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Crop–livestock interactions and livelihoods in the Gangetic Plains of Bihar, India

CIMMYT

Rice Wheat

CGIAR Systemwide Livestock Programme slp

Crop–livestock interactions and livelihoods in the Gangetic Plains of Bihar, India

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Acronyms

AI	artificial insemination
AU	animal unit
CIBR	Central Institute on Buffalo Research (Hisar, Haryana)
CIMMYT	International Wheat and Maize Improvement Centre (Texcoco, Mexico)
FYM	farm yard manure
GCA	Gross cropped area
HAU	Haryana Agricultural University
hh	household
IGP	Indo-Gangetic Plains, South Asia
ILRI	International Livestock Research Institute (Nairobi, Kenya)
KVK	Krishi Vigyan Kendra (Extension outreach program, India)
LGP	Lower-Gangetic Plain (subregion of the IGP, comprising the downstream plains in Eastern India [West Bengal], Ganges basin)
MGP	Middle-Gangetic Plain (subregion of the IGP, comprising the midstream plains in Eastern India [eastern U.P. and Bihar], Ganges basin)
MSP	minimum support price
n	number of observations
NGO	non-governmental organization
ns	non-significant
p.	probability
PAU	Punjab Agricultural University
RCTs	resource-conserving technologies
RWC	Rice–Wheat Consortium of the Indo-Gangetic Plains (New Delhi, India)
s.d.	standard deviation
SLP	CGIAR Systemwide Livestock Programme
TGP	Trans-Gangetic Plain (subregion of the IGP, comprising the plains in northwestern India [Punjab, Haryana], straddling Ganges and Indus basin)
UGP	Upper-Gangetic Plain (subregion of the IGP, comprising the upstream plains in north-central India [western U.P.], Ganges basin)
U.P.	Uttar Pradesh
ZT	zero tillage

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Foreword

The present study is the third in a series of five reports for the crop–livestock interactions scoping study. The first four reports each describe a particular subregion of the Indo-Gangetic Plains in India: the Trans-Gangetic Plains (TGP) comprising Punjab and Haryana (Erenstein et al. 2007b), Uttar Pradesh (Singh et al. 2007), Bihar (this report) and West Bengal (Varma et al. 2007). The fifth report synthesizes across the four subregions (Erenstein et al. 2007a). To facilitate write-up, synthesis and future reference, the reports all follow a similar outline and table format. This implies some repetition between reports, but this was still preferred over a single bulky report in view of the richness and diversity of the information and so as not to lose the local insights and relevance. Chapter 1 (Introduction), chapter 2 (Methodology), the action research needs for the IGP (part of 7.3) and most of the annexes are largely identical in each of the reports. Each of the reports can be read as a standalone report.

Executive summary

The research and development community faces the challenge of sustaining crop productivity gains, improving rural livelihoods and securing environmental sustainability in the Indo-Gangetic Plains (IGP). This calls for a better understanding of farming systems and of rural livelihoods, particularly with the advent of, and strong advocacy for, conservation farming and resource-conserving technologies. This scoping study presents an assessment of crop–livestock interactions and rural livelihoods in the Gangetic Plains of Bihar, drawing from a village survey in three districts (Bhojpur, Samastipur and Begusarai) and secondary data.

Bihar is one of India's poorest states: 44% of the rural populations are below the poverty line. Bihar is characterized by diverse rural livelihoods based on rice–cattle farming systems in a risk-prone and underdeveloped environment. Wheat is a non-traditional crop in Bihar but over the last decades has become a major crop and rice–wheat a major cropping system (17% of system area in the IGP). Farm size is low whereas half the population is landless, reflecting its high rural population density and population growth.

Livelihood platforms

Land is the central asset for the livelihoods in the surveyed communities, with only 65% of households having access to land and with an average landholding of 1.3 ha per farm household. The physical capital asset base is low, particularly in terms of rural infrastructure, public irrigation development and mechanization. Human capital was limited by illiteracy, with up to 57% of the household heads in the Begusarai cluster having no formal education.

Despite high pressure on the land, capital remains the most limiting production factor, with informal interest rates averaging 4.8% per month. Daily wage rates are low (Indian rupees, INR)[1] 49) and markedly similar across clusters. The surveyed villages tend to be net-suppliers of labour, with marked seasonal out-migration. Similar to U.P., gender inequity still plays a key role, reflected *inter alia* by gendered wage rates and even lower female literacy. Social structures, poor infrastructure and poor public services, including limited access to new knowledge, constrain innovation. Refreshing were the 'islands' of agricultural diversification represented by the commercial maize and vegetable plots, and their private sector support.

Livelihood strategies

Livelihood strategies in the surveyed communities predominantly revolved around crop–livestock systems and agricultural labour. Rice and wheat dominate the cropping pattern, but

1. Indian rupees (INR). In May 2008, USD 1 = INR 40.542.

systems are relatively diversified with significant roles for maize (monsoon and winter) and horticulture. Some 3–6% of the cultivated area is devoted to fodder crops in each season. Wheat and rice are primarily for domestic consumption reflecting limited surplus associated with productivity and farm size constraints. Important cash crops for smallholders included hybrid winter maize and vegetables.

Livestock complements the diversified rice–wheat based cropping systems as the basis of rural livelihoods. Compared to other IGP states, livestock ownership is more limited though and the aggregate livestock herd varied from a 'high' of 2.1 cow equivalents per household in the Bhojpur cluster to a low of 1.0 in the Begusarai cluster. The limited aggregate herd size reflects a more limited role for dairy and a prevalence of small ruminants. Buffalo were increasingly substituted by cattle along a W–E gradient, whereas crossbreds were more common than *desi* cattle. Backyard poultry is again markedly absent.

Similar to the rest of the IGP, crop production appeared as the main livelihood source for landed households, with livestock typically being complementary. Landless households depend primarily on their labour asset, including seasonal out-migration.

Crop–livestock interactions

Bihar is characterized by the prevalence of rice and wheat as food and feed crop. Wheat residues, and to a lesser extent rice residues, have scarcity value and are intensively collected, stored and used as the basal animal feed and eventual surpluses traded. Compared to the other IGP states, reported residue prices were relatively high (INR 1.7/kg for wheat straw and INR 0.8/kg for rice straw). Maize residues are also used as feed but the extent is limited by aflatoxin contamination. Similar to neighboring U.P., there is some stubble grazing and limited *in situ* burning of residues.

Livestock are primarily stallfed supplemented with grazing. The basal diet consists primarily of cereal straws (wheat, rice and some maize), complemented with a seasonal mix of produced green fodder, collected forage, compound feed and other crop by-products. Despite the growth of the dairy crossbred herd there was no significant trend towards specialization in dairy production and the role of bovines was not perceived as primary income earners.

Crop–livestock farms prevail in Bihar, but the level of crop–livestock interaction in terms of physical inputs has declined and is low, despite the integrated nature of the farming system and the apparent lack of specialization. Similar to the other IGP states, more interdependency between crop and livestock components is apparent at household level in view of complementary labour needs and internal non-monetary services.

Based on these findings the study goes on to explore the effects on livelihood security and environmental sustainability and provides an outlook and agenda for action for Bihar clusters as well as the generic action research needs that emerge from all the IGP clusters.

1 Introduction

The outstanding contribution of agricultural research towards improving the livelihoods of poor farmers on the Indo-Gangetic Plain (IGP) through the Green Revolution technologies is well documented (Frankel 1971; Pinstrup-Andersen and Hazell 1985; Lipton and Longhurst 1989; Hazell et al. 1991; Evenson and Gollin 2003). During the 1960s to 1980s, the planting in the irrigated fields of the IGP of high-yielding wheat and rice varieties, combined with the application of fertilizer, gave much improved cereal production. As a result India moved from a deficit in the staple grains, wheat and rice, to a secure self-sufficiency. Now, in the face of diminishing groundwater supplies and degrading soils (Kumar et al. 1999; Pingali and Shah 1999), the challenge is to sustain crop productivity gains, while supporting the millions of families on the IGP—most of whom are resource-poor—to diversify their farming systems in order to secure and improve their livelihoods.

Central to this challenge of ensuring improved livelihoods and environmental sustainability are the ruminant livestock—particularly buffalo, cattle and goats—which are an integral part of the IGP's farming systems. For decades, beneficial interactions between rice and wheat cropping and ruminant livestock have underpinned the livelihood systems of the IGP. Yet until recently, there has been little systematic research to assess the benefits of these interactions, or to evaluate the potential for improvement. Based on a review of over 3000 papers from South Asia, Devendra et al. (2000) reported a paucity of research that incorporates livestock interactively with cropping, and a woeful neglect of social, economic and policy issues. Bio-physical commodity-based crop or livestock research had dominated, a systems perspective was lacking and many of technologies which were developed were not adopted. More recently broad classifications of crop–livestock systems in South Asia and their component technologies have been documented (Paris 2002; Thomas et al. 2002; Parthasarathy Rao and Hall 2003; Parthasarathy Rao et al. 2004). However, it is clear that a better understanding of farming systems and of the livelihood objectives of landed and landless families, including how they exploit crop–livestock interactions, will be required if we are to be successful in improving rural livelihoods and securing environmental sustainability in the IGP.

Taking a systems approach and applying a livelihoods perspective (Ellis 2000) are particularly important because of the dynamics and diversity of the IGP's social geography, its agriculture and the complexity of the crop–livestock interactions. Current understanding of the interactions is only partial; hence the need to update our knowledge and to assess the implications for agricultural R&D, particularly with the advent of, and strong advocacy for, conservation farming and RCTs (resource-conserving technologies, e.g. zero-tillage, permanent beds and mulching). The RCTs are having some success in improving resource use efficiency for crop production (RWC 2005; Singh et al. 2005), but there is a lack of information about their impacts on overall farm productivity and its livestock components (Seth et al. 2003). Improving our understanding of crop–livestock interactions and their contributions to rural livelihoods will better position the R&D community to be more effective in addressing the major challenges of improving livelihoods while ensuring environmental sustainability.

It was against this background that the Rice–Wheat Consortium designed a scoping study with the following objectives:

- To assess rural livelihoods and crop–livestock interactions in the IGP
- To understand the spatial and seasonal diversity and dynamics of livelihoods and crop–livestock interactions, particularly in terms of the underlying drivers and modifiers
- To assess the corresponding implications for R&D programs.

The study was carried out across the Indo-Gangetic Plains of India, comprising the states of Punjab, Haryana, Uttar Pradesh (U.P.), Bihar and West Bengal. For the purposes of this study we grouped the Indian IGP into four subregions: the Trans-Gangetic Plains (TGP: Punjab and Haryana) and the Gangetic Plains of U.P., Bihar and West Bengal. The Gangetic Plains of U.P. thereby comprise the Upper-Gangetic Plains and part of the Middle-Gangetic Plains, Bihar comprises most of the Middle-Gangetic Plains and West Bengal comprises the Lower-Gangetic Plains (Figure 1). This report describes the study carried out in Gangetic Plains of Bihar. Its results and those from the other three subregion reports (TGP—Erenstein et al. 2007b; U.P.—Singh et al. 2007; and West Bengal—Varma et al. 2007) are drawn together in the main synthesis report (Erenstein et al. 2007a).

The study reports are structured as follows. The second chapter presents the overall methodology followed and details about the specific survey locations. The third chapter presents the study area drawing primarily from secondary data and available literature. The fourth chapter analyses the livelihood platforms in the surveyed communities, distinguishing between the livelihood assets, access modifiers and trends and shocks. The fifth chapter describes the livelihood strategies in the surveyed communities, with particular attention for crop and livestock production. The sixth chapter assesses the crop–livestock interactions in the surveyed communities, with particular emphasis on crop residue management and livestock feeding practices. The seventh chapter first discusses the effects on livelihood security and environmental sustainability and subsequently dwells on the outlook for the surveyed communities and draws together an agenda for action.

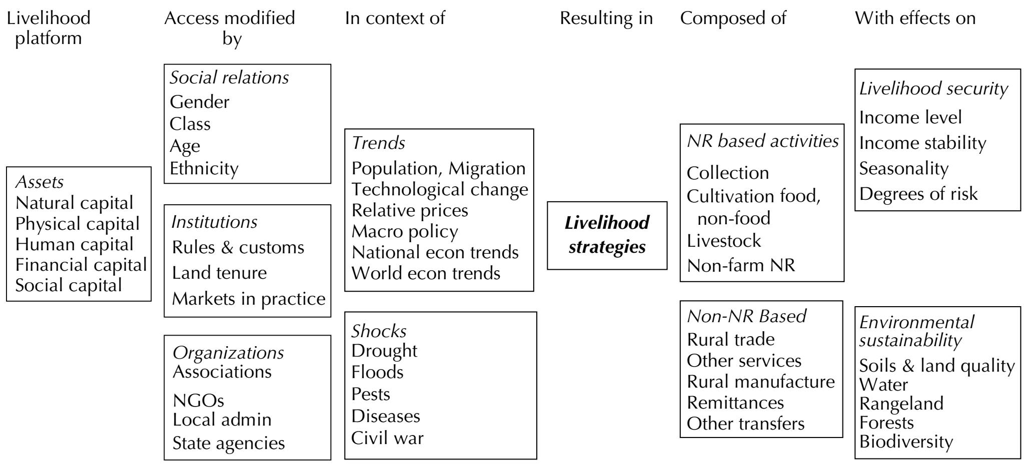
Legend: 1: Indus Plains; 2: Trans-Gangetic Plains [TGP]; 3: Upper Gangetic Plains [UGP]; 4: Middle Gangetic Plains [MGP]; 5: Lower Gangetic Plains [LGP]

Figure 1. *The Indo-Gangetic Plains and its five subregions.*

2 Methodology

Conceptual framework

The scoping study set out to assess rural livelihoods and crop–livestock interactions in the Indo-Gangetic Plains (IGP) through the combined use of secondary information and village-level surveys. In order to better dissect and understand livelihoods and the contributions of crops, livestock and interactions of the sample village communities, the scoping study took as its analytical framework the 'assets-mediating processes-activities' model presented by Ellis (2000, Figure 2).



Source: Ellis (2000).

Figure 2. *A framework for the analysis of rural livelihoods.*

The framework provides a systematic way of (i) evaluating the assets of households and communities and the factors (e.g. social relations or droughts) that modify access to these assets; (ii) describing and understanding current livelihood strategies; and then (iii) exploring the options for reducing poverty and addressing issues of sustainability. Of particular interest in our scoping study was to understand the dynamics of the livelihood systems and how these influenced decisions on the management of rice–wheat cropping and of livestock and their interactions, e.g. the trade-offs between RCTs (resource-conservation technologies) and the use of crop residues to feed buffalo for milk production. Taking this livelihoods approach ensured that natural resource-based and other activities were addressed and that their effects on livelihood security and environmental sustainability were assessed.

Figure 3 schematically presents the linkages between crop and livestock systems in the IGP that further guided the study. The scoping study did not intend a comprehensive assessment of the crop and livestock subsectors of India's IGP. Instead emphasis was placed on the linkages—the crop–livestock interactions—at the farm and village level between the two subsectors. The study therefore focused on the dynamics at the interface of the crop and livestock subsectors. Within that dynamics a further focus was placed on the management of crop residues because of their importance as ruminant livestock feeds and their role in natural resources management.

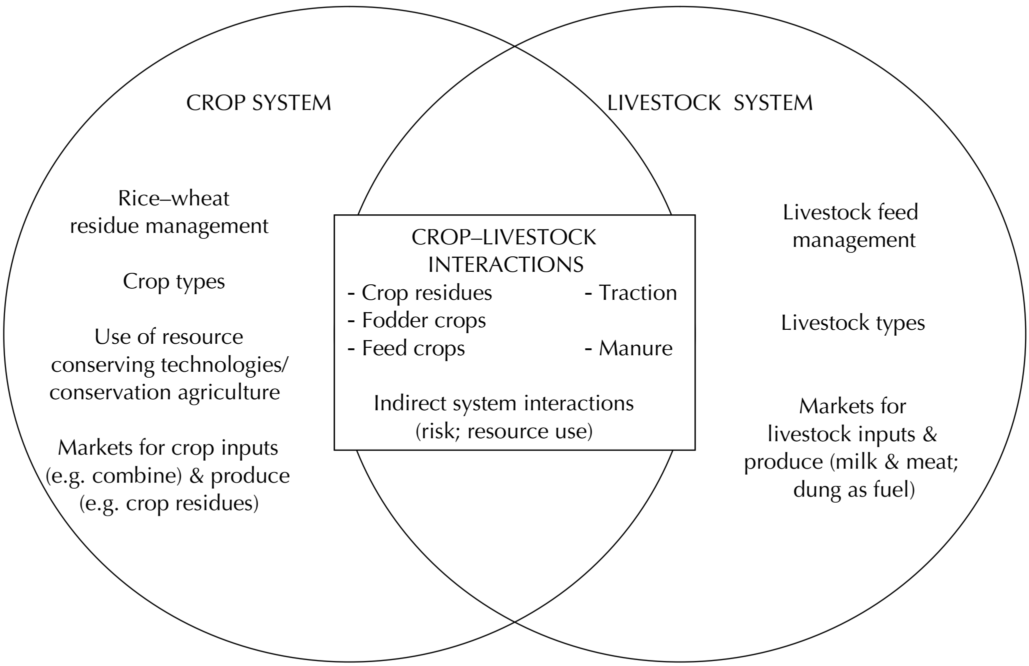
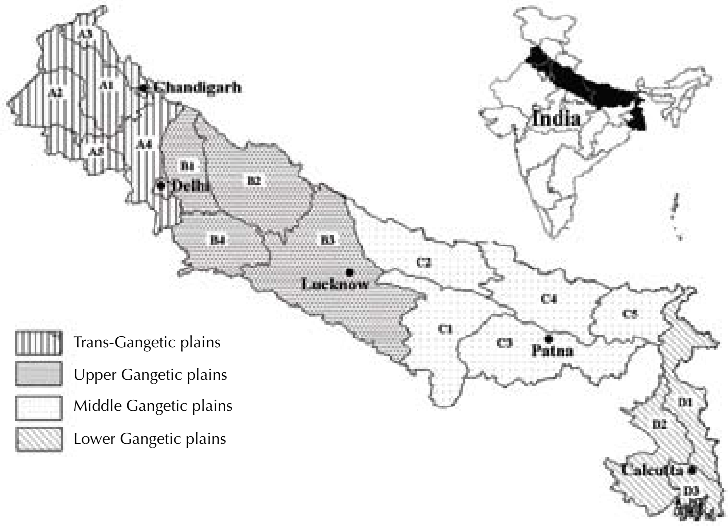


Figure 3. *A schematic representation of crop–livestock interactions in the Indo-Gangetic Plains.*

Village-level survey

The main data source for the scoping study was a village level survey of a total of 72 communities from April to June 2005. The communities were randomly selected using a stratified cluster approach. At the first level, we grouped the Indian IGP into four subregions: the Trans-Gangetic Plains (TGP: Punjab and Haryana) and the Gangetic Plains of U.P., Bihar and West Bengal. Each subregion comprises various agro-ecological subzones as described in the classification by Narang and Virmani (2001, Figure 4) and Kumar et al. 2002). At the second level, we purposively selected a representative district from each of the 3 main IGP agro-ecological subzones within the subregions. These locations were selected to reflect the range of agro-ecological conditions in the IGP and to capture the expected variation in farming systems, including level of access to irrigation services. At the third and final cluster level, we randomly selected 6 villages around a central point, typically the district headquarters. The villages were randomly selected by taking two villages off the main road along three opposing directions, one village typically relatively close (generally within 5 km) and the second further away (generally more than 15 km). Table 1 shows the name, cluster and agro-ecological classification of each village in Bihar for which a survey was carried out. Figure 5 shows the location of the 18 villages (based on readings from GPS units) within the three Bihar clusters.



Source: Adapted from Narang and Virmani (2001).

Figure 4. *Subregions and agro-ecological subzones of the Indo-Gangetic Plains.*

Table 1. *Name, cluster and zone of the 18 surveyed villages in the Gangetic Plains of Bihar*

Cluster (State)	Bhojpur (Bihar)	Samastipur (Bihar)	Begusarai (Bihar)
Village	H P English	Keosjagir	Lagauli
	Baldev Singh Ka tala	Dhurlakh	Adharpur Tajpur
	Dubauli	Gopalpur	Kushmahaut
	Siddih	Bhakhora	Meenapur
	Katteya	Baghi	Bidulia
	Ganghar	Kerai	Bhelva
Zone*	South Bihar Plains (C3)	North West Plains (C4)	North East Plains (C5)

* Following Narang and Virmani (2001, 6) and Kumar et al. (2002, 22).

Source: Adapted from Narang and Virmani (2001). Figure 4 maps the coded subzones.

Within each village we interacted with self-selected groups of key informants. We thereby attempted to include a representative range of village stakeholders during a half-day village visit, covering the diverse spectra of gender, social and wealth categories (including landed and landless). The half-day visit thereby typically included a briefing with key informants of the village, a larger group meeting with villagers (mainly landed), a separate smaller group meeting with landless, and a visual survey by walking through and around the village. The separate meeting with the landless was deemed necessary to enable their more active participation. However, we were less successful in involving women who were virtually excluded from the group discussions in Bihar (Table 2). In part, this was dictated by the prevailing social norms and definitely not aided by the male-biased team composition. Team members were thereby requested to be assertive and pay particular attention to gender issues in an attempt to readdress the imbalance.

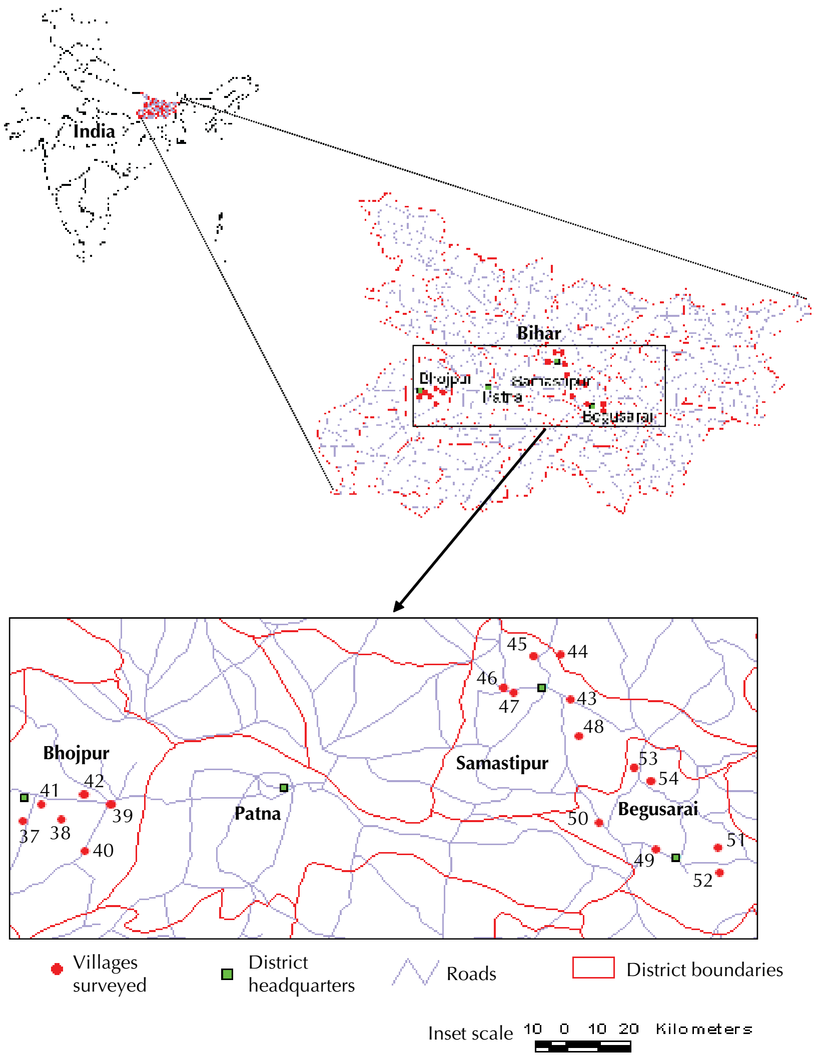


Figure 5. *Location of the 18 surveyed villages within the Bhojpur, Samastipur and Begusarai clusters in the Gangetic Plains of Bihar.*

Table 2. *Median number and gender of participants in the village group discussions in each cluster in the Gangetic Plains of Bihar*

Cluster	Village group discussion		Landless group discussion	
	# of participants	# of female participants	# of participants	# of female participants
Bhojpur	14	0	4	0
Samastipur	20	1	5	0
Begusarai	25	0	16	1
Overall	20	0	8	0

The village survey used semi-structured interviews using a survey instrument (Annex 4). A village leader was generally first asked to provide quantitative descriptors of the village (people, resources, infrastructure). Then group discussions described the crop and livestock subsystems practiced in the village and other significant aspects of village livelihoods. Particular attention was given to the management of crop residues and to livestock-feed resources. Data were collected on the expected drivers of crop–livestock interactions, like the cost of daily-hired labour and the level of access to irrigation.

At each stage of the survey process, respondents were asked to identify and discuss the critical issues that affected their living standards and the constraints to, and the opportunities for, improving their livelihoods and that of the village. In this way, the discussions attempted to provide a sound understanding of the opinions and perspectives of each village community and of its major social groupings regarding policy issues and policy making, i.e. to gain a 'user' or bottom–up perspective and to avoid being prescriptive.

At each location within each region three teams completed the survey instrument for two villages within a day. Members of a core team participated in the surveys in each of the four regions and in each of the three locations which constituted the subregion of each region. This gave continuity and consistency of research approach and ensured that the core team members absorbed and analysed the survey and related information from the village studies across the Indian IGP from Punjab in the NW to West Bengal in the east (Figure 1). Within each survey team at each cluster, the core members were joined by staff from the local Krishi Vigyan Kendra (Extension outreach program, India) or other State Agricultural University Departments and/or their counterparts in the Departments of Agriculture and Animal Husbandry of the State Government (Annex 3).

Analysis and integration of information

The quantitative primary data from the village surveys were summarized using descriptive statistics. These results were complemented by the information and statistics gathered from secondary sources. The descriptive statistics not only helped gain a better understanding of the type and extent of crop–livestock interactions within each subregion but also showed the variation within and across the four major regions. The descriptive statistics were also useful in examining informal hypotheses about the possible drivers of interactions between crops and livestock and in helping to identify the key modifiers of the effects of the drivers.

It should be noted that the nature of the survey method of collecting data dictates that each quantitative observation (e.g. area of irrigated land in the village or the number of buffalo) is a guesstimate from a respondent or group of respondents. As such, estimates of variables (e.g. mean number of buffalo for the subregion sample of villages) calculated from these guesstimates are indicative, not definitive, results and are therefore presented in the results section at an appropriate level of rounding (e.g. village population to the nearest 100).

The nature of the data and study also implies that the analysis is mainly descriptive. All the tables in the present report refer to village level survey data unless otherwise mentioned. These tables typically present unweighted averages across surveyed villages, i.e. the average of the 6 surveyed villages in each cluster and 18 villages in case of the overall mean for the subregion. This applies to both absolute and relative values (i.e. in the case of % of households [hh] the % was estimated at the village level and subsequently averaged across villages). These tables also present measures of variability and the significance of differences between clusters. However, with 6 villages per cluster and a total of 18 villages for the subregion, the likelihood of finding significant cluster effects is somewhat limited and some measures like Chi-square cannot be interpreted.

The livelihood framework can be applied at different scales. Our focus here is on the village and household levels. At the household level, we will often distinguish between farm households (with land access and crop production activities), landless households (no access to agricultural land [owned or rented] or crop production activities) and village households (includes both farm and landless). Finally, in applying the livelihood framework in this study, we use the principle of ‘optimal ignorance,’ seeking out what is necessary to know in order for informed action to proceed (Scoones as cited in Ellis 2000, 47).

It is important to remember that a scoping study, by its very nature, is not designed to provide definitive answers, but rather to flag issues for subsequent in-depth research. Therefore, the emphasis of the study methods was learning through drawing on available information and current knowledge from secondary sources and from the village surveys, interpreting and synthesizing the data from these sources and finally identifying gaps both in the information and our knowledge and in its application.

3 Study area[1]

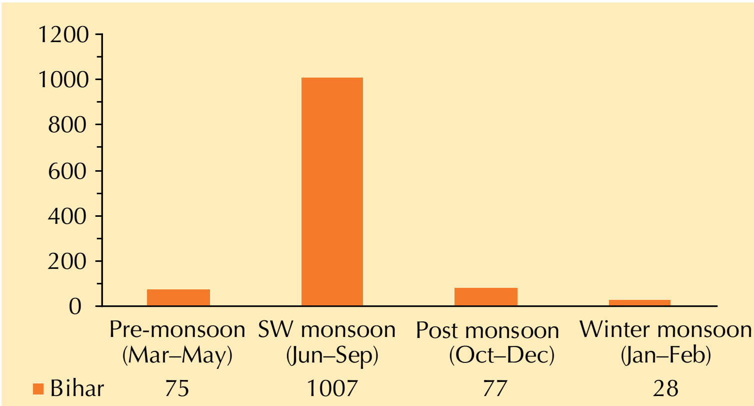
The Indo-Gangetic Plain (Figure 1) can be divided broadly into eastern and western subregions. The Gangetic Plain of Bihar covered by this report is within the eastern subregion in which rainfed (monsoon/*kharif*) lowland rice is the traditional cereal staple and the mainstay of food security. Only in recent decades have wheat and other cool season crops been introduced on a large scale in the eastern plains north of the Tropic of Cancer. Bihar and the eastern subregion in which it lies has a subhumid climate and problems of poor water control and flooding. By contrast the western subregion is mainly semi-arid and would be water scarce were it not for an excellent irrigation infrastructure of canals and groundwater tubewells. These sustain the winter/*rabi* wheat crop—the preferred cereal staple—which in recent decades has been complemented in the monsoon/*kharif* season by a major increase in the area of rice, resulting in higher cropping intensities and annual cereal yields in the western than the eastern subregion. Another important contrast between the two subregions is that whereas in the eastern IGP cattle are the predominant livestock, in the western IGP buffalo dominate. In broad terms therefore the eastern IGP, including Bihar, is characterized by rural livelihoods based on rice–cattle farming systems practiced in a more risk-prone environment than the western IGP where wheat–buffalo farming systems characterize rural livelihoods.

The Mid-Gangetic Plains (MGP) with its rice-based cropping system comprises Bihar State, the eastern parts of neighboring Uttar Pradesh State, India, and the eastern terrain region of Nepal (Figure 1). Bihar encompasses three subregions: the North West Plains (C–4), North East Plains (C–5) and South Bihar Plains (C–3), with one village cluster each for this study (Table 1, Figures 4 and 5).

Bihar is characterized by a hot subhumid climate with annual rainfall in the range of 1000–1500 mm (with 85% falling in June–September, Figure 6), the presence of low-lying flood-prone areas, periodically changing river courses, and a diversity of rice-based cropping systems. In parts, the underground water table is shallow and, given adequate infrastructure, can be easily exploited. But as yet the level of irrigation provision is markedly lower than in the Trans-Gangetic Plains (TGP) and the Upper-Gangetic Plains (UGP), although comparable to the level in the high-rainfall Lower-Gangetic Plains (LGP), as shown in Annex 1. The limited development of surface irrigation canals is also reflected by Bihar having one of the lowest densities of rivers and canals (3.4 km length per km^2 geographical area as against an IGP average of 11.0, derived from Minhas and Samra 2003). Other water bodies (particularly

1. The chapter presents background information for the study area drawing primarily from secondary data and available literature. Results from the village survey are presented in subsequent chapters.

tanks/ponds and reservoirs) comprise an estimated 1.7% of its geographical area (as against an IGP average of 2%, derived from Minhas and Samra 2003).



Source: IASRI (2005, 17).

Figure 6. *Season-wise normal rainfall (mm) in Bihar (1187 mm p.a.).*

Relative to the TGP and UGP subregions, the potential for area expansion and yield improvement for rice and wheat (and other crops) is quite high with the two cereal staples combined contributing no more than, on average, a third of the gross cropped area of each (Table 3; Annex 2). With an estimated 1.7 million ha of rice–wheat system area, Bihar comprises 17% of the rice–wheat system area of the IGP in India (Sharma et al. 2004). The rice–wheat system particularly prevails in the NW and South Bihar Plains (Table 3).

Table 3. *Rice, wheat and irrigated area, mean annual rainfall and prevalent soils in the Gangetic Plains of Bihar*

Zone*	Rice–wheat area ($\times 10^6$ ha)	Area (% of GCA) 1996		Irrigated area, % of GCA	Mean rainfall, mm/year	Soil type
		Rice	Wheat			
North West Plains (Samastipur)	0.74	44	27	41	–	Sandy loam to clayey
North East Plains (Begusarai)	0.28	46	19	38	–	Sandy to silty loam
South Bihar Plains (Bhojpur)	0.65	42	26	64	–	Alluvium
Bihar	1.67				1335	

Sources: Sharma et al. (2004) (RW area) and Kumar et al. (2002, 24) (other indicators).
*In '( )' survey cluster names for current study.

As the comparative socio-economic and development indicators for the IGP States shown in Annex 1 demonstrate, Bihar, relative to other IGP States, has a markedly higher level of rural poverty, the highest level of landless (51%), high rural and female illiteracy rates, one of the highest population densities and a high rate of population growth. The complex social stratification and weak governance further add to the challenges of development in Bihar (World Bank 2005). Bihar's continuing dependence on agriculture is based on the smallest average farm size of all IGP States, low levels of irrigation infrastructure, mechanization and fertilizer use, and an under-developed road infrastructure (Annex 1). The spread of private tubewells occurred mainly in the 1970s and the bulk of the increase in fertilizer use took place in the 1980s (Wilson 2002, 1231). However, whatever production increases were realized have been offset by population growth and, as a result, per capita food availability and labour productivity have remained at the same levels as in the 1960s (Kishore 2004, 3488–3489). The post-1991 increase in oil prices, reduction in subsidy on diesel and fertilizer and slackening in food prices have put further pressure on the profitability of agriculture in Bihar (Kishore 2004, 3489). The contrast is therefore stark between the rural livelihoods in Bihar and in the TGP (with its high productivity and low poverty). And whereas the latter is seen as the heartland of the Green Revolution with its striking impacts on agricultural productivity and profitability, livelihoods in Bihar have benefited much less from the Green Revolution, mainly because of the lack of infrastructural improvements (to overcome the effects of flooding and drought and to improve market access), the weak support from public institutions and poor state governance (e.g. Kishore 2004). As a result of this relative stagnation in agriculture and in the economy generally, there is out-migration of labour to metropolitan areas and to the TGP states of Punjab and Haryana for seasonal and year-round employment in agriculture.

In contrast to the dominant wheat–rice–buffalo farming systems seen in the TGP and UGP, farming systems in the MGP are much more diverse, reflecting a greater dependence on rain-fed cropping, the variability of soils (Table 3) and topography (uplands and lowlands). The main cropping systems include: rice–potato–wheat/sugarcane; maize/potato–wheat; rice–potato–maize; rice–chickpea/lentil; rice–potato–(boro)/onion; rice–lentil–onion; rice–maize/potato–boro; and, pigeonpea–wheat (Narang and Virmani 2001). Wheat is a non-traditional crop in Bihar, which increased from negligible levels in the mid 1960s to become the major *rabi* crop, primarily substituting various rainfed legumes (Wilson 2002, 1231).

Bihar is one of India's traditional maize growing areas (Joshi et al. 2005), but maize is becoming increasingly important, replacing competing crops like rice during the *kharif* season and wheat during winter/*rabi* season. Vegetable growing is also contributing to this diversification of cropping. Nonetheless, it has been reported that amongst all states in India, Bihar has the largest share of its gross cultivated area under cereals (90%) and this share increased during the last ten years (Kishore 2004, 3491). Prior to these recent changes, the

1980s and 1990s saw little change in cropping intensity, although there were significant increases in fertilizer use (Table 4).

Table 4. *Changes in input use and cropping intensity in the Gangetic Plains of Bihar*

Zone*	Year	Irrigated area (% of GCA)	Fertilizer (NPK kg/ha cropped)	Cropping intensity (%)	Rural literacy (%)
North West Plains (Samastipur)	1982	31	28	140	21
	1996	41	58	143	39
North East Plains (Begusarai)	1982	23	12	147	19
	1996	38	59	155	32
South Bihar Plains (Bhojpur)	1982	56	32	138	27
	1996	64	97	132	48

Source: Kumar et al. (2002, 29).
*In '( )' survey cluster names for current study.

A characteristic of Bihar is its fragmented landholdings, and the associated large proportion of rural landless families (Annex 1). Table 5 illustrates the prevalence of the marginal (< 1 ha) land holdings (84%) and an overall farm size mean of only 0.58 ha. Bihar tends to be characterized by a skewed distribution of land, despite previous attempts at land reform including the statutory abolishing of the *zamindari* system in the 1950s (Chakravarti 2001; Wilson 2002; Kishore 2004), the imposition of a Land-Ceiling Act (re-allocating land holdings of more than 6–18 ha; World Bank 2005, 92) and tenancy reform (World Bank 2005, 92). Land ownership and access to irrigation are closely associated with lower poverty, whereas nearly 25% of cultivated land in rural Bihar was leased-in (World Bank 2005, 16).

Table 5. *Land size distribution in Bihar State and India in 2000–01*

	State	Marginal (< 1 ha)	Small (1–2 ha)	Semi-medium (2–4 ha)	Medium (4–10 ha)	Large (>10 ha)	Total
% of landholdings	Bihar	84.2	9.2	5.1	1.4	0.1	100
	All India	63.0	18.9	11.7	5.4	1.0	100
Land size (ha/hh)	Bihar	0.30	1.21	2.62	5.24	15.50	0.58
	All India	0.40	1.41	2.72	5.80	17.18	1.32

Source: MoA (2006).

The combination of marginal landholdings, a risky crop production environment and low yields, dictates that cropping systems are mainly subsistence orientated, which would suggest an important role for livestock in rural livelihood strategies. However, as can be seen in Table 6, the Government's population statistics for the 'old' Bihar (i.e. before its subdivision into Bihar and Jharkhand states) show a 23% decline between 1992 and 2003 in indigenous (*desi*) cattle, some increase in buffalo and dairy crossbred cattle and a 14% decrease in the small ruminant flock. During the same period, there was a reported 60% increase in the poultry and pig populations. Nonetheless, Bihar still had 10% of the nation's cattle population, 13% of the pigs and 10% of the small ruminants, whereas it comprises only 2.9% of India's total geographical area.

Table 6. *Livestock populations in Bihar State and India in 1992 and 2003*

	1992			2003		
	Bihar* (× 10^3)	%	India (× 10^3)	Bihar* (× 10^3)	%	India (× 10^3)
Crossbred cattle	191	1.3%	15,215	1,419	6.4%	22,073
Indigenous cattle	21,963	11.6%	189,369	16,968	10.8%	156,865
Buffaloes	5,352	6.4%	84,206	6,529	7.0%	93,225
Small ruminants	20,275	12.2%	166,062	17,485	9.9%	176,101
Pigs	1,127	8.8%	12,788	1,780	13.1%	13,571
Poultry	17,655	5.7%	307,069	28,340	5.8%	489,012

Source: MoA (2004b).
* Including Jharkhand.
% reflects the state's share of the national herd.

As a result of these reported changes in livestock populations, the density of bovines (but not draught animals) and small ruminants has declined during the last decade with a proportionally greater decline per human capita (Table 7). On the other hand, poultry numbers have been stable per unit area, but have decreased by nearly 20% per human capita. Overall therefore the picture is one of declining livestock assets.

Table 7. *Density of livestock in Bihar* State in 1992 and 2003*

Indicator	Year	Bovines	Draught animals	Ovines and caprines	Pigs	Poultry
Per km^2	1992	158.2	8.5	116.6	6.5	101.5
	2003	169.0	15.7	105.1	7.1	147.7
Per 100 ha of GCA	1992	273.7	14.7	201.8	11.2	175.7
	2003	198.6	18.5	123.4	8.4	173.6
Per 100 ha of NSA	1992	369.9	19.9	272.6	15.2	237.4
	2003	284.0	26.5	176.6	12.0	248.3
Per 1000 people	1992	318.5	17.2	234.7	13.0	204.4
	2003	192.0	17.9	119.4	8.1	167.8

Source: Derived from MoA (2004b).
* Including Jharkhand.

Still livestock remains an important productive asset for rural households. The 1998 U.P.-Bihar living condition survey showed that (i) the majority of rural households own some kind of livestock and (ii) the poor and socially disadvantaged households tend to own small stock (goats rather than cattle or buffalo). As a result, the total value of livestock per household in the richest quintile is almost six times higher than that of the poorest quintile (World Bank 2005, 16).

Bihar's lingering agricultural growth and economic stagnation explain the persistent poverty. Tables 8 and 9 present selected indicators in relation to the Millennium Development Goals (MDGs) and overall development for the surveyed districts and for Bihar as a whole. These reiterate the high incidence of poverty, low human development and significant gender bias.

Table 8. *Selected MDG related development indicators at district level*

	% of population below the poverty line	% of households going hungry	Infant mortality rate (per 1000 births)	% of children getting complete immunization	Literacy rate (%)	Gross enrolment ratio (elementary level, %)
Bhojpur	46.7	2.8	74.0	12.0	59.7	67.0
Samastipur	63.0	1.4	67.0	20.0	45.8	56.5
Begusarai	55.1	0.1	74.0	16.4	48.6	55.6
Average all Bihar[1]	41.2	3.3	70.4	19.7	46.9	55.0

Source: Derived from Debroy and Bhandari (2003).
1. Unweighted average across all districts.

Table 9. *Selected additional development indicators at district level*

	0–6 sex ratio (fem per 1000 male)	% of 0–6 year olds in the population	Female: male literacy ratio (%)	Pupil: teacher ratio	Female work participation (%)	% of women receiving skilled attention during pregnancy
Bhojpur	938	34.6	57.2	70.7	11.7	58.3
Samastipur	945	39.3	56.5	99.7	13.2	7.9
Begusarai	940	37.9	60.6	67.0	15.9	28.0
Average all Bihar[1]	938	37.8	54.5	69.7	16.7	22.1

Source: Derived from Debroy and Bhandari (2003).
1. Unweighted average across all districts.

The Rice–Wheat Consortium (RWC) has recently tried to synthesize the biophysical and socio-economic drivers and modifiers of agricultural development in the IGP. Table 10 presents the RWC's summary description for the MGP, which comprises Bihar and E U.P. The table highlights the influences and interactions of natural, physical and human capital, and to which can be added the important elements of social and financial capital. These factors are key to our better understanding of the dynamics of agriculture, rural development and the underlying livelihood strategies within this major exponent of India's rural poverty. The summary serves as a useful complement to the livelihoods framework (Figure 2) when reviewing the results from the village surveys. And, because of the importance of biophysical and socio-economic interactions, it also provides a useful contextual framework in which to evaluate the complexity of the MGP subregion.

Table 10. *Characteristic biophysical and socio-economic features of the Mid-Gangetic Plain*

Biophysical		Socio-economic	
Climate	Hot subhumid, annual rainfall up to 1800 mm of which 75–78% received in monsoon season	Farmer characteristics	Primary level education and enterprising with less capacity to take risks; farmers generally poor and more risk prone. Agricultural holdings fragmented but relatively small sized. Farms highly diversified. Private sector agro-industries less conspicuous.
Physical features	Alluvial medium fine textured calcareous and acidic soils, gently sloping, low-lying, flood prone; drainage congestion, ground water quality low in pockets due to fluorides and arsenic. Changing river courses affect farming and livelihood conditions	Infrastructure for inputs: technology and extension	Poor infrastructure with relatively little extension support
Irrigation	Irrigated agriculture mainly in winter season, less ground water development, life saving irrigation in monsoon season or as flood management measure	Marketing of produce	More favourable to rice and wheat
Energy	Tractorization less popular, depends on animal power.	Research support	Research backstopping relatively inadequate
Bioclimate	Favourable to rice-based systems, highly diversified	Policy support	Less than adequate

Source: Unpublished background tables developed for RWC (2006).

4 Livelihood platforms

4.1 Livelihood assets

As was explained in the Methodology section, the scoping study took as its analytical framework the 'assets-mediating processes-activities' model (Ellis 2000) in order to better dissect and understand the contributions to the livelihood systems of the sample village communities of their crops, their livestock and their interactions. The starting point was to describe the natural, physical, human, financial and social capital assets (Figure 2) owned, controlled, claimed or in some other means accessed by the farm households, and then to assess how these are used to undertake production, engage in labour markets and participate in reciprocal exchanges with other households (Ellis 2000, 31).

4.1.1 Natural capital

The main natural capital assets utilized by the people for their livelihoods in the surveyed villages comprised land, water and livestock. In Bihar generally there is high pressure on land resulting from high human population density (Annex 1) but which, in terms of land use, is modified by the prevalence of flooded and waterlogged land and the presence or absence of irrigation. In the surveyed villages, because there was access to tubewell irrigation and flooded/waterlogged areas were not extensive (Table 14), land use intensity of cultivable area was high, averaging 86% (Table 29), well above the Bihar State statistics of 43%, and comparable to the TGP statistics (84% Punjab, 80% Haryana—Annex 1). The access to irrigation, restricted though it was, helped alleviate somewhat the marked seasonality of rainfall, which results from the southwest monsoon during June–September contributing 85% of annual rainfall.

In each of the clusters, the topography was an undulating plain with the sample villages having varying proportions of upland (used for the cultivation of maize, tobacco etc. in the monsoon/*kharif*) and lowland where rice is grown. The average altitude is a little above sea level (Table 11), but the variation within the land area of a village is important because of its implications for the proneness of lowlands to water-logging and flooding. These influence yields and cropping patterns (including the production of out-of-season vegetables and forages) and access for grazing livestock. In each of the clusters, the flooding of lowlands restricted crop productivity, and therefore also the availability of crop residues for ruminant livestock feeding, while contrarily, in the seasons of low rainfall, accessing irrigation water was difficult and costly. In the Bhojpur cluster, where there was an irrigation canal, access was problematic because of the small farm plot sizes. And in each cluster diesel costs were high for fuelling the irrigation pumps (e.g. INR 70–80/hr pumping, 15 hr/ha).

Table 11. *Natural capital indicators*

Cluster	Altitude (m)[a]	Access to land (% of hh)	Farm size (ha/farm hh)	Herd size (# of cow equivalents per hh)[b]
Bhojpur	46	78 b	1.1	2.1 b
Samastipur	59	70 b	1.8	1.5 ab
Begusarai	41	47 a	1.0	1.0 a
Mean (s.d., n, p.)	49 (22, 18, ns)	65 (23, 18, 0.05)	1.3 (1.3, 18, ns)	1.5 (0.8, 18, 0.08)

s.d.: Standard deviation; n: number of observations; p.: Significance of group-effect. ns: non-significant (p>.10). Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.
a. Indicative value from GPS.
b. Using following weights: 1.2 for buffalo, crossbred cows and draught animals; 1 for *desi* cows and equines; 0.1 for sheep, goats and pigs; and 1.4 for camels.

About half the households in the Begusarai cluster were landless (with one village having 58% and another two 80% landless). This is consistent with the Bihar State figure (Annex 1), whereas the Bhojpur and Samastipur clusters had only a quarter of households with no land. Similarly the average farm size, 1.3 ha (Table 12) for the three clusters is significantly higher than the overall Bihar State mean (Annex 1). Notable was that the average landholding in the Samastipur cluster (1.8 ha) was well over double the Bihar mean.

Table 12. *General physical capital indicators*

Cluster	Electricity supply (% of hh)	Public water supply (% of hh)	No. of phones (#/100 hh)	Availability public transport (% of villages)
Bhojpur	6	7	4	42
Samastipur	28	0	5	58
Begusarai	35	0	1	17
Mean (s.d., n, p.)	23 (35, 18, ns)	2 (9, 18, ns)	3 (5, 18, ns)	39 (37, 18, ns)

A factor affecting the use of these land resources were the blue bull herds (*neelgay*, and some stray cattle) that roam the area. They particularly constrain diversification away from rice–wheat. These negative impacts of 'livestock' on village livelihoods have to be judged against the positive contributions of livestock, which after land and water, are the next main natural asset both in terms of value and prevalence. As Table 11 shows, the reported average livestock herd was 1.5 cow equivalents per household, the lowest herd size reported across the surveyed subregions (Erenstein et al. 2007a), and another indicator of the prevailing poverty in Bihar. Herd size was the lowest in the Begusarai cluster (1.0 cow equivalent per household) and highest and double in the Bhojpur cluster. Within Bihar cluster villages there was considerable variation in terms of herd composition, and therefore the monetary value of this livestock capital: the proportion of households keeping the predominant dairy crossbred cattle varied between 69% in the Begusarai cluster to only 13% in the Bhojpur cluster where 22% of households had draught cattle (Table 31). On the other hand, 48% of the Bhojpur cluster households kept buffalo against only 25% in the Begusarai cluster. Small ruminants also contributed to the sum of livestock capital, contrasting with their virtual absence from the natural capital assets of the TGP and UGP clusters.

As elsewhere in the IGP, other natural capital assets are limited, for example, the seasonal water bodies did not result in important inland fisheries. Bamboo was common and served as a source of building material, while tree cover was generally restricted to homestead surrounds and field borders.

4.1.2 Physical capital

Consistent with the state-level indicators for Bihar (Annex 1), the surveyed villages reported a low physical capital asset base, whether through public or private investment. The surveyed villages typically had low coverage of utility services (electricity, piped water), few telephones and limited availability of public transport (Table 12), particularly when compared to the other IGP states surveyed (Erenstein et al. 2007a).

The density and quality of the rural road network was generally poor in the surveyed villages, again consistent with the state-level statistics (road density of 19 km/km^2 compared to 56 in West Bengal and 104 in Punjab—Annex 1). As a result in some of the surveyed villages, despite short distances to markets and urban centres, travel times were inflated by the poor condition of rural access roads (Table 13).

Table 13. *Selected market access indicators*

Cluster	Good access road (% of villages)	Travel time to urban centre (minutes)	Travel time to agricultural market (minutes)
Bhojpur	33	41	39
Samastipur	50	36	28
Begusarai	67	39	38
Mean (s.d., n, p.)	50 (51, 18, ns)	39 (13, 17, ns)	34 (13, 16, ns)

In common with Bihar State as a whole (Annex 1), the surveyed clusters were not well served by public investments in irrigation infrastructure; none of the 18 surveyed villages had canals or electric-powered tubewells as their primary source of irrigation (Table 14). Consequently private investment through diesel-powered tubewells were the primary source of irrigation in all villages, resulting in the Begusarai and Samastipur clusters achieving near 90% area irrigated and the Bhojpur cluster 64%. Nevertheless it is important to point out that diesel tubewells are relatively expensive to run (yet relatively secure *vis-à-vis* rural electricity). The reliance on diesel wells, often with a portable pumpset, is also reported elsewhere in Bihar (Wilson 2002; Kishore 2004). However, whereas it has been suggested that diesel pumpsets have facilitated almost universal access to groundwater in Bihar, intensity of groundwater irrigation has remained quite low as farmers continue to economize on their irrigation cost (Kishore 2004, 3488). The small land sizes and complex social structures in Bihar will also affect the utility and cost of the irrigation water supplied.

Table 14. *Irrigation indicators*

Cluster	% of area irrigated	Primary irrigation source (% of villages)			
		Electric TW	Diesel TW	Canal	Pumped from surface water
Bhojpur	64	0	100	0	0
Samastipur	90	0	100	0	0
Begusarai	86	0	100	0	0
Mean (s.d., n, p.)	80 (23, 18, ns)	0	100	0	0

As would be expected from the fragmented and small farms and the poor availability of other resources, the level of investment in large agricultural machinery in the three clusters was low (Table 15), consistent with the statistics for Bihar and the MGP generally. The reported levels are the lowest amongst the IGP states surveyed (Erenstein et al. 2007a). Putting this into the context of the variation within the IGP, whereas Bihar had 1.5 tractors/100 ha, Punjab had 10.4 and Haryana 9.4 (Annex 1). In the same way, there were no reports of power tillers or combines from the three clusters and only one Begusarai village reported two zero-till drills (Table 15). The absence of power tillers illustrates the preference of machinery owners for tractors, despite power tillers being smaller, cheaper and more suited to the prevailing smallholdings. Power tillers have been reported elsewhere in Bihar (e.g. Wilson 2002) and in West Bengal (Varma et al. 2007).

4.1.3 Human capital

Human capital comprises the labour and skills available to the household. The average family size reported was 9.4 (Table 16), the highest amongst IGP states surveyed (Erenstein et al. 2007a). The derived population density at the village level was 2000 people/km^2, much higher than the Bihar State figure of 881 for population density (Annex 1) and the estimates for the other IGP subregions surveyed (Erenstein et al. 2007a). In part, this resulted from the sampling of villages with limited village area, including some colonies of a power generation plant in the Begusarai cluster. On average, a third of the household heads in the surveyed villages had no formal education; the level was significantly higher in the Begusarai cluster and lower in the Bhojpur cluster. If no formal education can be taken as synonymous with illiteracy, this average suggests a similar level of literacy to the reported rates for Bihar State (male literacy 60%; Annex 1). Nevertheless the communities confirmed that they had excess, unskilled labour (aggravated by the small farm sizes and the high proportion of landless households) and that labour migration played an important role in the rural economy of the area.

Table 15. *Mechanization indicators*

Cluster	No. of tractors (per 100 farm hh)	No. of powertillers (per 100 farm hh)	No. of combines (per 100 farm hh)	No. of ZT drills (per 100 farm hh)
Bhojpur	1.8	0	0	0.0
Samastipur	0.9	0	0	0.0
Begusarai	4.5	0	0	0.13
Mean (s.d., n, p.)	2.4 (3.5, 18, ns)	0 (0, 18, ns)	0 (0, 18, ns)	0.04 (0.2, 18, ns)

Table 16. *Human capital indicators*

Cluster	Village level population density (people/km^2)	Family size (#/hh)	Hh head with no formal education (% of hh)
Bhojpur	1600 a	12.2	14 a
Samastipur	1300 a	8.9	28 a
Begusarai	3100 b	7.1	57 b
Mean (s.d., n, p.)	2000 (1300, 18, 0.03)	9.4 (4.4, 18, ns)	33 (25, 18, 0.00)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

4.1.4 Financial and social capital

Specific indicators for financial and social capital were not collected in the surveyed communities, but from the village discussions it became clear that they played an important and varied role that merits closer attention in future studies. These assets and the underlying processes like the social relations that shape them were perceived to be too problematic and sensitive to collect and quantify reasonably within the surveyed communities, particularly in view of our rapid scoping study with outsiders spending only half a day in each community.

Financial capital comprises the stocks of money to which the households have access. Convertible assets and cash savings from the various productive activities may serve as important sources of financial capital in the surveyed villages. In rural communities such as these, livestock often plays an important role as a productive convertible asset. Others include stocks of unsold produce. From the discussions it became clear that financial constraints were commonplace and that indebtedness was endemic in each of the three clusters. Much of the indebtedness resulted from households relying on the local credit market to alleviate seasonal shortages of finance and the costs of shocks, such as ill health in the family or the death of a valuable animal, such as a dairy cow or buffalo. The increasing importance of small ruminants in the MGP (relative to the TGP and UGP; see section 5.2) may reflect its role as a reserve of financial capital that is more easily divisible than a cow or buffalo in households with scarce financial capital.

Social capital comprises the community and wider social claims on which individuals and households can draw by virtue of their belonging to social groups of varying degrees of inclusiveness in society at large (Ellis 2000, 36). On average, the surveyed communities comprised 4300 people and 510 households (Table 17), providing a rough indicator of social coherence. The average village size was the highest amongst the IGP states surveyed (Erenstein et al. 2007a), and was particularly inflated by the Samastipur cluster. Social capital, based on the self-evident hierarchies, influenced some of the transactions within the community (e.g. mobilization of labour, credit, machinery, crop residues, milk). These same sources of social capital most likely also play important roles in times of crises. Social capital also plays an important role in migration as a livelihood strategy by linking sink and source areas (de Haan 2002).

Table 17. *Village size*

Cluster	# of people	# of households
Bhojpur	3300 a	240 a
Samastipur	6900 b	860 b
Begusarai	2800 a	430 a
Mean (s.d., n, p.)	4300 (3100, 18, 0.03)	510 (380, 18, 0.01)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

4.2 Access modifiers

The translation of a set of assets into a livelihood strategy composed of a portfolio of income-earning activities is mediated by a great number of contextual social, economic and policy considerations. The key categories of factors that influence access to assets and their use in the pursuit of viable livelihoods are access modifiers on the one hand and the trends and shock factors on the other (Figure 2). Access modifiers include social relations, institutions and organizations and comprise the social factors that are predominantly endogenous to the social norms and structure of which the rural households are part. The trends and shock factors consist predominantly of the exogenous factors of economic trends and policies and unforeseen shocks (such as a drought or disease epidemic) having major consequences on livelihood viability (Ellis 2000, 37–38). The access modifiers as pertaining to the study sites are reviewed here, whereas the subsequent section reviews the trends and shocks.

4.2.1 Social relations

The social positioning of individuals and households within society played a mayor role in the communities, with social complexity and rigid divisions clearly evident in the surveyed villages where striking poverty was common. These divisions resulted in the social exclusion of particular individuals or groups within the communities (e.g. based on caste, class/wealth, origin, gender). For instance, although living within the same village perimeter, landless, low caste households typically lived in specific areas within the village, often at its edge. However, as in the case of social capital, specific indicators of social relations within the surveyed communities were difficult to collect through the approach followed, exacerbated by the sensitivities involved (e.g. in the case of caste) and the complexity of social relations evident in these Bihari villages. As reported elsewhere, social or caste characteristics in Bihar are associated with constraints and lack of opportunities that cut across multiple dimensions (World Bank 2005, 17). It has been argued that 'caste continues to be the fundamental basis of social inequality in contemporary Bihar' (Chakravarti 2001, 1459), with privileged access to material and political resources. The debate now tends to emphasize the acute class (rather than caste, Kunnath 2006) inequalities that constrain equitable access to resources in Bihar and lead to rent-seeking behaviour (Wood 1995; Wilson 1999).

Yet at the same time farm fragmentation had continued to an extent that cases of extreme hardship were occurring in some high caste, landed families, now reduced to near landless status, who were severely constrained by the social unacceptability of women engaging in field-based crop labour. More generally women participated in both crop and livestock activities (Table 18), but gender inequity was evident in that women labourers tended to be paid less than males (70%, Table 20) and in the Bhojpur cluster had less say over the disposal of both crop and livestock income than in the other two clusters (Table 18). While livestock care was predominantly carried out by women (although not by those of the high caste, Rajput), their milking the cows and buffalo was less common.

At the state level, Annex 1 shows that Bihar's female literacy rate is significantly lower (34%) than male literacy (60%). At the local level, the limited participation of women during the group meetings suggested that, at least at such a public event, they will be essentially voiceless.

Table 18. *Gender issues*

Cluster	Women involved in		Women have say in	
	Crop activities (% of villages)	Livestock activities (% of villages)	Crop income (% of villages)	Livestock income (% of villages)
Bhojpur	100	83	33	33
Samastipur	100	100	83	83
Begusarai	67	83	83	83
Mean	89	89	67	67

4.2.2 Institutions

Land and credit market

Most land is held privately albeit in marginalized and small holdings. While in two villages in the Begusarai cluster there was no land rental market, elsewhere the rental and sales land markets were monetized. Not only were prices significantly lower, as expected, than in the TGP, reflecting lower crop productivity and poorer infrastructure, but these factors also resulted in significant variation amongst the rental prices reported by the three clusters (Table 19). There was less, although still considerable, variation amongst purchase prices. Land prices (rental and purchase) were highest in the Samastipur cluster, likely reflecting more agricultural opportunities and better market access than the predominant flood plains in the other clusters. The ratio of rental to purchase price at 2.1% was not significantly different between clusters and was very similar to the value reported in the TGP, albeit significantly lower than for neighboring U.P. and West Bengal (Erenstein et al. 2007a). This indicator of the average annual return to investment in land is lower than the prevailing rate of interest, suggesting that capital, rather than land, remains the most limiting production factor for these Bihari communities. One way of overcoming constraints to accessing land and financial capital that was reported was share cropping (at 50:50), although the statutory provision with regard to rent is 25% (World Bank 2005, 92).

Consistently the village groups reported major difficulties in accessing credit. If institutional credit was applied for, transaction costs were high with rent-seeking common or, for many households, was not available because of the limited sums involved or the lack of collateral. As a result informal moneylenders were the main source of credit in the surveyed villages. As Table 19 shows, the reported informal interest rates were very high, on average 58% on a yearly basis (4–5% monthly), which was approximately 2.5 times higher than reported in the TGP. What's more, in three villages in the Bhojpur and Samastipur clusters, a monthly rate of 9% was reported and in one village in the Begusarai cluster, 11%. In an Islamic village in the Samastipur cluster, there was reportedly no interest rate. The high rates compare with the 4–10% per month reported by Wilson (2002) in central Bihar.

Table 19. *Selected credit and land market indicators*

Cluster	Interest rate money lenders (%/year)	Irrigated land rental price (× 10^3 INR/ha)[a]	Irrigated land purchase price (× 10^3 INR/ha)	Rental:purchase price (%)
Bhojpur	56	7 a	450 a	2.1
Samastipur	66	14 c	800 b	1.9
Begusarai	56	11 b	530 a	2.6
Mean (s.d., n, p.)	58 (ns)	11 (4, 18, 0.01)	590 (290, 18, 0.09)	2.1 (1.1, 16, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

a. Based on combination of reported values and estimated values. Estimated values replace missing values using reported purchase price in village and 2.1% as average rental:purchase price ratio.

Other sources of credit included the provision of inputs on credit, credit from market traders, consumer credit from cooperative societies and, in the Begusarai cluster, the recently initiated public Kisan Credit Card scheme (a public scheme to facilitate farmer credit access to working capital).

Labour market

As was mentioned earlier, there is out-migration of labour both seasonally and for year-round employment from the MGP generally and from Bihar specifically. This was confirmed by the surveyed villages for which 83% reported seasonal out-migration (Table 20). Two outcomes were labour scarcities reported by nearly three quarters of the villages and an average peak wage rate 30% higher than the regular rate. Despite these stated scarcities of labour, the average male wage rate was only INR 49 per day and markedly similar across communities. The wage rates thereby are slightly under half those reported in the TGP clusters (INR 87), where wage rates typically nearly further double during peak periods (Erenstein et al. 2007b). Female wage rates were only 60 to 80% of male wage rates in the three clusters, which in part reflected differences in working hours and tasks. For some tasks, labour receives payment in kind.

Table 20. *Selected labour market indicators*

Cluster	Male wage rate (INR/day)	Female male wage ratio	Peak: average wage ratio	Labour scarcity (% of villages)	Seasonal in-migration (% of villages)	Seasonal out-migration (% of villages)
Bhojpur	50	0.7 ab	1.2	67	17	67
Samastipur	48	0.8 b	1.5	83	33	100
Begusarai	50	0.6 a	1.2	67	0	83
Mean (s.d., n, p.)	49 (5, 18, ns)	0.7 (0.2, 17, 0.01)	1.3 (0.3, 14, ns)	72 (46, 18, ns)	17 (38, 18, ns)	83 (38, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Agricultural input and output markets

While chemical fertilizer was reported as being used by all villages, improved seeds were only purchased by approximately half of the households in the surveyed villages, ranging from only 21% in the Bhojpur cluster to 68–83% in the other clusters (Table 21). Herbicides were reported as being used even less frequently, 16% on average—the lowest amongst the surveyed IGP states (Erenstein et al. 2007a). The low usage seemed more an issue of lack of adoption rather than lack of availability or poor responses to these inputs. By contrast the increasing diversification into vegetable and hybrid maize production seen and reported in some areas illustrates the willingness of farmers in Bihar to adopt new technologies based on purchased inputs. It suggests that non-price issues of external inputs, including lack of information and output market prices, are more important than input access issues. There are also active markets for tractor services (all clusters). Although not specifically covered in our villages, a rental market for diesel pumpsets is also likely, similar to that reported elsewhere in Bihar (Wood 1995; Wilson 2002; Kishore 2004).

Table 21. *External input use (% of hh reportedly using)*

Cluster	Purchase improved seeds	Chemical fertilizers	Herbicides
Bhojpur	21 a	100	20
Samastipur	68 b	100	23
Begusarai	83 b	100	3
Mean (s.d., n, p.)	57 (40, 18, 0.01)	100 (0, 18, ns)	16 (29, 15, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Agricultural produce markets in Bihar are dominated by rice and to an extent by wheat. Farmer-reported prices for wheat were similar across the villages in the three clusters and largely reflected the prevailing Minimum Support Price (MSP) for 2004–05 (INR 6.4 per kg) (Table 22), although the associated public procurement system is primarily active in the Western IGP only. On the other hand, paddy, the major crop and the cereal staple of Bihar, attracted prices below MSP levels for 2004–05 (INR 5.9 per kg Grade A and INR 5.6 per kg common grade) (Table 22). Paddy prices in Bihar thereby were the lowest amongst the surveyed IGP states (Erenstein et al. 2007a). At least for wheat in the surveyed area, the relatively assured market and stable prices reduce market risk for this crop, benefiting wheat producers. In the same way, other crops do not benefit from similar price-support schemes and are thereby subject to market risk, with middlemen playing an influential role in setting market prices.

Table 22. *Selected commodity prices (INR/kg, farm gate)*

Cluster	Wheat	Paddy
Bhojpur	6.2	4.4
Samastipur	6.4	5.8
Begusarai	6.6	4.1
Mean (s.d., n, p.)	6.4 (0.4, 14, ns)	4.6 (1.3, 8, ns)

For comparative purposes selected livestock prices were compiled during the group discussions (Table 23). The reported purchase/sale prices of the different bovine types suggest significant differences in relative livestock demand and preferences, although not consistently across the three clusters. While in the Bhojpur cluster dairy crossbred cows had a premium over buffalo, the reverse was true in the Begusarai cluster, while in the Samastipur cluster similar prices were reported for buffalo and dairy crosses. Generally *desi*/local cattle fetched prices that were 2.5 times lower than buffalo or dairy crosses. Noteworthy are the relatively lower prices for non-*desi* bovines in the Samastipur cluster. Compared to the other surveyed IGP states, Bihar reported the highest *desi* prices, crossbred prices at par with the TGP and U.P. and buffalo prices significantly lower to the TGP and U.P. (Erenstein et al. 2007a).

More surprisingly, milk prices were relatively constant at INR 9–10 per litre across the three surveyed clusters and villages despite their relative, though varying, closeness to urban centres. Milk that was marketed was reported as sold both to intermediaries (local milk traders, cooperatives and milk collection centres, all for sale to consumers rather than for industrial processing) and/or directly within the village or locally. Some farmers reported a preference to sell milk to vendors instead of cooperatives due to higher prices

(INR 10 vs. 8). Prices for buffalo milk ranged from INR 9 to 12 and for cow's milk from INR 8 to 9, reflecting the lower fat content of the cow's milk. Milk price differentiation was specifically reported in 4 villages in the Begusarai cluster, but only one village each in the other clusters. One village in Samastipur specifically reported a flat milk rate irrespective of fat.

Table 23. *Selected animal and produce prices (INR, farm gate)*

Cluster	Local cow (INR/head)	Crossbred cow (INR/head)	Buffalo (INR/head)	Milk (INR/litre)
Bhojpur	5300	14,000	12,100 a	9.9
Samastipur	5300	11,300	10,800 a	10.1
Begusarai	5000	12,800	15,300 b	9.4
Mean (s.d., n, p.)	5200 (0.8, 17, ns)	12,700 (3500, 18, ns)	12,700 (3500, 18, 0.06)	9.8 (1.3, 15, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Another traded bovine product was manure with villages in the Samastipur cluster reporting prices of INR 0.2–0.4 /kg, while prices in the Begusarai cluster were less than half, INR 0.08–0.15/kg. Prices for small ruminant sales (mainly goats) reached a festival peak of INR 500–1000/head. There are also markets for crop residues (mainly rice straw) and other livestock feed (e.g. concentrates, green fodder). These will be dealt with in more detail when discussing crop–livestock interactions (Chapter 6).

4.2.3 Organizations

In terms of organizations, the study focused the discussions on agricultural services. While the use of artificial insemination (AI) was widespread in two clusters, in the third, the Bhojpur cluster, it was significantly less used (Table 24). Nor were crop and livestock extension and veterinary services widely used. AI was apparently on the increase, aided by its availability through cooperatives and from self-employed veterinarians (previously Bihar had 2000 'unemployed' vets). AI services were helping maintain and increase the population of dairy crossbred cattle and to reduce the need for and the cost of keeping bulls for natural service.

Despite the reported use of extension services, the overall impression was a low level of access to new knowledge from public sources. However there were examples of the increasing provision of extension by private sector suppliers of agricultural inputs, such as seeds and agrochemicals, for maize and vegetable production. Absent (except for milk) were market organizations providing processing, e.g. of fruits and vegetables, in spite of high production levels and potentials.

Table 24. *Use of selected agricultural services (% of hh reportedly using)*

Cluster	Artificial insemination	Veterinary services	Livestock extension	Crop extension
Bhojpur	39 a	42	36	25
Samastipur	95 b	60	30	35
Begusarai	95 b	38	63	10
Mean (s.d., n, p.)	77 (36, 18, 0.00)	47 (49, 14, ns)	41 (44, 14, ns)	23 (29, 6, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

4.3 Trends and shocks

Whereas the agricultural productivity of the western IGP was changed dramatically by the Green Revolution, the agriculture of Bihar has been much less responsive to new technologies, apparently because of limited road and irrigation infrastructure and poor public services and the effects of these constraints on agricultural productivity and level of market participation (e.g. Kishore 2004). Against that background of slow change, some shifts in the cropping systems were reported: oilseed and pulses have declined or been dropped completely because of pests and low productivity; marketing problems have eliminated sugarcane; and although maize planting is inhibited by the menace of blue bulls and stray cattle, wheat and vegetables are increasing in the area in response to market demand and the crop's relatively good profitability. It was also stated that maize was increasingly important as food crop. As regards livestock, the decline in *desi* cattle numbers was said to relate to their low yields and profitability, while the higher yielding and more profitable dairy crossbreds were on the increase, as were goats because of their role as income generators.

Despite poverty and low wage rates, tractor use was widespread (Table 25), both for cultivation and for transport. Tractor use thereby varied from a 'low' of 79% of households in the Bhojpur cluster to near universal use in the Begusarai cluster. Limited ownership of tractors (Table 15) implies that most farmers had access to tractor services. In contrast to the western IGP, no combiner use was reported (Table 25). In the western IGP, zero tillage wheat using a tractor drawn zero tillage seed drill has been spreading recently (Erenstein et al. 2007a). Two out of five of the surveyed communities in Bihar had knowledge of the zero tillage seed drill, with a tendency for knowledge to decrease along a W–E gradient (Table 25). The use of zero tillage was still uncommon though and limited to only one village in the Begusarai cluster having zero-till drills, with its use linked to cost savings for zero tillage wheat (Table 25). In part, the limited penetration reflects the only very recent efforts to accelerate the diffusion of zero tillage in Bihar.

Table 25. *Mechanization and zero tillage (ZT) indicators*

Cluster	Use of tractor (% of farm hh)	Use of combiner (% of farm hh)	Knowledge of ZT (% of villages)	Use of ZT (% of farm hh)
Bhojpur	79 a	0	67	0.0
Samastipur	89 ab	0	33	0.0
Begusarai	97 b	0	17	0.2
Mean (s.d., n, p.)	88 (13, 18, 0.06)	0 (0, 9, ns)	39 (50, 18, ns)	0.1 (0.2, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Notwithstanding these changes in cropping and livestock practices, a striking feature of the surveyed communities was a sense that they were waiting to be helped, exhibiting a strong dependence on hoped-for government intervention and demonstrating a lack of personal initiative. Refreshing were the 'islands' of agricultural diversification represented by the commercial maize and vegetable plots, and their private sector support. Worrying was the apparent prevailing weakness of all public institutions (whether for infrastructural development or knowledge services), confounded by the complexities of the social structure. Research efforts to support genetic improvement of maize, wheat, rice and livestock (particularly goat) is needed. Lack of extension support for crops and for livestock is a serious hindrance in the area. Stagnation was endemic.

In these generally stagnant communities, in which out-migration was a common coping strategy with the prevailing poverty, shocks seemed primarily individual and social in scope (e.g. accidents, sudden illness, loss of access rights, etc.). These would have immediate effects on the viability of the livelihoods of the affected individuals and households, the majority of which had few reserves, given that even livestock holdings were meager.

In recent years, different parts of central Bihar have seen increased activity of the naxalite movement, politically mobilizing the under-class against the dominant class and the subsequent backlash of Ranvir Sena, a private caste militia to protect the landed gentry (Wilson 1999; Chakravarti 2001; Louis 2005; Kunnath 2006). This has increased insecurity and undermined law and order. In view of the sensitivities, these issues were not explored within the context of this study and are only flagged here.

5 Livelihoods strategies

The asset status of households—mediated by social factors and exogenous trends and shocks—results in adoption and adaptation over time of livelihood strategies. The strategies are dynamic and are composed of activities that generate the means of household survival (Ellis 2000, 40). The present chapter reviews the main livelihood activities in the surveyed communities: crop production, livestock and non-farm based activities.

5.1 Crop production

In Bihar, for rural households with access to land (owned or hired, i.e. farm households) the major activity is crop production. Seasonal cropping patterns are distinct and influenced by variation in topography (upland/lowland and therefore drainage), soils, depth to groundwater, availability of reliable irrigation and degree of diversification related to market opportunities. As elsewhere in the IGP, rice–wheat systems predominate, but the relatively lower availability of reliable irrigation (compared to TGP and W U.P.) generally results in increased dependence on rainfall.

In the surveyed villages, the cropped area in *kharif*/monsoon season was allocated to rice (37%), other cereals, including monsoon maize (15%), horticulture (12%), fodder crops (6%), pulses/oilseeds (5%), sugarcane (1%) and other crops (6%), but with considerable variation over the three clusters (Table 26). One village in the Begusarai cluster grew no rice, while monsoon maize was grown in two-thirds of villages surveyed in the Begusarai and Samastipur clusters, and by half the villages in the Bhojpur cluster. While the area cultivated for vegetables in the Begusarai cluster was small relative to the other two clusters, vegetable growing was reported in at least four of the six villages surveyed in each cluster (and all villages in the Samastipur cluster). Similarly, although relatively small areas of fodder crops were reported (except in the Begusarai cluster), most villages reported fodder crop cultivation and half the villages reported some grazing land. The other crops primarily encompassed tobacco, which was limited to a significant area in the Samastipur cluster. It was only in the Begusarai cluster that a small area of sugarcane was grown.

Table 26. *Crop share of* kharif *area (% of village cultivable area)*

Cluster	Rice	Other cereal	Sugarcane	Horticulture	Pulses/ oilseeds	Other crops	Fodder crops
Bhojpur	42	5	0	13	2	0 a	2 a
Samastipur	38	10	0	21	3	18 b	4 a
Begusarai	31	30	3	3	11	0 a	12 b
Mean (s.d., p.) [n=18]	37 (27, ns)	15 (23, ns)	1 (4, ns)	12 (16, ns)	5 (9, ns)	6 (15, 0.03)	6 (8, 0.04)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

In *rabi*/winter season, the village cropped area was allocated to wheat (48%), horticulture (17%), other cereals, including winter maize (15%), pulses/oilseeds (6%) and fodder crops (3%) (Table 27). All villages reported that they cultivated *rabi* fodder crops, with average area again highest in the Begusarai cluster. Some villages, particularly in the Samastipur cluster, had grazing land available during the *rabi* season. Again in the *rabi* as in the *kharif* season, there was significant variation amongst the clusters. For example, in the Bhojpur cluster no winter maize was grown, whereas it was grown by nearly all villages in the two other clusters. Similarly, horticultural crops (mainly vegetables) were grown by nearly all villages in winter and covered nearly 30% of the cultivated area in the Samastipur cluster, but only 6% in the Begusarai cluster.

Table 27. *Crop share of* rabi *area (% of village cultivable area)*

Cluster	Wheat	Other cereal	Sugarcane	Horticulture	Pulses/ oilseeds	Other crops	Fodder crops
Bhojpur	61 a	0 a	0.0	15 ab	8	0	1 a
Samastipur	29 b	23 b	0.0	29 b	2	0	2 a
Begusarai	54 a	21 b	1.4	6 a	8	0	6 b
Mean (s.d., p.) [n=18]	48 (18, 0.00)	15 (16, 0.01)	0.5 (2, ns)	17 (16, 0.04)	6 (6, ns)	0 (0, ns)	3 (4,0 0.06)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Over the year, therefore, an important feature of the cropping in the Begusarai cluster was maize production, which required different management and marketing in the monsoon and winter seasons. In the Bhojpur cluster, the diversification from a rice–wheat system was influenced by the availability of irrigation. When it was not available, a rice–pulse (lathyrus, lentil, gram) system was used, and barley might replace wheat. In the Samastipur cluster cropping was diversified from rice–wheat to include vegetables/potato (also as an intercrop with maize) and tobacco. The latter and high-yielding hybrid maize were produced as cash crops, in contrast to the staple rice–wheat crops, which were generally lowly productive and serving subsistence needs. In neither season were major differences in cropping patterns reported for large- and small-scale farms.

Overall, rice–wheat was the main cropping systems in the surveyed communities (39%—Table 28), though particularly prevalent in the Bhojpur cluster. Wheat-based systems prevailed in 22% of the communities, and included three villages with fallow–wheat (17% overall) and one village with horticulture–wheat/horticulture (6%). Maize–wheat systems were reported in 17% of the communities, though limited to the Begusarai cluster. Maize-based systems were reported in 11% of the communities, and included one village with maize–maize (6%) and one village with tobacco–maize (6%), both in the Samastipur cluster.

One village reported a rice–horticulture system (6%) and another reported a horticulture–horticulture system (6%), both in the Samastipur cluster. Notable was that while rice and wheat cropping was common, they were associated with low productivity and returns, and a high level of home consumption (Table 30). On the other hand, the vegetable and winter maize crops were commercially oriented through private sector suppliers of inputs and output market agents. In this respect, the difference between winter and monsoon maize was also noteworthy, having markedly different crop management, productivity and marketing.

Table 28. *Main cropping system (% of villages)*

Cluster	Rice-based	Rice–wheat based	Wheat-based	Maize–wheat based	Maize-based	Other
Bhojpur	0	67	33	0	0	0
Samastipur	17	17	17	0	33	17
Begusarai	0	33	17	50	0	0
Mean [n=18]	6	39	22	17	11	6

Despite the constraints of topography and irrigation availability, the seasonal cropping intensity in the surveyed villages in the Samastipur and Begusarai clusters averaged over 90% in both *kharif* and in *rabi*, resulting in an annual cropping index of over 180% (Table 29), comparable with those reported in the TGP surveyed clusters of Patiala and Kurukshetra (Erenstein et al. 2007b). By comparison, the intensity in *kharif* was significantly lower in the Bhojpur cluster, 64%, due to significant inundation of the flood plains during the monsoon.

Table 29. *Cropping intensity indicators (% of cultivable land)*

Cluster	*Kharif*	*Rabi*	Annual
Bhojpur	64 a	86	150
Samastipur	95 b	85	180
Begusarai	89 b	96	185
Mean (s.d., n, p.)	83 (28, 18, 0.10)	89 (14, 18, ns)	172 (34, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

The yields for rice and wheat in Bihar clusters (Table 30) were amongst the lowest in the surveyed IGP states (Erenstein et al. 2007a). The difference with the TGP clusters is particularly striking (2.6 vs. 3.8 t/ha for wheat and 2.9 vs. 6.3 t/ha for paddy), particularly for rice, reflecting the lower level of irrigation and of input use and the subsistence versus market orientation (Table 30). The paddy yields were particularly low in the Begusarai cluster where extensive rice cultivation practices prevailed in view of significant inundation on the flood plains. Overall though, rice–wheat yields are relatively low in Bihar (Annex 2). This reflects a relatively unfavourable growing environment (including droughts and floods) and the less frequent use of modern varieties in marginal environments (Thakur et al. 2000) and that farmers economize on production costs including irrigation. The latter implies that farmers wait for the monsoon rains to sow paddy nurseries, which subsequently delays the paddy harvest beyond the optimal wheat sowing time (Kishore 2004). Late wheat sowing forces early maturity due to terminal heat, resulting in low wheat yields. Only 19% of wheat and 29% of rice production was reported as marketed in Bihar clusters (Table 30), the lowest levels reported in the surveyed IGP states (Erenstein et al. 2007a). The subsistence orientation of wheat and rice reflects the limited surplus in view of the low yields and small diversified farms.

Table 30. *Rice and wheat: Yields and marketed surplus*

Cluster	Wheat (t/ha)	Paddy (t/ha)	Marketed share wheat (%)	Marketed share paddy (%)
Bhojpur	2.1 a	3.6 b	17	29
Samastipur	2.6 b	2.9 b	12	17
Begusarai	3.0 b	1.1 a	24	45
Mean (s.d., n, p.)	2.6 (.5, 18, 0.00)	2.9 (1.6, 15, 0.06)	19 (16, 14, ns)	29 (29, 10, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

In summary therefore, these three Bihar village clusters showed a continuing dependence of rice and wheat crops, mainly to satisfy subsistence needs, but with cropping systems diversifying towards maize and vegetables because of natural factors (e.g. topography), the varying availability of irrigation and the market opportunities related to accessing inputs and for the sale of outputs.

5.2 Livestock production

5.2.1 Types of livestock

In the clusters of villages which were surveyed in Bihar, ownership of any specific livestock type did not reach 45% of all households (Table 31), a markedly lower proportion than in the TGP and U.P. (Erenstein et al. 2007b; Singh et al. 2007). Along with the smaller size of the farms, this reflects the prevalence of poverty in this subregion. What is more, not only the level of ownership but also the livestock type, with a shift from large to small ruminants, i.e. from buffalo and cattle to goats and sheep, indicates the lower resource base and more diverse livelihood strategies in Bihar associated with this more risky production environment.

As Table 31 shows, buffalo and cattle were each kept by about a third of households, while only in the Bhojpur cluster were draught animals kept by a significant number of households (22%). Perhaps surprisingly (relative to prior expectations) many more households owned crossbred (dairy) than *desi* cattle. Buffalo were increasingly substituted by cattle along a West–East gradient in Bihar. Buffalo stock per household decreased from a high of 0.8 heads in the Bhojpur cluster to only 0.2 heads in the Begusarai cluster (Table 32). On the other hand, 69% of households were reported to have crossbred cattle in the Eastern Begusarai cluster, as against only 13% in the Bhojpur cluster in the West. Also in the Begusarai cluster, a fifth of households owned *desi* cattle, compared to only 3 and 2% in the Bhojpur and Samastipur clusters, respectively. Remarkably common across the three clusters were the small ruminants (caprines and ovines), owned by around 40% of households (Table 31). Goats were favoured because of their short gestation (two litters per year, but reportedly with 30% mortality). As in the TGP and U.P., only a very few households were reported to keep poultry, and fewer still equines, camels and pigs.

Table 31. *Livestock ownership (% of hh)*

Cluster	Buffalo	Local cow	Crossbred cow	Draught	Caprine and ovine	Pigs	Poultry	Equine and camel
Bhojpur	48	3 a	13 a	22 b	42	3	3	2
Samastipur	32	2 a	28 a	6 a	39	3	6	0
Begusarai	25	20 b	69 b	4 a	46	0	4	0
Mean (s.d., p.) [n=18]	35 (30, ns)	8 (14, 0.02)	37 (34, 0.00)	11 (16, 0.09)	42 (30, ns)	2 (5, ns)	4 (6, ns)	0.6 (2, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 32. *Livestock numbers (heads per hh)*

Cluster	Buffalo	Local cow	Crossbred cow	Draught	Caprine and ovine	Pigs	Poultry	Equine and camel
Bhojpur	0.8 b	0.1	0.2	0.2	2.1	0.2	0	0.0
Samastipur	0.5 ab	0.2	0.5	0.1	1.5	0.0	0	0.0
Begusarai	0.2 a	0.1	0.5	0	1.2	0.0	2	0.0
Mean (s.d., p.) [n=18]	0.5 (0.5, 0.05)	0.1 (0.1, ns)	0.4 (0.3, ns)	0.1 (0.2, ns)	1.6 (1.4, ns)	0.1 (0.2, ns)	1 (2.8, ns)	0.0 (0.0, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Livestock keeping was not restricted to landholders or to land owners of a specific class of holding size, although small ruminants were generally associated more with the landless and small-scale farmers. Some livestock were managed by the landless on a share basis. The proportion of landless households having livestock was reported to vary from 35 to 100% amongst the surveyed villages. The livestock represented for these households a significant source of fuel (from dung) and milk and some income, as well as playing an important role as a source of cash to meet unforeseen requirements. But a recurring comment was that there were labour constraints to keeping livestock, e.g. for supervising grazing.

For those keeping bovines, it was said that in the Bhojpur cluster the better educated opted for cows and the lower educated for buffalo. In the Begusarai cluster, the factor driving the choice was said to be wealth, with richer households preferring cows, while in the Samastipur cluster buffalos were reportedly being replaced by crossbred cattle because they were less cumbersome, requiring less grazing. Within the village clusters surveyed the expected shift from buffalo to cattle as one moves from the TGP and UGP into the MGP was confirmed. Nevertheless while consistent with overall expectations of buffalo vs. cattle, the data from these clusters do not reflect the state level data trends shown in Table 6, which indicate a lower proportion and growth of crossbred dairy cattle. One factor affecting the size and structure of the bovine herd that requires more investigation is the apparent importance of Bangladesh as a market for live bovines, particularly males.

Notwithstanding the overall trend in bovines across the IGP, a striking feature of the livestock population in Bihar was that the herd and flock sizes for a household were on average only one bovine and 1.6 small ruminants (Table 32), i.e. an aggregate herd of only 1.5 cow equivalents. This is not only much smaller than in the TGP, but with a much higher proportion of small-stock. Indeed, in the TGP clusters an average of 3.3 bovines and 0.4 small ruminants were recorded, for an aggregate herd of 4.6 cow equivalents (Erenstein et al. 2007b). Herd size was the lowest in the Begusarai cluster (1.0 cow equivalent per household) and highest and double in the Bhojpur cluster (Table 33). Clearly in Bihar livestock do contribute to the livelihoods of some households, many of which are seriously resource-constrained, but at a level that is probably small relative to those from cropping, agricultural labour and non-farm activities.

Table 33. *Livestock and milk sales*

Cluster	Herd size (# of cow equivalents per hh)	Regular livestock sales (% of villages)	Non-local livestock sales (% of villages)	Marketed share milk (% of output)
Bhojpur	2.1 b	0	33	32 a
Samastipur	1.5 ab	17	17	74 b
Begusarai	1.0 a	17	0	83 b
Mean	1.5	11	17	65
(s.d., n, p.)	(0.8, 18, 0.08)	(32, 18, ns)	(38, 18, ns)	(29, 17, 0.01)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

5.2.2 Marketing of livestock

Predictably, and as shown by the results in Table 23, the preferences of bovine keepers were matched by the much higher prices (a differential of approx. INR 7,500), they paid for buffalo and dairy crossbreds relative to *desi* cattle. The reported prices for small ruminant sales (mainly goats), which reached a festival peak of INR 500–1000/head, were approximately 10 to 20% of the reported market value of an adult *desi* cow. Nevertheless these potential sources of a lumpy cash sum to household income have to be assessed against the small herd sizes and the infrequent and irregular sales of an animal (Table 33).

Another source of income was the marketed share of milk production, approximately three-fourth in both the Samastipur and Begusarai clusters, but only one-third in the Bhojpur cluster, reflecting variation in production levels, subsistence needs and access to local and distant markets.

These reported sales of animals and of milk are complemented by the use of dung for fuel and manure or its sale for cash income (Table 47). Yet in total these are unlikely to be a major source of total household income, except for poor landless and marginalized households with limited employment opportunities. Consequently the aggregate livestock herd appears to fulfill the integrated functions of providing milk for household needs (with any surplus sold to the market), dung for fuel and manure (Table 47) and herd growth for savings, financing and insurance purposes. In each of the clusters, the productivity of the bovine herd was reportedly low, although the shift towards more crossbred dairy cattle suggests a move towards a more market orientation. The overall scenario underlines the importance of large and small ruminants, and particularly the latter, as complements to the cereal-based cropping system in the risk-avoidance livelihood strategies of these rural households.

5.3 Non-farm based activities

As well as their involvement in crop and livestock production, many of these households in these rural communities were engaged in different types of income-generating activities. Such activities typically included casual daily labour on other farms, self-employment and employment/service elsewhere. Seasonal out-migration was common in the cluster villages (Table 20), mainly to work in other states as farm labourers (e.g. in Punjab and Haryana) or as manual workers in other sectors (particularly construction) in large towns and cities. Working as a farm labourer was the main employment reported by the resident landless in the three clusters. The prevalence of out-migration and the low livestock base were other indicators of the relative poverty of this region.

5.4 Relative importance of livelihood activities

In the surveyed communities, the main livelihood activities were crop farming (47%), farm labour (21%), employed outside district (18%), livestock rearing (11%) and self employed (2%) (Table 34). Practicing agriculture, whether crop or animal, was the main livelihood source for 53 to 64% of households. The importance of crop farming was thereby relatively low compared to the other IGP states surveyed (Erenstein et al. 2007a). There was also a tendency towards fewer crop households in the Begusarai cluster where, along with the Samastipur cluster, households depending principally on animal agriculture (livestock rearing) tended to be more common than in the Bhojpur cluster. Employment on other farms also tended to be more common in the Begusarai cluster, as would be expected because of the cluster's high proportion of landless households, 53%, about double that of the other two clusters (Table 11). The clusters were typical mixed (crop–livestock) farming areas, with crop productivity generally low because of issues related to water management which, when associated with flooding, led to the increased importance of livestock, particularly goats and cattle. The prevailing smallholder farms generally relied on family labour and therefore local employment opportunities were limited for the landless and marginalized households, resulting in out-migration to search for employment as the principal livelihood strategy for nearly 20% of all households (Table 34). Indeed, the relative importance of non-local employment was the highest amongst the IGP states surveyed (Erenstein et al. 2007a).

Table 34. *Main livelihood activity (% of hh)*

Cluster	Crop farming	Livestock rearing	Employed on other farms	Self employed	Employed outside district
Bhojpur	54	5	17	3	22
Samastipur	51	13	20	3	14
Begusarai	38	15	26	2	20
Mean (s.d., p.) [n=18]	47 (21, ns)	11 (15, ns)	21 (12, ns)	2 (3, ns)	18 (11, ns)

The variation amongst the clusters reflects the differential asset base of the households (Table 35). Across the surveyed communities, small-scale farmers were the majority of households (61%), followed by the landless poor (35%). A very small minority of households were large farmers (1%) or landless rich (3%). As explained above, the Begusarai cluster had many landless poor households, almost 2:1 with small-scale farmers, whereas in the other two clusters the ratio was closer to 1:3 or 4. Bihar State as a whole has over 50% landless (see section 3 and Annex 1) and over 80% marginal (<1 ha) land holdings (Table 5). Therefore the Begusarai cluster, rather than the other two clusters, represents more closely the state average (Annex 1).

As would be expected for this scenario of a high proportion of resource-poor households, in which marginalized, small and no land holdings were the rule, and family labour predominant, there was no market for permanent farm labour in the surveyed clusters, whether for crop or livestock enterprises (Table 36). Neither were casual labourers employed to care for livestock. Even for crop activities, only a third of all farm households reported hiring casual labour, varying from a high of half the farm households in the Bhojpur cluster to only 15% in the Samastipur cluster (Table 36). Indeed, the incidence of hiring casual labour was the lowest amongst the IGP states surveyed (Erenstein et al. 2007a). These statistics help explain the importance of employment outside the district and they highlight the plight of the landless who depend primarily on their labour asset with, for some households, livestock providing an important contribution to their livelihoods.

Table 35. *Categorization of village households (% of hh)*

Cluster	Landless rich	Landless poor	Small farmers (<4 ha)	Large farmers (>4 ha)
Bhojpur	3	21 a	77 b	0 a
Samastipur	1	26 a	73 b	1 a
Begusarai	5	59 b	34 a	2 b
Mean (s.d., p.) [n=18]	3 (7, ns)	35 (24, 0.00)	61 (26, 0.00)	1 (2, 0.02)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 36. *Labour use by enterprise*

Cluster	Crop		Livestock	
	Use of casual labour (% of farm hh)	Use of permanent labour (% of farm hh)	Use of casual labour (% of hh)	Use of permanent labour (% of hh)
Bhojpur	51 b	0	0	0
Samastipur	15 a	0	0	1
Begusarai	26 ab	0	0	0
Mean (s.d., p.) [n=18]	31 (31,0.10)	0 (0, ns)	0 (0, ns)	0 (1, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

6 Crop–livestock interactions

The previous two chapters presented the livelihood platforms and livelihood strategies pursued by the surveyed communities. Within this context, the present chapter specifically looks into the crop–livestock interactions. We start by reviewing the flows of the crop activities into the livestock activities. Particular emphasis is put on understanding crop residue management and livestock feeding practices. We subsequently address the reverse flows from livestock into crop activities, particularly in terms of manure and traction services. The chapter ends with an assessment of crop–livestock interactions.

6.1 Crop residue management

Throughout South Asia, crop residues (principally straws) are an important by-product of crop production. As elsewhere in the IGP, the major cereals (rice, wheat and maize) in Bihar are managed to harvest their residues primarily for feeding ruminant livestock (Table 37). With high population densities and much lower above-ground biomass yields than in, for example, the TGP and NW U.P., the surveyed communities reported high pressure on crop residues for feeding livestock and the presence of active fodder markets.

Table 37. *Crop residue collection for* ex situ *livestock feed (% of hh)*

Cluster	Wheat	Rice	Maize	Other crops
Bhojpur	100	58	7	42
Samastipur	100	92	65	17
Begusarai	100	80	51	0
Mean (s.d., n, p.)	100 (0, 18, ns)	76 (39, 17, ns)	46 (49, 14, ns)	19 (38, 18, ns)

Although rice is the traditional food crop in Bihar, and rice straw the traditional dry fodder, wheat straw (*bhusa*) is also a valued commodity with all households reporting that they harvested the *bhusa* for *ex situ* livestock feeding (Table 37). In the same way the increasing incorporation of maize into the cropping system for the production of grain for sale and for subsistence food also served to provide fodder for the ruminant herd in these communities, particularly in the Samastipur and Begusarai clusters. By-products from some other crops, for example pulses, grown in the Bhojpur cluster and to an extent in the Samastipur cluster, were additional sources of feed (Table 37).

There appears to be considerable variation in the livestock pressure on the crop residues over clusters (Table 38), but these differences are generally not statistically significant, reflecting considerable variability and our limited sample size. Only the pressure on generic crop residues shows a significant difference: the Begusarai cluster being markedly higher than the Samastipur cluster (Table 38), associated with the tendency for farm size to be largest in the Samastipur cluster. On aggregate, the livestock pressure indicators also do not differ significantly from the indicators for TGP and U.P. (Erenstein et al. 2007a). It is worth flagging though that these indicators are in area terms and thereby fail to capture variations in intensity, particularly in view of the higher (cereal) biomass yields achieved and the larger areas devoted to planted fodder crops in the TGP (Erenstein et al. 2007b).

Table 38. *Indicators of livestock pressure on crop residues (cow equivalents per ha at village level)*

Cluster	On crop residue (cow eq./ha)	On cereal residue (cow eq./ha)	On wheat residue (cow eq./ha)	On rice residue (cow eq./ha)
Bhojpur	2.1 ab	2.9	5.2	29
Samastipur	1.0 a	1.9	8.1	6.5
Begusarai	2.5 b	3.7	8.6	40
Mean (s.d., n, p.)	1.9 (1.2, 18, 0.08)	2.8 (1.8, 18, ns)	7.3 (4.9, 18, ns)	24 (41, 17, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

In all the surveyed villages, crop residues were collected for use as livestock feed by manually harvesting the residues for *ex situ* use (stall feeding) and, except in the Begusarai cluster, through *in situ* stubble grazing (Table 39). Non-feed uses, which included rice straw for thatching, construction and as fuel, and maize stalks as fuel, were practiced by all villages in the Samastipur cluster, by two-third in the Begusarai cluster and by one-third in the Bhojpur cluster. Bamboo and wood from trees were other sources of building materials and fuel. Such was the demand for crop residues that only in the Samastipur and Begusarai clusters were maize residues burnt in the field (Table 39). That neither rice and wheat residues nor stubble fields were burnt, unlike in the TGP (Beri et al. 2003; Erenstein et al. 2007b), is another indicator of the scarcity and value of the residues, particularly from the rice and wheat crops, for these resource-poor households and the prevailing manual harvesting practices.

Table 39. *Crop residue management practices (% of villages)*

Cluster	*Ex situ* feed use	*In situ* grazing	Non-feed use	*In situ* burning
Bhojpur	100	67 b	33 a	0
Samastipur	100	67 b	100 b	17
Begusarai	100	0 a	67 ab	17
Mean (s.d., n, p.)	100 (0, 18, ns)	44 (51, 18, 0.02)	67 (49, 18, 0.05)	11 (32, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

After the rice and wheat residues were manually harvested and subsequently threshed, they were stored in close proximity to the house. In the case of rice, the manually threshed and relatively intact straw is generally kept in loose piles or in stacks. In the case of wheat, threshing is often by mechanical thresher which finely chops the wheat straw (*bhusa*). The chopped residues were then stored in semi-permanent round structures (*bhusakar* or silos) to protect the chopped crop residues from rain, vermin and pests (see pictures in Annex 5). Alternatively, and particularly in the Bhojpur cluster, the chopped residues were stored inside the house. The wheat *bhusa* was generally stored for 9 months, and the rice straw for about half that (Table 40). By contrast the maize residues were stored in heaps close to the house and used soon after harvest because of the danger of aflatoxin contamination if stored for any lengthy period (see Annex 5:9 and 12).

Table 40. *Duration of crop residues storage (months)*

Cluster	Wheat	Rice
Bhojpur	9	5
Samastipur	9	7
Begusarai	8	4
Mean (s.d., n, p.)	9 (3, 18, ns)	5 (3, 14, ns)

As Table 41 shows, about half of the villages in the Bhojpur and Samastipur clusters, but not in the Begusarai cluster, grazed their ruminant livestock on the rice and wheat stubble fields after harvest, presumably in order to maximize the utility of the crop residues as livestock fodder.

Table 41. *Crop residue grazed* in situ *(% of households)*

Cluster	Wheat	Rice
Bhojpur	63 b	36
Samastipur	50 b	53
Begusarai	0 a	0
Mean (s.d., n, p.)	38 (49, 18, 0.05)	31 (46, 17, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

There were several ways of trading crop residues between households. All surveyed villages reported sales of crop residues (Table 42). In the Bhojpur and Begusarai clusters, crop residues (in combination with their unthreshed grains) were given in varying proportions as in-kind payment for harvesting labour (e.g. in the Begusarai cluster some villages reported shares of 1/8–1/16 of the wheat harvest, 1/11–1/16 for rice and 1/16 for maize). No village reported that crop residues were given away. This again reflects the scarcity of livestock feed and the value to livestock keeping households of the crop residues as fodder. Only 4–7% of households reported being net sellers of wheat and rice straw, while in the Samastipur and Begusarai clusters nearly half the households reported being net buyers of wheat straw, i.e. having a fodder deficit (Table 43). While most fodder was traded within the village, some was purchased from outside, mainly directly from producers, but some was supplied by traders.

Table 42. *Crop residue transaction practices (% of villages)*

Cluster	Sales	In-kind payment	Given away
Bhojpur	100	33 ab	0
Samastipur	100	0 a	0
Begusarai	100	67 b	0
Mean (s.d., n, p.)	100 (0, 18, ns)	33 (49, 18, 0.05)	0 (0, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 43. *Categorization of households as deficit or surplus in crop residues (% of hh)*

Cluster	Surplus (net seller)		Deficit (net buyer)	
	Wheat	Rice	Wheat	Rice
Bhojpur	6	8	12 a	18
Samastipur	1	0	46 b	31
Begusarai	13	2	43 b	14
Mean (s.d., n, p.)	7 (13, 18, ns)	4 (8, 17, ns)	34 (28, 18, 0.05)	21 (30, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

On average, wheat straw fetched double the price of rice straw (Table 44). The average price of the wheat straw was INR 1.7 per kg varying from a seasonal low of INR 1.4 after the wheat harvest to a seasonal high of INR 2.4 during the winter months (Table 44). Wheat *bhusa* quality factors that reportedly affected prices included primarily its dryness, and to a lesser extent, size and presence of impurities/dust. By comparison the rice straw prices averaged INR 0.8 per kg, with a seasonal variation from 0.6 to 1.4. Amongst the three clusters the average prices and at the peak and at the trough varied more for wheat than for rice straw. Prices were consistently higher in the Samastipur cluster. In the same cluster maize residues were said to fetch INR 0.4–0.5/kg, that is appreciably less than rice straw.

Table 44. *Crop residue prices (INR/kg)*

Cluster	Wheat			Rice		
	Average	Peak	Trough	Average	Peak	Trough
Bhojpur	1.2 a	1.8 a	1.2	0.6	0.9	0.5
Samastipur	2.0 b	2.8 b	1.7	1.2	2.0	0.8
Begusarai	1.9 b	2.4 b	1.4	0.6	0.9	0.4
Mean (s.d., n, p.)	1.7 (0.6, 18, 0.03)	2.4 (0.6, 16, 0.02)	1.4 (0.5, 16, ns)	0.8 (0.6, 10, ns)	1.4 (1.2, 7, ns)	0.6 (0.4, 7, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

As Erenstein et al. (2007b) have pointed out, interesting though the participation rates in residue markets are, they fail to capture the households that cannot participate. Indeed, it is likely that in these clusters and generally in Bihar, there will be many residue-deficient smallholder and landless households who will lack the purchasing power to buy fodder; hence the importance of the non-market transactions. Residue in-kind payments (particularly for harvesting labour) and residue gifts are primarily from landed household to (landless) labourers. These will represent an important source of supplementary income, livestock feed and/or fuel for the landless.

Despite the stated scarcity of dry fodders, crop residue characteristics did not appear to play a major role in farmers' varietal choices for rice, wheat and maize production, which were primarily driven by expectations of high grain yield. The importance of the yield of wheat and rice straw was commented upon by some of the surveyed villages, but issues of fodder quality (nutritional value) were not mentioned. Whether this was because there is no important variation for fodder quality characteristics in the available varieties or because quantity requirements far outweigh any quality considerations needs to be investigated.

6.2 Livestock feed inputs and availability

As discussed in the previous chapter, livestock production in Bihar is based primarily on keeping a mix of bovines and goats. These are managed in a stall feeding system using mainly crop residues, sometimes complemented by grazing (also see pictures in Annex 5). Where land use intensity is low and in the *rabi* season, grazing (e.g. of fallow and wasteland) becomes more important (e.g. in Bhojpur one village reported that grazing was their primary feed source). Yet, with fragmentation of farms increasing pressure on land, and common properties being allocated to individuals, grazing in the surveyed clusters was on the decline.

For stall feeding the basal diet is mainly wheat *bhusa* (chopped straw) and rice straw with, in some areas, increasing contributions from maize stover (Table 37). As discussed in the previous section landowning households use their own *bhusa*, but purchases and *bhusa* received in lieu of wages or from share-cropping are also important sources of basal feed especially for marginalized and landless households (Tables 42 and 43). Despite the decrease in common properties and the quite high cultivation intensity, grazing remains an important feeding practice as does the collection of grasses/forage, e.g. from the banks of irrigation channels or from field boundaries and roadsides (Table 45). Another source of green fodder was the planting of forage crops, which occupied on average 6% of cultivable land in the *kharif* season (Table 26) and 3% in the *rabi* season (Table 27). These limited areas of forage crops produced seasonally Egyptian clover (*berseem*) (although flowering problems were mentioned), oats, sorghum, Sudan grass and teosinte. The cut-and-carry grasses were reported to be worth INR 10,000–17,500/ha per crop. Other sources of green fodder were sugarcane tops (in the Begusarai cluster), maize thinnings, weeds from the cereal crops and indigenous mustard. In the Samastipur cluster, not only was lack of green fodder a constraint to livestock feeding but grazing was also constrained. Both for the landed and the landless the difficulties in accessing fodder were related to poor irrigation facilities and the associated problems with electricity supply. There was no indication that the production of planted forage was increasing, so despite the growth of the dairy crossbred herd, it would appear that there is, as yet, no significant trend towards specialization in dairy production in any of these three clusters.

Table 45. *Use of feed sources (% of hh)*

Cluster	Other crop by-product*	Compound feed	Grazing	Collected grasses/forage	Green fodder
Bhojpur	76	17 a	50	37	43
Samastipur	80	71 b	29	37	70
Begusarai	82	30 a	53	70	19
Mean (s.d., n, p.)	79 (32, 18, ns)	39 (41, 18, 0.05)	44 (44, 18, ns)	48 (39, 18, ns)	44 (44, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison. *Other than crop residues.

In addition to the feeding of the green fodders, whether collected or from planted sources, another complement to the *bhusa* basal diet was a range of locally available other crop by-products used by about 80% of livestock keeping households, both from their own production and purchased (Table 45). Of these by-products, the nutrient-dense types were used primarily for lactating milch animals, although apparently fed at low levels. A frequent comment was that the quality of oilseed cakes (mustard, rape, cotton seeds) was variable. These nutrient-dense feeds included wheat bran, which was reported to cost INR 6–7/kg, i.e. less than the prevailing milk price (Table 23). As the production response may be significantly more than 1 liter milk per 1 kg nutrient-dense feed, this suggests their use would show a good profit, raising the question therefore why these 'straights' (non-compounded feeds) are not used more intensively. Contributing factors may include the small quantities of home-produced by-products, the reported variability of the 'straights' and of the small quantities of compounded feed that was purchased (at a cost of INR 5–8 /kg) for lactating animals, and cash flow constraints. It was said that the use of compound feeds was increasing, especially in the Samastipur cluster, to stimulate milk yield.

When reviewing these various sources of feed supply, the clusters can be seen to be facing an overall feed deficit relative to the increasing milk production potential as the herd is upgraded towards dairy crossbreds. At the same time, reported milk production levels were low, suggesting that most bovine keeping households did not have as a primary objective the regular sale of milk, but rather satisfying immediate household needs. In the same way, there were limited reports of mineral mixture purchases, despite known links between poor reproductive performance and mineral deficiencies. Overall therefore one can conclude from the reported feed management practices that while bovines represented an integral part of the livelihood strategies of a significant proportion of landed households, their role was not perceived as primary income earners, but more as converters of readily available crop residues (principally wheat *bhusa* and rice straw) into: (i) milk primarily for household consumption with any surplus being sold; (ii) dung for use as manure and/or fuel or for sale (Table 47); (iii) traction power mainly for transport (Table 46); and, (iv) herd growth as a means of capital saving. The production function of goats was presumably mainly as a means of capital saving.

Table 46. *Comparative indicators of external and livestock input use for crop production (% of farm hh reportedly using)*

Cluster	Tractors use	Draught animals use	Chemical fertilizers use	FYM use
Bhojpur	79 a	15	100	23 a
Samastipur	89 ab	11	100	80 b
Begusarai	97 b	5	100	82 b
Mean (s.d., n, p.)	88 (13, 18, 0.06)	10 (11, 14, ns)	100 (0, 18, ns)	64 (44, 17, 0.03)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

It is important to point out that bovines and goats also fulfilled these same roles for some landless households, for which feeds came mainly from the collection of free resources: bunds, weeds in fields, rice residue, and from purchases of rice straw, wheat *bhusa* and green fodder or through partial in-kind payment and the grazing, e.g. on stubbles and common property resources, especially for the goats.

Table 47. *Dung use (% of dung allocated to use)*

Cluster	As fuel	As FYM	Other
Bhojpur	92 b	8 a	0
Samastipur	31 a	69 b	0
Begusarai	48 a	48 b	3
Mean (s.d., p.) [n=18]	57 (35, 0.00)	42 (35, 0.00)	1 (5, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

6.3 Livestock input to crop production

The use of farmyard manure (FYM) and the provision of traction services are the two main direct contributions from livestock to the production of crops. An indirect contribution can come from livestock income supporting crop production, e.g. through purchases of inputs.

In the Bihar cluster villages, FYM use was reported by two thirds of farm households, although by only 23% in the Bhojpur cluster (Table 46). This low rate was consistent with the much higher rate of dung used for fuel reported in the Bhojpur cluster, 92% compared to only 31 and 48% in the Samastipur and Begusarai clusters, respectively (Table 47). As was mentioned in section 6.1, alternative fuel sources in this subregion were wood, bamboo and crop residues, and particularly in the Bhojpur cluster fuel seemed scarce.

In each of the clusters 100% of farm households were reported to be using chemical fertilizers (Table 46). While this will contribute to short-term nutrient supply to the crops, it will not enhance soil physical structure in the way FYM can. The detailed studies on the regularity and intensity of manure application in the TGP (e.g. Sidhu et al. 1998) do not appear to have been carried out in Bihar, perhaps because of the lower cropping intensity and yields in Bihar and therefore the lower availability of biomass. Nevertheless it would seem important to assess in Bihar how its relatively high ratio of livestock, mainly ruminants, to cultivated area (Table 38) can be exploited through any potential for improved management of their excreta for crop production, particularly for high-value crops like vegetables.

While most bovines and goats were stallfed or tethered close to the homestead for significant parts of the year allowing the recovery of most of the dung produced, it may be that dung and therefore FYM was not managed as systematically as in the TGP and U.P. The use of dung for fuel approached 60% across the three clusters (Table 47) with the process mirroring the practices observed in the TGP and U.P. (Erenstein et al. 2007b; Singh et al. 2007): dung cakes being produced manually mainly during the dry season to allow adequate drying in the open (see Annex 5:4) and then stored in stacks. These stores of dung cakes are for both household use and sale, the latter serving as income, including for livestock owning landless households.

While draught animal use was reported by 10% of farm households, mechanization was widespread with nearly 90% of farm households reporting the use of tractors (Table 46). Livestock's contribution as a traditional source of traction for crop production and for transporting crops to market has therefore declined appreciably over the last 20 years or so. Scarcities of fodder will have contributed to this decline given the need to maintain bullocks (whether cattle or buffalo) year-round for what is a largely seasonal task of cultivation and weeding. Where draught animals were still kept, it was commented that a household might keep one bullock and depend on a neighbour for the matching pair. As a result in these clusters and perhaps more widely in Bihar, it would appear that custom hiring and some limited ownership of tractors has largely replaced bovines as sources of draught power, and as a result diminished the importance of what was previously a major crop–livestock interaction.

6.4 Assessing crop–livestock interactions

Integral to the survey process were discussions with each of the village groups of their perceptions of the advantages and disadvantages of crop–livestock interactions. In these three Bihar clusters, the feedback was similar to that from the other three subregions in that it consistently addressed the contribution of the individual crop and livestock enterprises to household consumption, income and, implicitly, risk avoidance, while dwelling little on the interactions between the crop and the livestock enterprises.

In these communities, the agriculturally based livelihoods of the landed households were invariably derived from a combination of crop and livestock enterprises in which the flow of resources were generally from the crops in the form of crop residues to the ruminant livestock (mainly bovines) as feed for producing milk, herd growth and dung. Of the dung production only 42% was returned to the arable land as manure, the rest being used as or sold for fuel. Whereas draught provision by livestock to cropping had been important historically, mechanization has significantly reduced this role of livestock in crop production and marketing. Therefore while these were crop–livestock farms, the level of crop–livestock interaction in terms of physical inputs has declined and is low, despite the integrated nature of the farming system and the apparent lack of specialization in either crops, e.g. vegetable production, or livestock, e.g. dairy production or seasonal goat finishing. On the other hand, market surpluses from crops and from livestock were relatively lower in the Bihar village clusters than in the TGP and W U.P., so that the in-kind contribution from crops (grains, vegetables) and livestock (milk, fuel) to household consumption were more important and particularly valued for not requiring cash outlays.

In the same way, the village groups recognized the continuing advantages of having both crops and livestock because of their complementary labour use and cash income flows. While income from the cereal crops were essentially seasonal, the steady daily cash from the sale of milk from cattle and buffalo and the occasional sales of small stock and dung cakes, played important roles in the management of household finances. These roles of livestock were even more critical to landless families dependent on daily-paid crop labour as their major cash income source. Casual labour supplied by the landless for cropping activities could serve as a source of crop residues in part or whole payment, and to gain gathering rights of fodder for their few livestock.

Less explicit were any significant contributions of livestock income to crop production and vice versa. Nor was there explicit mention of bovines or goats (the main small stock) serving as an important source of capital accumulation or fulfilling non-market functions such as insurance. The extent that crops and livestock and their interactions contribute independently or interactively to the economies and financial management of landed and landless households in Bihar requires further study, particularly in farming systems undergoing change, e.g. where cropping patterns are incorporating maize and vegetables and livestock systems are adopting dairy crossbred cattle. These changes are more likely to occur where access to markets is good, for example adjacent to highways, in peri-urban areas and in villages targeted by private sector market agents. The changes also impact on labour demand with market-oriented vegetable growing and milk production potentially competing for household and employed labour.

A recurring negative crop–livestock interaction which was mentioned was the crop damage and nuisance caused by blue bulls and by stray cattle, particularly males. The religious status of cattle in Bihar precludes their slaughter and yet the communities and district authorities had not put in place reliable mechanisms for reducing the costs associated with these roaming animals and their wildlife counterparts, the blue bulls.

7 Discussion and recommendations

7.1 Livelihood security and environmental sustainability

Livelihood systems in Bihar are dominated by primary production from crops and livestock on small farms with fragmented, low-productivity landholdings poorly served by infrastructural and institutional support (Kumar and Jha 2003). Human population and livestock densities are well above national averages, putting increasing pressure on natural resources. Poverty of all livelihood capital assets is endemic. The prevailing unequal distribution of land and resources undermines the prospects of agriculture providing a viable escape strategy from the prevailing poverty (e.g. Wilson 2002; Kishore 2004).

In the face of these constraints, which were clearly evident during the village surveys, out-migration—a livelihood strategy traditional to this region—continues to play an important role. De Haan (2002) points out that mobility of the rural population of Bihar has been an integral part of the society for many decades, and that migration is not just a response of poor families to their poverty, but that the reasons are more complex with migrants drawn from various social strata. In fact the poorest often cannot afford to migrate (de Haan 2002).

A self-evident livelihood strategy of landed families is combining the growing of various crops and keeping ruminant livestock. The surveyed clusters show primarily smallholders cultivating *kharif* rice—the staple grain—and *rabi* wheat with small livestock holdings, such that these farming systems are more subsistence than market-oriented. And, in contrast to the high productivity areas of Punjab, Haryana and western Uttar Pradesh, there is no general security of irrigation services with which to exploit more production from these small, fragmented landholdings. Similarly many areas are prone to flooding and water-logging (Kumar and Jha 2003). As a result in Bihar there are fewer opportunities for low-risk diversification of cropping and livestock (only about half as much land per farm is planted to forages in Bihar as in the TGP) and fewer opportunities for the landless to secure casual agricultural employment.

Therefore while the small herds and flocks of bovines and goats added value, reduced risks and stabilized incomes through converting low value crop residues to higher value milk, live weight and dung, the contributions of these crop–livestock interactions to livelihoods were not allowing families to escape the apparent poverty web in which the majority are trapped. Dependence on livestock for income and employment was also said not to be attractive to the young generation because its year-round labour demands reduced their mobility to pursue other livelihood options. As elsewhere in the IGP, a common refrain was the desire of the parent generation to equip their children to escape a farm-based livelihood.

Current low levels of natural and physical capital and the recurring generational fragmentation of these assets constrain the sustainability of even these meager livelihoods and they drive the efforts of parents to move their children from the land. Isolated patches of crop diversification—the introduction of vegetables and commercial maize grain production—indicated some potential for agricultural intensification, but high rates of interest for credit and weak agricultural R&D support inhibited risk taking. These challenges were even greater for the marginal landholders and the landless for whom urban employment may be dream beyond their level of education.

7.1.1 Environmental sustainability

High human population and livestock densities are putting increasing pressure on the natural resources of Bihar, exacerbated by the prevailing poverty. Water management is a key area which was highlighted during the village group discussions and which recurs in the literature (Kumar and Jha 2003). Poor access to reliable irrigation and the negative effects on productivity from flooding and waterlogging have to be addressed. In the Begusarai cluster there were reports of a declining water table. With the spread of private diesel-powered tube wells, these threats are likely to become more widespread and require urgent study to inform policy making and short- and medium-term action planning. Climate change will likely make these systems even more vulnerable.

In the same way, the high cropping intensities reported in the Begusarai and Samastipur clusters and prevailing crop management practices are leading to the deterioration of soil structure and composition. As in the TGP and U.P., organic matter (OM) management is particularly problematic because of the largely one-way extractive flows from cropped land leading to the depletion of soil OM. How best to tackle these biomass management issues in ways compatible with the prevalent crop–livestock livelihood strategies is a major researchable area in this and neighbouring subregions.

7.2 Outlook and constraints

It is self evident that agriculture dominates the economy of Bihar, yet agriculture development has been slow and its contribution to economic growth poor. The small and fragmented landholdings, the high proportion of landless rural households, poor governance and weak organizational support continue to inhibit growth whether in crop or in animal agriculture, a recurring scenario observed in the three village clusters. As Kumar and Jha (2003) report, there has been considerable under-investment in agricultural R&D in this region; many agricultural and rural development institutions have become practically non-functional, partly because of poor financial support. Lack of coordination and integration exacerbate their ineffectiveness. In the absence of a supportive policy and institutional environment, the bio-physical and climatic challenges faced by Bihar's rural population are daunting, a situation resulting in the desire of the parental generation to equip their children to escape a farm-based livelihood. Yet for many households the reality is that urban employment may be a dream beyond their level of education. At the same time there are very limited opportunities through public institutions to acquire the new technical knowledge required to improve crop and livestock productivity and to create rural employment.

In the face of these challenges, there were some signs of hope garnered during the village surveys in the three surveyed clusters. For crop production these were mainly the growing of the cash crops hybrid maize and vegetables with the support of private sector inputs and improved market linkages. For livestock it was the adoption of dairy crossbred cattle supported by both public and private delivery of AI (artificial insemination). But generally crop productivity was low constrained by the absence of irrigation, inadequate drainage, barriers to accessing markets (including credit) and to technical knowledge, all of which contributed to high production costs and risks especially for diversifying from the staple cereal grains. During the surveys there were reports of lack of quality seeds and the adulteration of fertilizers. Corruption was a significant barrier to credit. On the other hand, there were few reports from the villagers of pest or soil problems, despite the largely one-way extractive flows of crop biomass leading to the depletion of soil OM. Constraints faced by livestock keepers mirrored those of crops, with barriers to accessing markets, credit, technical knowledge and irrigation, and their having insufficient fodder, in part because of the low biomass yields of the staple crops, but also because of the apparent lack of the collective action required to improve grazing and increase forage production. For the majority of the landless, life was a fight for day-to-day survival in the face of low wage rates, uncertain employment, and difficulties in getting access to land for housing, cropping and livestock-keeping and for sourcing fodder.

For a more hopeful outlook, improved governance at state and local levels will be required to create an enabling environment through providing and maintaining more basic infrastructure—roads, village electricity and water supplies, flood control—and by increasing access to markets, to better primary education and health care and to more effective knowledge services such as agricultural extension targeting the resource poor, especially women. Changes in land tenure through consolidation will also be required. The outlook should be an economy that not only creates more agricultural employment through, e.g. cash crops like fruit, vegetables and milk, but that also absorbs labour from agriculture into non-agricultural jobs.

Clearly for farm households (i.e. those with access to land) successful diversification of cropping to include high-value products such as vegetables will be dependent on their securing access to water, to finance and to input and output markets. Vertical integration giving value addition is also likely to be key, whether for vegetables, fruit, milk and possibly for meat, particularly from goats. In Bihar, the relative success of the Bihar State Milk Co-operative Federation (Comfed) is a promising indicator of what's possible when there is strong leadership and good governance.

It is probable that sustained diversification and intensification, whether of crops or of livestock production, will require significantly increased productivity of the major staples crops, particularly rice. While producing more grain will be farmers' prime objective—to be achieved through better agronomic practices, including RCTs (resource-conserving technologies), and the use of more inputs—the increased biomass will also yield more crop residues and by-products for feeding to livestock.

For significantly higher productivity, taking advantage of Bihar's undoubted good potential for both crop and livestock production, a concerted program of inter-disciplinary action-oriented research will be required, focusing on improving and broadening the basis of the livelihoods of rural households, both landed and landless. Crop and livestock production and their interactions will be key elements, but non-agricultural aspects will be critical for success.

To have significant impacts on livelihoods, the action-oriented research will require a change in paradigm from conventional reductionist, plot/animal-level research to people-centred, participatory and holistic methods through iterative research-for-development approaches that are inter-disciplinary and multi-institutional (Rangnekar 2006). An important objective has to be to strengthen the capacities of collaborating organizations to undertake participatory, inter-disciplinary research in support of sustainable rural development, building extension capacities and with the involvement of women a core activity. While technological improvements will be a key component, equally if not more important will be addressing these policy and institutional constraints at all levels from within villages to central government.

7.3 Agenda for action

As in the other three subregion reports (see, e.g. Erenstein et al. 2007b), this scoping study for the Gangetic Plains of Bihar has set out to present primary information from village-level surveys, to relate the information to secondary sources, and to draw some broad conclusions that address the interface of Bihar's crop and livestock subsectors. Specifically it has focused on the management of crop residues because of their importance as ruminant livestock feeds and their role in natural resource management. The intention was not to provide any definitive answers or recommendations, but rather to flag issues for research.

In the parallel report on the Trans-Gangetic Plain (TGP), Erenstein et al. (2007b) highlighted the need in the TGP—India's 'breadbasket' and the heartland of the Green Revolution—for a more enabling environment for economic and human development with two specific objectives: to enhance the human capital base and skills through basic education; and to stimulate the economic growth of the secondary and tertiary sectors to absorb surplus labour from the primary sector and the rural landless. As has been outlined in the previous section of this report, these priorities for action are even more urgent in Bihar where low productivity and poverty are endemic. In the same way the second intervention identified for the TGP, a more enabling environment for agricultural development, also needs to be urgently addressed in Bihar. Agriculture has an important role in driving pro-poor economic growth, largely by default, as there are few other candidates with the same potential for supporting broad-based pro-poor growth (Kydd et al. 2004; World Bank 2007).

As was explained above in the Outlook subsection, for these broad objectives to succeed, it is clear that a change in R&D paradigm will be required. The change will involve a shift from a reductionist, plot/animal-level research to people-centred, participatory and holistic methods and to inter-disciplinary, multi-institutional approaches.

Cross-cutting action research needs for the IGP

The present study and its companion studies also highlight a set of specific research needs that cut across the subregions. These specific needs relate to the land use systems of the IGP and their crop, livestock and crop–livestock interaction components and include action-research to:

- Understand and address <u>local</u> variation in land use systems and the resulting constraints and opportunities for diversification and intensification;
- Address key issues including community-action for improved management of water and livestock resources and ways to increase market access for inputs (including knowledge) and outputs;
- Improve the productivity of the staple crops, including through identifying resource-conserving technologies (RCTs), while factoring in any trade-off effects on the feeding of crop residues to livestock; and, related to that:
    - i. Investigate whether variation in rice, wheat and maize varieties for fodder quality (nutritional value) is an avenue for increasing the available quantity and quality of crop residues for feeding goats, cattle and buffalo; and,
    - ii. Investigate organic matter (OM) management and particularly crop biomass management issues impacting on the prevalent crop–livestock livelihood strategies of landed and landless households, taking account of the multiple functions of the crop residues and of the various livestock species within a household and community.

Central to achieving the overall goals of improving livelihoods and more sustainably using natural resources in the IGP, will be strengthening the client orientation and productivity of the agricultural R&D community. Research on crop–livestock interaction can serve as a good entry point for that process.

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Annex 1. Socio-economic and development indicators in IGP states

Indicators		Year/source	Punjab	Haryana	Uttar Pradesh	Bihar	W. Bengal	All India
Population (× 10^6)		2001 (1)	24.4	21.1	166.2	83.0	80.2	1029
Increase (%)		1991–2001(1)	20.1	28.4	25.9	28.6	17.8	21.6
Population density (per km^2)		2001 (3)	484	478	690	881	903	325
Rural population (%)		2001 (3)	66.1	71.1	79.2	89.5	72.0	72.2
Farming population (%)		2001 (3)	32	46	48	31	25	
Landless population (%)		2001 (2)	22	19	29	51	33	
Literacy	Male (%)	2001 (4)	76	79	70	60	78	76
	Female (%)	2001 (4)	64	56	43	34	60	54
Rural population below poverty line (%)		1999–2000 (1:9–10)	6.4	8.3	31.2	44.3	31.9	27.1
Share of agri. in GSDP at 1993–94 prices (%)		2001–02 (1)	39	31	33	35	23	24
Per cap income at current prices		2002–03 (2)	26,000	26,600	10,300	6000	18,800	18,900
% of Hh in income classes (INR/month)	< INR 3000	2002–03 (2)	52.4	64.2	80.7	85.1	77.8	
	INR 3001–6000		38.7	26.5	14.9	10.6	16.4	
	INR 6001–10000		6.5	6.8	3.4	3.3	4.4	
	INR 10001–20000		2.2	2.5	0.9	1.0	1.4	
	> INR 20000		0.1	neg.	neg.	neg.	0.1	
Geographical area (× 10^3 ha)		2000–01 (3)	5036	4421	24093	9416	8875	328724
Cultivated area (× 10^3 ha)		2000–01 (3)	4250	3526	17612	7437	5417	141087
Area irrigated (%)		2000–01 (3)	95	83.9	72.8	48.7	43.5	39.1
% Area irrigated by source	Canal	2000–01 (3)	24	50	24	31	11	30
	TW		76	50	69	55	53	40
	Others		0	0	7	14	36	30
Cropping intensity %		2000–01 (3)	187	173	154	147	168	137
Average farm size (ha)		2000–01 (5)	4.03	2.32	0.83	0.58	0.82	1.32
# of tractors (× 10^3)		2001–02 (3)	442	331	677	107	35	3084

# of pumpsets energized (× 10^3)		2002 (4)	811	427	815	276	112	13044
Expenditure by SAU's (× 10^6 INR)		2004–05 (4)	1410	1025	738	708	594	
Foodgrains	Area (× 10^6 ha)	2002–03 (1)	6.13	3.98	17.90	6.88	6.54	111.50
	%		5.5	3.6	16.1	6.2	5.9	100
	Production (× 10^6 t)		23.49	12.34	36.30	10.27	15.52	174.19
	%		13.5	7.1	20.8	5.9	8.9	100
Marketed	Rice	1999–2002(1)	96	91	74	68	55	70
Share (%)	Wheat	1999–2002(1)	80	78	58	67	–	67
Fruits	Area (× 10^3 ha)	2002–03 (4)	40.5	31.9	280.3	294.8	152.2	3787.9
	Production (× 10^3 t)		578	237	4314	3038	1786	45203
Vegetables	Area (× 10^6 ha)	2002–03 (4)	0.14	0.16	0.85	0.61	1.21	6.1
	Production (× 10^3 t)		2.3	2.1	15.8	8.3	17.4	84.8
Milk production (× 10^6 t)		2002–03 (1)	8.7	5.1	15.3	2.6	3.6	87.3
Egg production (× 10^9)		2002–03 (1)	3.5	1.2	0.8	0.7	2.8	40.2
Fish production (× 10^3 t)		2002–03 (1)	66	35	250	166	1120	6200
Dry fodder (× 10^6 t)		2002–03 (4)	29.4	18.9	80.8	15.6	21.6	377.7
Green fodder (× 10^6 t)		2002–03 (4)	25.5	19.0	35.8	1.3	1.9	503.1
Wet dung production (× 10^6 t.)		1987 (4)	33.2	34.5	24.2	22.4	21.7	615.5
Electricity consumption for agriculture (%)		2001–02 (1)	27	42	20	23	7	25
Road length (Km/100 km^2)		2000 (3)	104	59	53	19	56	45
Fertilizer use (kg/ha)		2003–04 (4)	184	167	127	81	122	90

Sources: (1) MoA (2004a); (2) Business World (2005); (3) ESO (2004); (4) IASRI (2005); (5) MoA (2006).

Annex 2. Area, yield and production of major crops in IGP states

Crop	State	1974–75 Area (× 10^3 ha)	1974–75 Production (× 10^3 t)	1974–75 Yield (kg/ha)	2003–04 Area (× 10^3 ha)	2003–04 Production (× 10^3 t)	2003–04 Yield (kg/ha)
Wheat	Punjab	2213	5300	2395	3444	14489	4207
	Haryana	1117	1954	1749	2303	9134	3966
	U.P.	6152	7176	1164	9150	25567	2794
	Bihar	1478	2000	1353	2119	3778	1783
	W. Bengal	422	837	1984	426	986	2315
	All-India	18010	24104	1338	26581	72108	2713
Rice	Punjab	569	1179	2072	2614	9656	3694
	Haryana	276	393	1426	1016	2793	2749
	U.P.	4530	3523	778	5952	13012	2187
	Bihar	5228	4540	868	3557	5393	1516
	W. Bengal	5420	6543	1207	5857	14662	2504
	All-India	37889	39579	1045	42496	88284	2077
Maize	Punjab	522	898	1720	154	459	2981
	Haryana	124	125	1010	15	38	2573
	U.P.	1394	827	593	947	1319	1392
	Bihar	881	572	650	607	1440	2374
	W. Bengal	46	52	1137	41	97	2359
	All-India	5863	5559	948	7322	14929	2039
Sugarcane	Punjab	123	6150	50,000	123	7870	64,000
	Haryana	161	5910	37,000	161	9340	58,000
	U.P.	1492	61479	41,000	2030	112754	56,000
	Bihar	141	5568	40,000	103	4222	41,000
	W. Bengal	29	1682	58,000	17	1268	Na
	All-India	2894	144289	50,000	3995	236176	59,000
Total Pulses	Punjab	328	245	746	48	48	824
	Haryana	781	374	479	196	149	740
	U.P.	3154	2185	694	2708	2339	886
	Bihar	1554	867	558	684	562	824
	W. Bengal	682	376	550	252	30	840
	All-India	22024	10020	455	23440	14940	637
Total Oilseeds	Punjab	368	290	790	87	102	1167
	Haryana	214	149	694	640	990	1547
	U.P.	3784	1927	509	1140	928	814
	Bihar	296	132	446	149	125	842
	W. Bengal	204	75	369	684	651	952
	All-India	17313	9152	529	23700	25290	1067
Cotton	Punjab	547		373	452		414
	Haryana	246		311	526		372
	U.P.	35		118			150
	Bihar	–		–	–		–
	W. Bengal	–		–	–		–
	All-India				7630		370

Source: MoA (2005b).

Annex 3. Survey team members

Name	Institution	Participation in cluster (team)		
		Bhojpur	Samastipur	Begusarai
Dr Joginder Singh	PAU (Ludhiana)	A	A	A
Dr Bill Thorpe	ILRI-India (Delhi)	A	A	A
Dr Sunil Kumar	KVK, Ara	A		
Sudhir Kumar Singh	Farmer, Norhapanapur		A	
Mr Mazharul Haque	Farmer, Maniyarpur		A	
Dr Ram Niwas Singh	EO, KVK, Begusarai			A
Om Prakash Gupta	DAO, Begusarai			A
Shailender Kumar	DAO, Begusarai			A
Dr Arun Varma	Retired (ADG ICAR)	B	B	B
Dr SS Singh	CIMMYT (Patna)	B		
Dr Olaf Erenstein	CIMMYT-India (Delhi)		B	
Dr Paras Nath	TO, KVK, Samastipur		B	
Dr Vid. Chaudhary	TA, KVK, Begusarai			B
Dr Gaurav Yadav	CIMMYT, Begusarai			B
Mr Rajesh Ranjan	DMR, Begusarai			B
Dr Olaf Erenstein	CIMMYT-India (Delhi)	C		C
Manjinder Singh	Research Associate	C	C	C
Dr SS Singh	CIMMYT (Patna)		C	
Dr P Kumar Divedi	KVK, Ara	C		
JS Roy	A-A B C, Samastipur		C	
Dr VB Jha	Incharge-KVK, Begusarai			C

Annex 4. Survey instrument

Crop-livestock interactions scoping study
Farmers group discussion

State: …………District: ……………………. Village: ……………………………..
Date: ………… Team members: …………………………..…………………
…………..……………………………..…………..……………………………..

GPS code: …………… X- Coord: …….………….   Y-Coord…………………..
(Decide on a code you will use on the GPS unit and on the checklist. Make sure it's a unique identifier. Take reading in village – probably place of meeting)

0 Village characteristics (from key informant)

Number of people in village: ……	**Number of households: ……**
	Number of farm hh: ……
	Number of landless hh: ……

Prevailing cropping system: ……………………………………

Overall assessment of the road infrastructures in the area:

Availability of public transport:	1. high, 2. low, 3. non existent
Type of public transport:	1. bus, 2. jeep/van, 3. train, 4 ….
Travel time by public transport:	
• to nearest urban centre (70% ag; more than 500)	…
• to nearest agricultural market centre	…
Distance to all weather road	… km
Quality of all weather road:	1. Good, 2. Bad

Access to basic facilities:

% of hh with **electricity** : ….	
% of hh **piped public water**: …	
Number of phones in village: …	

Education level of the household heads

Education level	% households in the location
No formal education	
Primary level	
Secondary level	
Higher level	

Introduction

Start by setting the scene – create common understanding for whole group.
Focus: Crop residue mgt – linkage between crop and livestock mgt. Changes and implications. Problems and solutions. Questions typically assess indicators of change - try to understand why. Write down any related information on additional space/sheets.

When estimating % shares of population, ask "out of 10 farmers in this location, how many…". You don't have to get a consensus. If this is the case, indicate range of answers.
The exercise does not have to be "linear"- for example, if the participants give answer for subsequent questions at the same time, note the answer down and don't ask again! Write down any additional related discussion. Try to involve all participants in discussion.

Number of **farmer participants**: ……	# of **women** among participants: ……

1 Land resource

Total village land area (ha): ………

	Private irrigated *(specify main source …………………)*[a]	Private rainfed	Communal	
Divide village area by land type				*(check total = 100% or village area)*
Prevalent number of crops per year				
Rental price (Rs per year per ha)				
Purchase price (Rs per ha)				

[a]*e.g. 1. Canal; 2. Electric tubewell; 3. Diesel tubewell; 4. Other……*

2 Main types of crops grown

First assess the types and aggregate area of crops and fodder that are grown in the area (first column).

Season	Type *(use large categories, eg pulses, vegetables)*	Indicative aggregate area (ha)	% of farmers growing crop
Kharif	Rice		
	Basmati rice		
	Sugarcane		
	Vegetables		
	Forage (specify …………….)		
	Others………		
	Others………		
	Others………		
	Fallow		
	Communal land		
		(check seasonal total = 100% or village area)	
Rabi	Wheat		
	Vegetables		
	Pulses		
	Forage (specify …………….)		
	Others………		
	Others………		
	Others………		
	Fallow		
	Communal land		
		(check seasonal total = 100% or village area)	

List any significant **changes in crops** over last decade:

	Crops area decreased	Crops dropped out	Crops area increased
Crop(s)			
Why			

Do small and large landholdings grow different types of crops?: 1. Yes; 0. No

Crops mainly grown by small holders (<4 ha)	Crops mainly grown by large holders (?4 ha)

3 Livestock population

Type	% of households keeping livestock	Total number of animals in village *(to nearest 10)*	Trend over last decade *(1-Up; 2-Down; 3-Same)*	Why *(reason for up or down trend)*	Who owns *(0-Landless, 1-Small, 2- Large, 3-All)*	Main feeding system *(1-Only grazing, 2-Stall feeding, 3-Both)*
Buffalo milch						
Dairy cattle (indigenous)						
Dairy cattle (cross bred)						
Draft animals (main purpose 1. transport; 2. crop production) Type ……………						
Sheep						
Goat						
Pigs						
Poultry						
Others…						
Others…						

Of all livestock dung produced in the village, how much is…

Use of dung	% of total
Used as fuel	
Used as manure	
Other …	
Not used/wasted	

4 Livelihood types

Main livelihood activity

Assess the main sources of livelihood in the area. Start by asking the type of activity (crop, livestock etc…). Only after, try to assess the importance of each activity (%). To do this, ask "out of 10 farmers in the area, how many are mainly crop farmers " If you cannot get a consensus, indicate range of answer.

Activity	**% households in the location who derive a main part of their living from the activity**
Crop farming	
Livestock rearing	
Employment on other farms	
Self employment (e.g. business)	
Employment outside the district	
Other, specify	

Breakdown of main livelihood activity by landholding
Subdivide the households by their landholding. Assess corresponding main sources of livelihood using previous categories.

Landholding	% households in the location	Predominant income source
Landless but "rich"		
Landless and "poor"		
Small (< 4 ha)		
Large (?4 ha)		

Note: Landless do not cultivate land. Check with first page for total number of landless and farmers.

5 Non-feed inputs and services for livestock activities

	% households using	Any significant change in use over last decade	Why *(reason for change, e.g. availability)*
AI services			
Bull services			
Veterinary services			
Extension messages			
Other inputs, specify: ……..			
Other services, specify: ……			

6 Inputs and services for crop activities

	% farmers using	Changes in use over last decade	Why (reason for change)
Purchased improved seed			
Chemical fertilizer			
Manure			
Herbicides			
Tractors			
Combine harvester			
Draft animals (specify main use: 1. tillage; 2. weeding; 3. marketing)			
Extension messages			
Other inputs, specify:……			
Other services, specify: ……			

Number of **tractors** in village: ……	Number of **combiners** in village: ……

7 Marketing of farm products

7.1 Sales of main crops and livestock products

Produce	% of average production sold or exchanged	Main market outlet	Price [1]
Wheat			
Rice			
Basmati rice			
Other crops…..			
Other crops…..			
Other crops…..			
Other crops……			

Milk			
Dung as manure			
Dung as fuel			

[1] *Indicate if price is seasonal and provide corresponding range.*

7.2 Sales of animals

Where are surplus animals mainly sold?	1. Local; 2. Outside community, ….
How regular is the sale of surplus animals as source of income?	1. Regular; 2. Irregular *(sporadic sales, as needed, etc.)*

Types of animals	Price [1]
Local cattle	
Crossbred cattle	
Buffalo	

[1] *Use Heifer price (36 months animal) for buffalo and cattle. Indicate if price is seasonal and provide corresponding range.*

8 Crop residue use

In this section we look at crop residues only – i.e. the dry fodder/straw as byproduct from crop production. Next section includes green fodder and other byproducts.

Are crop residues **collected** to be used as livestock feed *ex situ*? 1. Yes; 0. No

	Wheat	Rice	Other … ………
% of farms using			
Main livestock types for which used			
How are residues collected from field?			
Changes in use *(if any)*			

Are crop residues **processed** (e.g. chopped) before use as feed? 1. Yes; 0. No

	Wheat	Rice	Other … ………
How are residues processed?			
Problems with processing *(if any)*			
Number of choppers in village			

Are crop residues **stored** for later use? 1. Yes; 0. No

	Wheat	Rice	Other … ………
Duration			
How are residues stored?			
Problems with storage *(e.g. spoilage, fire, rodents, etc…)*			

Are crop residues used for **other uses** than livestock feed? 1. Yes; 0. No

	Wheat	Rice	Other … ………
List types of uses *(e.g. fuel, construction, other…)*			

Are crop residue stubbles **grazed** *in situ*? 1. Yes; 0. No

	Wheat	Rice	Other … ………
% of farmers using			
When & where			
Type of animals			
If not own animals, grazing fees			

Are crop residues **sold**? 1. Yes; 0. No

	Wheat	Rice	Other … ………
% of farms with residue surplus (selling more than buying)			
% of farms with residue deficit (buying more than selling)			
What is main outlet for those selling	1. Local; 2. Outside ……...	1. Local; 2. Outside ……...	1. Local; 2. Outside ……...
What is main source for those buying	1. Local; 2. Outside ……...	1. Local; 2. Outside ……...	1. Local; 2. Outside ……...
Describe crop residue marketing chain if sold outside *(e.g. form, intermediaries, time and regularity transactions; storage location)*			

Crop residue **prices**

	Wheat	Rice	Other ……
Average grain yield			
Average residue price			
Are residue prices seasonal? • At peak • At trough	0. No; 1. Yes Month: … Price: … Month: … Price: …	0. No; 1. Yes Month: … Price: … Month: … Price: …	0. No; 1. Yes Month: … Price: … Month: … Price: …
What other factors affect prices? (non-seasonal - e.g. variety, quality, etc)			

Are crop residues used as **payment in kind**? 1. Yes; 0. No

For which crops	1. Wheat, 2. Rice, 3 …
Specify (for what; to whom; why; when)	

Are crop residues also **given away** for free? 1. Yes; 0. No

For which crops	1. Wheat, 2. Rice, 3 …
Specify (to whom; why; when)	

Are crop residues **burned in the field**? 1. Yes; 0. No

	Wheat	Rice	Other ……
% of farms burning			
Why			
Trend in use (if any)			

Criteria determining which **crop variety** to cultivate

	Wheat	Rice	Other ……
What is the main criterion determining which variety to grow?			
Is crop residue use an important criterion?	0. No; 1. Yes	0. No; 1. Yes	0. No; 1. Yes
If yes, explain (e.g. quantity, quality, etc)			

Of all above crop residue uses, **which use** of crop residues is the **largest** by volume? Second and third largest? *(tick column)*

	Wheat			Rice		
	1	2	3	1	2	3
Used as stall feed						
Used as stubble feed						
Used for non-feed						
Burned in field						
Left in field						
Other …						

Of all above crop residue uses, **which users** of crop residues are the **largest** by volume? Second and third largest? *(tick column)*

	Wheat			Rice		
	1	2	3	1	2	3
Used on own farms						
Sold/exchanged within village						
Sold outside village						
Other …						
Not used						

Notes:

9 Other feed inputs for livestock activities

Feed source	Main source (1.own, 2-purchased)	% of households using	Main livestock types for which used	Specify season (when)	Price (Rs/Kg)	Changes in use over last decade	Why (reason for change)
Crop byproducts ………………… ………………… ………………… …………………							
Compound feed (dairy meal)							
Grazing							
Collected grasses/forage							
Produced green forage ……							
Other, specify:							

Other practices using normal crops for green fodder (e.g. wheat, barley, etc)

Practice	% of farmers practicing it
Grazing of green crop (before grain) *in situ*	
Selling of green crop (as forage)	

10 Overall fodder/feed availability

How would you categorize the village in terms of **self-sufficiency** on an annual basis for the following **feed sources** *(tick one column)*

	Deficient (importing)	Self-sufficient	Surplus (exporting)
Crop residues			
Other crop byproducts			
Grazing			
Collected grasses/forage			
Produced green forage			
Other, specify: ________			

Fodder/feed availability

Which are the critical months when fodder/feed is not available?	
Suggestions to improve upon problem of fodder/feed availability	

11 Other system issues

Use of hired labour

Activities	% of farmers hiring casual labour	% of farmers hiring permanent labour
Crop-related activities		
Livestock-related activities (specify activities….)		
For other agricultural activities, specify: ……..		

Casual wage rate

Male: Rs …… per day	Female: Rs …… per day

Is there occasionally **shortage** of casual labour? 1. Yes; 0. No

Peak period	
Casual wage rate during peak	Rs …… per day
Does casual labor from elsewhere migrate to the village during those times?	0. No; 1. Yes, from …

Does casual labor from the village also seasonally migrate to other places?	0. No; 1. Yes, to …

Role of women

	Crop related activities	Livestock- related activities
Are women in the village involved in?	0. No; 1. Yes	0. No; 1. Yes
Which are their main tasks?		
Have women more say over income from crop or livestock? *(tick)*		

Crop-livestock interactions

	In same farm household	In same village
What are the main **advantages** of having simultaneously crop and livestock…		
What are the main **disadvantages** of having simultaneously crop and livestock…		

(e.g. soil/land health, water use, pest control, water use, labor use, income, etc…)

Financial crop-livestock interactions

How significant is the use of income from crops for buying livestock or livestock inputs?	0. Not significant; 1. Significant.
How significant is the use of income from livestock for buying crop inputs?	0. Not significant; 1. Significant.

Local interest rate with village money lenders

Seasonal loan ………	Investment loan ………

Have you heard of zero-tillage? 1. Yes; 0. No

What % of farmers use zero-till drill?	
How many zero till drills are there in community?	
What is your perception of zero-tillage technology?	

Future outlook

	Crop production	Livestock production
Do farmers want to expand crop or livestock production?	0. No; 1.Yes	0. No; 1.Yes
How/which activities?		
What are the hindrances? (e.g. credit, market, land resources, water…)		
Any other constraints?		

What is the main problem affecting the village?

Comments:

Close group discussion and thank participants. Take a tour of village and surrounding fields to observe first hand. Please note any observations, discussions and general perception of crop-livestock issues if not covered before.

Crop-livestock interactions scoping study
Landless group discussion

After completing group discussion with farmers, request to meet a small group (5-10) of landless households from the village. Try hard to include some women. Discuss with them below and related issues.

Number of **participants**: ……	# of **women** among participants: ……

What share of landless households have livestock?:

Main types of animals:

How do they procure the livestock feed? (types, seasons, prices):

Describe importance of livestock to them (e.g. relative to other sources):

What problems do you face?

Annex 5. Selected photographic impressions from study area

Bhojpur cluster


1. Livestock pen


2. Village scene


3. Wheat *bhusa* stack


4. Dung cakes


5. Survey scene


6. *Desi* cow

Samastipur cluster


7. Livestock pen with dairy crosses


8. Mixed livestock pen


9. Village scene with maize residues


10. Harvesting maize residues


11. Survey scene


12. Maize residue piles and wheat bhusa stack

Begusarai cluster

13. Livestock pen and wheat *bhusa* stack

14. Survey scene

15. Animal shed

16. Manual dehusking of maize

17. Survey scene

18. Crossbred pen and wheat *bhusa* stack