exerted in accordance with UNCLOS provisions,[17] permits wide autonomy and natural asymmetry between the national regulations (for example, Article 234 itself can be differently enforced, therefore disturbing the circulation of maritime polar traffic and multiplying the security risks).

The 1991 Arctic Environmental Protection Strategy (AEPS) gave an important boost to cooperation in the Arctic and to integrating countermeasures. In the Alta Declaration (1997), adopted by the Arctic Council, the Parties acknowledge that the

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[15]See also the increasing participation of non-Arctic states, but the recent rejection of a permanent status for China, EU, and Italy. In 2009, France named a special ambassador for the Arctic and Antarctic international negotiation.

[16]http://arctic-council.org/article/about. See also Arctic Council Rules of Procedure: http://arctic-council.org/filearchive/Arctic%20Council%20-%20rules%20of%20procedure.pdf.

[17]LOS Convention: http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm.

See particularly the following parts: II° (territorial sea), III° (right of transit passage), VI° (archipelagic States), IX° (enclosed or semi-encloses seas, including therefore the Arctic sea) and XII° (protection and preservation of the marine environment).

Arctic environment consists of ecosystems with unique features which are particularly vulnerable to impacts resulting from human activities, and as such require special precautionary and protective measures.[18] More significantly, they agree on the necessity of taking joint action to promote the early completion of the ongoing work on an

> "International Code of Safety for Ships Operating in Polar Waters under the auspices of the IMO".

So, before analysing the revival of claims and the Arctic navigation issue, some preliminary remarks concerning the UNCLOS Convention will be useful.

UNCLOS Framework Concerning Polar Maritime Navigation

In the regulatory corpus of laws concerning relations among states in polar maritime areas, and particularly with regard to maritime navigation, the MARPOL Convention 1973–1978[19] and the UNCLOS, so-called Sea Constitution, are part of the fundamental and general discipline. We note that the Arctic Council States clearly affirm that the UNCLOS framework provides a solid foundation for responsible management of this ocean.

Duty to Protect and to Respect

There is substantial agreement over the rules provided in UNCLOS Part XII, and Articles 192 and 197 in particular, as forming a body of international customary laws. In exerting their sovereign right to exploit their own resources, States have an incontestable "obligation to protect and preserve the marine environment". Such recognition has a particular value: it makes it compulsory to respect the principles of prevention (a duty in international law) and precaution; the necessity, legally recognized and binding, of cooperation in the international field while also taking into account characteristic regional features.[20]

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[18] Alta Declaration, 13 June 1997, http://arctic-council.org/filearchive/The%20Alta%20Declaration.pdf.

[19] International Maritime Organization (IMO), Convention for the Prevention of Pollution caused by Ships, London, 2 November 1973, as modified by the London Protocol, 17 February 1978 (MARPOL 73/78). This Convention provides for 6 attachments of which only the first and the second are of a binding nature.

[20] See International Tribunal for the Law Of the Sea (ITLOS), The MOX Plant Case (Ireland v. United Kingdom), Provisional Measures, Order of 3 Dec 2001, http://www.itlos.org/cgi-bin/cases/case_detail.pl?id=10&lang=en; International Court of Justice (ICJ), Gabčíkovo-Nagymaros Project (Hungary/Slovakia), Judgment of 25 Sept 1997, § 140, http://www.icj-cij.org/docket/files/92/7375.pdf); Permanent Court of Arbitration (PCA), Award of the arbitral tribunal dated 24 May

According to Article 194.5, actions “shall include” those necessary to protect and preserve rare or fragile ecosystems, as well the habitat of endangered species.

These duties find application in the dispositions provided for various sea areas; the right of innocent passage (Part II) or, again, the right of transit through the straits necessary to international navigation (Part III). The coastal States, as sovereigns (and/or as possessors of sovereign rights), adopt specific laws to prevent and control pollution in the sea environment (Article 21). In their turn, every vessel, (to this end the role of the State to which the ship belongs is essential; Part VII), exerting its right of innocent passage, must

> “carry documents and observe special precautionary measures established for such ships by international agreement” (Article 23).

Protection and Cooperation for Specials Areas (international straits, semi-enclosed seas, polar regions)

At the same time, in those straits fit for international navigation, ships must “comply” with generally accepted international regulations, procedures, and practices for the prevention, reduction, and control of pollution from ships (Article 39.2b) and the coastal States adopt measures relating to the above mentioned transit to protect the environment, thus applying the international rules regarding the discharge of oil, oily wastes, and other noxious substances in the straits (Article 42.1b).

This system provides further rules of particular interest for the polar regions. Part IX, for example, regarding enclosed and semi-enclosed seas and applicable therefore to the north pole, guarantees enforcement of protection of these special seas. Article 123 stresses that the involved States should cooperate bona fides (Vukas 2000) with each other (directly or through an appropriate regional organization) in the exercise of their rights and in the performance of their duties and “should coordinate their activities” in the sectors of scientific research – protection of the sea environment and managing of the living resources of the sea.

Article 211 guarantees better enforcement of the general principles, where it underlines that States

> “shall establish international rules and standards to prevent, reduce and control pollution of the marine environment from vessels and promote the adoption, in the same manner, wherever appropriate, of routeing systems designed to minimize the threat of accidents which might cause pollution of the marine environment, including the coastline [. . .]”.

2005 (corrected), Iron Rhine Arbitration (Belgium/Netherlands), § 59, http://www.pca-cpa.org/upload/files/BE-NL%20Award%20corrected%20200905.pdf.

To this end, Paragraph 6 allows a Coastal State, in the presence of particular oceanographic conditions in its Exclusive Economic Zone (EZZ) and provided that the international measures are insufficient, to obtain from IMO (following appropriate consultations and IMO determination) the possibility, in that area,

> "to adopt laws and regulations for the prevention, reduction and control of pollution from vessels implementing such international rules and standards or navigational practices as are made applicable, through the organization, for special areas".

However, this provision, which must be interpreted also taking into account Paragraph 7, is not sufficient to cover the polar regions' requirements. In fact, the State involved "shall not require" foreign vessels to observe design, construction, manning, or equipment standards other than generally accepted international rules and standards.

Arctic Article

Article 234[21] was specifically agreed between Canada, the ex-URRS (Brubaker 2000), and the USA to answer specific needs for protection and control of the sea pollution coming from vessels "in ice-covered areas within the EEZ". This Article is an additional international step, having as its specific aim protection of the Arctic Ocean *without* the previous consent of the IMO and *without* the *ratione materiae* limits *ex* Article 211.

The rule provides that the States are able to adopt special laws if three essential conditions are met: the laws must be non-discriminatory in their content and enforcement in respect of ships flying different flags; they must have due regard for navigation and in protecting the marine environment; they should be based on the best available scientific evidence. In conformity with and, actually, in application of the spirit underlying the UNCLOS Convention (Articles 237 and 311.5), Parties can assume further obligations, through different Conventions, in relation to the protection of the sea environment.

The Arctic Navigation Issue

Navigation: Climate Change and Revival of National Interests

There is concern that trends in Arctic climate change may overwhelm the adaptive capacity of some Arctic ecosystems and reduce or even eliminate populations of living resources. The political implications of these changes could be enormous.

[21]Part XII; Section 8: Ice-Covered Areas; Article 234.
http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm.

"Warming Island" and the last "Stray Dog West" underline that rising temperatures create not simply the problem of melting ice but that it is possible to change the topography of coastlines. For example, "nunataks", at the margins of Greenland's ice sheet, are being freed of their age-old bonds, thus exposing a new chain of islands.

Simultaneously, the consecutive prospect of climatic evolution and increased technical expertise stimulates the revival of national interests. The US and Canada argue over rights in the Northwest Passage and the delimitation in the Beaufort Sea; Norway and Russia differ over the Barents Sea and the Western Nansen Basin[22]; Canada and Denmark are competing over a small island off Greenland (Hans Island); Denmark and Russia (Benitah 2007) are claiming the north pole. Canada affirmed in 2007 it would map its entire Arctic seabed. It is planning to build a deep-water port for patrol vessels near the eastern entrance of the Northwest Passage.[23] The Arctic States have clearly expressed their divergent interests in the Arctic continental shelf, but, on the other hand, their common interests regarding the international community.

Considerable reserves of oil and gas have already been found in the Barents, Pechora, and Kara Seas, and are transported either southwards via pipeline or westwards via the Northern Sea Route. In this regard, Russian petroleum and shipping industries will benefit from a warming Arctic.

Although considerable uncertainty is attached to estimates of freight volume and sailing frequency, they indicate the likelihood of significant, long-term resource development activity in the Arctic. With the forecast of northern summers characterized by ice-free waters, the Arctic becomes more relevant both from an economic perspective, and for the risks connected with increasing maritime navigation. The States, in accordance with Article 196,

> "shall take all measures necessary to protect the marine environment from pollution resulting from the use of technologies under their jurisdiction".

The Arctic Passages

The navigation season (often defined as the number of days per year in which there are navigable conditions – generally meaning less than 59% sea ice concentration) for the Northern Sea Route (NSR) is projected to increase from the current 20–30 days per year to 90–100 days by 2080; it follows that much attention has focused on the Northwest Passage and the NSR (Fig. 47.1).

[22] http://www.un.org/Depts/los/clcs_new/commission_submissions.htm.

[23] The Arctic: Canada's Legal Claims; http://www.parl.gc.ca/information/library/PRBpubs/prb0805-e.htm.

Fig. 47.1 Northwest Passage compared with currently used shipping route[24]

Fig. 47.2 Northern Sea Route compared with currently used shipping route[25]

The Northwest Passage comprises a collection of alternative maritime transit routes linking Europe and the Atlantic Ocean with Asia and the Pacific Ocean, routed through the northern tier of the North American continent. The route is 9,000 km shorter than transiting the Panama Canal and 17,000 km shorter than the Cape Horn route (Fig. 47.2).

The Northern Sea Route has been open to marine traffic of all nations since 1991. It is the seasonally ice-covered marine shipping route across the north of Eurasia from Novaya Zemlya in the west to the Bering Strait in the east. It could represent up to a 40% saving in distance from northern Europe to northeastern Asia and the northwest coast of North America, compared to southerly routes via the Suez or Panama Canals.

According to Arctic Report 2009, growth prospects for navigation through the NSR will be more important: movement across the Northwest Passage would be

[24]Hugo Ahlenius, UNEP/GRID-Arendal; http://maps.grida.no/go/graphic/northern-sea-route-and-the-northwest-passage-compared-with-currently-used-shipping-routes.

[25]Hugo Ahlenius, UNEP/GRID-Arendal; http://maps.grida.no/go/graphic/northern-sea-route-and-the-northwest-passage-compared-with-currently-used-shipping-routes.

more difficult and less easily determined, subject to recently formed floating icebergs, and a parallel erosion risk in coastal zones, where facilities for activity and landing exist. Traffic will generate harmful external effects, and impose additional stress on the natural environment. Technological advances in shipping design and construction and navigation might also improve the safety and feasibility of the passage for more routine traffic.

Regarding the Northwest Passage, the expected inflow of shipping traffic has revived debate over the legal status of this route, with Canada suggesting the passage lies within its territorial or even internal waters, and the United States and the European Union viewing the passage as an international strait open to all nations. At the moment of ratifying the UNCLOS Convention in 2003, Canada did not accept compulsory dispute settlement provisions contained in Section XV, Part 2, concerning, inter alia, historic claims.[26] Such debate is connected with the rules in force on the basis of the UNCLOS Convention, especially Part III, Article 234, and the IMO's role.

Canada has enforced Article 7 (concerning the straight baseline in reference to a recognized sovereign right "to establish the breadth of its territorial sea [. . .] measured from baseline") by a broad interpretation, through which the northern waters of its continental territory (partially by those islets that define the so-called Canadian Arctic) would represent some inland waters. In this way, a portion of the Northwest Passage, which according to general rules should be defined as territorial sea and subject to Part III, is excluded by rules connected with the right of transit passage.

In May 2009, the House of Commons passed an Act to amend the Arctic Waters Pollution Prevention Act, specifically the definition of Arctic waters.[27] Following the European Union position, the enforcement of this Part would imply the limitation of legal powers by coastal states over vessels in order to give, for example, special protection to the sea environment. In this manner, the sovereign right would be limited in order to strengthen the right of non-suspendable transit passage in international Straits (Articles 39 and 44).

The US contests the Canadian declaration of these waters as being internal and holds that any claim submitted under Article 35a, in conformity with the definition of a straight baseline for establishing the breadth of its territorial sea (in accordance with Article 7)

> "couldn't have the effect of enclosing as internal waters areas which had not previously been considered as such".

Controversy over resources or environmental protection does not exist. According to Professor Kraska (2007),

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[26]See the Declaration at: http://www.un.org/Depts/los/convention_agreements/convention_declarations.htm#Canada.

[27]http://www2.parl.gc.ca/Sites/LOP/LEGISINFO/index.asp?Language=E&Chamber=N&StartList=A&EndList=Z&Session=22&Type=0&Scope=I&query=5652&List=toc-2

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> "Canada has never really decided how to do this or precisely what theory might be most effective in obtaining the support of the international community".

Canada does not oppose international navigation,

> "so long as conditions and controls established by Canadians to protect the security, environmental and economic interests of our northerners are met".

This last point is not controversial until, in accordance with Article 38.3, the Canadian rules respecting international standards of protection, are applied in a non-discriminatory way, and are the result of IMO discussion.

Into the debate has been introduced the question of the role of Article 234. A portion of the Northwest Passage, as well of the Northeast Passage, seems to fall within the classic definition of a strait used for international navigation (Article 45).

The purpose of transit is to exploit the comparative advantages of such routes in terms of their shorter length with respect to traditional ways. However, in view of the unusual and changeable Arctic conditions, other Arctic routes might be considered more suitable (Article 36), thus depriving Canada or Russia of a say. This again underlines the special problems connected with activities in polar areas. It is for this purpose principally, as we have already said, that Article 234 of the UNCLOS Convention was introduced.

The question of coordinating rules relating to right of transit with the necessary obligations for protective measures to better protect the polar marine environment must be considered as fundamental.

Reflection on the importance of Articles 38.3, 39, and 41 would seem to preclude simultaneous application of Articles 211.6 and 234. Since the right of transit passage is defined as *lex specialis* in respect of the general UNCLOS balance between Coastal State and User State, provided the contemporary limitation of intervention possible for limited activities, what value could be given to a rule (Article 234) that, while abstract, seems to be contradictory?

Bearing in mind Article 211.6, a safety rule concerning pollution by vessels (for the adoption of additional rules on the basis of cooperative activities in IMO's statutory law), it follows that it is necessary to recognize national legislative action in the polar areas, even though it must respect, besides the right of innocent passage, the three prior underlined requirements. The scope is to find – conforming to international law – an effective balance between opposing rights, giving special attention to the protection of the environment.

However, as the Permanent Court of Arbitration underlined in its Iron Rhine Arbitration, the State that enjoys an international special right (in our case the right of transit passage within the polar sea of another State), must integrate its right with the duty to prevent harmful damage to that State and its waters.[28] It follows the simultaneous enforcement of Part III of the Convention, of the international rules

[28]PCA, § 220-223. http://www.pca-cpa.org/upload/files/BE-NL%20Award%20corrected%20200905.pdf.

pertinent to International Standards, and nationally enforced rules, too. Respecting the *non discrimination principle*, to which Articles 42.2 and 234 refer, is fundamental here.

Guidelines for ships operating in the Arctic's ice-covered waters, the Polar Code, were adopted in December 2002 after long debate. In a certain sense, they resolve the difficulty of normative "co-presence", through a common definition process inside the International Maritime Organization.[29] The IMO Guidelines outline a harmonized system of classes of ships that operate in the Arctic. They designate different levels of capability for operating in ice-filled waters, providing non-mandatory recommendations to reduce the risks to which ships operating in the Arctic are exposed. These include construction and equipment recommendations, and guidelines on operations, damage control, and environmental protection.

In parallel with IMO efforts, the International Association of Classification Societies (IACS) has developed a set of unified technical construction standards for the hull and machinery of ships sailing in polar waters.

Scientific Research and Legal Regulations: Strengthening Cooperation

The connection of the polar regions with the global climate increases general interest in this region as a common concern.[30] In this regard, we note that the IPY 1957 research was an exceptional propellant in the adoption of the Antarctic Treaty.[31] Success achieved in the field of science promoted recognition of the need to cooperate in the legal sphere, especially on environmental issues. In 1991, scientific and environmental issues were legally recognized in the context of the incontrovertible internationalization of the Southern Spaces (ATS).

The importance of strengthening inter-state links, both in scientific and legal research, should therefore be stressed. This exercise is central to the concept of sustainable development, the fundamental international principle for harmonizing environmental and economic specific needs and of whose intent the legal contents of Articles 211.6 and 234, as well as Part XII, seem to be a preliminary expression.

> "Such laws and regulations shall have due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence".

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[29]Guidelines for Ships Operating in Arctic Ice-Covered Waters; http://www.imo.org/includes/blastDataOnly.asp/data_id%3D6629/1056-MEPC-Circ399.pdf.

[30]Salekhard Declaration 2006; http://arctic-council.org/filearchive/SALEKHARD_AC_DECLARATION_2006.pdf.

[31]"Acknowledging the substantial contributions [. . .]; Convinced that the establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the I.G.Y. [. . .]"; http://www.ats.aq/documents/ats/treaty_original.pdf.

This period is representative in underlining the contribution of scientific research, by virtue of which inter-state cooperative spirit gradually increases: the cooperative scientific approach obtained under this rule the consecration of "legal necessity" (regulation of cooperation among States and respective obligations and rights). In this sense, the IPY 2007–2008 represents both a further step in strengthening the knowledge of climate change and a due exercise in outlining the measures to undertake in the various regulatory spheres.

According to NOAA's Report, ease of navigation is not present in any Arctic area and is all the more uncertain given the unpredictability of the behaviour of ice masses. Ice residence times are typically longer in the western Arctic in the region of the Beaufort Gyre. The eastern Arctic is dominated by the Transpolar Drift, which carries sea ice out of the Arctic Basin via the Fram Strait. The development of a relatively younger, thinner ice cover makes the current ice cover intrinsically more susceptible to the effects of atmospheric and oceanic forcing.

A further element for reflection follows: the impossibility of predicting, and therefore the underlying risks involved in future economic activity (Rio Declaration, Principle 15), including maritime navigation, require broad application of the precautionary principle,[32] which shape the UNCLOS provisions, "of taking into account, and in a proportionality way, regional characteristic features".

The federal route partially moves in this preventive direction (environmental cooperation was identified as an initial step in promoting comprehensive safety in the region), particularly through the creation within the Arctic Council of 6 Working Groups. Of greater significance for our purposes is the work of the PAME W.G. (Protection of the Arctic Marine Environment). The PAME mandate is to address policy and non-emergency pollution prevention and control measures relating to the protection of the Arctic marine environment (land- and sea-based activities). These include coordinated action programmes and guidelines complementing existing legal arrangements.

Moreover, in the "declaratory Salekhard Chart", we note that the parties seem to recognize the development of safe and environmentally secure marine transportation and subsea pipeline development

> "as a priority issue closely linked to climate change, technological advance and resource use, which will have economic, social and environmental impact in the Arctic".

Within the Emergency Prevention, Preparedness, and Response Working Group (EPPR), major importance is given to international cooperation.

National rules also present some features of convergence: comparative analysis of legislations has highlighted how national practices adopted by Canada, the US and Russia present many similarities, including interpretation of the most

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[32]Separate Opinion of Vice-President Weeramantry, Gabčíkovo-Nagymaros Project, http://www.icj-cij.org/docket/files/92/7383.pdf; Separate opinion of Judge Treves, Southern Bluefin Tuna Cases (New Zealand v. Japan; Australia v. Japan), Provisional Measures, § 9, http://www.itlos.org/case_documents/2001/document_en_126.pdf; The MOX Plant Case (Ireland v. United Kingdom), § 80–84, http://www.itlos.org/cgi-bin/cases/case_detail.pl?id=10&lang=en.

controversial points (such as rules relating to straits used for international navigation and Article 234 concerning strengthened measures of protection). This interpretative convergence may lead to a broader legal interpretation of 234 which can be more strongly pleaded (Brubaker 2000). However, a hidden risk is the abandonment of the Arctic Council, a "work in progress" forum, which started slowly with the AEPS and strengthened through 10 years of activity.

Finally, the UNCLOS Convention, the duty of cooperation and various other rules, such as the precautionary principle and sustainable development, may help to address these difficult challenges. However, the trailblazing nature of the polar regions makes them presaging examples of the validity of international regulations for more effective protection of the environment. In the Arctic, for example, indigenous peoples already face problems arising from climate change.

Sovereignty and Safety in a Climate Change Context: Better Legal International Cooperation as a Fundamental Direction

As stated, existing legal provisions recognize the peculiarities of the polar regions. The coordination of these rules has allowed some obstacles to be overcome by interpretational means on the basis of which Arctic States may adopt special rules in respect of customary law. The duty to protect the marine environment, especially as dictated under UNCLOS Part XII, and the pronounced technical difficulties occurring in these regions, have led the Parties to improve cooperation through a regional framework and in line with the role of the IMO (Polar Code). The sovereignty of the northern States could warrant, at least abstractly, effective application of protective measures taken to safeguard this special ecosystem.

Nonetheless, with the melting of polar Arctic ice and as a result of emerging commercial prospects, territorial claims and national interest seem to have taken renewed strength, sometimes in contradiction with international rules and the spirit that is at the basis of the region's legal systems. The complex search for a legal balance to answer to the new challenges must, realistically, take account of sovereignty issues in the Arctic Region. Environmental change has reinvigorated this historical legal question.

However, the development of oil reserves on the Arctic Shelf with insufficient scientific knowledge, experience, and ecological safeguards could lead to catastrophic results for the northern ecosystem. The Exxon Valdez ecological disaster close to the Arctic Circle[33] highlights the difficulties and the degree of unpredictability in polar shipping.

To guarantee the Arctic ecosystem, to ensure security and sovereignty, to promote safe navigation through designated routes, and to better protect polar areas and marine environment – challenges that directly or indirectly must also

[33] Supreme Court of The United States. June 25, 2008, Exxon Shipping Co. Et Al. V. Baker Et Al. http://www.supremecourtus.gov/opinions/07pdf/07-219.pdf.

take into account the broader issue of climate change – it is necessary to further promote cooperation between the Arctic Council and IMO.

> "The obligation to cooperate with other States whose interests may be affected is a Grundnorm of Part XII of the Convention, as of customary international law for the protection of the environment".[34]

Moreover, if the sovereignty of these states and its exercise in accordance with international general law are undisputed, it is necessary to emphasize the co-existence with other international rights: the above mentioned right of transit, but above all, the High Sea rights implying that a portion of the Arctic Ocean should not be subject to territorial claims by States (Article 89).

It should not be forgotten that the need to strengthen international cooperation as a legislative technique derives also from another factor. If it is true that states are liable

> "for the fulfilment of their obligations concerning international marine protection"

and they are to be liable for non-compliance with such obligations in accordance with international law (Article 235), the current general principle of sovereign immunity for warships and military vessels and aircraft owned or operated by a State and used only on government non-service (Article 236) requires exclusion from the Convention's rules of a significant number of vessels operating in the polar oceans.[35]

If in the Ilulissat Declaration the Arctic countries seem to agree upon the development of the regional cooperation as a primary framework, and in this way "closing" the Arctic Ocean question, better knowledge of changes in the Arctic region has pushed the parties to accept a stronger international cooperation. As a matter of fact, in the Salekhard Chart, the Arctic Parties have recognized the value of the Arctic environment; in 2008 and 2009, they stated that bear protection and Arctic climate need a global and effective response as well.

The Arctic question affects all of us; the European Community and some countries are trying to slowly "open the door" to the Arctic States' sovereignty and experiences.

Conclusions

The Arctic Council States have grown a certain awareness concerning a balance between "opening and closing" strategies, especially via the UNCLOS Convention, because it "provides a solid foundation for responsible management of this ocean".

The last Tromsø Declaration seems to give two significant signs of an increasing Arctic marine environment action, based on growing cooperation:[36]

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[34]Separate opinion of Judge Wolfrum, The MOX Plant Case, p. 4. http://www.itlos.org/case_documents/2001/document_en_202.pdf.

[35]For the Antarctic System, see http://www.ats.aq/devAS/info_measures_list_filtered.aspx?lang=e&cat=9.

[36]Tromsø Declaration, The Arctic Council, 29 April 2009, http://arctic-council.org/filearchive/Tromsoe%20Declaration-1..pdf.

- "Urge that the ongoing work in the IMO to update the Guidelines for Ships Operating in Arctic Ice-Covered Waters be completed, application of its relevant parts be made mandatory, and global IMO ship safety and pollution prevention conventions be augmented with specific mandatory requirements or other provisions for ship construction, design, equipment, crewing, training, and operations, aimed at safety and protection of the Arctic environment".[37]
- "Approve the establishment of a task force to develop and complete negotiation by the next Ministerial meeting in 2011 of an international instrument on cooperation on search and rescue operations in the Arctic".

The north polar states can best achieve widespread global support in managing the marine Arctic by acknowledging the international importance of the north pole and consequently by working through the specific Multilateral Agreements, the Regional Framework, and the IMO in order to develop a comprehensive package of internationally accepted regulations.[38]

References

Books

Francioni T, Scovazzi T (1996) International law for Antarctica. Kluwer Law, The Hague

Rothwell DR (1996) Polar regions and international environmental law. Cambridge University Press, Cambridge

Tamburelli G (2008) The Antarctic legal system – the protection of the environment of polar regions. Giuffrè, Milan

Vidas D (2000) Protecting the polar marine environment. Cambridge, Cambridge

Wolfrum R (2000) International, regional, and national environmental law. Kluwer Law, The Hague, Boston

Chapters in Edited Books

Andreone G (2008) Fisheries in the Antarctic and in the Arctic. In: Tamburelli G (ed) The Antarctic legal system – the protection of the environment of polar regions. Giuffrè, Milan, pp 71–93

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[37]See "Arctic Marine Shipping Assessment 2009 Report"; http://arctic-council.org/filearchive/amsa2009report.pdf.

[38]See for example the Norwegian efforts at the IMO to establish compulsory sailing lines outside its territorial sea along the coast of northern Norway: http://www.atlanterhavskomiteen.no/Publikasjoner/Internett-tekster/Arkiv/2006/R-FN-4%20Environment%20&%20Marine%20Transport.pdf.

Arts K, Gupta J (2004) Climate change and hazardous waste law: developing international law of sustainable development. In: Schrijver N, Weiss F (eds) International law and sustainable development: principles and practice. Martinus Nijhoff, London, pp 519–535

Boyle A (2000) Globalism and regionalism in the protection of the marine environment. In: Vidas D (ed) Protecting the polar marine environment. Cambridge University Press, Cambridge, pp 5–34

Brubaker RD (2000) Regulation of navigation and vessel-source pollution in the Northern Sea route: Article 234 and state practice. In: Vidas D (ed) Protecting the polar marine environment. Cambridge University Press, Cambridge, pp 224–256

Comba D (2008a) A greater knowledge of the effect of climate change on the oceans as an essential interpretational basis for future polar sea navigation. In: Tamburelli G (ed) The Antarctic legal system – the protection of the environment of polar regions. Giuffrè, Milan, pp 95–115

Del Castillo Laborde L (2008) Environmental awareness regarding the Arctic and Antarctic regions. In: Tamburelli G (ed) The Antarctic legal system – the protection of the environment of polar regions. Giuffrè, Milan, pp 27–53

Dupuy P-M (2003) Le principe de précaution et le droit international de la mer. In: AA. VV (eds) La mer et son droit. Mélanges offerts à L. Lucchini et J. P. Quéneudec, Pedone, Paris, pp 205–238

Loibl G (2004) The evolving regime on climate change and sustainable development. In: Schrijver N, Weiss F (eds) International law and sustainable development: Principles and practice. Martinus Nijhoff, London, pp 97–115

Rothwell DR, Joyner CC (2000) Domestic perspectives and regulations in protecting the polar marine environment: Australia, Canada and United States. In: Vidas D (ed) Protecting the polar marine environment. Cambridge University Press, Cambridge, pp 149–174

Stokke OS (2000) Radioactive waste in the Kara and Barents Sea: Russian implementation of the global dumping regime. In: Vidas D (ed) Protecting the polar marine environment. Cambridge University Press, Cambridge, pp 200–220

Vukas B (2000) United Nations convention on the law of the Sea and the polar marine environment. In: Vidas D (ed) Protecting the polar marine environment. Cambridge University Press, Cambridge, pp 34–56

Wolfrum R (2003) Le régime de l'Antarctique et les Etats Tiers. In: AA. VV. (eds) La mer et son droit. Mélanges offerts à L. Lucchini et J. P. Quéneudec, Pedone, Paris, pp 695–703

Articles

Benitah M (2007) Russia's claim in the Arctic and the vexing issue of Ridges in UNCLOS. Am Soc Int Law 11:235–251

Boisson De Chazournes L (1995) La mise en œuvre du droit international dans le domaine de la protection de l'environnement: enjeux et défis. In: Revue Générale du Droit International Public, pp 37–76

García-Salmones M (2009) Taking uncertainty seriously: adaptive governance and international trade: a reply to Rosie Cooney and Andrew Lang. Eur J Int Law 20(1):167–186

Gaskell N (2003) Decision making and the legal committee of the international maritime organization. Int J Mar Coast Law 18(2):155–214

Kraska J (2007) The law of the Sea Convention and the Northwest passage. Int J Mar Coast Law 22(2):248–269

Moolenar EJ (2004) Multilateral hot pursuit and illegal fishing in the Southern Ocean: the pursuits of the Viarsa 1 and the South Tomi. Int J Mar Coast Law 19(1):19–42

Oude Elferink AG (1998) Does undisputed title to a maritime zone always exclude its delimitation: the Grey Area issue. Int J Mar Coast Law 13(2):245–271

Oude Elferink AG (2002) The Continental Shelf of Antarctica: implications of the requirement to make a submission to the CLCS under Article 76 of the LOS convention. Int J Mar Coast Law 17(4):485–520

Roberts J (2005) Protecting sensitive marine environments: the role and application of ships' routeing measures. Int J Mar Coast Law 20(1):135–159

Scott K (2003) Institutional developments within the Antarctic treaty system. Int Comp Law Q 52(2):473–487

Weckel P (2002) Chronique de Jurisprudence Internationale, TIDM. Ord. Du 03.12.01 (Mesures Conservatoires), Usine MOX (Irlande c. Royaume-Uni). In: Revue Générale du Droit International Public, pp 203–207

Weckel P (2005) Chronique de Jurisprudence Internationale, CPA. Sentence de fer du Rhin de Fer (Belgique/Pays-Bas). In: Revue Générale du Droit International Public, pp. 720–721

Electronic Sources

Arctic Climate Impact Assessment, ACIA (2004) Sea Arctic climate impacts assessment and key findings. Synthesis volume, pp 10–11. http://www.acia.uaf.edu

Arctic Marine Shipping Assessment, ASMA (2009) Arctic Marine Shipping Assessment Report. http://arctic-council.org/filearchive/amsa2009report.pdf

Comba D (2007) Plateau continental austral : les prétentions du Royaume-Uni. Sfdi-Sentinelle, No. 123. http://www.sfdi.org/actualites/a2007/Sentinelle%20123.htm#antarctique

Comba D (2007) Un incident en Antarctique illustre les difficultés de navigation dans les régions polaires. Sfdi-Sentinelle, No. 128. http://www.sfdi.org/actualites/a2007/Sentinelle%20128.htm#antarctique

Comba D (2008) Les régions polaires et la dorsale de Lomonossov", Sfdi-Sentinelle, No. 159. http://www.sfdi.org/actualites/a2008/Sentinelle%20159.htm#arctic

Comba D (2008) Réduction de l'extension de la calotte arctique et application de la Convention sur le droit de la Mer. Sfdi-Sentinelle, No. 150. http://www.sfdi.org/actualites/a2008/Sentinelle%20150.htm#arctique

Comba D (2008) XXXI Réunion des Parties Consultatives sur l'Antarctique. Sfdi-Sentinelle, No. 153. http://www.sfdi.org/actualites/a2008/Sentinelle%20153.htm#antarctique

Comba D (2009) Conseil Arctique : déclaration de Tromsø. Sfdi-Sentinelle, No. 190. http://www.sfdi.org/actualites/a2009/Sentinelle%20190.htm#arctique

Comba D (2009) Les 50 ans du Traité sur l'Antarctique et la déclaration conjointe sur l'Année Polaire. Sfdi-Sentinelle, No. 186. http://www.sfdi.org/actualites/a2009/Sentinelle%20186.htm#poles

Comba D (2009) Tourisme en Antarctique, révision de l'Annexe II du Traité. Sfdi-Sentinelle, No. 189. http://www.sfdi.org/actualites/a2009/Sentinelle%20189.htm

Comba D (2009) Projet de loi visant à renforcer la juridiction canadienne sur les eaux arctiques. Sfdi-Sentinelle, No. 175. http://www.sfdi.org/actualites/a2009/Sentinelle%20175.htm#arctique

Comba D (2009) Stratégie politique étasunienne pour l'Arctique. Sfdi-Sentinelle, No. 173. http://www.sfdi.org/actualites/a2009/Sentinelle%20173.htm#arctique

Comba D (2009) Nomination de l'Ambassadeur français chargé de la négociation internationale pour les pôles Arctique et Antarctique. Sfdi-Sentinelle, No. 184. http://www.sfdi.org/actualites/a2009/Sentinelle%20184.htm#poles

Couma T (2007) Arctique/ Le Canada et la Russie s'engagent à recourir à la Convention sur le droit de la mer pour régler tout différend relatif à cette zone. Sfdi-Sentinelle, No. 129. http://www.sfdi.org/actualites/a2007/Sentinelle%20129.htm#arctique

Couma T, Comba D (2007) Plusieurs Etats annoncent leurs prétentions sur l'Arctique. Sfdi-Sentinelle, No. 119. http://www.sfdi.org/actualites/a2007/Sentinelle%20119.htm#arctique

Pincovai E, Comba D (2008) France-Programme EXTRAPLAC: résultats de la 3ème campagne relative au plateau continental de la zone Kerguelen. Sfdi-Sentinelle, No. 142. http://www.sfdi.org/actualites/a2008/Sentinelle%20142.htm#plateau

National Oceanic and Atmospheric Administration, NOAA (2007) NOAA's Arctic Report 2007. http://www.arctic.noaa.gov/reportcard/seaice.html

Weckel P (2008) Déclaration d'Ilulissat: les cinq Etats riverains se partagent l'Océan Arctique. Sfdi-Sentinelle, No. 151. http://www.sfdi.org/actualites/a2008/Sentinelle%20151.htm#arctic

Weckel P, Comba D (2008) Position de la France au sujet des plateaux continentaux de l'Antarctique. Sfdi-Sentinelle, No. 136. http://www.sfdi.org/actualites/a2008/Sentinelle%20136.htm#antarctique

Chapter 48
The Role of Climate Change in the Darfur Crisis

Salah Hakim

Abstract Located in western Sudan, Darfur covers 500,000 km^2, and has a population of 7.4 million. The Darfur crisis started in 2003, with a tragic cost in human life and population displacement. Climate change is the root cause of the crisis. This is not to diminish the political, socio-economic, and ethnic factors. The Darfur crisis is so complex because a multitude of factors are operative simultaneously. The impact of climate change has been well documented in several other ecosystems. The sedentary farmers of the Fur tribe and the nomadic tribes have enjoyed peaceful coexistence for centuries. The Fur and other sedentary tribes own the land and the nomads have the right to use the rangeland; when minor clashes arose, they were quickly diffused by tribal leaders.

Conflicts gradually developed from low to high intensity, fuelled by shrinkage in natural resources caused primarily by climate change. While precipitation in Northern Darfur has dropped by 30% over the last 80 years, resulting in repeated bouts of drought, livestock and human populations increased significantly. A political solution to the crisis, though essential, will not remove the underlying causes of the conflict driven by climate change. The solution is robust development of the region based on strategies of adaptation to climate change, which will reduce poverty and provide alternative livelihoods. The industrialized nations, who caused climate change, are obliged to fund such an endeavour. Lessons learned from Darfur will hopefully prevent such a tragedy from happening elsewhere.

Keywords Adaptation · Climate change · Conflict · Crisis · Darfur · Fur · Natural resources · Nomads

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Introduction

Located in western Sudan, Darfur covers about 500,000 km^2, between latitude 10° N and 22° N, and longitude 23°5′ E and 27°45′ E. It has a population of about 7.4 million. Darfur was the last addition to modern Sudan. It was annexed to Sudan in 1917 (NFC, SECS 2009).

Darfur covers a range of ecological zones from the Sahara desert in the north to the high-rainfall savannah in the south. In the central region lies Jebel Marra massif, extending for 70 miles in length and 30 miles in width, with an altitude of 1,000 m. It is blessed with fertile soil and abundant water resources.

The Fur tribe, the largest tribe in Darfur, inhabits the central belt of Darfur, including Jebel Marra massif. The Fur are sedentary farmers; other small-scale farmer tribes also dwell in this region, including Masalit, Berti, Bargu, Bergid, Tama, and Tungur. The desert most northern part of Darfur is occupied by camel herder tribes such as Zaghawa, Bedyat, Mahariya, Irayqat, Mahamid, and Beni Hussein. This area is directly impacted by desertification, primarily caused by climate change. In the southern part of Darfur live cattle herders such as Rezeigat, Habaniya, Taaysha, Maaliya, Beni Halba, Meseiriya, Daju, Birgid, Beegu, Salamaat, and Fallata (Ali 2004) (Fig. 48.1).

Land Use and Conflict Resolution

The sedentary farmers of the Fur tribe and the nomadic tribes have enjoyed peaceful coexistence for centuries. The Fur and other sedentary tribes own the land and the pastoralists have the right to use the rangeland. When minor clashes arose, they were quickly diffused by tribal leaders. The native administration played a central role in resolving conflicts, until it was abolished by the May Revolution regime in 1970. The administration was a system of self governance established by the British, who recognized the traditional tribal system and used it in their favour. The native administration helped to collect taxes on behalf of the government, and keep the peace in remote areas that would otherwise incur high costs to administer. Tribal leaders were given limited judicial powers; this enabled them to settle minor conflicts between tribal members. More importantly, these tribal leaders were capable, in coordination with other tribal leaders, to settle inter-tribal conflicts. In this case, leaders of the tribes in question, in the presence of other respected dignitaries in the region and government representatives, would get together and work out a resolution to the satisfaction of all parties. This conflict resolution mechanism served the region very well for decades. However, the abolition of the native administration weakened the authority and influence of tribal leaders. This effective conflict resolution mechanism was lost, and no equally effective one was developed. Now the government is proposing reinstating the native administration once again. A new legislation to that effect is prepared and will soon be sent to the National Assembly, the Sudanese parliament, for enacting into law.

Fig. 48.1 Map of Darfur
Source: Alert Net 2009

Climate Change and The Crisis

The Darfur crisis is now the largest humanitarian crisis in the world. It is so complex because a multitude of factors are operative simultaneously. Climate change is the root cause of the crisis. This is not to diminish the political, socio-economic, and ethnic factors. The impact of climate change has been well documented in several other ecosystems. The most evident is the shrinking ice caps in the north pole, as portrayed in Al Gore's documentary, *An Inconvenient Truth*.

It is now widely accepted that climate change has caused bouts of droughts, as experienced in Darfur and other parts of Africa. British home secretary John Reid pointed to global warming as a key factor behind the conflict in Darfur, and called it a warning sign. UN secretary general Ban Ki-moon described the Darfur problem as an ecological crisis due, at least in part, to climate change. Ms Alessandra Giannini, who led a worldwide climate study conducted by Columbia University, concluded that the drying of Darfur is due to changes in global climate (Faris 2009). Jeffrey

Sachs, an economist, wrote, “The deadly carnage in Darfur, Sudan, for example, which is almost always discussed in political and military terms, has roots in an ecological crisis directly arising from climate shocks” (IRIN News 2007).

The political, socio-economic, and ethnic factors related to this crisis, have been extensively covered in print and the audio-visual media. This paper is focused on the environmental dimension of the crisis. Climate change has caused serious deterioration in natural resources. It caused desertification in the northern part of Darfur and diminishing natural resources in central and southern Darfur. This intensified the competition for natural resources between sedentary farmers and nomadic pastoralists. Deterioration in natural resources has been blamed on human activities during the 1970s and 1980s. However, examination of climatic data of Darfur points to the fact that climate change is the driving force behind deterioration in natural resources. Unsustainable use of natural resources made the situation even worse.

There has been a drastic and steady decline in rainfall over a relatively short period of time. Table 48.1 shows this decline in rainfall in North, South, and Central Darfur between the mean of 1946 to 1975, and the mean for the next 30 years between 1976 and 2005.

North Darfur, the driest of the three regions, has shown the largest decline in rainfall, amounting to 34%. Obviously this factor alone is capable of causing significant change in vegetation communities even in the absence of destructive human activities such as overgrazing, shifting cultivation, or felling of trees. It is certain that we are witnessing a major shift in climate. This alone can bring about change in vegetation composition as fewer drought-resistant species disappear, and may even lead to the disappearance of vegetation cover altogether. This is what is happening in northern Darfur at the fringe of the desert, where the encroachment of the desert is evident. It is estimated that the desert has moved southwards 100 km in 40 years (UNEP 2007). This deterioration is also manifested in areas to the south in degradation of natural resources, forests and rangeland alike. It is safe to conclude that this deterioration in natural resources, resulting in desertification in northern Darfur, is a direct result of climate change. This is not to deny the fact that overgrazing, shifting cultivation, and felling of trees exasperate the situation even further. Increase in human and livestock populations puts more pressure on

Table 48.1 Average annual rainfall in North, Central, and South Darfur in 1946–1975 and 1976–2005

Rain gauge location	Average annual rainfall (mm) 1946–1975	Average annual rainfall (mm) 1976–2005	Reduction (mm)	Reduction (%)
El Fashir Northern Darfur	272.36	178.90	−93.46	−34
Nyala Southern Darfur	448.71	376.50	−72.21	−16
El Geneina Western Darfur	564.20	427.70	−136.50	−24

Source: UNEP (2007)

shrinking natural resources. Expansion in cultivation at the expense of rangeland and forests have made a bad situation worse.

Other Factors Contributing to The Crisis

In Central Darfur, government statistics indicate a population growth of 12%, from 3 persons per km^2 in 1956 to 18 persons per km^2 in 2003. (UNEP 4.16). The total population of Darfur increased from 2,076,733 in 1973 to 4,638,203 in 1993 (Ali 2004). Because of a porous border, a significant part of this population growth is attributed to immigration across the western border, as well as from the drier regions in the north. It is estimated that livestock in North and Central Sudan has increased by 400% since 1961 (UNEP 2007). At the same time, poorer rangeland required pastoralists to cover larger areas of range to provide adequate nutrition for their livestock. This complex land-use pattern fuelled further competition for resources.

According to UNEP, in southern Darfur, land under cultivation increased by 138% between 1973 and 2000, while rangeland and closed forest decreased by 56% and 32% respectively. This expansion in cultivated land is in part due to new rain-fed large mechanized agricultural projects. However, small scale farmers under conditions of dwindling productivity tend to expand their land under cultivation to make up for deficits in total production.

It has been documented that the number and width of pastoralists migration routes between wet and dry season rangeland have been steadily decreasing. This is due to several factors. The primary factor is expansion in cultivation, both large and small projects. To compensate for decreased productivity due to drought, small-scale farmers expand their cultivated plots, cutting into these migration routes. Also due to a reduction in rainfall, farmers started to use new water harvesting techniques such as terraces, which made it possible to cultivate slopes that were not previously cultivated and were natural rangeland used by pastoralists. Another factor is the fact that pastoralists started to move in larger groups with larger herds. This has been made necessary due to lack of security and an increase in armed robbery. It is also reported frequently that due to a decrease in water resources caused by bouts of drought, farmers started to fence water sources, depriving pastoralists from access to water (UNEP 2007).

The Crisis

As natural resources continued to dwindle, tribal conflicts increased in numbers and intensity. This, unfortunately, took place in the absence of an effective conflict resolution mechanism. Tribal conflicts have been recorded since 1932 (Ali 2004). Between 1932 and 1979, more than 40 years, there were only 11 tribal conflicts recorded. This number jumped to 13 during the decade of the 1980s alone and further increased to 18 in the 1990s. The 1980s witnessed one of the most severe droughts in the region, which triggered famine and massive human displacement.

The previously mild conflicts evolved into a bloody conflict of tragic proportions. The Darfur crisis started in 2003, with an enormous cost in human life and population displacement. UNHCR estimated that 300,000 people may have died, and 2.7 million were displaced from their homes (IRIN News 2009).

If no action is taken, there is enough evidence that the situation will get worse. It is predicted that climate change is accelerating and will result in wide-ranging shifts in climate variables. Changes in the mean and variance rainfall and temperature are predicted that will impact food production and prices, nutrition and health (Heltberg et al. 2009).

Climate models for northern Kordofan, which is comparable to northern Darfur indicated that temperatures are set to rise by 0.5°C to 1.5°C annually between 2030 and 2060, with an average rainfall decline of 5%. The impact on food production is expected to be disastrous. Sorghum, the staple food in the region, could see a decrease in production of 70%. (HCENR 2003). This grim forecast calls for immediate and decisive action.

The Solution

It is clear that there is mounting pressure from the international community on all parties to reach a political solution. All parties are not interested in a prolonged conflict. Therefore, it seems reasonable to assume that a political solution can be achieved in the near future. However, a political solution to the crisis, though essential to stop the bloodshed and bring a conclusion to humanitarian sufferings, will not remove the underlying causes of the conflict driven by climate change. If we make the mistake of assuming that the conflict is over by signing a political settlement, we will be surprised by the conflict, over meagre natural resources, soon flaring once again.

The solution is robust development of Darfur based on strategies of adaptation to climate change, which will reduce poverty and provide alternative livelihoods for the people of Darfur. Such a development effort should remove a significant proportion of the population from natural resource use into new jobs and activities that are more rewarding financially and help reduce pressure on natural resources weakened by decades of overuse and deterioration.

Adaptation to climate change must be mainstreamed in the policy of the central and local governments. This development initiative must put climate change adaptation and mitigation at the core of its activities. The Sudan Higher Council of the Environment and Natural Resources (HCENR) proposed five projects for funding adaptation to climate change in Sudan NAPA. Now project proposals for these have been drafted. One of them is a water harvesting and spreading project in Southern Darfur (HCENR 2007).

The World Bank, the UN, and the African Development Bank conducted a joint assessment mission for Darfur. It is composed of two tracks. One is an early recovery programme for returning the war-affected population. The second is focused on medium- and long-term needs to achieve the Millennium Development Goals. This development scheme must address the establishment of infrastructure that the region lacks. Roads, transport facilities, communication, and electricity are essential at the first stage, starting with rebuilding destroyed infrastructure. Significant effort is needed in healthcare and education.

New agriculture policy is called for in Darfur. Such policy must take into account the reality of climate change and its impacts, and the fact that farmers share the land with nomad pastoralists. New varieties of the traditional crops are needed with more resistance to drought, as well as new crops suited to the prevailing conditions. More active and focused extension is needed, aided by new improved seeds and basic agricultural tools, while benefiting from indigenous knowledge accumulated over time. Water harvesting techniques should be introduced whenever possible. Darfur agricultural products have suffered in the past from marketing problems, especially in Jebel Marra. Marketing is essential to encourage production and give farmers a fair price for their crops.

An awareness campaign should go hand in hand with the implementation of the development plan. This awareness programme would help local people understand and adopt activities of adaptation to climate change; and encourage sustainable use of their natural resources. The government decision to reinstate the native administration is a step in the right direction. A conflict resolution should be built around the native administration with support from the local government and academia.

The forests of Darfur are excessively exploited for timber and charcoal production. There is an opportunity for Darfur to use the Clean Development Initiative (CDM), and the Reducing Emissions from Deforestation and Degradation (REDD) programmes under the UN Convention on Climate Change. This will benefit the local communities financially, as they receive compensation for conserving their forests and natural resources.

Historically, women in Darfur have been more active economically, relative to women in other parts of the country. The development plan must make an extra effort to empower women and get them involved in the development activities.

For decades, Darfur has known the *shail* system, where a merchant funds cultivation operations for poor farmers, and gets paid at harvest time in kind. In such a system, the farmer is the weaker party. However, this has been the only line of credit available to the small farmers. It is time for the government to step in and provide a system through which poor farmers can access credit from lending institutions outside the traditional culture which deprives them from credit. It is time to try a small loan programme to fund farmers and pastoralists, and boost local development.

It is true that the poor countries who have not caused climate change will be the ones to suffer most from its impact. There is an ecological debt to humanity on the back of the developed countries that caused climate change. These rich countries will hopefully be willing to fund a development programme in Darfur. Donors pledged billions at the end of the civil war in southern Sudan. They will hopefully do the same now for Darfur.

Lessons Learned

Valuable lessons must be learned from the Darfur crisis. The UNEP report (2007) warns that Darfur "holds a grim lesson for countries at risk". Faris (2009) wonders if Darfur is the canary in the coalmine. Other areas in Africa where livestock herders and farmers compete for dwindling resources at risk must now take notice. Some experts say that Darfur represents an emerging pattern of conflicts over resources, and it is not possible to separate climate change from population growth and rising needs for resources (Brawn 2009). In a working paper to the War College in Newport, RI, Yackle states, "Africa hinges upon mitigating the effects of climate change to prevent future conflicts such as Darfur".

Mild resource-based conflicts were reported in the Gedarif and Blue Nile states of Sudan, during 2005 and in the preceding years. However, there is no room for complacency. The status of these conflicts is similar to the situation in Darfur during the decade before 2003. These too can escalate into violent conflicts, as experienced in Darfur. In Darfur's situation, the governments, local and central alike, did not heed repeated warnings, and denied the existence of a problem or underestimated the conflict, until it evolved into the tragedy we see today (Babiker et al. 2005).

Low intensity conflicts over natural resources across Africa should be a reason for concern. This is a very important lesson to learn from the Darfur tragedy. Shrinkage in the natural resource base caused by climate change can gradually turn mild conflicts over resources into violent ones if necessary measures, including mitigation and adaptation to climate change, are not implemented. The lessons learned from Darfur will hopefully prevent such a tragedy from happening elsewhere in the future.

References

Alert Net (2009) Darfur profile. http://www.alertnet.org/db/crisisprofiles/SD_DAR.htm

Ali O (2004) Natural resource-based conflict resolution: the case of Greater Darfur. Paper presented at Workshop on Natural Resources and Land Tenure System, Khartoum, 1–2 Nov 2004

Babiker M, Wadi E, El Hilo M, Ali BA (2005) Resources-based conflicts and mechanisms of conflict resolution in Sudan (North Kordofan, Gedarif and Blue Nile states). Oxfam, UNDP, Sudan Environment Conservation Society, Khartoum, p 45

Brawn J (2009) A hostile climate: Did global warming cause a resource war in Darfur? Seed Magazine (27 Apr 2009). www.seedmagazine.com

Faris S (2009) The real roots of Darfur. Atlantic Magazine. www.Atlanticmagazine.com

HCENR (2003) First National communication under the UN framework convention on climate change, vol. II, p. 216. HCENR, Sudan

HCENR (2007) National Adaptation Program of Action (NAPA). Higher Council for the Environment and Natural Resources (HCENR), Khartoum, Sudan, p 54

Heltberg R, Siegel BS, Jorgensen SL (2009) Addressing human vulnerability to climate change: toward a 'no regrets' approach. Glob Environ Change 19:89–99

IRIN News (2007) Sudan: climate change- only one cause among many for Darfur. IRIN News (27 June 2007). www.irinnews.org

National Forest Corporation (NFC) and Sudan Environment Conservation society (SECS) (2009) Towards an environmental work plan for peace in Darfur, Khartoum, April 2009, NFC, SECS, Khartoum, Sudan, p 20

Nimir M (2008) The environmental roots of Darfur problem. In: Najmeldeen N (ed) Issues of nomads and peace, Workshop Proceedings, 11–15 May 2008, Khartoum, Sudan, Amal Center, Khartoum, pp 29–37

Oxfam (2009) Oxfam international report. www.oxfam.org. Accessed 30 Apr 2009

UNEP (2007) Post-conflict Environmental assessment of Sudan. UNEP, Nairobi

Yackle TA (2007) Global climate change: threat multiplier for AFRICOM. Naval War College, Newport, RI, USA

Chapter 49
Virtual Ocean Acidification Laboratory as an Efficient Educational Tool to Address Climate Change Issues

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Abstract As the carbon dioxide concentration in the air is increasing, the oceans are changing: they are getting warmer (global warming) and more acidic (ocean acidification). These threats are very likely to have substantial impacts on marine ecosystems and on terrestrial species that depend on the oceans (e.g. human beings). To prevent the most dramatic consequences of such changes to the climate, citizens need to take collective actions. In that respect, education is a key factor to increase our awareness and understanding of climate change. Within the educational project Inquiry-to-Insight (I2I) we have developed, implemented, and tested Information Communication Technology (ICT) tools addressing the climate change issue with high school students.

One such tool that we have developed is an open access virtual animation and laboratory on ocean acidification (OA). This tool allows students to improve their background knowledge of OA and to become virtual scientists, conducting and analysing research on the effect of ocean acidity on a key and well known marine organism: sea urchin. Our results from a pilot study in two high schools in Sweden and California indicate that the OA I2I activities in particular, and other I2I tools in general, increase students' awareness and understanding of OA.

Keywords Education · Ocean acidification · Virtual laboratory · ICT · Climate change · Scientific method

Introduction

The world's oceans are changing. They are getting warmer but are also becoming more acidic. Since the beginning of industrialization and the use of fossil fuels on a large scale, mankind has emitted 361 gigatonnes of carbon into the atmosphere. Between 1800 and 1999, the ocean has absorbed approximately 155 gigatonnes of

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this carbon (Sabine et al. 2004), making the world's oceans the largest sink of anthropogenic carbon dioxide (CO_2). As CO_2 penetrates seawater, it combines with water to yield carbonic acid, which leads to a drop in pH: a process referred to as "Ocean Acidification" (OA) (Caldeira and Wickett 2003). Since the beginning of the industrial revolution, rising atmospheric CO_2 levels have caused the pH of the oceans to fall by 0.1 unit, corresponding to a 25% increase in acidity. Predictions for the coming century suggest that these changes will accelerate rapidly, and that within a few decades, the oceans will be two to three times more acidic than they are at present (a pH drop of 0.3–0.4 units, Caldeira and Wickett 2003, 2005).

This global change in seawater acidity is a major threat and is likely to have important consequences for marine species and ecosystems (see Doney et al. 2009 for review). The rate of change in seawater pH is 100 times anything seen in the past hundreds of millennia. In this way, marine species in the coming century will find themselves in conditions that their ancestors never have had to face (Ruttiman 2006). It follows that OA will have direct and indirect impacts on humans, since the goods and services provided by the ocean will be affected.

So far this issue has been the little-known "evil twin" of global warming (Richard Feely cited by Savitz and Harrould-Kolieb 2008). However, while some short-term solutions exist for organisms to avoid the temperature increases resulting from global warming (e.g. migration), OA is global and unavoidable for marine species.

Climate change issues need to be considered very seriously and collective actions are of the upmost importance. Three different kinds of environmental behaviour can be adopted by citizens in response to such global threats (Lubell et al. 2007) (1) support for policies designed to decrease global warming risk, (2) environmental political action, (3) engaging in personal sustainable behavior that can have an impact on global warming (i.e. reducing one's "carbon footprint").

Four main factors can stimulate environmental behaviours:

- The major factor is the perception of threat (Lubell et al. 2007); people will be more interested in taking action to deter global warming if they understand the significance of the problem (Mohai 1985).
- Perception of personal influence; people need to believe that their action will make a difference (Mohai 1985).
- Degree of education; studies suggest that better educated individual is more likely to take action to protect the environment (Jones and Dunlap 1992).
- Awareness of the consequences of particular behaviour. Citizens need to understand the benefits of their environmental actions (Lubell et al. 2007).

Education can be directed at, and can presumably have a positive influence on, those four factors. In that respect, education will be of key importance in increasing environmental awareness and understanding for the next generation of citizens, policymakers, and educators. Our educational project Inquiry-to-Insight[1] (I2I) aims to address these issues in a innovative manner.

[1] http://i2i.stanford.edu/.

Inquiry-to-Insight Project

Started in November 2008, the I2I project is a collaboration between Stanford University, California, USA and Gothenburg University, Sweden and their respective marine stations; Hopkins Marine Station and Sven Lovén Center for Marine Sciences, Kristineberg. The I2I project offers an educational programme combining various ICT tools. The I2I concept involves pairing classes from different countries within a private social network. This international collaboration gives students the opportunity to compare views, attitudes, and lifestyles related to environmental issues and to broaden their points of view. Within these discussions, students will explore and compare their differing attitudes and environmental choices, their carbon footprint (thanks to an online animation developed by I2I)[2] and their (self-described) bad environmental habits. Students will work collaboratively on an in-depth investigation related to climate change questions (e.g. food choice, media attention to environmental problems, transport).

A pilot study was conducted, pairing senior students from one school in Sweden and one school in California. The Swedish students are enrolled in a national marine biology programme at Gullmarsgymnasiet, Lysekil. The students from Seaside High School, Seaside, California are members of an advanced biology class.

We describe the initial results of this study in more detail below.

Virtual Scientific Conference

To support the learning context and to clarify students' understanding, interactions between scientists and students are important (Lawless and Rock 1998). Unfortunately, this demands more time and money than schools can typically afford, and more time than most active research scientists can allocate. The virtual conference can be a good alternative to gather scientists and students into a discussion. In that respect, VoiceThread, a multimedia slideshow allowing group conversations, seems to be an effective tool.[3]

During our pilot study, I2I scientist Sam Dupont – a leading researcher at the Sven Lovén Centre for Marine Science studying the biological impacts of ocean acidification – created a 15-min virtual conference on ocean acidification for high school students. Students can have a look at the conference at any time, learn at their own pace, and have ongoing discussions and direct interaction on the topic with other students and I2I team members by leaving questions and comments (audio, video, document, text) through the VoiceThread tool.

A concern was that Swedish students could feel insecure and lack confidence about their use of English in comparison with the Californian students. The ICT

[2]http://i2i.stanford.edu/footprint/footprint.html.

[3]http://voicethread.com.

tools can reveal their full potential by obviating this concern. In fact, ICT tools give Swedish students time to formulate, modify, and improve their comments while interacting with students, teachers, and the I2I staff.

Ocean Acidification Curriculum

An open access curriculum addressing the issue of ocean acidification[4] has been developed by the I2I team. This online curriculum is divided into two parts: an interactive animation presenting ocean acidification background and a virtual lab addressing the question: How does ocean acidification effect sea urchin larval development?

Ocean Acidification Animation

The animation provides an overview of the carbon dioxide emission rising and the consequences of changes in the ocean pH on living organisms. The animation introduces the issue step by step:

1. The explanation of the increase in carbon dioxide in the air through time, related to human activity and its consequences; global warming and ocean acidification.
2. A drag and drop interactive game to compare pH of different liquids and to get familiar with the principles of pH (Fig. 49.1).
3. An interactive graph presenting the pH drop in the ocean and a possible scenario for the near future.
4. Calcification – the process in which the mineral calcium builds up in soft tissue as calcium carbonate, causing it to harden – is a key physiological process for many marine organisms to build a skeleton or shell. It is believed to be one of the processes most affected by ocean acidification (OA). The carbonate chemistry and its link to calcification are described; a simple click on each step provides an in-depth and clear explanation of the reaction. This page describes how a drop in pH in the water can interfere with the calcification process (Fig. 49.2).
5. An interactive model demonstrates how the steps of the calcification reaction would be affected under different future emission scenarios (optimistic, middle ground, pessimistic) based upon actual future greenhouse gas emissions scenarios used by the Intergovernmental Panel on Climate Change (IPCC). Students can time travel between 1895 and 2090, shifting from one scenario to another to see how each chemical of the reaction will be affected, what the resulting pH would be, and how that would be predicted to impact calcification in marine organisms (Fig. 49.3).

[4] http://i2i.stanford.edu/CarbonLab/co2lab.swf.

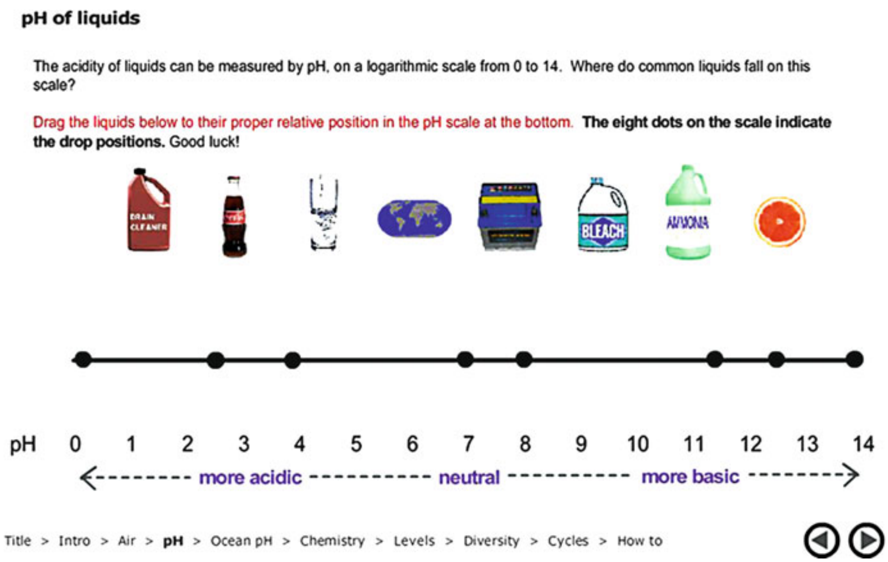

Fig. 49.1 Drag and drop game to introduce the concept of pH through familiar liquids

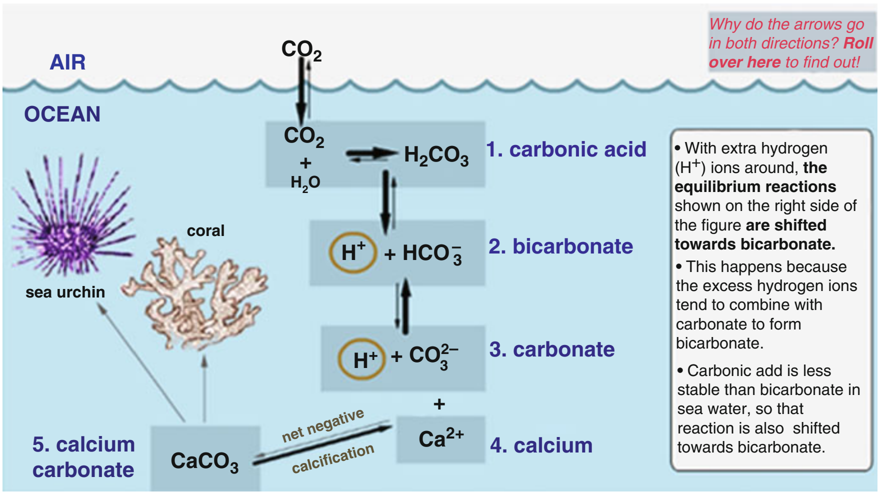

Fig. 49.2 Calcification reaction in the sea water

6. Description of the three main forms of calcium carbonate used by marine organisms to build their skeleton, and which organisms depends on what form.
7. Another drag and drop game on a life tree helps pupils picture the phylogenic relationships between some key marine calcifiers, animal and non-animal.

To illustrate what the consequences of ocean acidification can be on a well-known species, we have used the sea urchin as a model for our virtual OA lab.

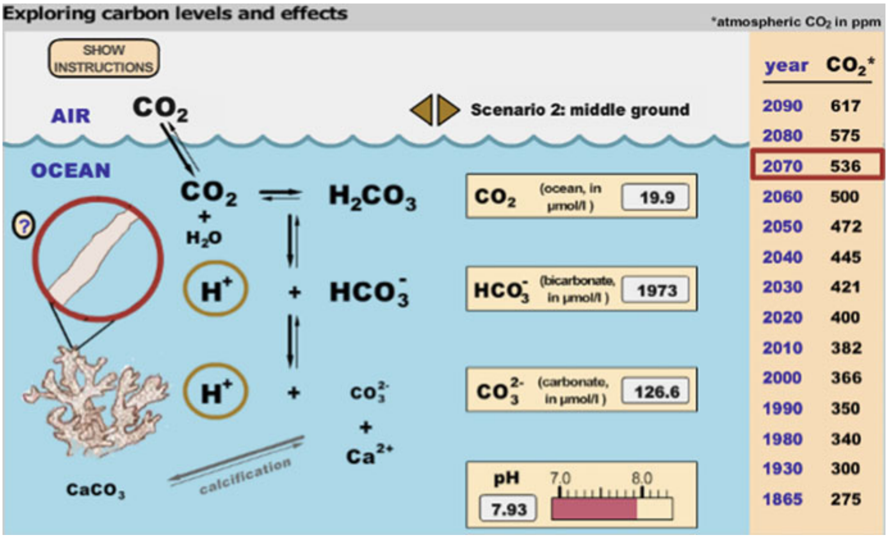

Fig. 49.3 Modifications in the parameters of the calcification reaction through time and under different scenarios; an interactive model

Because of their unique skeleton, sea urchins are one of the most studied organisms in OA field. In particular, their larvae are likely to be strongly impacted by low pH. The complex life cycle of a sea urchin and its magnesium calcite calcium carbonate skeleton development are then described.

Virtual Lab

As students complete the ocean acidification background, they become virtual scientists addressing the question: How does ocean acidification (OA) affect marine life? They perform an experiment to test the impact of OA on sea urchin larval development. They culture sea urchin larvae in 2 different pH conditions (8.1 as a control and 7.7 as the pH value that we can expect for 2100 under a pessimistic CO_2 emissions scenario).

Using an interactive virtual lab, students complete all the procedural steps of the experiment on their lab bench (Fig. 49.4), set up replicate cultures, feed the larvae, make water changes and observe larval development over time.

After 5 days of culture, larvae are mounted on microscope slides for measurement (morphometric) analysis using a virtual microscope. The virtual lab has a database of fifteen individual larvae at each pH (five larvae in three replicates per treatment), and each student measures three randomly chosen larvae at each pH (one larva in each replicate; Fig. 49.5). Each student will thus work on a unique data set. The data the students analyse is actual data addressing this question gathered on

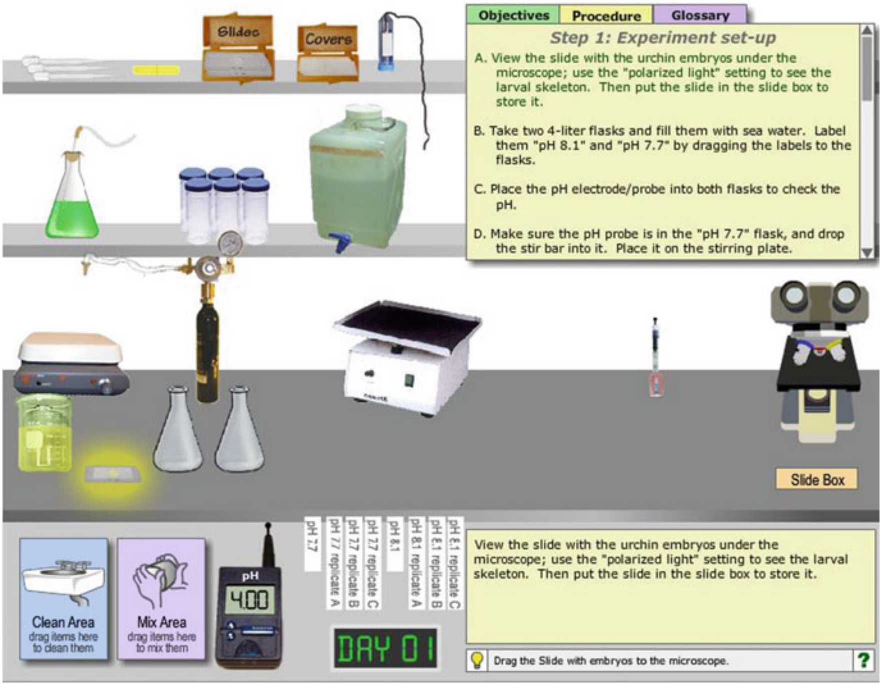

Fig. 49.4 The interactive acidification lab bench

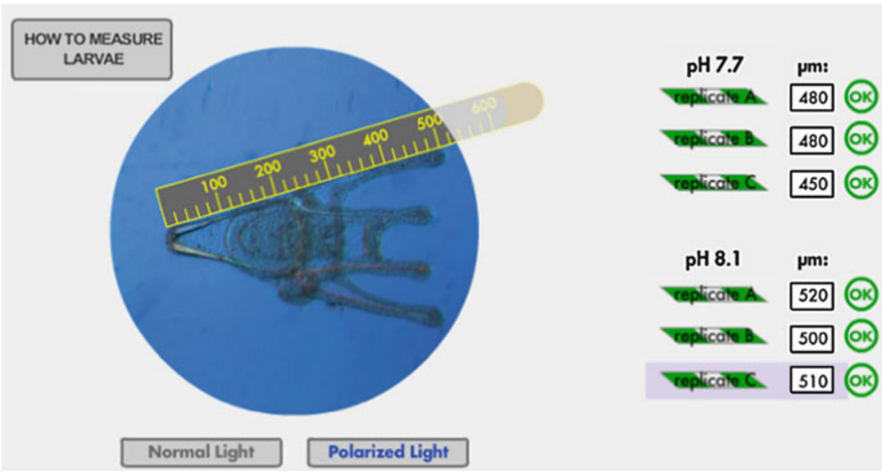

Fig. 49.5 Measurements of the larvae (morphometric analysis). Students align the ruler alongside the larva, and enter their measurement in the boxes on the right. We allow a range of possible measurements around the measurements made by our staff scientists

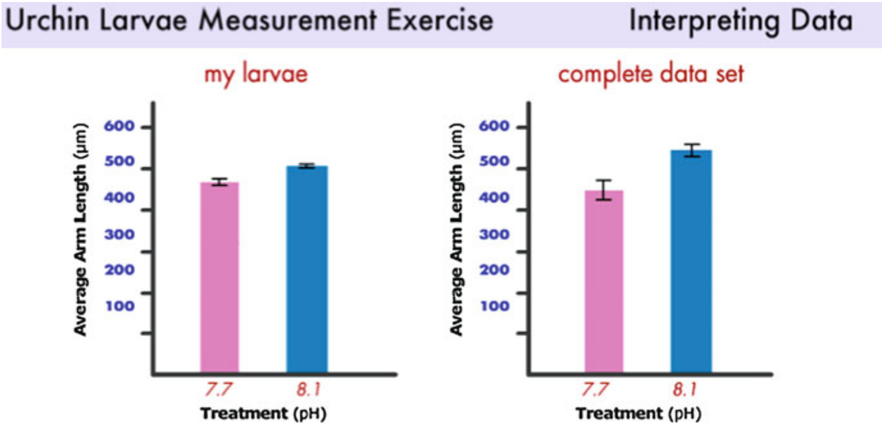

Fig. 49.6 Comparison between results from a subset of data randomly assigned to each student ("my larvae") and the complete data set. In this example, the difference between the treatments is higher in the complete data set, with its increased number of larvae analysed per replicate

the sea urchin *Paracentrotus lividus* by I2I scientists Dupont and Thorndyke, leading researchers at Sven Lovén studying OA impacts on marine life.

After completing the morphometric analysis, students calculate the treatment means using their own unique measurements, and then compare these subsample results with the entire statistical sample (Fig. 49.6).

Students will discover that the effect of their subset can be very different from the complete data set. Aside from educational goals related specifically to OA, this virtual lab addresses the scientific method and its limitations: an experiment is an abstraction from reality that scientists try to reach. That is why deep critical thinking is essential to get an objective view on the world in general and environmental issues in particular.

Results

In order to evaluate our tools addressing the ocean acidification (OA) issue, students filled in a survey at the beginning and end of the project. The OA survey is designed to assess students' knowledge on this issue and includes six questions. The knowledge score was range from 0 (all wrong answers) to 1 (all right answers).

Our tools significantly increase students' knowledge on ocean acidification. Figure 49.7 compares the results from the pre- and post-surveys from the Californian and Swedish students. While there was no significant difference between Sweden and California (an average score of 0.55; $F = 0.27$, $p < 0.6$), a significant increase in knowledge of 30% ($F = 11.6$. $p < 0.001$) was observed in both countries as a result of exposure to the I2I OA activity (ANOVA II, $F = 3.96$, $p < 0.01$).

Students were also asked to evaluate their level of knowledge with a value between 0 (no knowledge at all) and 1 (best knowledge). The Table 49.1 shows

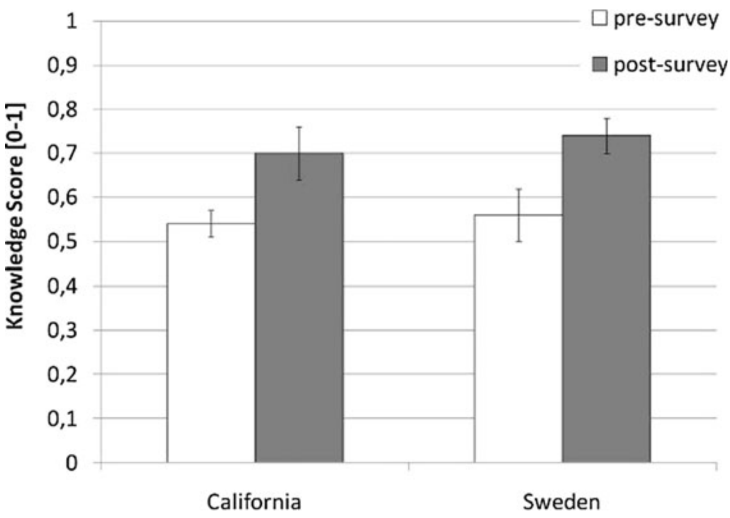

Fig. 49.7 Increase in knowledge (scored between 0 and 1) after the OA animation. Pre-survey in California, n = 15. Pre-survey in Sweden, n = 15. Post-survey in California, n = 9. Post-survey in Sweden, n = 13. The error bars represent the standard error of mean

Table 49.1 Increase in student self-estimation of knowledge on OA before ("pre") and after ("post") undertaking the OA activity. Mean ± standard error of mean

Value	California (pre) (n = 15)	California (post) (n = 9)	p	Sweden (pre) (n = 15)	Sweden (post) (n = 13)	p
[0–1]	0.358 ± 0.052	0.454 ± 0.058	*	0.56 ± 0.04	0.676 ± 0.036	*

that student self-evaluation increases significantly through time by almost 27% in California and by almost 21% in Sweden.

Figure 49.8 illustrates the relation between self-estimation of knowledge and real knowledge on ocean acidification. The symbols (dots and squares) above the line indicates that students' knowledge is higher than their self-estimation of knowledge, which means that they underestimate themselves. The symbols below the line indicate that students overestimate themselves since their knowledge score is under their self-estimation of knowledge.

The majority of our students from both countries underestimate their knowledge before and after I2I participation.

Discussion

We evaluated a group of 30 high school students – 15 in Lysekil, Sweden and 15 in Seaside, California, USA – for their knowledge on the topic of ocean acidification (OA) before and after undertaking our online OA activity. In both groups of

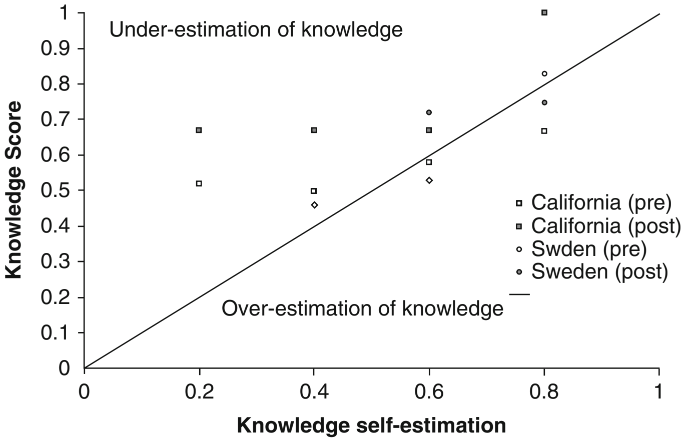

Fig. 49.8 Relation between self-estimation and real knowledge on OA

students, knowledge of OA increased by about 30% as a result of exposure to the I2I OA activity. These preliminary results, showing similarity across the ocean, may indicate the broad applicability of our OA activity across cultures.

Interestingly, students in both the US and Sweden underestimated their knowledge of OA, both before and especially after exposure to the I2I OA activity. The fact that their knowledge increased more than they realized may be seen as a validation of our interactive approach: our activity is designed to be engaging and entertaining, something the students may not generally associate with the learning process. It is possible that they learn more than they realize in this context, something we might refer to as "stealth teaching". More extensive and complete evaluations will be required to evaluate this possibility.

On the I2I project as a whole, our preliminary results (full evaluations to come) show that student response and enthusiasm surpassed expectations. On both sides, students were eager to meet the sister students. Students show an important interest for the social networking aspect of the I2I project. However, it has been a challenge to bring an educational focus to ICT tools that students use mainly or exclusively in a social context.

By contrast, students participated actively when they were guided in forum discussions related to environmental issues (e.g. "bad environmental habits" or "comparison of students' carbon footprint"). Moreover, students who never or rarely spoke in class often participated very actively.

Conclusion

Our preliminary results show that the new tools that we developed increase students' awareness and understanding of environmental issues. This project will also help each school fulfil its goal of education in four different ways.

The scientific dimension is provided by virtual laboratory experiences and virtual discussion with scientists. Laboratory experience is critical for understanding science; lectures and readings do not adequately convey the scientific process (Skolverket 1995; Singer et al. 2005). Yet laboratories are disappearing because they are expensive, require more time than the typical class period, and entail extensive teacher preparation and set-up. Computer-based virtual activities, which simulate (and ideally complement) real lab experiments give the student the flavour of the actual experience. The labs we have developed are made more relevant (Hines et al. 2009), as the students repeat actual experiments on environmental problems, including acquisition and analysis of real data. The students will have the opportunity to discuss such data with the scientists who collected it thanks to VoiceThread discussions.

The critical thinking dimension is provided by teacher-directed (and scientist-validated) analysis of internet content. The web is full of facts about the environment, but this information does not necessarily lead to constructive action since this media often presents contradictory views, even on issues that have a broad consensus in the scientific community (Boykoff and Boykoff 2004; Hart 2007). Making use of resources that are available in the digital world, evaluating the source of this information, and learning to assess apparently conflicting views is a critical part of the learning process. Student understanding of the strengths and limitations of the web will be an important benefit from this project.

The international dimension is a unique aspect of this project. Students in sister schools in Sweden and the US (as well as other countries as the project progresses) will communicate, collaborate, and compare personal, family, and cultural views on attitudes and behaviours related to environmental problems in their respective countries. We believe that this comparative approach, which provides a novel and motivating experience, will remove the narrow perspective where students in each country may feel that their countries' mode of behaviour is the only possible route. This international component broadens the students' view and provides a global approach to shared problems (Cole 2006).

The education dimension is supported by ICT and the peer discussion via social networks within and between classrooms in the different countries. Various studies (Zucker and Light 2009; Myndigheten för skolutvekling 2007) show that students' performance, engagement, and motivation are improved by ICT tools when they are wisely embedded in the curriculum, and that peer discussion increases understanding (Smith et al. 2009). Such findings form an important foundation for our project. We believe this project will be a model for use of those emerging technologies (Hines et al. 2009).

The innovative hypothesis being examined by the I2I project is that sharing views on common environmental problems by social networking will motivate students, enhance learning, and shift student views from an insular to a global one. If validated, this approach would become a paradigm for enriching education and providing global perspectives. The possibilities are limitless, ranging from examination of other shared environmental problems to looking at seemingly intractable differences between countries.

Further Research

In the coming years, our goal will be to:

- Undertake larger-scale and more complete testing of our online activities, including the use of control groups of students exposed to a non-interactive ("paper") acidification curriculum.
- Improve our ocean acidification activity and create new activities on other environmental issues such as habitat issues and mercury toxicity.
- Expand the project to other classes and other countries. I2I project and tools will be translated into Spanish and French.
- Test if the increase in knowledge is associated with a change in behaviour.

References

Boykoff MT, Boykoff JM (2004) Balance as bias: global warming and the US prestige press. Glob Environ Change 14:125–136

Caldeira K, Wickett ME (2003) Oceanography: anthropogenic carbon and ocean pH. Nature 425:365

Caldeira K, Wickett ME (2005) Ocean model prediction of chemistry changes from carbon dioxide emission to the atmosphere and ocean. Geophys Res Lett 110

Cole M (2006) The fifth dimension: an after-school program built on diversity. Russell Sage Foundation, New York

Doney SC, Fabry VJ, Feely RA, Kleypas JA (2009) Ocean acidification: the other CO_2 problem. Annu Rev Mater Sci 1:169–192

Hart P (2007) In denial on climate change. Extra! http://www.fair.org/index.php?page=3418

Hines PJ, Jasny BR, Mervis J (2009) Adding a T to the Three R's. Introduction to special issue, Science 323:53

Jones RE, Dunlap RE (1992) The social base of the environmental concern: have they changed over time? Rural Sociol 57:28–47

Lawless JG, Rock BN (1998) Student scientist partnership and data quality. J Sci Educ Technol 7:5–13

Lubell M, Zahran S, Vedlitz A (2007) Collective action and citizen responses to global warming. Polit Behav 2:391–413

Mohai P (1985) Public concern and elite involvement in environmental conservation issues. Soc Sci Q 66:820–838

Myndigheten för skolutvekling (2007) Internationell forskningsöversikt kring IT i skolan. Liber Distribution, Stockholm

Ruttiman J (2006) Sick seas. Nature 442:978–980

Sabine CL, Feely RA, Gruber N, Key RM, Lee K et al (2004) The oceanic sink for anthropogenic CO_2. Science 305:367–71

Savitz J, Harrould-Kolieb E (2008) The oceans' acid test: can our reefs be saved? Front Ecol Environ 6:515

Singer SR, Hilton ML, Schweingruber HA (eds) (2005) America's Lab Report: Investigations in High School Science. Committee on High School Science

Skolverket (1995) Naturvetenskaplig begreppsförståelse i gymnasieskolan

Smith MK, Wood WB, Adams WK, Wieman C, Knight JK, Guild N, Su TT (2009) Why peer discussion improves student performance on in-class concept questions. Science 323:122–124

Zucker AA, Light D (2009) Laptops program for students. Science 323:82–85

Chapter 50
"Pace of Change": Climate Change and the Empowerment of Local Communities

Lia Carol Sieghart and Delfin Ganapin

Abstract It is widely recognized that although climate change impacts will affect all countries, marginalized communities in the South will be disproportionally affected. Poor people in the developing world have limited capacity to cope and adapt, and are highly dependent on climate-sensitive sectors such as agriculture, forestry, and fisheries. The Global Environment Facility Small Grants Programme (GEF SGP) is strengthening communities and working with civil society to respond to climate change while addressing their pressing development needs. Communities can act on global climate change concerns through the application of local solutions that generate local benefits. GEF SGP is the delivery mechanism by which the GEF and UNDP support the implementation of the United Nations Framework Convention on Climate Change at the community level. Much planning and policy making on addressing the adverse effects of climate change is based on "top-down" assessments (such as modelling data, economic assessments, National Communications, and National Adaptation Programmes of Action), which provide relevant macro-level guidance; however, this can significantly benefit from bottom-up governance. The paper will provide case studies on how empowerment of local communities provides critical guidance to national planning and policy making and consequently ensures calibration and relevance to end beneficiaries. The paper will show how local communities can be in the driver's seat to leverage systemic policy changes at a national level, thereby accelerating the pace of change.

Keywords Climate change · Empowerment · Local communities · Mainstreaming · Ownership · Policy making

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Introduction

Climate change is one of the most critical challenges ever to face present and future generations. Human activities, above all the burning of fossil fuels and changes in land use and land cover, spurred on by economic and population growth, are leading to increasing concentrations of greenhouse gases in the atmosphere. Induced by the build-up of heat-trapping gases, the impacts range from sea level rise, melting ice caps and glaciers, changes in soil moisture, increasing intensity of storms, with amplified incidences of drought and flooding. Climate change has brought increased attention to the function of environmental factors in social and economic development and poverty reduction strategies. It is one of the most serious threats to poverty eradication. Developing countries, and primarily the poor, are the most vulnerable to climate change, as they are mainly dependent on climate-sensitive economic activities (such as subsistence agriculture, fisheries and forestry) and local ecological resources. Climate change will most likely affect the ability of developing countries to obtain their poverty reduction and sustainable development objectives as captured in the Millennium Development Goals (MDGs). Empowering poor people and marginalized communities, improving local governance, and providing adequate infrastructure and services are required to meet the MDGs.

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted as the basis for a global response to climate change. With 192 Parties, the Convention enjoys near-universal membership. The Convention recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases (GHGs). Under the Convention, governments (1) gather and share information on greenhouse gas emissions, national policies, and best practices; (2) launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technical support to developing countries, and (3) cooperate in preparing for adaptation to the impacts of climate change (UNFCCC 1992).

Since 1992, the Global Environment Facility Small Grants (2009) (GEF SGP) has taken the task of supporting communities and civil society organizations (CSOs) in their environmental efforts that at the same time lead to poverty reduction and the empowerment of local communities. Through a country-driven and decentralized approach and partnerships with local CSOs and government, SGP develops its understanding of how local livelihood strategies and contexts, poor people's challenges, efforts, values, and aims relate to climate change. Through its strategic priorities, it is the mechanism by which the GEF and UNDP support the implementation of the United Nations Framework Convention on Climate Change at the community level. As a corporate programme of the GEF, the SGP is mandated by the guidance of the UNFCCC Conference of the Parties (UNFCCC COP) to address climate change challenges. Grants are made directly to non-governmental (NGOs) and community-based (CBO) organizations in recognition of the key role they play as a resource and constituency for climate change and development concerns. Highly decentralized and demand-driven, SGP encourages maximum country and community ownership. Local communities are the integral partners in the process of project design and implementation. The programme operates on the principles that local people will be empowered to protect the environment when they are organized to take actions, have a measure of control over access to the natural resource base, can deploy the necessary information and knowledge, and believe that their social and economic welfare is dependent on sound long-term natural resource management. In each participating country, the GEF SGP operates in a highly decentralized and country-driven manner through a National Coordinator and a voluntary National Steering Committee (NSC). Grants are screened, approved and disbursed at the national level by the NSC. The NSC typically encompasses representatives from local NGOs, CBOs, government, academia, UNDP, co-funding donors, indigenous peoples' organizations, the private sector and the media. The majority of NSC members are from the non-governmental sector. The NSC uses the democratic principles of fairness, transparency, and collaborative decision-making. This multi-stakeholder approach guarantees direct participation of people and communities in local development and strengthens human, social, and institutional capital. The NSC provides a unique platform to enhance multi-faceted stakeholder cooperation. Further, it plays a key role in linking good practices and lessons learned to the larger policy making and process, as well as to global climate change governance. The NSC is the vehicle by which GEF SGP links to national policy making and development planning. This approach has proven to be successful in getting resources from many sources to grantee partners in need and thereby realizing the twin objectives of addressing the growing threat of climate change and enhancing the wellbeing of local communities. By raising public awareness, building partnerships and promoting an enabling institutional framework the grant-making outcomes extend far beyond merely disbursing grants to local stakeholders. Thus, the 20% of its more than 11,000 projects that are in the climate change portfolio (GEF SGP, 2009), create impacts beyond its environmental objectives and the numbers of projects.

Policy Making and Empowerment of Local Communities: Experiences from GEF SGP

Providing local communities with tools and training to make informed decisions is a key element of the GEF SGP climate change projects. Strengthening communities' capacity to reduce poverty and promote sustainable livelihoods helps to create an enabling environment to address climate change. The GEF SGP establishes concrete mechanisms and models to help communities address climate change, and to increase their political participation and influence in society. For example, much planning and policy making on addressing the adverse effects of climate change is based on "top-down" assessments (such as modelling data, economic assessments, National Communications and National Adaptation Programmes of Action). While they provide relevant macro-level guidance, they can however significantly benefit from bottom-up inputs and governance. For example, one of the best ways to combat climate change is to draw on people's own experiences and perceptions, and to use that as an integral ingredient of policy responses. Despite the general small size of grants (maximum US$50,000) given to NGOs and CBOs for the implementation of community-based climate change activities, experience has shown that numerous projects have helped shape national policies. While projects are primarily designed to support activities to combat climate change while contributing to local development, the motivating factor towards policy impacts lies within the opportunities open for mainstreaming, replication, and upscaling. Community-based action is the starting point for scaling national responses. Working in 119 countries, the programme's important lesson learned is that the empowerment of local communities is directly related to people's opportunities and capabilities to make and express choices and to transform those choices into desired actions and outcomes – vital to effective project design and implementation and perhaps more importantly to their sustainability. Projects with this framework eventually establish concrete institutional mechanisms for citizen input at the local level, and increase the capacity of citizen groups to address public issues at both local and national levels. In this way, SGP has developed models and approaches to catalyse the promotion of renewable energy, energy efficiency, sustainable transport, and community-based adaptation that also inputs into policy making and development planning. The following case studies demonstrate how integrating empowerment of local communities into climate change action provides a potent constituency that can provide critical guidance to national planning and policy making and consequently ensures calibration and relevance of policies and plans to those most vulnerable to climate change.

Case Study 1

Greenhouse gas (GHG) emission reductions through use of energy-efficient technologies by textile processing units in Tamil Nadu, India

National Coordinator: Mr Prabhjot Sodhi

Project Proponent: Technology Informatics Design Endeavour (TIDE)

The textile processing cluster in southern Tamil Nadu accounts for approximately 50% of Indian textile mills, 35% of Indian yarn production, and about 19% of Indian textile workers. The textile industry in this region consumes significant quantities of fuel wood to meet its thermal energy requirements for the production of hot water used for dyeing textile yarn. Required fuel is collected from the nearby forested areas, thereby leading to significant deforestation problems. In addition, the smoke generated proves to be a substantial health hazard on the workforce. In short, conventional stoves consume significant quantities of fuel wood, are highly energy inefficient, generate substantive amounts of GHG emissions and create an unhealthy working environment. Consequently, it is key to explore environmental and energy-efficient options for heat generation. The overall objective of the project is the development of sustainable mechanisms for the reduction of GHG emissions from textile processing units in Tamil Nadu. The project outputs include the development of a sustainable network to promote and disseminate energy-efficient technologies for the textile processing units, and to install energy-efficient stoves and solar systems. The project aims at the removal of major barriers hindering the adoption measures (Fig. 50.1).

In the course of the implementation the project proponent, Technology Informatics Design Endeavour, (TIDE) designed, tested, and disseminated nine different technologies, all of which were low cost options, easy to maintain, user-friendly and energy-efficient. The project developed energy-efficient, biomass-fired water heaters for heating of water to temperatures that are required by the dyeing units. These water heaters are movable from one location to another, save about 60% of biomass (as compared to consumption levels in conventional stoves), and are compatible with the operations of the units. The approach resulted in a “basket of choice”, thereby being able to accommodate a broad variety of end-user needs. The project activities focused on demonstration of fuel-efficient devices, developing an entrepreneurial network and market development activities. In addition, a project information centre was opened in the Komarapalyam (Namakkal district). Fuel-efficient textile bleaching stoves and biomass briquettes are now being sold by entrepreneurs facilitated by the market development activities of the project.

The project successfully contributed to empowerment in the following ways (1) it transformed the energy demand market into one that is not only much more energy efficiency-oriented, but also where the cost of adopting is economically

Fig. 50.1 Energy-efficient stove – demonstration model. (Courtesy of Mr Prabhjot Sodhi)

feasible and therefore within the management capacity and control of local stakeholders; (2) it demonstrated that energy efficiency can significantly contribute to local sustainable development and create new economic opportunities while mitigating greenhouse gas emissions and reducing harmful air pollutants; and (3) strengthened cooperation and collaboration at the community level in the process of enhancing energy security. In addition, the Ministry of New and Renewable Energy is developing policy guidelines for all textile units following the technical specifications as developed by the project. In 2008, TIDE was awarded with the Global Ashden Prize, an internationally recognized yardstick for excellence in the field of sustainable energy (Sodhi 2009).

Case Study 2

Energy-efficient housing for the poor

National Coordinator: Mr Masood Lohar

Project Proponent(s): Research and Development Foundation and Participatory Efforts for Health Environment; Aga Khan Foundation, Pakistan

The project area includes Northern Areas, Chitral, and Nathiagali region of the high mountain ranges of Hindukush, Karakoram, and Himalayas of northern Pakistan. The area is spread over 74,000 km^2 with a total population of approximately 1 million. The region experiences very cold winters, with temperatures falling to −30°C. Up to 95% of all households use timber from adjacent forest areas as the main material in housing constructions. Furthermore, biomass is the primary source of energy. Women and children spend significant periods of time searching for fuel wood for cooking and heating, which places immense pressure on local forest ecosystems. In the winter season, additional fuel wood needs to be purchased, thus increasing the burden on the already pressing economical household situations. The inefficient use of biomass generates smoke and is leading to poor indoor air quality and related health problems.

Since 1997, the Building and Construction Improvement Programme (BACIP), a project of the Aga Khan Housing Board in Pakistan, has been conducting applied research on improved stoves and construction techniques. However, the challenge to make these improvements accessible to local residents and integrate those into local patterns of life remained. Through research and demonstration, the project intended to pilot an approach to curb the degradation of the forest ecosystems and the excessive consumption of fuel wood for household energy generation with the development of an “Energy-Efficient Model House” equipped with energy-efficient housing and technological (EE & HI) products, such as a fuel-efficient stove, water warming facility, floor insulation and roof-hatch windows. Links to local and national governments was also a vital component particularly in the development of market support mechanisms and a policy enabling environment to facilitate broad based opportunity of installation and use of these EE & HI products. These

Fig. 50.2 Energy-efficient housing model. (Courtesy of Mr Masood Lohar)

project activities were also determined as critical for long term social and environmental sustainability (Fig. 50.2).

In the course of project implementation, the “Energy-Efficient Model House” was developed, tested, and piloted in Thatta in 2004. In 2007, it was further refined and piloted in the Badin district in an additional GEF SGP funded project. The project relied solely on local material and local labour to make it within the capacity of the local participants to implement and manage. The “Energy-Efficient Model House” received enormous attention from local government representatives. The model house was defined as an outstanding example to fulfil the needs of conserving energy, promoting local empowerment and reducing poverty. In 2008 a co-financing agreement was signed between the UNDP and the Government of Sindh to replicate through SGP the model house in the disaster- and poverty-stricken areas of Thatta, Badin, and Karachi districts. This “energy-efficient housing for the poor” project, co-financed by the Government of Sindh and the UNDP, is the replication of the GEF SGP “Energy-Efficient Model House” at a mass scale. The construction of 500 such houses in the targeted area is under progress along with providing safe drinking water and solar lighting. Recently the Government of Pakistan announced the planned construction of 1 million energy-efficient houses for the poor replicating the “Energy-Efficient Model House” (Lohar 2009).

Case Study 3

National Coordinator: Ms Alejandra Alarcon

Project Proponent(s): Fernandez y Véliz Community Agricultural Community

The Fernandez y Véliz Community Agricultural Community is located in northern Chile, a place affected by drought, land degradation, soil erosion, overgrazing, and deforestation. People depend primarily upon wood for cooking, thereby accelerating pressure on the decreasing forest areas. However, the area enjoys high availability of solar radiation at an utilizable level. Longer average sunshine hours indicate high energy production from solar energy technologies. In addition, during the coldest period of the year, the average sunshine hours are over 8 h per day. The high availability of solar energy during this period represents an important opportunity for thermal (e.g. to heat water, cooking) and electrical (e.g. direct conversion of sunlight to electricity) applications. It is prudent to explore renewable energy off-grid options, especially through sustainable community-based initiatives. However, the few existing approaches on solar systems rely heavily on imported material and fail in the long run, due to missing and prohibitive imported spare parts and maintenance challenges. The project funded by the GEF SGP in cooperation with the European Union was thus aimed at the promotion of solar power for cooking, as well as the establishment of relevant local capacity to construct and maintain solar cookers. The implemented activities included awareness raising and capacity building on climate change and the development of local expertise on the construction of solar ovens. The project included the establishment of a local centre of excellence for the development and maintenance of solar ovens at the community level. Linking with local government officials was also an important activity. In the closing ceremony, attended by high-level officials, the project successfully demonstrated 180 solar cookers that it was able to develop in a community-based approach through a high profile activity. Convinced by the relevance and efficacy of the solar cookers, the municipality is developing a regulatory framework for the establishment of a neighbourhood development fund aimed at replication and upscaling of the solar oven technology on a much wider scale (Alarcon 2009) (Fig. 50.3).

Conclusions and Recommendations

Climate change represents an important additional stress on those systems already affected by increasing resource demands, unsustainable management practices, and pollution. These stresses will interact in different ways across regions, but can be expected to reduce the ability of environmental systems to provide, on a sustained basis, key services and goods needed for successful economic and social development. The selected case studies reveal how a process commences at the community level and, from there, advances to national decision-makers. They show how local communities can be in the driver's seat in project implementation and thus convincingly demonstrate relevant and effective actions that can serve as basis to leverage systemic policy changes at a national level. While the direct contribution of a single community project might be small in volumes of GHG reductions, the eventual overall cumulative and impacts of its accompanying components of local

Fig. 50.3 Closing ceremony. (Courtesy of Ms Alejandra Alarcon)

empowerment and linking with governments at various levels that inform and influence policy and support scaling up have demonstrative effects at both national and global levels. The case study projects applied a twofolded approach with equal importance (a) a community-based approach that empowered local community partners through their direct involvement in planning and implementation of projects; and (b) linking with local and national governments that eventually strengthens and widens local empowerment. The success shown by these combined approaches provide proof that local communities' needs and interests and their empowered action can be at the forefront of national policy planning on addressing climate change. Eventually, community-based approaches and action will form the foundation for global efforts at addressing climate change concerns, providing the basis by which global action becomes relevant and sustainable.

References

Alarcon A (2009) Information provided by Ms Alarcon on 16 July 2009
Global Environment Facility Small Grants Programme (2009) www.undp.org/sgp
Lohar M (2009) Information provided by Mr Lohar on 16 July 2009
Sodhi P (2009) Information provided by Mr Sodhi on 16 July 2009
United Nations Framework Convention on Climate Change (1992) www.unfccc.int

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