LIVESTOCK ECONOMICS

Archana Ruhela/ Malini Sinha

Livestock Economics

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Preface

Animal-rearing has its origins in the transition of societies to settled farming communities rather than hunter-gatherer lifestyles. Animals are domesticated when their breeding and living conditions are controlled by humans. Over time, the collective behaviour, life cycle, and physiology of livestock have changed radically. Livestock production has played a key role in the development of human civilisation. Development of animal-rearing techniques has steadily increased the productivity. A remarkable shift in livestock production practices has occurred over the past century in response to new technologies. Many governments have subsidised livestock sector to ensure an adequate food supply.

Livestock economics, or the application of economic methods to optimising the decisions made by livestock producers, grew to prominence around the turn of the 20th century. It focused on maximising the yield of livestocks while maintaining a good ecosystem. Throughout the last century, the discipline expanded and the current scope of the discipline is much broader. Livestock economics today includes a variety of applied areas, having considerable overlap with conventional economics. It combines the technical aspects of livestock production with the business aspects of management, marketing and finance.

This book provides comprehensive coverage of the history of livestock and animal health economics, theory and tools for the economics of animal health and production, a review of the application of economics to animal diseases and health problems, and worldwide examples of economic analysis and policy making. It draws on both extensive literature and experience in livestock economics and related issues in Europe, Asia, Africa and Latin America. It will be a valuable reference tool for students, who are preparing for a wide variety of exciting careers in the marketing of commodities sold and inputs purchased by agricultural producers; agricultural finance; and management of agribusinesses, farms and ranches. It will also useful for professional in agricultural services, economic development, commodity promotion and agricultural policy analysis.

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Changing Trends in Livestock Production

The domestication of animals and their integration with crop agriculture have provided the main avenue for agricultural intensification and this, in turn, has allowed for unprecedented economic and human population growth. Livestock production, mainly as a result of pressures in this process, has become an important factor in environmental degradation. All these pressures on the environment are the result of a process of change in which the rising demand for livestock commodities is creating a new role not only for livestock but also for the environment. In essence, the conflict between livestock and the environment is a conflict between different human needs and expectations.

Table 1. Animal production growth rates in percent for major livestock products from 1990 to 1995

Commodity	*Developing countries*	*Developed countries*
Ruminant meat	4.3	-2.0
Pork	8.5	-1.2
Poultry	12.1	1.9
Milk	3.4	-1.9
Eggs	9.4	-1.5

The world's livestock sector is growing at an unprecedented rate. Livestock are not only important as producers of meat, milk and eggs, which are part of the modern food chain and provide high value protein food, but other non-food functions; although of declining importance, still provide the rationale for keeping the majority of the world's livestock. For millions of smallholder farmers, animal draught power and nutrient recycling through manure compensate for lack of access to modern inputs such as tractors and fertiliser, and help to maintain the viability and environmental sustainability of production. Often, livestock constitute the main, if not the only, capital reserve of farming households, serving as a strategic reserve that reduces risk and adds stability to the overall farming system. As such, livestock can satisfy a large variety of human needs. Yet, in many places, livestock production is growing out of balance with the environment or is denied access to traditional key resources, and degradation is the result. The driving force behind the surge in demand for livestock products is a combination of population growth, rising incomes and urbanisation. The world's population is currently growing at 1. 5 percent; the growth rate is 1.8 percent in the developing countries and stagnating at less than 0.1 growth in the developed countries. The real incomes of consumers in the developing countries have doubled since the early 1960s. With the exception of the 1980s, per capita GDP has grown annually by over 3 percent per year. There is a strong positive relationship between level of income and consumption of animal protein. As people become more affluent, consumption of meat, milk and eggs relatively increases compared to the consumption of staple food. Diets become richer and more diverse, and the high-value protein that livestock products offer improves the nutrition for the vast majority of people in the world. Incomes have increased in most countries over the past five years, particularly in Asian countries. In the developed countries, however, increasing incomes are no longer associated with incremental consumption of animal protein as markets have become saturated.

Currently, over 80 percent of the world's population growth occurs in cities of developing countries. World-wide, urbanisation has risen from 30 percent of the population to 45 percent in 1995 and is projected to reach 60 percent by 2025. In the developed countries, urbanisation rates have levelled at 80 percent while in the developing world urbanisation still averages 37 percent with marked differences between the regions: 74 percent in Latin America but only 34 percent in Africa and Asia. In the past, many governments tried to slow down urbanisation, but it is now increasingly recognised as a rational pattern of development as economic activity at higher levels of development benefit from agglomeration. Urban populations differ from rural populations in a higher consumption of animal products in their diets, further fuelling the demand.

Table 2. Gross Domestic Product per capita and annual percentage change in different word regions

Region	*GDP/kaput (US$, 1994)*	*change % 80–90*	*per year % 90–95*
OECD-countries	21,393	2.1	0.9
East and South East Asia	947	6.1	9.2
South Asia	318	3.4	3.3
Central and South America	3,392	-0.1	1.4
West Asia & North Africa	2.309	-2.2	-0.5
Sub-Saharan Africa	482	1.1	-1.3
Eastern Europe and CIS	1.502	1.2	1.0

The rapidly increasing demand for livestock products pushes against a traditional resource base for livestock production that cannot expand at the same pace. Diversity is a main characteristic of traditional livestock production. A wide array of feed resources is being used, most of which have no or only limited alternative value. These include pastures in marginal lands, crop residues and agro-industrial by-products, but also waste from households and industrial food preparation.

The scope for increasing the traditional feed resource base is limited. Firstly, across the world the most productive pasture lands are being turned into cropland as the demand for high-potential arable land continues to increase. Likewise, degraded cropland is followed and reconverts into poor pastures. As a result, the overall pasture area may not change much but the land productivity is likely to be lower. Technologies that increase pasture productivity have shown impressive results in Latin America but, globally, productivity growth is marginal. Secondly, the basic principles of crop research are to optimise the transformation of land resources, solar energy and inputs into high-value products, for example, into grains. Consequently, the availability of crop residues for animal feed does not increase with rising yields.

The desire for greater productivity form livestock is resulting in a change in the use of animal genetic resources. Traditional genotypes, which have developed through exploitation of harsh environments, cannot match the sector's demands for higher productivity. Now that the means exist to modify the bio-physical environment, even in the tropics, exotic genotypes are being introduced which provide a higher return on external inputs. Consequently, the use of indigenous breeds is diminishing.

As the world economy develops and many countries industrialise, people seek different uses of livestock. Today, non-food functions are generally in decline and are replaced by cheaper and more convenient substitutes. The following trends may be depicted:

- The asset, petty cash and insurance function that livestock provide is being replaced by financial institutions as even remote rural areas enter the monetary economy;
- With the notable exception of sub-Saharan Africa and some areas in Asia animal draught is on the decline as more farmers mechanise.
- Manure continues to be important for nutrient management in mixed farming but its role in overall nutrient supply is declining because of the competitive price and ease of management of inorganic fertiliser.
- Although the demand for natural fibres is still high, and in some places even increasing, there are increasingly more synthetic substitutes for wool and leather.

The opportunities that arise from a strong market demand conflict with the limited potential to expand the conventional resource base. This results in an extremely dynamic situation in terms of technology and resource utilisation. Technological progress has achieved a doubling of productivity per animal in OECD countries over the past 30 years. A major productivity gap remains in developing countries. Closing this productivity gap could offer opportunities to relieve the strain on natural resources but it is clear that this cannot be obtained by expanding the conventional resource base. Increasingly, the world livestock sector resorts to external inputs, notably high quality feed but also more productive breeds and better animal health and general husbandry inputs.

Grazing systems offer only limited potential for intensification, and livestock production is becoming increasingly crop-based. Thus, the importance of roughages as a feed resource is decreasing at the expense of cereals and agro-industrial by-products. There is an important species shift towards monogastric animals, mainly poultry and pigs. While ruminant meat accounted for 54 percent of the total meat production in the developing countries in 1970, this has gone down to 38 percent in 1990, and is projected to decrease further to 29 percent in 2010. This species shift reflects the better conversion rates for concentrate feed by monogastric animals.

Livestock production is being separated from its land base and urbanised, and is assuming the features of industrial production. In recent years, industrial livestock production grew at twice the rate (4.3 percent) of that in mixed farming systems (2.2 percent) and more than six times the grazing system production growth (0.7 percent). This trend has accelerated in the past five years.

In agro-ecological terms livestock production is growing more rapidly in humid and sub-humid zones than in arid tropical zones and the highlands. The growing human population largely explains the expansion of livestock into the more humid zones: when people move into an area, land is cleared which reduces the threat of animal diseases that would otherwise have precluded livestock production. It is, therefore, in these zones that pressure on the environment will build up most rapidly. The complexity of livestock-environment interactions makes generalisations difficult and has left a void in the development of comprehensive policies in this regard.

In some regions, such as the Americas, livestock ownership is severely skewed in favour of the wealthier groups in society. For example in southern Africa and Central America, political decisions are often influenced by livestock owners. In the European Union and the USA, the livestock lobbies belong to the most powerful political action groups. Yet in many other regions, such as the Indian sub-continent and North Africa, livestock is especially owned by the poor. In sub-Saharan Africa, herders are politically marginalised.

Typically, livestock products have a high elasticity of demand but traditionally a low elasticity of supply, particularly in land-based smallholder production. Because of this demand pattern it has been argued that livestock development tends to favour the higher-income sectors of society - an isolated view, yet one that has deterred potential donors - but does not adequately take account of benefits on the supply side. These factors have created a *policy void* which is further exacerbated by the general move, in developing and developed countries alike, to reduce the presence of governments and to liberalise markets and trade.

Following the GATT agreement, international trade is being liberalised; in many countries more reliance is put on market forces and national economies have become deregulated. Thus, there has been a trend away from national self-sufficiency to a greater reliance on international trade. Price supports and subsidies are successively being removed and producers left to compete. Likewise, capital, labour and commodity markets are increasingly turning international. In very general terms, this means that the global pattern of livestock production in terms of geographical distribution, resources used and technology applied is redeveloping along more rational premises. Livestock production becomes less productive where it has benefited from domestic market protection and it may become more productive where it used to be penalised because it had no access to international markets. Market liberalisation is also an important factor in national markets in many developing countries where goods now move more freely and price administration is decreasing. Trade is a major determinant of livestock environment interactions and is of international dimension.

Trade changes the geographical pattern of livestock production, with potential negative and positive impacts. Trade also changes the pattern and level of consumption. Trade separates production from consumption, in geographical terms. For trade both in feed and in livestock products, this has implications which need to be addressed in national policies and international agreements. An analysis conducted by FAO suggests that in many cases trade liberalisation and environmental concerns are compatible. Given an appropriate response to environmental protection, whether through market incentives or through regulation, and adequate services, consumer needs can be met at lower environmental costs than in a protected market.

A world economy emerges, with great opportunities but also inherent dangers. How can public goods, human well-being, equality, health and the environment be protected and fostered? At the same time, the realm of governments is being reduced. Extended public services have been trimmed, forced by the need to reduce budgets and to respond to international market pressure. This trend started in the late eighties in most countries and accelerated in the early nineties. Reduced government interventions have had the most dramatic effects in the CIS and Eastern European countries, reshaping the livestock sector in technological and institutional terms. Starting in 1979, China began adopting market-oriented principles of economic management. In the OECD countries, reduced subsidies are changing the role of livestock as a converter of surplus products generated by wasteful policies, and more rational patterns of livestock production are evolving. Many developing countries embarked on major reforms, including reductions in public services, privatisation of state-owned enterprises, removal of interventions that had caused currency overvaluation, and reduced capital controls.

With reduced budgets, governments are becoming more selective in their policy measures and subsidies, and services become better targeted. In many instances, for example in EC countries, this implies a move away from price subsidies to more direct forms of income subsidisation. At the same time, the roles of public and private services are changing. Governments are increasingly concentrating on roles where they are essential as guardians of public goods.

In many developing countries, economic development is finally taking place and at an unparalleled speed, involving a vast amount of resources. Animal production is part of this development. Because of its major impact on global agricultural production, this provides a unique opportunity towards the creation of jobs, income and poverty alleviation in developing countries.

Increased attention to livestock-environment interactions is therefore of critical importance in sustaining the world's resource base. These interactions have been the subject of much conjecture, often lacking objectivity, and over-simplifying complex relationships. Such scarcity of informed decision-making has often aggravated he negative effects. For example, the misperceptions regarding overgrasing in the arid areas led to measures which controlled stocking rates and movements, thereby causing more, rather than less, land degradation. A better understanding of the complementarity of domesticated and wild animals would have led to greater species wealth and improved well-being of local human populations.

Finding the balance between increased food production and the preservation of the world's natural resources remains a major challenge. It is clear that food will have to be produced at less cost to the natural resource base than at present. Arguably, the environmental problems associated with livestock production would best be resolved by reducing consumption of their products, as many environmentalists suggest. We believe that chances for lowering the overall demand are close to nil and that the billions of poor people have a right to improve their diet. We acknowledge that consumption of meat and other livestock products is excessive in some countries and social classes, causing medical problems such as cardiovascular diseases and high blood pressure. For the large majority of people, however, particularly in the developing countries, livestock products remain a desired food for nutritional value and taste. This, as well as the developing requirements of the majority of countries need to be respected.

The role of livestock is changing, away from a multi-purpose tool and companion, engrained in many societies and company through history to a sole provider of food, or better high value animal protein. In many ways, this change is too rapid for the mass of agricultural producers to keep pace with; new forms of production emerge. At the same time, different roles are assigned to the environment, thoroughly modified in large parts of the world, but left largely untouched in vast areas.

Undoubtedly, livestock are at the core of big environmental problems and other risks, such as threats to human health. But they are also at the core of global change with emerging opportunities for development and human well-being. These need to be seized, and in the process, the role of international organisations, governments, farmers and other stakeholders needs to be redefined. Already, some requirements can be identified:

- Changes in the availability and use of livestock resources need to be documented and monitored to provide for better decision-making
- Policies and technologies need to be devised that tap the surging demand for the development of broad segments of the population, in particular in the developing countries
- Guidelines and principles need to be formulated on *how* to make choices rather than *what* choices to make.

Livestock development issues of global concern, such as efficient agricultural resource use, land husbandry, changes in demand for food and primary products, international exchange of goods, capital and knowledge, all call for international coordination to help manage the speed and direction of these changes since they go beyond the capacity of individual national governments. These issues must be dealt with both from a policy and technology perspective to be blended into strategies that position livestock in development so as to make their optimal contribution.

LIVESTOCK PRODUCTION SYSTEMS

Livestock plays an important role in nutrition – directly through the consumption of animal products by livestock owners and their families; and indirectly through the sale of animals and animal products as a source of income. In the past food security studies have concentrated on quantifying the output of cereal crops and the importance of livestock in providing food security has seldom been examined. It has been stated that the role of livestock in food security is usually undervalued. However, it is not simple to quantify the actual role of livestock to include aspects other than direct food production; an effective method to quantifying the importance of livestock has not been developed.

Livestock can be considered as a production system as shown in Figure 1, which divides the system into the following: inputs; animal health; animals which are the unit of production; outputs which are the products; and the market which purchases the products and sets the price to the producer. Each of these categories is examined in the following sections.

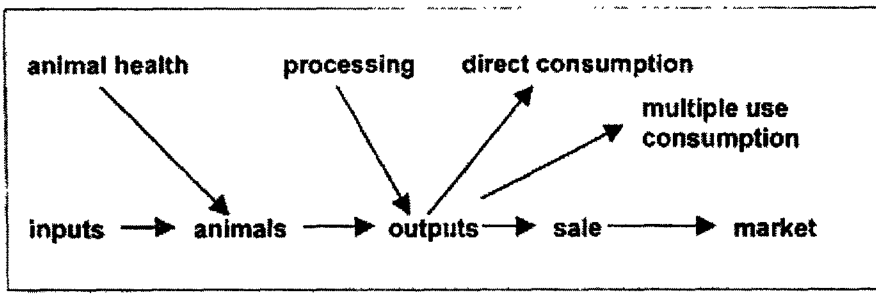

Figure 1. The Livestock Production System

Inputs into Livestock Production

This section outlines inputs into livestock production in general terms. A more detailed examination into inputs for different species in the three countries examined in detail are examined in the sections for the specific countries.

Inputs into livestock production consist of land, housing, water, labour (which is often provided by women), and livestock feed. The most important input into small scale livestock production is livestock feed.

When considering human food security livestock feed can be subdivided into two categories - (i) food that can be used for human consumption, and (ii) food not normally used, or that is unsuitable, for human consumption. In order to examine livestock feed it is therefore useful to consider the following questions:

- What alternative uses does the feed used have? Can it be fed to people? Can it be used as feed for other livestock?
- Is feed grown specifically for animal feed? If so could the land be used to grow other crops for human consumption?

Animal Health

This section discusses the general role of animal health inputs and the form of those inputs. Animal health inputs into the livestock production system are examined separately as disease prevention methods are put in place to limit the effects of disease which is a negative input on production. The value of animal health measures is therefore in the form of the preventive measures, specifically to avoid production loss.

The Animals

The genetic composition of animals in the production system determines the response of the system to the different inputs. Often, local livestock breeds do not produce at a high level as they have been selected for survival under difficult conditions, including under-nutrition and exposure to various diseases. In contrast, highly productive breeds are more susceptible to disease, thereby increasing the need for animal health measures. These animals often require a high level of nutrition to gain the production benefits.

Outputs from Livestock Production

Outputs from livestock production vary by species. The outputs are therefore considered in general in this section.

- Direct consumption outputs are those consumed directly by the farmer's family and can only be consumed once such as milk and eggs.
- Multiple use consumption outputs are those that can be used as inputs for the production of additional outputs and are therefore made use of several times. For example, manure can be used to generate biogas, and the residue used as fertiliser which effectively doubles the value of the manure.
- Sale goods are those sold by the farmer to produce income. The categories are not mutually exclusive. Wastes are goods that are not used and produce pollution. These are regarded as negative outputs.

Livestock statistics generally quantify the products that are eaten and traded such as meat, milk and eggs and do not consider products such as draught and manure.

Processing

In some cases suitable processing is essential for an output to be used. An example is the tanning of leather. The processing of outputs results in an increase in their value, for example, the production of cheese from milk. Processing can also increase the shelf life of the product.

The Market

The market is included as part of the livestock production system. Without an available market paying a fair price it is not feasible to consider the expansion of production by increasing inputs in the other parts of the system.

LIVESTOCK POPULATION, PRODUCTION AND TRENDS

This section examines the distribution and productivity of several species of livestock in the region. Production per head was calculated as the total production divided by the livestock population in the country. It is used as an indicator of productivity. This number was used to indicate whether changes in total production were due to an increase in livestock population or the productivity of animals in the country. In most countries examined there was an increase in cattle population.

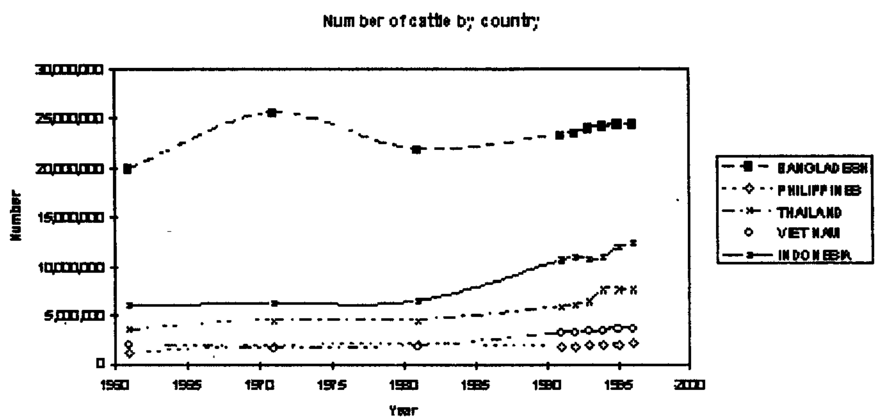

Figure 2. Cattle population

Most countries examined showed an increase in cattle population, except in Bangladesh where the number of cattle tended to fluctuate over time without a consistent trend. In Bangladesh the number of cattle per person in rural areas has been decreasing over time. In the other countries studied, the number of cattle per person was stable or increasing slowly.Production of meat and milk per animal varies considerably between countries. The rapid increase in milk production per head of cattle in Indonesia and Thailand illustrates the potential to increase production in the region especially where production per head is at low levels. Meat production per head of cattle, except in the Philippines where it is increasing rapidly, does not show any sustained trends. Meat production per head of cattle is much lower in Bangladesh than in other countries.

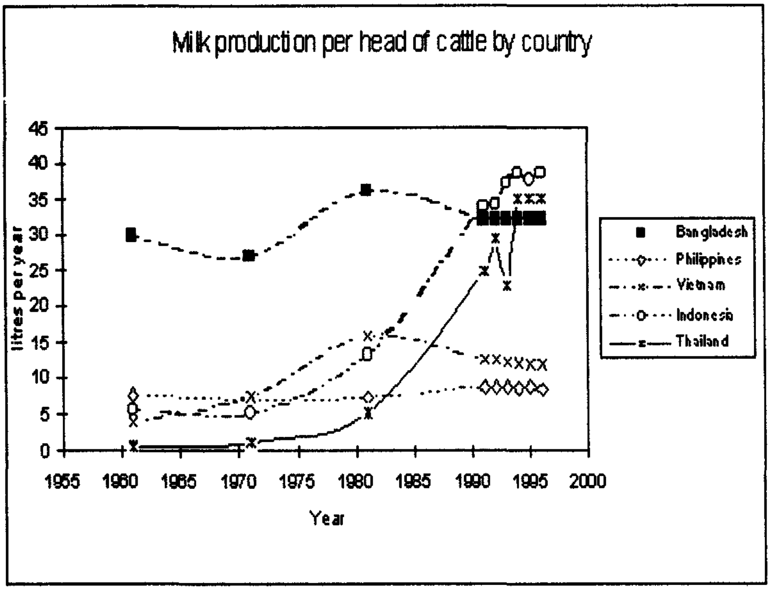

Figure 3. Milk production

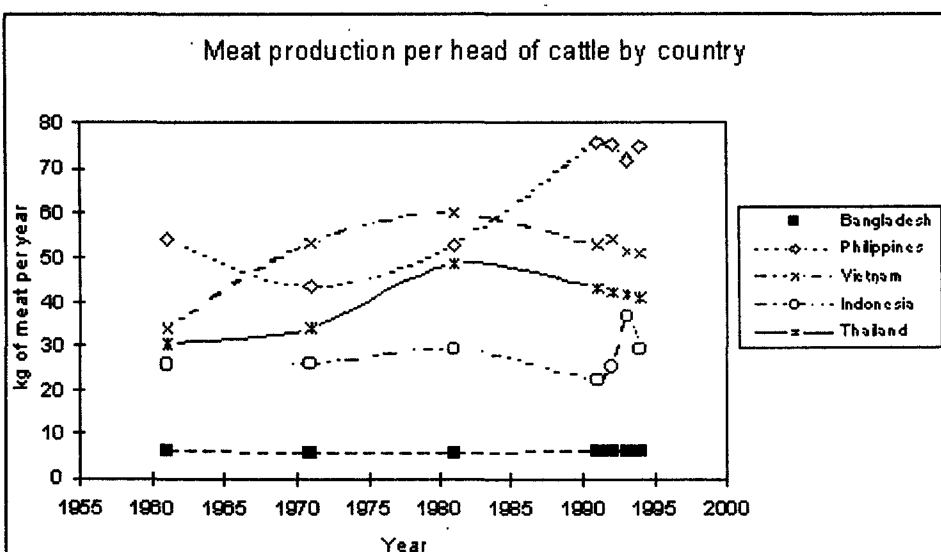

Figure 4. Cattle meat production

Figure 5 shows that the number of goats is increasing rapidly in Bangladesh. Its growth is slower in other countries. In contrast, Figure 6 demonstrates that production per goat is increasing in the Philippines and not in the other countries.

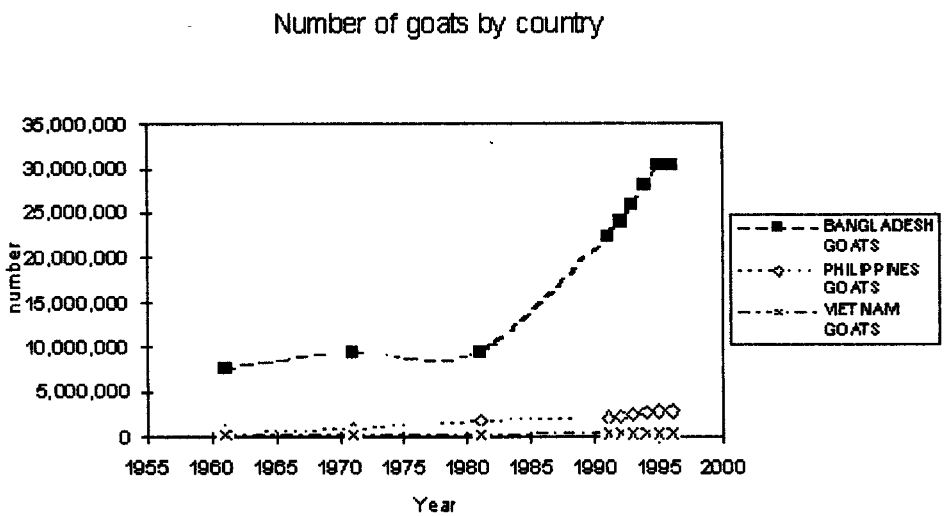

Figure 5. Goat population

Pig numbers are increasing in the region, in particular in Vietnam and Indonesia. Production per head is also increasing, most rapidly in the Philippines.

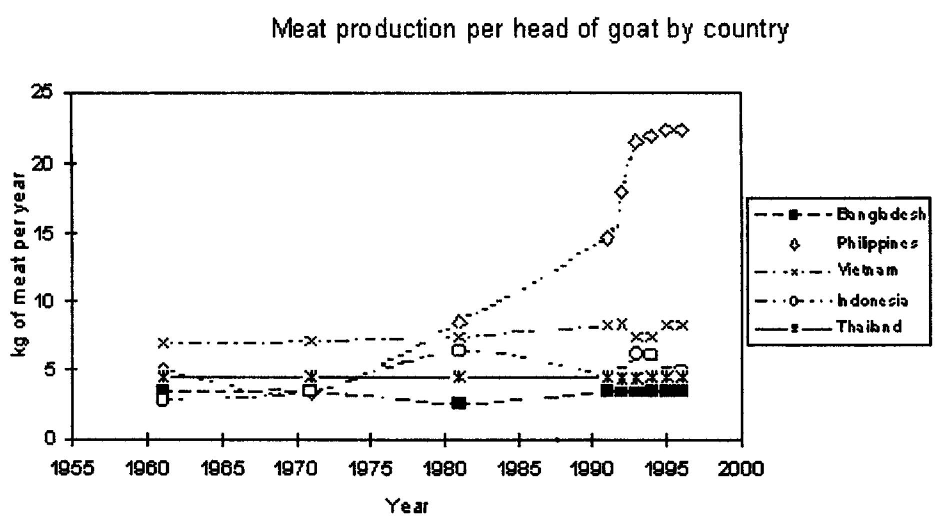

Figure 6. Goat meat production

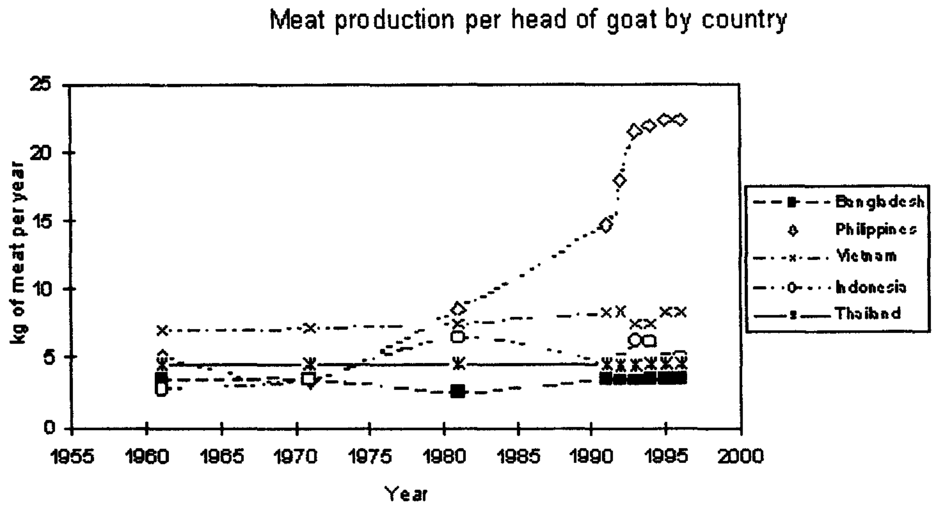

Figure 7. Pig population

The chicken population has increased, with the largest increase noted in Indonesia. Sharp increases in meat production per chicken were observed in the Philippines and Thailand, with a similar situation applying to egg production. Production of livestock products is increasing throughout the region.

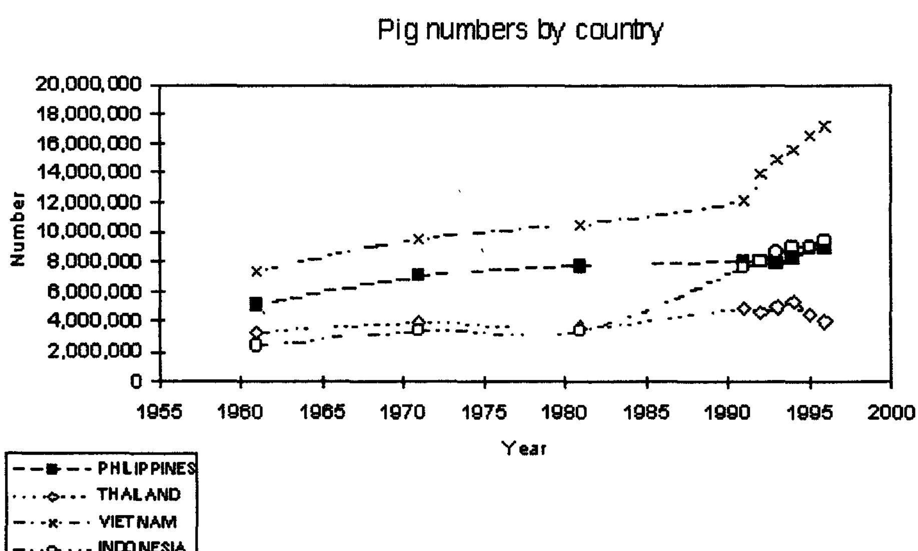

Figure 8. Pig meat production

In almost all cases this is due to an increase in the productivity of animals as well as an increase in animal numbers. In countries where income is increasing, the quantity of animal products consumed also increases. In the case of the Philippines and Vietnam, beef consumption is gradually increasing; in Thailand the increase has been more rapid in recent years. Similar trends for other livestock products may be noted, with expanding markets throughout the region.

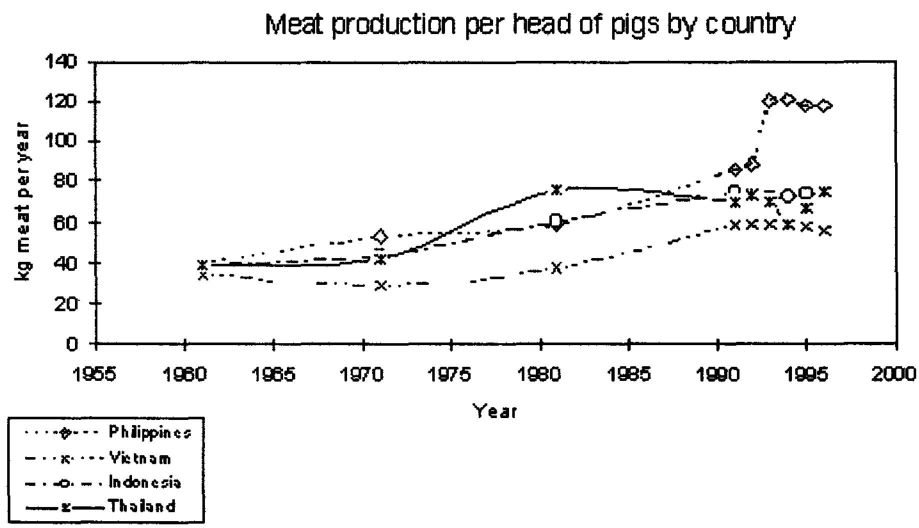

Figure 9. Chicken population

ROLE OF LIVESTOCK IN FOOD SECURITY

Livestock provides not only food for the producers, but also a range of other products which could be sold or consumed by the livestock owner to provide nutrition, income, traction and fuel. The major products of livestock include draught power, meat, milk, eggs, manure which is used as fertiliser or fuel, feathers, fibre, hides, and horns. In addition to these products livestock serve as an asset and may provide a reserve that can be converted to cash in times of need.

Livestock Production and its Role in Food Security

Growing and selling livestock enables the poor rural families (in particular women) to enter the cash economy. In this way, livestock production provides increased stability in income for the family without disrupting other food producing activities.

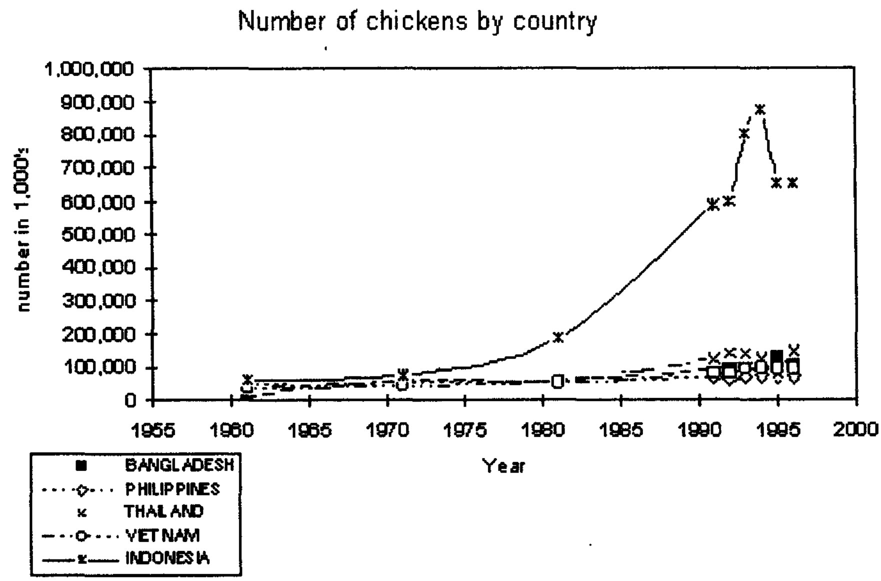

Figure 10. Chicken meat production

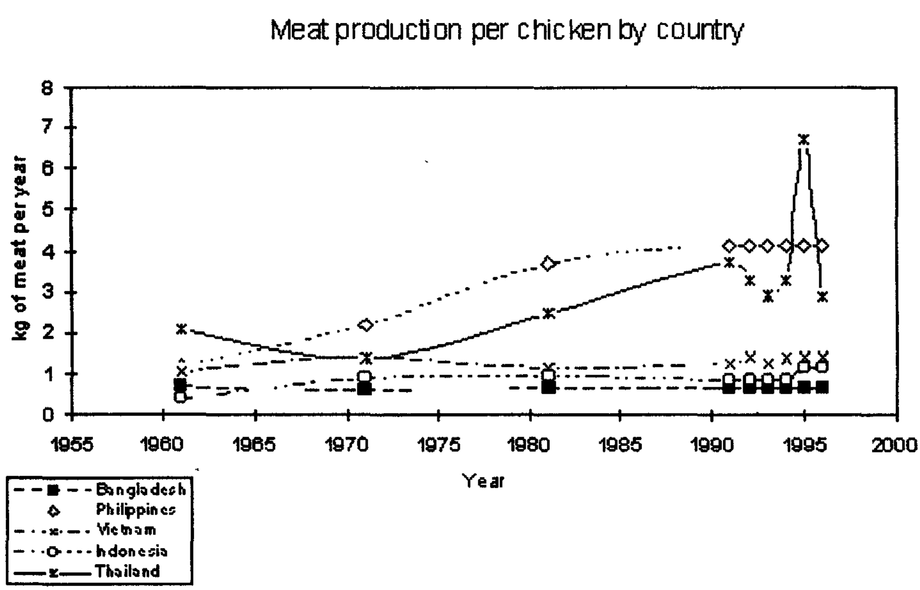

Figure 11. Chicken egg production

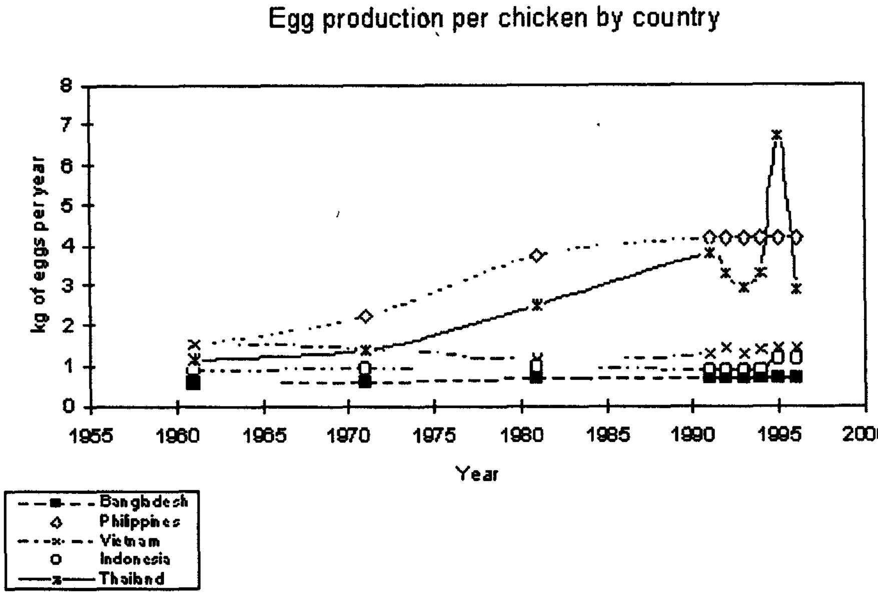

Figure 12. Bovine meat consumption, selected countries

The majority of livestock in the countries studied are kept by smallholders, with each producer owning a small number of animals. Specific areas are not set aside for grazing or fodder production but livestock are fed on crop residues. They are "opportunistic feeders." In most cases, feeding his livestock does not cost the farmer anything. Their diet is mostly made up of residues from the farmer's own crops, and the livestock graze and scavenge on common or waste land. Small scale producers do not feed their livestock with food that is otherwise used for human consumption.

In contrast to the small scale producer, commercial production is generally intensive and based on imported livestock feeds. This situation differs from the mountainous areas in Vietnam where land could be set aside for grazing.

Table 3. Value of large ruminant production in Bangladesh

Outputs	*Valuation method*	*Quantity produced*	*Value per unit (taka)*	*Total value of prod'n (taka)*	*Proportion of total prod'n*
Power	hire/day	96,027,120	160	15,364,339,200	0.22
Milk	price/litre	806,000,000	19	15,314,000,000	0.22
Meat	price/kg	151,500,000	70	10,605,000,000	0.15
Hides	price/hide	757,500	500	378,750,000	0.01
Manure	price/kg	7,825,125,500	3.75	29,344,220,625	0.41
Total (taka)				71,006,309,825	

Livestock produced under the prevailing small scale conditions in the region have a low level of productivity. This is partly because the diet is generally at or below maintenance levels, and all of the food is used for maintenance rather than production of livestock products. This is demonstrated in the case of large ruminants in Bangladesh where dung is the most valuable output from these animals.

In most cases livestock are an integral part of the system of sustainable mixed farming. This is true in Vietnam with the VAC system. This system enables farmers to make maximum use of outputs such as crop residues and animal manure which are often considered of low value.

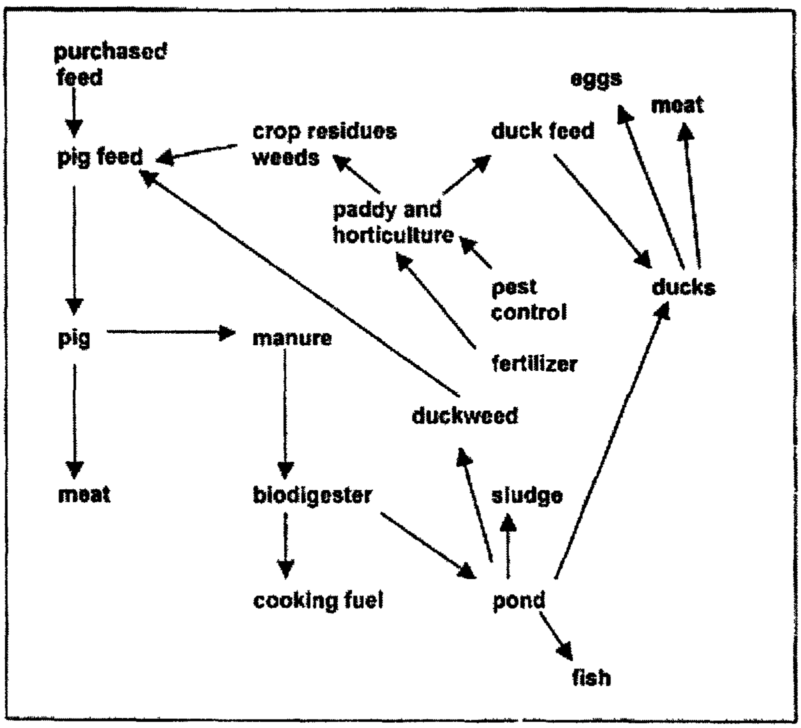

Figure 13. Livestock in sustainable farming, example of VAC system in Vietnam

In Bangladesh the system of production is less integrated. The maximum value is not necessarily gained from all outputs of cattle production.

Constraints to Small-scale Livestock Production in Asia

Problems in increasing livestock production were almost similar for the countries under study. The most significant constraints are nutrition, animal health, animal productivity/ genetic make-up of the animals, extension of information provision of finance to small scale producers, and marketing

Nutrition

The provision of adequate nutrition to livestock is a major problem in the region. However, considerable information on alternative feed resources is available and there is a need to extend this information to livestock owners. Any information should include production benefits derived from alternative feeds and appropriate feeding regimes.

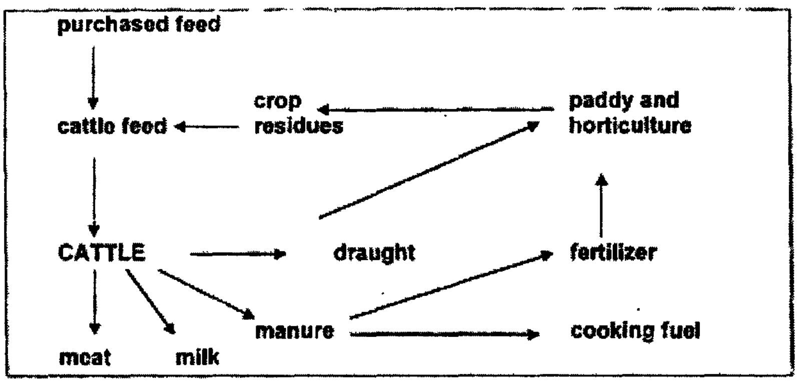

Figure 14. Cattle production in Bangladesh

A slight increase in feed intake through the provision of supplementation has been noted to lead to large increases in production. For example, supplementary feeding of indigenous cattle by smallholders in Bangladesh increased milk yield from 1 litre per day to 5 litres per day. It is important to note that this change took place without any change in the genetic make up of the animals.

Livestock health

Livestock health is a limiting factor to production. While the specific disease cited varied between countries, it was noted that a major problem was the low level of knowledge and understanding of livestock producers of the benefits of disease control. However, even those aware of the benefits had limited access to appropriate vaccines and therapeutic drugs.

In some situations cooperatives and non government organisations (NGO's) have provided limited training and assisted in organising vaccination of stock. Milkvita in Bangladesh conducts a vaccination programme for dairy cattle against foot and mouth disease. No doubt its aim is to protect its milk supply, but its assistance is invaluable in the livestock industry in the country. In another example, the Bangladesh Rural Advancement Committee (BRAC) has trained people who serve as vaccinators to livestock owners in their area. These vaccinators keep the appropriate vaccines and charge for their services.

As livestock owners become commercially based, they will become more aware of the benefits of disease control but will not be aware of the most appropriate methods for disease control. Government veterinary services are not tailored to meet these aims and there is a need for them to reassess their role in livestock health.

Animal productivity/genetic make-up of the animals

When animals are fed a low quality rations and are not protected from disease, genetic traits for survival are more important than those for production. With an increase in nutrition and health, large gains are made in productivity. Improvements in production traits only become important once certain conditions in health and nutrition are met and production levels reached. These conditions vary between species.

Extension of information

The collection, organisation and distribution of information is important in successful livestock development. Most farmers in the region are smallholders. As each country has a large number of farmers, it would not be possible for agencies to have regular contact with each farmer. In this situation, it would not be cost effective to provide smallholder farmers with extension service. Instead it would be more appropriate to base the service at the community level.

Many agencies have contact with farmers, in particular NGOs which are involved in rural development. The provision of extension material and technical support to these agencies would provide a more effective method of extension.

Livestock in sustainable agricultural production

The role of livestock in the VAC system in Vietnam is shown in Figure 13. In this situation, livestock produce outputs which are used or sold by the farmer utilising inputs produced on the farm. Livestock can have a variety of effects on the environment. The significance of these effects depends on the use of livestock by man rather than in any specific action of livestock. Where land has become severely degraded, livestock can play a role in the rehabilitation of that land. As degraded land is being rehabilitated, it can be grazed at low intensity for weed control, thereby serving three purposes: (1) it provides food for the livestock; (2) their cropping of weeds preserves soil moisture; and (3) livestock dung contributes to soil fertility during the rehabilitation.

Effects of intensive livestock production systems on the environment

Intensive systems require large amounts of water and produce considerable quantities of manure in a small area of land. The effect of this waste on the environment can be negative or positive, depending on the use to which it is put. In areas with high human population, the animal waste adds to the large amount of human waste if not used. Because the aim of intensive industries is usually to improve profit margins, environmentally friendly and sustainable practices may not be in the immediate interests of intensive enterprises. Mechanisation which is encouraged in intensive enterprises reduces employment available to the community.

Increasing Livestock Production

Livestock owned by small scale producers in the region are producing at low levels. This is due to a combination of factors. The main factors are limited feed resources with animals fed a submaintenance to maintenance diet. Figure 15 describes a relationship between milk production and nutrition. In the situation, the small scale producer inputs are likely to be at point d and result in low production as most of the feed intake is used to maintain the animal. A relatively small increase in feed inputs would result in a large increase in production - for example an increase in feed inputs to point e would result in a large increase in milk production.

Increasing livestock production requires that all parts of the livestock production system be examined to determine the areas which would give the greatest benefit. An example of rapidly increasing the value of a livestock product is the use of a biodigester for the production of methane for household cooking and the production of fertiliser. This process effectively doubles the value of livestock manure to the family.

An individual family, community or corporation must have the following to be able to buy and raise livestock: (1) money to purchase parent stock; (2) land in which to keep them; (3) food to feed them with; (4) a market for their products; (5) a way to remove and/or recycle their waste; and (6) adequate hygiene and disease control (which is especially important in intensive production) and which could be on a property and regional basis The form of development (intensive to extensive) and selection of stock type will depend on many factors: (1) need for a rapid return on the initial investment; (2) need for a constant cash flow; (3) availability of land; and (4) location of market and infrastructure (such as transport to market).

The animal revolution

The presence of a large number of relatively unproductive animals can lead to the conclusion that livestock are a drain on the resources of a poor country. However, an alternative approach can be taken in which the productivity of these livestock can be rapidly increased with a small increase in inputs. In addition, more effective use of the outputs from livestock production through processing and marketing can lead to considerable increases in the effects of livestock production on the lifestyle of livestock producers. In Bangladesh six-fold increases in milk production from indigenous cows have been achieved with small increases in inputs. This demonstrates the potential to dramatically increase production from livestock in the region.

Increasing Livestock Production and Productivity

Small scale producers

Several common factors were cited as limiting livestock production in all three countries studied, namely: (1) nutrition; (2) animal health; (3) animal productivity (genetic makeup); and (4) extension of information to producers. Most smallholders keep livestock with a low level of productivity. This can be greatly increased by improving the nutrition and health of these animals. Once the farmer purchases livestock for the purpose of increased production, he should consider their genetic make-up and modify production characteristics to take advantage of improved nutrition and health. However, unless genetic make up restricts production, there are advantages in using indigenous animals which have better disease resistance and ability to survive periods of poor nutrition. This study did not delve into which species of animals should be targeted to increase productivity. Poultry involves the smallest investment for commercial production and therefore reduces the risk or effect of failure due, for example to disease outbreak. When production is low, gains could be large by increasing the level of nutrition of lactating cows irrespective of their genetic make-up. In this situation the need to increase production traits only becomes relevant once production reaches a relatively high level.

Intensive livestock industries

In Asia and the Pacific, intensive livestock industries rely on imported genetics, technology and feed. The margins gained by these producers are often small and require a high level of management skills and technical expertise to survive. In addition, intensive livestock industries often compete with people for food. This is because the use of by-products and waste products does not allow the rapid growth that is associated with these industries.

Increasing the value of livestock production

The value of livestock production to small scale producers can be increased by: (1) providing markets and market access; (2) effective processing of product, and (3) increasing the quality of the product.

Animal welfare and food security

Improving the nutrition and health of livestock in rural areas would provide many positive benefits for animal welfare. Many animals are now kept under poor conditions and are often underfed and poorly cared for. Once the animals become productive, they become of greater value to the owner and provide an income that can be increased by better feeding and health care. Some countries in the Asia Pacific Region have demonstrated that a rapid increase in livestock productivity is possible. A number of livestock in the region have low levels of production as a result of low levels of nutrition and health. A relatively small input into fodder production and health, comprising a small increase in inputs, would result in a large increase in production. This is because much of the inputs would be used for production rather than for maintenance of the animal. This is a similar situation to the Green Revolution, during which for relatively few changes in inputs the outputs of crop production were greatly increased.

Many animals receive maintenance or below maintenance levels of nutrition resulting in low levels of production. Increasing the quantity of feed by reducing the number of animals does not provide a solution as the nutritional value of the available feed is low. The addition of a small amount of higher quality feed can have a large effect on production in this situation. In the case of milk production, the use of cattle with a small body size would result in reduced maintenance requirements of the animal, thus enabling more efficient use of available feed for milk production.

The effectiveness of many livestock projects in Bangladesh shows that production could be increased rapidly. A major step in this process would be the education of livestock owners to view their livestock as income earning. Generally, the role of livestock had centered on the outputs that can be consumed and are usually quantified by standard government-collected statistics. However, this study demonstrates that such a method of estimation is flawed, greatly underestimating the importance of livestock. For example, such statistics underestimates the value of large ruminant production in Bangladesh by at least 50%. The large rural population, small farm size and intensive land use in the region do not allow the setting aside of areas specifically for livestock grazing or fodder production. As a result the provision of adequate nutrition for livestock production is a major constraint.

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Economic Considerations for Livestock Production

The success of any livestock development scheme depends in part on the broader development objectives pursued by a country and the corresponding government policies used to secure those objectives. Broad policy objectives of governments often include economic efficiency, economic growth, equity, food security, stabilisation and inflation control, revenue generation and sustainability. Each of these objectives can be pursued through a variety of policy instruments including taxes, subsidies, tariffs and price controls. While some of these objectives and policy instruments are mutually reinforcing, in a number of cases they can conflict with each other. For example, the equity objective is often framed in the context of providing food (including milk and meat) at prices the poor can afford. If done by means of consumer subsidies, it may mean favouring the urban sector (rich and poor) at the expense of the rural population. On the other hand, if the supply of cheap food is achieved by paying food producers low prices, this may discourage domestic production which conflicts with the efficiency and other objectives.

Thus, a key consideration in any livestock development scheme is to understand the underlying development objectives and the policy environment within which the scheme will operate. Taking dairy development as an example, it may simply be that economic conditions, together with technology and infrastructure, have developed to the point that inherently stimulates a vigorous response in the dairy sector. Or it may be that dairy development is being driven by food security or self-sufficiency goals. Dairy development schemes that are driven by either food security or self-sufficiency goals will have different self-imposed strictures on the extent of dairy sector development with varying implications for producers and consumers.

A strict self-sufficiency goal implies that all dairy consumption must be supplied by domestic production. The opportunity cost of this option (i.e. the benefits foregone by not using the resources applied in dairy production in the best alternative) may be quite high and efficient economic growth may become jeopardised, particularly if the country does not have a comparative advantage in dairy production. On the other hand, a balanced food security goal based on careful analyses of trends in international trade and a country's comparative advantage may call for dairy imports to supplement domestic supplies. The implication then is that the trade-offs among objectives need to be recognised and carefully weighed in order to strike an appropriate balance among goals. At the same time, it will be necessary to consider how the livestock sub-sector fits in with the rest of agriculture and how consistent the natural and economic conditions are with an expanded livestock sub-sector. Such careful analysis will permit the identification of new policies that need to be instituted to promote livestock development as well as the removal of those policies hampering development. At this point, it is worthwhile to use an example from the West African region to examine how the economic policies pursued by governments have influenced the development of the livestock sub-sector.

Again, taking dairy production as an example, various studies have shown that in West Africa, government objectives with respect to the dairy sector have frequently been pursued through the use of direct measures including consumer price controls, import tariffs, import licences, foreign exchange allocations and physical quotas on imports. Exchange rate policies while not directly targeted at the dairy sector, have also been cited as influencing dairy development through the impact of over valued currencies on consumption and production of dairy products.

A priori, some of these measures can be expected to lead to high domestic prices which may in turn serve to stimulate domestic dairy production. Conversely, consumer price controls and over-valued exchange rates will tend to encourage imports and discourage domestic production. A related issue here is the surplus dumping of dairy products by producers of Western Europe and North America which has resulted in downward pressures on international prices of milk and other dairy products and availability of these commodities for importation on cheap commercial and/or confessional terms (food aid).

The combined effect of domestic and external influences on the dairy sector will differ across countries. For the region as a whole, it appears that the overall impact of domestic economic policies and surplus dumping by developed countries has resulted in an adverse impact on domestic dairy production. On the other hand, in West Africa as a whole dairy consumption has increased more rapidly than dairy production. While total dairy production grew at about 2% per annum between 1975 and 1985, the corresponding growth rate for dairy consumption was about 5%. In most countries production per capita has actually declined as production increases have lagged behind population growth. At the same time, consumption per capita has been growing at about 2% per annum.

The growing excess demand has been met by imports. Total dairy imports in volume terms grew at an average of 10% per annum between 1975 and 1985. Over this period, imported dairy products in the West African region accounted for 45% of total consumption of liquid milk equivalents. The corresponding figures for individual countries range as high as 90% for Cote d'Ivoire, 85% for Ghana and 81% for Liberia. The imported dairy products were mostly dried milk (48%) and evaporated and condensed milk (44%) from EEC countries.

Ordinarily, it could be argued that given the high income elasticities of demand for dairy products and increases in population and per capita income, the huge imports of dairy products into West Africa should not come as a surprise. However, an analysis of the trends in West African milk consumption and dairy imports found that less than two-thirds of the increases in commercial dairy imports could be explained by increases in population and per capita income. Von Massow found that economic policy in general, and inappropriate prices and over-valued exchange rates in particular, have stimulated dairy imports into West Africa beyond what was expected from growth in population and per capita income. Over-valued currencies tend to encourage imports and discourage exports. Thus, the production of export commodities are directly discouraged through lower prices and domestic production of imported commodities is inhibited by the downward pressure on their prices from imported goods.

Having briefly examined the impact of economic policies on some aspects of livestock development in West Africa, two questions might be posed at this stage:

(i) what should be the main policy objectives of smallholder cattle development schemes?

(ii) what policies are needed to encourage and promote smallholder cattle production in West Africa in order to reverse the present dependence on imports?

Regarding the first question, the main aim of smallholder livestock development schemes should be a combination of increased production efficiency and adequate opportunities for sale of meat and dairy products at reasonable prices. Smallholder cattle development schemes should also aim at reducing risk and uncertainty in dairy production and incomes. In the absence of price stabilisation policies and effective marketing information, price fluctuations may be large due partly to the perishable nature of livestock products. By reducing risk and uncertainty the contribution of livestock products to the incomes of producers will become more stable, thus ensuring the sustained interest of the smallholders.

In order to achieve these objectives, however, appropriate policies will be needed. This brings us to the second question. Pricing and marketing policies that will provide adequate incentives to smallholders to produce meat and milk within competitive cost structures are essential. Available evidence from other parts of Africa indicates that the price elasticities of supply for animal products are relatively low. For example, Rodriguez obtained a short-run supply elasticity of 0.6 for milk in the commercial dairy sector of Zimbabwe. This means that a 10% rise in milk price will induce an increase of 6% in milk output. Thus, given the existing level of technology, a substantial increase in output in response to rising prices should not be expected. A key point here is the production response which can be expected within the existing technology. The response may be very different, however, if the price rise stimulates adoption of new technology packages, which at the same time reduces cost per kg of output.

SUPPORTING INSTITUTIONS

Overall, it is important for governments to implement appropriate pricing and marketing policies as well as provide facilitating institutions and infrastructure to encourage additional investment in livestock production to increase output. Some of the more important facilitating institutions include agricultural extension for providing information, education and training necessary to support technological change; veterinary and animal health services; efficient markets for inputs and outputs; credit institutions; and land tenure institutions.

The importance of these supporting institutions is illustrated by two specific examples of dairy development experiments: the first is the zero grazing project in Kenya. The Kenya projects seem to be viable and growing in numbers. The second is the cross-bred dairy cows introduced by ILCA in the Ethiopian highlands, which have not been sustained after ILCA's support was withdrawn at the end of the on-farm test period.

The zero-grazing system is a relatively complex system involving high producing dairy cows; appropriate building structures to facilitate feeding, sanitary milking, manure management, calf rearing, and animal health management; and high yielding forage (rapier grass) managed for maximum nutritional value and sustained by regularly applying manure from the stalls as the grass is cut.

This system has been introduced in various parts of Kenya including the coastal area where tick and tse-tse burdens are present. The systems are successfully operated by farmers with no previous experience with cattle. The confinement aspect of the system helps reduce the tick-borne disease and trypanosomiasis hazards to manageable levels.

The Kenyan zero-grazing system requires a high level of extension input over an extended period of time to teach the broad range of management skills required by the systems whether or not the farmers have previous experience with livestock. A regular supply of concentrate feeds is required as well as a ready market for the milk. Veterinary and breeding services as well as credit are required. Clearly, the zero grazing technology is not a viable technology without the existence of the supporting institutions and markets for inputs and outputs. With this support, however, the system offers great potential for increased dairy output, with significantly reduced inputs per unit of product leading to significantly higher incomes for small farmers.

In 1982, ILCA initiated a study to test a technology consisting of the integration of cross-bred dairy cows with improved forage production for farmers in the Ethiopian highlands near Debre Berhan research station. Over a three-year period 40 dairy test farmers (DTF) joined the experiment. The DTF participated in a group training course on forage production, dairy husbandry, animal health, and economics and marketing. The training course was provided by ILCA staff. The DTF adopted the dairy test package at their own risk and expense. Cross-bred cows were provided by ILCA with 50% cash down payment and 50% on credit. Improved cross-bred bulls were available at the ILCA research station. ILCA also provided veterinary services, supplementary wheat bran, and forage seeds at cost. The farmers themselves decided whether or not to accept ILCA's recommendation and paid cash or used short-term credit for inputs received from ILCA.

Results from 1983 to 1985 showed that cash income of the DTF were 120% higher than the control farmers. Farmers indicated satisfaction with the cross-bred cow and improved forage technology indicating higher income, regular cash flow and availability of milk for children as the main advantages. The test was concluded in 1986 and a follow-up survey was undertaken in 1987, 15 months after the end of the test period. The inavailability of continued institutional support after ILCA's withdrawal resulted in farmers facing major problems in sustaining the application of the technology.

During the test period ILCA provided a source of concentrates. However, after the test period concentrates proved difficult to obtain and sources were unreliable. A follow-up survey showed that only 11% were using concentrates. Some farmers were located near the Dairy Development Enterprise (DDE) milk collection points. However, the system of milk collection does not always work efficiently and frequent breakdowns occur. Farmers faced severe problems in marketing milk, particularly during fasting periods of which there are 140 days during the year. The absorption capacity in nearby Debre Berhan town is limited and marketing costs are high.

Disease problems also emerged as a major constraint after ILCA withdrew its veterinary services in 1985. Veterinary drugs proved difficult to obtain. The availability of appropriate cross-bred bulls also proved to be a major problem.

While land tenure was not a constraint mentioned by the DTF, their tenure rights are not secure. Farmers do not own their land. They have use rights but have no guarantee that they will next year have access to the same land they till this year. As a result farmers may be discouraged from investing in land improvements. In general, it is thought that insecurity of tenure may inhibit the adoption of certain technologies.

A similar case in point might be the adoption of alley farming technology in West Africa. This technology requires a considerable initial investment and its benefits accrue over a long time. In some cases, ownership of trees is separated from land use rights, and often, land use rights are also not secure over a long enough term to recover investment costs in trees. ILCA in collaboration with the University of Wisconsin Land tenure Center is undertaking a study of the role of land and tree tenure in the adoption of technology in the case of alley farming in West Africa. It was clear that effective extension and veterinary services as well as effectively functioning markets for inputs and milk were essential in maintaining the cross-bred cow and improved forage technology. The existence of these supporting institutions appear to be a necessary condition for the adoption of the cross-bred cow and forage technology in the Ethiopian case.

Further, there is a potential problem when these support systems are created through donor programs which must be donor sustained over a long period of time. Unless these support systems can be taken over by the national institutions, there is a chance that the technology cannot continue, and in reverting to the pre-support system technologies the farmers could be worse off than if they had never adopted the output-increasing technology in the first place. This potential problem needs to be addressed in promoting new, higher-input technologies. Considerations also need to be given to how institutional support systems can be phased in to meet the incremental needs of technological change.

Research is needed to indicate the cost and potential benefits to national economies from the establishment of effective supporting institutions which appear necessary for the adoption of output-increasing livestock technologies. Clearly, a holistic approach is needed to the improvement of efficiency of small-scale livestock production, while at the same time putting in place a set of consistent policies to provide adequate incentives and an economic environment that will help promote self-sustaining growth within the sector.

MARKET AND DEMAND ANALYSIS

In reference to agricultural commodities, marketing is the performance of all business activities involved in the flow of goods and services from the point of initial production until they are in the hands of the ultimate consumer. Marketing involves the transformation of goods in space, time and form from producers to consumers. We want these processes to be efficient, i.e. the transformations in space, time, and form should be accomplished at the lowest possible cost consistent with consumer preferences and incomes. Thus, the fundamental issue is economic efficiency in meeting consumer demand. The marketing system must provide information flows from the consumer back through the processing, transportation and storage functions to the producer. The producer responds to price signals producing commodities in relative quantities dictated by prices and costs. The efficient marketing system responds by providing goods and services over time and space and in the form consumers want at the lowest possible cost. The general justification for marketing studies is to determine whether or not the marketing system is functioning efficiently. It is thought that efficiently functioning markets benefit both producers and consumers. Marketing research can range from studies of aggregate demand to those addressing the questions of how items are placed on the grocery store shelf. Such a broad range of issues requires different approaches to research. Kohls and Uhl present the following main approaches: (1) market functions, (2) market organisation, and (3) participating institutions and organisations.

Market functions are classified as:

a) physical functions of transportation (space utility), storage (time utility), and processing (form utility);

b) facilitative functions including standardisation, financing, risk bearing, and market intelligence (or information); and

c) exchange functions including buying (assembling) and selling.

Market organisation is analysed in the following terms:

a) *structure* - number and size of firms, product differentiation, and conditions of entry;

b) *conduct* - firm's price, product and promotional strategies; and

c) *performance* - trends in food prices, stability of prices, margins, profits, trends in marketing costs etc.

In analysing the institutions of marketing, the concern is with the nature and character of the various intermediaries and related agencies and the place in the marketing process the intermediaries occupy. These can be classified as follows:

a) Merchants which comprise retailers and wholesalers;

b) Agents including brokers and commission agents;

c) Speculators;

d) Processors and manufacturers; and

e) Facilitative organisations such as grain exchanges, livestock auctions, and stockyards.

Demand and supply relationships are also of interest in market studies. In demand analysis, the main parameters of interest are the relationships between consumption and product price and the relationship between consumption and income. The price elasticity of demand measures the percent change in consumption expected from a one percent change in price. Income elasticity measures the expected change in consumption from a one percent change in per capita income. The location of demand, quality of product demanded, the form of the commodities and accompanying services are also important in connection with consumption/demand analysis. Both the price and income elasticities are useful in projecting the future levels of demand. Price elasticities are also useful in assessing the probable impact of government policies affecting commodity prices or the probable impact on consumption of increased marketing efficiency. Demand analysis including the patterns of consumption are also useful in product promotion. Consumption patterns can be affected by demographics, commodity price levels, availability and prices of substitutes, etc.

PURPOSES OF MARKETING STUDIES

Marketing studies are thus undertaken for various reasons, including the following:

i) To understand the efficiency of the existing marketing system and of alternative marketing systems. This may help in developing lower cost or more effective marketing which may, through lower marketing margins, result in both higher prices for producers and lower cost for consumers. The higher producer prices may stimulate production, while the lower consumer prices will stimulate demand. This should not be construed to mean that traditional marketing systems are inefficient. As will be mentioned later, many studies have found existing traditional systems to be efficient in the context of the infrastructures of their economy.

ii) To learn how the marketing system links with the whole production system. This will help in understanding and minimising marketing constraints to increased agricultural output.

iii) To learn how government pricing policies will affect consumption and production of certain commodities and estimate the potentials for stimulating or inhibiting output through price policy.

iv) To study how consumption patterns are affected by demographics, ethnicity, urbanisation, etc. This may be especially useful in identifying niches in terms of consumer groups and commodity forms.

Past Livestock Marketing Studies

In the livestock sub-sector, some rather notable mistakes have been made as a result of misdiagnosis of the efficiency of traditional marketing systems. It is fair to say that these diagnoses were not founded on careful research. For example, during the 1960s many observers diagnosed the private livestock marketing systems in Africa to be inefficient and not capable of bringing sufficient capital for needed development of marketing infrastructure and information systems. This led to large donor investments in marketing infrastructure, mainly through statal and parastatal marketing organisations, sometimes to the detriment of the more efficient private agents.

The performance of the statals and parastatals, with few exceptions proved mostly disappointing to disastrous. Ariza-Nino et al found that... "Throughout the 1970s the traditional marketing system for livestock and meat in West Africa demonstrated remarkable ability to adjust to changing conditions. It should continue to do so in the future. Given the shortcomings of the physical infrastructure, the system operates efficiently. Little evidence of monopoly power or collusion among traders and butchers has been found. High marketing costs and rates of return on capital in cattle trade reflect the high transport costs and taxes involved, and risks and uncertainties encountered. Calls for reorganisation of the livestock and meat trade appear unnecessary."

Bekure and McDonald conclude..."In the past governments in Africa have intervened in various ways in order to regulate and increase the efficiency of the marketing system. These interventions have ranged from the control of livestock and meat prices to the outright purchase and sale of animals and meat. Experience, however, shows that the scope for increasing efficiency lies neither in attempts to regulate and control the market participants, nor in efforts to control prices, nor in the creation of parastatals but rather in facilitating the operations of the market participants and instituting measures which reduce their costs."

Most of the agricultural marketing policy and marketing efficiency studies of the 1970s have dealt with livestock and meat marketing. There are virtually no parallel studies of dairy marketing systems. For this reason most of ILCA's current and planned work in marketing focuses on dairy products.

Mbogoh reviewed some experiences of dairy development and marketing in selected sub-Saharan African countries including Kenya, Ethiopia, Burundi, Zambia and Nigeria. Overall, he found that the pricing problem appeared to be at the core of dairy development and marketing improvement programs. Marketing and processing development tends to be along lines that involve very high cost operations, and in order to keep consumer prices down, the practice has often been to limit the price paid to producers. In some cases, direct sales of raw milk to consumers have been banned under the ruse of protecting human health. However, few studies demonstrating a significant health problem have been undertaken to support this contention. The undeclared and real objective is to eliminate competition from the more efficient traditional marketing system. Mbogoh notes that the major goal of development-oriented policies should be to try to achieve improvements in both operational and pricing efficiency of the production and marketing systems.

von Massow studied dairy imports and import policy in Mali and their implications for the dairy sector in the Bamako area. He found that the marketing system then in existence did not provide sufficient services to stimulate domestic production. Local milk production was largely neglected in favour of processing and distributing imported milk products. His results suggest that greater emphasis on market system development was necessary to stimulate local production.

Debrah and Anteneh studied milk sales by intra-urban, pert-urban and rural producers in and around Addis Ababa, Ethiopia. Rural producers were stratified into two sub-samples: one group located near rural fluid milk collection centers (0-3 km) and the other group located far from collection centers (> 3-15 km). They found that small intra- and peri-urban producers sold whole milk directly to nearby households. Approximately 50% of the milk consumed in Addis Ababa was produced by intra-urban producers. Larger producers, mainly located in the pert-urban areas, sold milk to the Dairy Development Enterprise (DDE), a state-owned milk processing plant, at approximately 50 to 60% of the price per litre which the smallholders received by selling fresh milk directly to consumers.

The small-scale producers are able to economically sell their surplus to nearby neighbours. As the number of lactating cows increases, the cost of direct sales to neighbours in terms of labour time increases while the per unit cost of transportation to the dairy plant decreases. Thus, the larger producers in the intra- and peri-urban areas find it economical to sell to the dairy plant while the smaller scale producers find it more economical to bypass the dairy plant and sell directly to consumers. Another factor encouraging sales to DDE is that preferential treatment in the allocation of concentrate feeds is given to those producers who deliver to DDE.

Despite the need to import hay from the surrounding countryside at considerable expense, the small scale urban producers are able to compete successfully with pert-urban and rural producers in supplying urban consumers. Their marketing costs are low. They can deliver the milk to a nearby consumer within minutes of milking; total transport costs are minimal; refrigeration and packaging are also saved. Consumers boil the milk so lack of processing by smallholders poses no health problems and eliminates yet another cost of marketing through commercial channels. A major part of the cost of hay is recovered through the sale of dung cakes for fuel.

Indeed, the contrast with the costs of marketing through commercial channels is remarkable. The DDE plant receives milk at EB 0.50 per litre and sells at EB 0.70 per litre. Thus, the marketing margin is EB 0.20 per litre or 40% of the price paid to producers. The small-scale producers sell directly to consumers for EB 0.74 to 0.86 per litre.

The DDE, however, is playing an important marketing role by serving the larger scale producers and extending a market for fluid milk into the rural areas. The farmers are responding to the marketing opportunity by shifting from butter production to fluid milk. Careful financial monitoring is important to indicate economic efficiency of its operations and pinpoint the possibilities for increasing the operating efficiency. Thus, the parallel formal and informal marketing channels existing for the same product may improve overall efficiency over what could be achieved with only one or the other system. The phenomenon of smallholder dairying in intra- and peri-urban areas is not unique to Addis Ababa, but can be found in many sub-Saharan African cities, especially in the highland and semi-arid zones. The main economic considerations supporting this pattern are: first, small-scale milk production is profitable and competitive; second, transport costs in both collection and distribution are very high and by locating close to the consumers both are minimised; third, milk is highly perishable, so locating close to the consumer eliminates the need for expensive refrigeration, processing and packaging; and fourth, quality control by consumers is easy.

While direct sales are economically feasible for urban and peri-urban producers, rural producers often have very limited direct outlets for fresh fluid milk. Preservation and transport to urban markets is expensive and frequently not feasible. Various traditional processed products (e.g. butter, ghee, soured milk, cottage cheese) have long been the main dairy products of smallholders and pastoralists.

Waters-Bayer has studied dairy production and marketing of the settled Fulani agro-pastoralists in central Nigeria. While their herds number 50 to 60 head, they are still considered small scale in terms of dairy production. Average daily milk surpluses per household, above requirements for calves, varied from 2 kg in the dry season to 6 kg in the wet season. The women of the household divide the surplus between household use and sales. These producers are typically located in rural rather than urban areas.

The Fulani producers in this area have traditionally produced and marketed milk in two main processed forms: a soured milk product called nono, and butter. Women market the nono and butter on a regular but not necessarily daily basis. Another form of marketing involves additional processing by combining the milk with a cereal dumpling or with kuka juice. Prices vary by season per unit liquid milk which is also diluted more in the dry season with kuka juice. Thus the de facto variability in the price of milk is even greater than the variation in the price per unit of liquid milk product sold.

Optional marketing through a modern commercial dairy plant is very inefficient by comparison - "Per litre of raw milk, the closest dairy plant offered less than one quarter of that which women gain as year-round average by processing it as nono and butter". The plant did not offer collection service from the rural areas, and made no adjustment in price during the dry season. It is perhaps significant that the main purpose of the dairy plant has been to recombine imported powdered skim milk and butteroil for sale as liquid milk usually at relatively low prices compared to local dairy products.

There is a growing demand from rising populations for dairy products. Urban fluid milk markets are attractive for urban and pert-urban producers. Rural producers may mitigate high transport and preservation costs by processing their milk into butter and cheese. Further research into improving small-scale processing and marketing may provide greater benefits to rural producers than promotion and development of large-scale modern dairy processing plants. The justification of each system is based on economic efficiency considerations. In the case of dairy products, space, time and product form aspects of marketing are all critically linked. First, we are dealing with a highly perishable product. Second, production is far removed from consumption centers in many parts of Africa. There is a need to explore and describe the existing marketing infrastructure and the present marketing chains linking production with consumption in each country. Currently, ILCA has dairy consumption surveys underway or recently completed at Bamako in Mali and at Ibadan and Kadunain Nigeria. We plan to initiate another in the Mombasa area in connection with the Kenya coastal dairy research program.

PRODUCTION-RELATED ASPECTS

The fundamental economic problem is efficiency in both the short- and long-term. The test for any new technology is first, does the value of the output exceed the cost of the inputs used in its production; second, is there an alternative use for the same inputs which will yield an even greater value of output? Economic efficiency requires that the first test be affirmative, and the second test negative. If a new technology involves greater risk in terms of variability in output, the impact on food/income security as well as farmers' willingness to accept more risk in exchange for higher expected income must be considered.

In making these tests one should also be assured that the technology is presented in its best economic light. That is, inputs should be presented in their most efficient combination and the production process carried to its economic optimum. In addition, the risk implications of any new technology must be understood and addressed in terms of the producers' ability to bear risk and their willingness to accept greater risk in exchange for higher expected returns. Technologies that reduce risk may be particularly welcome.

Livestock production may be increased by increasing output per animal, or by increasing the number of animals, or a combination of these. The economic efficiency problem in livestock production is, however, very complex. A single species may produce many products under a wide array of systems varying in time rates of input use and production. Inputs such as labour, capital, land, and different feedstuffs can be used in different ratios to obtain a given output though perhaps a different rate of output per unit time. Feedstuffs can also be used in different ratios and combinations including pasture, crop residues, and forage crops, each used singly or in combination with cereal grains, pulses, and/or industrial by-products from crop and food processing.

The problem is further complicated by the fact that different livestock species and even crops may use the same inputs. At the same time, some livestock outputs (e.g. draught power and manure) are important inputs in crop production while the output of feedstuffs from crops and crop residues are inputs in livestock production. Thus, while our main focus is on cattle milk and meat, interactions with other cattle products, or with other livestock and crops cannot be ignored in addressing the full range of economic considerations in cattle production. Complexities in dealing with the economic efficiency problem also emanate from the interactions and trade-offs among or between the technical constraints enumerated in paragraph 5 above. Such interactions and trade-offs are important aspects which economic considerations should address.

Increasing the Quantity and Quality of Feed

The seasonal variability in supply of feedstuffs and the poor quality of feed is regarded as the main constraint to increased livestock production in much of sub-Saharan Africa. The trend in livestock and cattle numbers has been upward throughout most of the cattle producing areas. However, in most cases, since the 1950s, livestock numbers have increased at a lower rate than human populations. Apart from improved disease control and health care, there is some question as to whether these increases have mostly followed increased utilisation of existing annual feed supplies or whether they followed increases in forage/fodder production. There is some evidence that both have played a role in supporting increasing livestock numbers.

Increased cropping in the semi-arid and subhumid areas has provided increased fodder from crop residues and increased crop aftermath for grazing. While some of these increases have come at the expense of grazing, it is thought that, on balance, total feed supplies have increased, rather than decreased, from expanded cropping. As cropping activities are extended through bush clearing by farmers and increasingly by sedentary herders, tsetse populations are reduced sufficiently to permit expanded grazing territories. Further, exchange arrangements between herders and farmers permit herders greater access to crop residues and aftermath forage production. Depending partly on the cropping patterns adopted, the expansion of cropping areas reduces range feed supply in the rainy season, but increases feed from crop residues for the dry season.

In addition, several important new technologies have been developed which show considerable promise for increasing fodder and forage for cattle. Three of these are alley farming, fodder banks, and zero grazing. For example, alley farming in Nigeria, Ghana, Côte d'Ivoire and Togo has demonstrated the potential to provide increased animal feed, directly through use of trimmings from the leguminous trees and indirectly, through increased crop yields providing greater production of crop residues. However, the trimmings also have an alternative use in providing mulch and green manure for crops and the economic trade-off between this use and use for livestock feeding must be tested. Studies by ILCA suggest that up to 25% of the total leaf matter can be used as fodder without adverse effects on the yields of crops that are associated with the system.

Fodder banks in northern Nigeria and Mali were designed originally to provide fodder during the dry season. The fodder banks are fenced areas planted with a legume for grazing during the dry season. The legumes provide several special benefits. First, they provide a high protein supplement which enhances the feeding value of lower quality roughages. Second, they add nitrogen to the soil which has been shown to increase the growth and yield of both the volunteer grasses emerging in the legume stand and the cereal crops which follow it in the rotation. Finally, the improved soil filth, resulting from the legume in the fodder bank, makes soil tillage easier which is very important under hand-hoe tillage. In addition, livestock productivity may be enhanced in terms of an increased number of conceptions and a reduced calving interval, reduced seasonal weight loss and reduced mortality.

Farmers adopted different strategies in utilising the fodder banks in the dry season. In areas where cropping intensity is high, there might be a wet season nutritional problem which may be overcome by grazing the fodder bank in the wet season. There may thus be merit in supplementary feeding during the wet rather than the dry season. There are some possible benefits in support of this strategy which, however, needs further testing. First, the total yield of digestible nutrients is greater if harvested during the wet season. Second, the proportion of the nutrients utilised for production will be greater if utilised during the wet season when the animals are already in a positive energy balance. Thus, the total contribution of the fodder banks to animal production may be greater if they are used in the wet season rather than in the dry season. The result of this strategy is perhaps even greater where seasonal imbalance is compensated by mobilisation of body reserves during the dry season "harvested" in the form of weight gain in the wet season.

Increasing the quantity and quality of feed is only one of several constraints which needs to be overcome in the smallholder zero grazing dairy systems in Kenya and Malawi. Other important constraints included capital, labour, market outlets, animal health and disease, acquisition of suitable breeds and management. Proper management of all aspects of the zero grazing system was essential to its viability and this was achieved through an intensive and effective extension and farmer training effort. Economic viability of the system required that every component of the entire system be managed properly.

The three systems just described, particularly the zero grazing system, represent relatively high-input, high-output systems. Proper management of the zero grazing system makes it possible to increase greatly the production and utilisation of cattle feed on small farms. Most of these operations supplement cut-and-carry green fodder with concentrate feeds. Risk aspects related to farmers' financial ability to acquire purchased inputs on a regular basis, including substantial amounts of feed, are mitigated by continuous daily sales of milk. However, regular availability of marketed inputs remains a problem.

Reducing the export of by-product feeds is another potential source for increasing both the quantity and quality of livestock feeds. In 1984, the latest year for which FAO figures are available, West Africa exported 25,000 metric tons of molasses valued at US $1 million; 246,650 metric tons of high protein oilseed cake or meal valued at US $37 million; and 24,616 tons of fish meal valued at Us $10 million. For sub-Saharan Africa as a whole the figures are 312,200 metric tons of molasses at US $10.8 million; 365,000 metric tons of oil crop cakes or meal at US $53 million, and 26,616 tons of fish meal at US $10.9 million. While the trend in utilising these high quality ingredients for domestic livestock feeding is on the increase, there remains a substantial tonnage of exports. The question of whether utilising these byproduct feeds domestically would contribute more to national incomes than exports needs to be investigated country by country.

While there are many technically feasible ways of increasing the quantity and/or quality of livestock feed, finding economically efficient ways to do so remains problematic. The main problem seems to be the high opportunity cost of land and labour which must be diverted from other crop commodities. For example, in the Ethiopian highlands, oats is a crop which potentially can produce high quality hay. However, it is often not harvested at its peak feeding value because of the conflict in the use of labour with other cropping activities. This results in lower quality although lower cost fodder. Another example in Ethiopia is hay harvested from bottom lands, which is frequently done late because of labour shortage, resulting in rapidly declining hay quality.

On very small-scale subsistence farms, the opportunities to introduce forages for livestock are very limited. However, intercropping cereals with legumes, which is a common practice in southern Nigeria, offers some potential for increasing the quantity and quality of feed output per unit area. The opportunity cost of labour and land in producing forage is reduced by interplanting with cereals.

IMPROVED NUTRITION

The economics of nutrition is very complex. An animal's quality and value, or the amount and value of animal products may be varied by alternative feeding/nutritional regimes which also vary in costs. Thus, choice of a least cost set of feedstuffs for a given output is of interest. But the question is which is the best output? And if we establish the best level of, say, milk output, what are the tradeoff implications for the output of calf production or of traction? Thus, optimum nutritional regimes can often be determined only in the context of the whole system.

One important issue throughout sub-Saharan Africa concerns the optimum utilisation of low quality roughages in feeding cattle and small ruminants. It is recognised that one way to increase the feeding value of low quality roughage is to supplement it with high protein feedstuffs. This results in an increase in both the digestibility and the dry matter intake of the low quality roughage. However, increasing the protein level alone may still leave the supplemented roughage low in energy resulting in low daily energy intake. Economical utilisation of low quality roughages in milk production, or in accelerated growth and/or fattening usually requires further supplementation with high energy concentrates.

Brokken and Brokken and Bywater illustrate the methodology for analysing the technical and economic tradeoffs between roughages and concentrates in cattle feeding. Further analysis using this methodology with African data for goats, sheep and cattle, confirms the limited usefulness of low quality roughages when the goal is to produce weight gain.

Low quality roughages are very often over-priced in terms of their feeding value relative to higher quality roughages and concentrates for use in producing liveweight gain or milk. Low quality roughages are important for maintenance, or for use as an economical input in negative energy balance feeding strategies. It is probably due to thin that they are priced relatively higher. That is, one seeks the cheapest way to sustain an animal between wet seasons.

In this connection, ruminants, and especially cattle, are well adapted to seasonal variation in feed supplies. They can endure extended periods of weight loss during periods when their nutritional requirements for maintenance and production exceed nutrient intake, and then rapidly regain their condition during a relatively short period of compensatory growth following the return of the rainy season. Thus, cattle are very well adapted to minimum input grazing systems utilising low quality roughages which provide the least cost means for survival of the animals between wet seasons.

In cases where animals have good quality grazing, but are limited in the amount of time they are allowed to graze, supplemental feeding with low quality roughage may prove very beneficial. If the protein value of the pasture is high, the feeding value of the low quality roughage will be enhanced. The animals may benefit from increased daily energy intake in terms of a reduced anestrous period, increased weight gain and milk production, among others.

Selective or strategic feeding, concentrating on particular animals or supplementing at particular times of the year, has been suggested as a possible way of increasing productivity in pastoral systems. Examples include: supplemental feeding of calves to increase growth rates, to reduce mortality and morbidity, possibly to reduce the age of sexual maturity; and, supplemental feeding of heifers and/or cows to reduce nutritional anestrous, or to increase milk production with resultant positive effects on calf production.

In the first case, on-going ILCA calf feeding tests in the Sidamo Region of southern Ethiopia show improvements in weights from pre-weaned supplementation, but this advantage is not sustained after weaning. In the second case, tests to determine the economies of supplementing the most productive cows or the worst ones, von Kaufmann and Blench found that it was more economical to preserve capital by supplementing the worst cows than to increase the productivity of the best animals. Pastoralists in Nigeria tend to supplement their worst cows when they manage their sown legume pastures.

GENETIC IMPROVEMENT

In an economic context, genetic improvement means increasing productivity in ways that increase the value of all animal products of a particular species above the costs of inputs. This definition introduces the concept of relative prices of multiple inputs and products as well as of technical input-output relationships, i.e. technical efficiency parameters. The efficiency parameters include milk yield, fertility rates, calving interval, growth rates, survival rates, etc.

Increasing the potential output per animal is one avenue that, under some circumstances, may increase output per unit of inputs (feed, labour, land, capital) and therefore result in reduced costs per unit of animal product. In the case of milk yield or growth rates this usually involves increasing the animal's capacity to ingest feed at rates above its maintenance requirements to enhance traits related to increased milk yield, or in the case of meat, increased growth rates. However, in cases where feed supplies are very limited, or high quality feeds are very costly, it may be infeasible or impractical to provide rations that are of sufficient quality to capitalise on the full genetic potential of high producing animals. This is often the case in African situations where feed supplies are inadequate to be able to capture the full genetic potential of even low potential breeds.

In low input systems where the genetic potential of the indigenous breeds is not a limiting factor, increasing the genetic potential for growth or milk output will not result in greater output per animal. In any case, increasing output per animal may reduce output per hectare of land. For example, Jones and Sandland demonstrated that the relationship between stocking rates and output per animal are such that output per hectare continues to rise as stocking rates increase beyond that which achieves maximum output per head. Therefore, in cases where genetic potential is not a limiting factor but adequate feed is, upward genetic change may not result in increased output either per head or per hectare. On the other hand, in cases where both genetic potential and adequate feed supplies are limiting factors, selecting for higher milk yielding or faster growing animals may actually be associated with reduced fertility, reduced disease resistance, and increased mortality rates. Thus enhancing genetic potential under these conditions could make matters worse instead of better. It is thus important to consider the relationship between technical constraints such as between genetic potential and feed/nutrition. It is even more important to consider, even if at a general level, the economic consequences of pursuing a single technical solution which could be ineffective without being combined with another.

Very high potential dairy cows are usually kept in drylot and stall fed. High producers may consume up to 3 times their maintenance requirements. While moat of the energetic efficiency is reached at close to 2 times maintenance, feed costs per kg of output continue to decline significantly up to 3 times maintenance. Such high energy intake requires supplementation with high energy concentrates which in most of the developed world are cheaper per calorie than roughages. Thus, as concentrates are added to the diet, daily energy intake increases, energy requirements per kg of milk decrease, and cost per unit of feed energy decreases. All of these factors are mutually reinforcing and favour maximising utilisation of concentrates. This is further reinforced by the increasing efficiency of labour and capital as output per head increases. When concentrates are not cheaper per calorie than roughages, one must consider the trade-off between the reduction in energy per unit output and the increase in cost per unit energy as the proportion of concentrates in the diet increases. Optimum daily energy intake will frequently fall between 2 to 3 times maintenance requirements. This will very likely be the case under African conditions for the foreseeable future.

HEALTH AND DISEASE

While the fundamental economic consideration (economic efficiency) is unchanged, there are some special complicating problems arising in economic analysis of animal health delivery systems and disease control. These relate to the justification of public expenditure for animal health programs, and the extent to which these services should be publicly or privately financed.

The economics literature dealing with public finance distinguishes between public goods and private goods. Pure private goods are those from which the service provider can exclude those who do not pay for them and from whose use a specific benefit accrues to only one individual at a time. Pure social goods are the opposite of these: one cannot exclude others from enjoying the benefits which the services create and consumption of these goods by one person does not reduce the benefits available to others. In the real world, there are few examples of purely private or purely social goods. In the case of livestock services, Anteneh illustrates that AI services are essentially a private good because the benefits almost totally accrue to an individual cattle owner in terms of increased milk production and subsequent own consumption and sales. In contrast, he notes that dipping services used by an individual livestock owner always generate both private and social benefits. Private benefits accrue to the owner in terms of protection against tick-borne diseases. At the same time, other cattle owners benefit because the danger of tick infestation from potential hosts is reduced. Both those who dip their animals and those who do not, benefit from Mr. A dipping his animals.

Thus, the dipping activity of one individual generates external benefits to nearby cattle keepers: a phenomenon recognised in the economics literature as an externality. An externality arises any time a production or consumption activity generates a beneficial or detrimental effect on some other individual who is not a party to the activity. In Anteneh's example summarised above, Mr. A's dipping gives rise to external benefits to those who do not dip. So dipping is an example of a partly private and partly social good where, in economic terminology benefits are partly "externalised" and partly "internalised".

The main methodology for dealing with efficiency questions in animal health and disease control is cost-benefit analysis. The cost-benefit methodology usually involves one of three approaches: cost/benefit ratios, net present value (NPV), or internal rate of return (IRR). It is important to include both private and social costs and benefits in making the cost-benefit calculations. Briefly, these methods involve calculating the stream of future costs and benefits expected from a specific health care practice or package, properly discounted in each future period for opportunity returns that could be earned by employing capital in the best alternative investments.

Disease has direct costs in terms of its effects on all productivity parameters through both mortality and morbidity. Losses due to morbidity are expressed through infertility, abortion, extended calving intervals, delays in reaching maturity, lowered milk output, lowered draught power, increased culling rates, and lowered weight of fattened or culled animals. Thus, losses are realised in terms of lowered output and/or wasted inputs. In addition, there are indirect costs in terms of potential production lost in cases where a disease threat inhibits or prevents cattle production. Putt et al mention two examples. First, in eastern Africa, tick borne diseases, particularly East Coast Fever, may prohibit introduction of improved, exotic breeds of cattle except under extremely efficient tick control. In passing, it is worth noting, that an important aspect of the small-scale, zero grazing dairy systems is that they permit relatively efficient tick control. Apparently, confinement is an important key to control of tick-borne diseases as well as trypanosomiasis in this system. The second example is tsetse-transmitted trypanosomiasis which often prevents access of livestock to large and potentially very productive land resources, also limiting the potential employment and productivity of labour. The loss of potential markets, resulting in lowered prices is another indirect cost affecting some producers as happens for example when export markets are lost due to outbreaks of foot-and-mouth disease. Like other investments, the decision to invest in disease control is based on the level of net benefits. Investment is justified as long as the flow of future benefits exceeds the flow of future costs. In cases where the investment decision maker does not fully bear all costs and/or does not fully capture all benefits, the level of investments are not likely to be socially optimal. Having discussed the methodology for dealing with efficiency questions in animal health and disease control, it is worthwhile to briefly examine some of the issues involved in the implementation of health and disease programs.

Veterinary services can be classified as preventative, curative, and promotional. The terms preventative and curative are more or less self-explanatory, though the term promotional perhaps needs explanation. Promotional veterinary service refers to extension and educational efforts toward improved animal care and husbandry. Leonard argues that preventative and promotional services are public goods and are appropriate governmental activities under virtually all circumstances. But curative practice is a private good, suitable for government support only in cases involving support for the very poor. Leonard argues that evidence suggests that commercialised practice will actually deliver a greater quantity of clinical care more equitably than a highly subsidised public service does.

Anteneh has analysed animal health services in 20 countries in West, Central, East and Southern Africa. He found that in most of these countries, animal health services are provided by government departments. He found that the main factors necessary to effectively provide these services include: (i) availability of adequate finance; (ii) availability of trained manpower, and (iii) an appropriate organisational and management setup for supporting the delivery system.

In most cases one or more of these necessary factors was missing. In many cases the problem was inadequate and declining financing. Often funding for non-staff recurrent expenditures on livestock services, e.g. i.e. for medicines, transport, etc. was too little, in one case as low as 5%, of total recurrent expenditure. As funding declined, the organisational set-up deteriorated, becoming increasingly top heavy with senior level staff. Sere notes that the structure and intensity of veterinary services required by an animal production system are determined by:

a) The production pattern

b) The diseases prevailing

c) The resources available

d) The costs involved

e) The technical control strategies available

f) The external effects caused by the diseases and their control measures.

Thus, the need and demand for veterinary services varies by system. Our concern here being smallholder systems, review of health inputs required for nomadic/migratory systems and smallholder/sedentary systems is in order. In the nomadic systems, herds migrate over large areas, grazing communal lands. This system favours exposure to contagious diseases such as rinderpest and contagious bovine pleuropneumonia (CBPP) as herds migrate over wide areas and intermingle with other herds while grazing and at watering points. Sporadic outbreaks of these diseases cause varying levels of mortality. Productivity impairing diseases such as internal parasites, tuberculosis and mastitis are of less importance. The main demand for veterinary services is for preventative measures, mainly vaccinations to reduce cost and risk of high mortality owing to outbreaks of contagious diseases. The returns to curative practices are limited because of the very low per animal productivity while the costs of such measures are quite high owing to the low density of the livestock population and high transport costs.

54. The demand for veterinary services is somewhat different in the smallholder, mixed farming and intensive dairy systems. The density of livestock tends to be much greater where mixed farming systems prevail, but the livestock are held in small herds which tend to be relatively isolated from each other. Sere notes that in the small mixed farming situation, infectious diseases tend to linger continuously throughout the population rather than to recur as epidemics. Prevalence of productivity impairing, parasitic, diseases is favoured by poor hygiene and poor nutrition. As a result, veterinary costs in these systems tend to be high, while per animal returns tend to be low, for example, compared to intensive dairy systems. This situation favours mass vaccination campaigns, low density veterinary posts conducting extension activities and marketing drugs (antihelmintics, trypanocides). The disease pattern in the small-scale intensive dairy systems is similar to that in the mixed farming systems.

RISKS

Risk is a constraint to increased productivity. It is associated with producer behaviour toward technical and policy solutions which can increase or decrease the level of risk producers are prepared to accept in adopting them. It is therefore extremely important that producer risk be taken as a major consideration in the process of technology development or policy formulation if the ultimate acceptance by producers is seriously taken as an objective. Cattle milk and meat production is a risky business. Production takes place under highly variable economic, institutional and environmental conditions.

In sub-Saharan Africa, producers face a variety of price, disease and resource risks which make their incomes fluctuate from year to year. The types and severity of the risks faced by producers will vary depending on the production system, climate, policy and institutional setting. For example, in semiarid areas risks linked to environmental variability pose a serious threat to herd survival, while in humid areas the risk of disease outbreak is of overwhelming importance. Nonetheless, production and marketing risks seem to be prevalent throughout sub-Saharan Africa and do have, at least, two important implications for small holder producers.

First, numerous empirical studies have demonstrated that farmers typically behave in risk-averse ways. As such, farmers often prefer production plans that provide a satisfactory level of security, even if this implies sacrificing income on average. Achieving a secure livelihood may involve engaging in less risky enterprises, diversifying into a greater number of activities to spread risks, using well tried techniques rather than venture into new technologies, and retaining a larger share of the farm output for family subsistence. The risk-averse behaviour of farmers suggests that improvements to animal management practices that increase productivity but involve an increase in income variability may not be acceptable to smallholders unless the expected increase in income is substantial.

The second point relates to the differential ability of various groups of producers to bear risk. Initial resource endowments in terms of herd size, land, labour and capital and the level of investment in non-agricultural enterprises all serve to determine the risk bearing ability of a household. The distinct differential impact of risk on smaller and larger producers that have been reported in semiarid areas suggests that production strategies, herd composition and offtake decisions, and the adoption of new technologies will differ between various classes of producers. Recognising the varying impact of risks on producers would call for an array of interventions to satisfy the risk bearing abilities of different categories of producers. More importantly, price stabilisation and effective marketing information can help to reduce the price risk confronting livestock producers. In addition, suggested interventions to increase production should be such that they would not put household survival in jeopardy.

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3

Dairy Economics

Farm production economics is concerned with the choice of production pattern and resource uses in order to maximise the objective function of the farm operator, their families, the society or the nation, within a frame work of limited resources. The laws of production economics explain the conditions under which the quantities can be maximised (profit, output, national income) or minimised (cost, use of physical input).

The main objectives of production economics are.

1. To determine and define the conditions, which provide for optimum use of resources.
2. To determine the extent to which the existing use of resources deviates from the optimum use.
3. To analyse the factors or forces which are responsible for the existing production patterns and resources use.
4. To delineate means and methods for changing the existing use of resources to the optimum level.

In India the dairy farming is still existing as a subsidiary to the agriculture, which gives additional income to agricultural labours, small and middle farmers. In India growing atleast one or two dairy animals by farmers have many advantages of economic importance.

1. Dairy animals fits well in any diversified farming programmes i.e. it can be clubbed with agriculture, fisheries, horticulture, etc., which helps to give additional source of income.
2. In agriculture different types of roughages as paddy straw, Jawar straw, Wheat straw etc., are bulky fetching less amount and also not possible economical to transport them to long distances. Dairy animals are efficient convertors of roughage to produce milk.

3. The prices of most of the agricultural produce show great fluctuation where as milk will not have such fluctuations in price.
4. The income from agriculture is seasonal and the farmer receives income on harvesting crop only where as dairy animals gives money daily and it is distributed throughout the year. The economics can be calculated daily also.
5. Normally farmers will not take milk by spending money. But the family members will consume certain amount of milk invariably, which improves the family diet in terms of nutrition.
6. Legumes and grasses are grown on farm providing fodder to the animals. These crops are soil conserving and soil building crops. The manure produced will be utilised as natural fertilisers for growing, agricultural crops economically.
7. The male animals are utilised for draft purpose: In India still most of the agricultural operations are carried by use of bullocks power: In India the size of the land holdings are small and it is becoming still smaller portions by divisions and they cannot afford for mechanical farm operations.
8. Even after death, the carcasses are utilised for meat meal production, bone meal production, blood meal production etc., skin is used as hides.

In dairy farming the cost feed accounts for roughly 60-65% of the cost and so the economic milk production mainly depends upon the economic feed formulations. There are other factors also which contribute to the economics of dairy farming. The economic factors in a successful dairying one.

1. *The effective breeding policy:* Selection of high yielding animals for dairy farming. For breeding high record site or good sites semen for. All should be utilised. Unless the animal have high productive nature, even heavy feeding of balanced nutrition cannot improve the milk production much.
2. *Economic feeding practices are important which can alone decrease the cost of production milk appreciably.* Feeding of adlibitum of green forages will decrease the feed cost and ultimate less cost of milk production. Feeding of certain amount of leguminous fodders still improve the milk production.

Feeding of certain amount of dry roughages will improve the butter fat content, which again adds to the high payment for the milk.

Among the concentrate feed ingredients, most of the traditional ingredients are competed by human beings, so the cost is increasing resulting high feed cost making dairy farming uneconomical. Use of unconventional feeds which are available at throw away price or less price will decrease the feed cost resulting low cost of milk production.

3. The managemental conditions are cardinal in maintaining the optimum level of production and also to keep up the animal health. Ill health reduces the milk production drastically and, it take more time to reach original production.
4. The optimum use of land, manure resources to produce fodder with less investment, which ultimately affects the economic milk production.
5. The ability to direct and make use of labour efficiently after the economics of milk production.
6. Efficient disposal of milk plays half of the economic role in dairying. Even a small price increase in the sale price of milk, will have much impact on the economics of dairy farmings.
7. Sound business practices appropriate to dairy farming is important at all levels. Let purchases of inputs, and also disposal of products and by products.

The main theme of dairy economics rests on maximum reduction in feed cost producing high level of milk production economically and proper disposable of milk.

Postproduction of milk, milk processing and preparation of milk products also comes under dairying. A medium or big size dairy farm simultaneously they can have either processing of milk 1 production of many dairy production. Some times more profit can be obtained in the sale of processed milk/dairy products. Simultaneous establishment of processing plant will increase the income of dairying 30-40% and establishment of products factory will increase the profit by 40-50 % over dairy farming. If these processing or products factories are established within farm premises it reduces the cost of raw material i.e. milk collection and transportation costs. Further the quality of milk produced in own dairy farm will be superior as it is processed immediately without lapse of time, limiting less processing problems, uniform quality of milk is obtained which troubles less in products preparations compared to wide variation is collected milk from various sources.

ECONOMIC VIABILITY FOR DIFFERENT SIZE OF DAIRY AND ENTERPRISE

1. *Economic planning:* The following factors requires considerable attention when one decides to go for milk production on a farm.
   - Suitability of the farm
   - Suitability of farm, buildings and other fixed equipments.
   - Supply of right type of labour.
   - Availability of capital capability of the farmer.
   - Physical condition of the soil.

- Climate
- Water supply

The basis of economic planning of dairy farm depends upon the following factors.

a) Size of the herd
b) Level of milk yield
c) Feeding policy and stock density
d) Farm area devoted to dairy farm and stocking density
e) Housing facilities
f) Seasonal production policy
g) Raising replacement stock.
h) Watching milk yield
i) Check on food quantity and quality
j} Labour utilisation.

a) *Size of the herd:* The result of National investigation of milk i shows that upto the a certain point, herd size has an important on the profitability of milk production. No appreciable improve profitability was noted with a level of cows above 40. Infact a distinct in profits seemed to result above that level. The greater part of variety profits was found to be due to reduction in costs of labour percent increase in herd size. The size of herd depends upon the following factors.
   - Method of milking
   - Milking of shed facility
   - Milk yield
   - Cow shed layout
   - Labour efficiency
   - Area under forage

Most of the farmers appear to find that herds of 30 cows with a cowshed layout and 40 with parlour system can be handled conveniently and efficiently. It is assumed that a producer in his interest maintain normally a herd of 130 animals consisting of 40 milking animals, 40 dry animals and 2 bulls and rest comprising followers.

The number of cows to be handled efficiently and conveniently is dictated by the acreage of farm and cow shed accommodation. Every farmer should ascertain periodically whether his herd size could be increased, at the same time, carry out.culling process with discretion.

b) *Level of milk yield:* Statistical evidence appear to favours high yielding herd. The upward tendency in profit with the increasing in milk yield is what one should expect but upto certain limit only, because the food cost per cow- also increases due to extra concentrate with the increase in milk yield

c) *Feeding policy and stock density:* It is observed that feed accounts for 61% in cost structure of milk production in buffaloes, therefore attempts to lower the feed cost will reduce the cost of milk production, which can be achieved by use of less of concentrates and use of more green fodder.

d) *Density of stocking and farm area devoted to dairy farm:* Dairy unit of 3 cows and followers can be maintained on one acre fertile and fully irrigated land.

e) *Housing facilities:* The yard and parlour system requires less capital investnent per cow and less labour /cow compared to conventional cow shed.

f) *Seasonality in milk production:* Milk plants offer incentive in the form of or by way of higher price for milk during lean period of summer months so that the farmer may obtain more milk in those months of higher prices.

g) *Raising replacement stock:* Most dairy farmers prefer rearing most of their heifers on their farm to maintain required number because to avoid risk of buying poor quality stock and also it is proved that use of by products and unconventional feed stuff heifer can be raised cheaply.

h) *Watching milk yield:* The dairy milk yield record of an individual cow can be used as a guide for rationing, an indication of status of health on faulty feeding and as a basis culling.

i) *Check on Feed Quantity & Quality:* Depending upon the milk yield and requirements of an animals, farmers must work out the ration for each cow and write it on the chart against the animal. It helps to ensure the supply of right quantities of concentrates, from time to time depending upon the quality and quantity of roughage.

j) *Labour Utilisation:* Cost of labour is second to cost of feed in the annual cost of keeping of a cow. Loose housing system saves labour because cows come to milking parlour instead of man going to cow. Manure loader can be used in the loafing area. *Viability for small size farms:* For a family (2) members having 2-5 acres of land for crop production the economically size of dairy farm is 2-5 animals, depending upon their interest, capability, availability of fodder and marketing facilities. These two family members can work for 2-5 animals without engaging any extra labour and also without affecting the routine farm operations. The dairy farming will act as side employment to the main agriculture work. These small farms will be more economical than larger farms due to:

a) No dependence on external labour to work.

b) Agricultural by products I wastes can be utilised to produce more profitable milk item.

c) It helps to increase the fertility of agricultural lands in the way of manure.

d) It gives more income which is daily cash crop to the farmer without waiting for a season to get money.

e) More supervision on the individual animals as animals are less and also the owner will have more enthusiasm and love with animals.

f) No problem with marketing of milk, as the quantity is not bulk.

Viability for large farms

The farms having more than 25 animals comes under large/commercial farms and 5-25 animals will come under medium farms. The economic viability of large farms depends on

a) Effective management/supervision on materials and animals.

b) Individual animal feed requirements calculation and feeding.

c) Effective labour use and management.

d) Production of green fodder required.

e) Preparation of nutritive concentrate mixture.

f) Effective breeding management.

g) Effective health control measures.

h) Effective marketing of milk and milk products.

i) Culling and replacement of animals in the farm.

When comparative to small farms, survivability of large farms will be difficult as over head charges will be more in all aspects, in addition to lack of individual responsibility and care on the animals.

ECONOMIC PRINCIPLES INVOLVED TO ENHANCE BENEFITS IN DAIRYING

The various factors that can influence the dairy farms profitability can be enlisted and linked as given below.

Gross profitability/acre.

Gross profitability/cow

Milk produced/cow	Milk price	Replacement cost	Variable	cost
Lactation yield breed	Quantity of milk	-Replace cow cast	Labour	Other
	-Quantity	- cost of	cost	cost
Feeding	Of produce	new cow	Feed	cost
Management	Advertisement	-cost of	Fodder concentrate	
Calving index	Govt. policies	calves		
Decrease incidence			House Purchases	

By detailed study of the above factors that influence profitability of a dai farm, the following principles can be drawn to maximise profits.

1. *Selection of good animals:* A good lactating breed and also good animal is that breed will yield more milk production.
2. *Balanced feeding:* Feeding of animals with standard DCP al TDN content of required quantity will increase/maintain the m production.
3. *Green fodder feeding:* Feeding of adlibitum green fodder v decrease the use of concentrates which ultimately decrease the cost production of milk.
4. *Conservation of greens:* The green fodder will be excess during flush season. It should be converted into silage/hay which preserve it nutritive value of green fodder and it can be used during summer in plain of green fodder which will reduce the cost of milk production.
5. *Formulation of concentrates with unconventional inqredients:* Certain unconventional feed ingredients are not used for any purpose which can be conveniently used in concentrates formulation to decrease the cost of concentrate, as the cost of concentrates place an important role in the cost of milk production.
6. *Uses of agricultural by products:* The use of agricultural products like straws etc. will decrease the cost of milk production.
7. *Effective utilisation of labour:* The cost of labour ranks second after feed cost in dairy farming. The effective use of labour depends on
   - Proper planning of cattle housing unit
   - Loose housing system saves labour and energy

- Proper grouping of buildings in layout for saving time of labour.
- System of tieing is conventional housing system

Tail to tail tieing will decrease the labour requirement as 'it is man time is spend in back of the animal for cleaning, which space in tail to tail system.

8. *Replacement of the herd:* After few lactation's, the animals are culled to remove uneconomical animals, which should be replaced by growing own calves or by purchase. It is scientifically proved that replacement of dairy stock by growing their own calves is more economical and also have the information about the animal.
9. *Milk price:* The profitability of dairy farming mainly depends upon the sale price of milk. Even a marginal extra price per litre of milk will have higher profitability per year. It is better to practice home/Institution delivery of milk to get more price for milk, even a considering the distribution costs.
10. *Advertisement:* Advertisement about the quality and benefits of the milk will give more demand and price ever, after deducting the advertisement costs.
11. *Conservation in to milk products:* During flush season more milk will be produced and also the factories will pay less price. To get maximum profits some milk can be converted into products like cream, ghee, butter, paneer etc., which will also solve the problems of marketing of milk and also gives 30-50% extra profits over the cost of milk.
12. *Good-management practices:* Clean environment will produce more milk, when compared to uncleanliness in the" sheds. Proper protection of animals against environmental conditions like heat and cold will helps to maintain the production, other wise drastic fall in production is not protected. Maintenance of proper timings of feeding and milking will help in maintaining the optimum production. Maintenance of cattle health by proper vaccination and treatment will definitely helps in production of more milk.

ECONOMIC INSTITUTIONS SUPPORTING DAIRY DEVELOPMENT PROGRAMMES. PROGRAMMES

For starting any business, the foremost important resource one should give prime importance is finance. One cannot start any business/industry on their own money. The rural people are poor or middle income people and so they cannot afford to invest large amounts for establishment of any size of dairy farms. Several institutions are concerned either directly or indirectly in the activities or providing finance to establish dairy farm, milk collection centres, dairy plants etc. They are

1. *Indian Dairy Corporation:* Earlier it is the financing agency for all the dairy developmental activities i.e. establishing dairy plants, chilling centre, progeny

testing farms, formation of dairy cooperatives under Anand pattern. Now there is no- Indian dairy corporation and it is merged with NDDB.

2. *National Dairy Development Board:* Earlier it is only implerfientation agency implementing all the dairy developmental programmes throughout the country. After merging of Indian dairy corporation, now it is acting as financial as well as implementation of dairy developmental activities in the country. It provides finance to all the state owned milk cooperative federations, for the establishing and or increasing the capacity of milk processing f dairy products factories; chilling centers, feed factories, establishing progeny testing farms, improving Artificial insemination centers. The NDDB also acts as agent for international business/loan for the development of dairy industry. NDDB will provide finance to the state federations Or cooperative society by taking guarantees from the respective state government. The finance will be different types i.e. with nominal interest, no interest and repayment of one scheme to investment for other scheme. NDDB also involved in the research activities of dairying. Eg: Embryo transfer Technology, cross breeding programme, indigenous dairy processing equipment development.

3. *National Bank for Agriculture and Rural Development (NABARD).* This is the apex bank for refinancing for all types agricultural operations for the commercial banks at less interest. Earlier this is a wing in reverse bank as agricultural refinance wing of reserve bank. NABARD will not directly finance to the dairy farms, -dairy factories or allied business, but only through commercial banks. For community/social schemes like water shed, small irrigation schemes, tanks rural roads etc., it will finance directly to the state government to provide basic amenities to agriculture and related fields. For community work the interest rate is very low.

4. *Commercial Bank:* In-our country there are 28 nationalised banks and many private banks who are financing for dairying. These banks will finance for small to large dairy farms, dairy factories, feed mixing plants other dairy based business. The amount of finance will vary from 75-85% of the cost of project depending upon scheme or non scheme projects. For dairy farms one should have their own land and no loan will be given for land. The interest rates charged will be 12-15.5% P.A. depending upon the amount of loan.

5. *Cooperative Bank:* In each state apex cooperative bank will be there, in each district cooperative bank which will have branches throughout the district in rural areas. Just like commercial banks, cooperative banks will give for all dairying projects for both short term and long term loans, the rules and regulations are almost commercial banks with little less interest rates.

6. *Village Cooperative Societies:* For a cluster of villages cooperative societies will be there, which will give loans for small scale animal husbandry activities. The finance for

these societies will be by cooperative banks. The interest rates will be less compared to commercial banks.

7. *State Financial Corporation:* Each state will have state financial corporation (SFC) which will also finance for dairy projects. The interest rates are almost equal to commercial bank: In our state Andhra state financial corporation is located at Hyderabad and it is branches in all district head quarters.

8. *Dairy Development Cooperative Federation and District Milk Producers Cooperative Societies:* The state dairy development cooperative federation will get some loans from NDDB and other agencies for development of dairying, which will be provided to district unions, who will inform will give loans to milk producers. They will not give loans directly to the beneficiaries, but they will procure good genetic high milk producing animals and distributed to the beneficiaries. Part of the amount will be subsidy and the remaining amount will be treated as loan with less interest rates.

9. *District Rural Development Agencies:* In each district one DRDA will be there which will operate most of the centrally and state sponsored schemes. DRDA will assist programmes like

   a) Draught 'prone area programmes (DPAP)

   b) Small farmers development agencies (SFDA)

   c) Marginal farmer and Agricultural labour development agency

   d) Integrated rural development programmes.

   The (IRDP) DRDA will sponsor the above schemes by sanctioning loans by commercial, banks and provide subsides from 25-50% depending upon the classes of people involved in the schemes.

10. *B.C and SC Corporation:* SC and BC corporations will arrange loans for dairy programmes of respective class of people through milker commercial/cooperative banks and provide subsidy of 25-50%.

11. *Tribal Development Agencies:* For the development of tribal areas, the government has established tribal development agencies which will give subsidies and arrange loans through financial institutions.

MILK PROCUREMENT

Surveys for Milk Potential Area for Surplus

To assess whether any project or industry would be available in a certain area, a survey of available resources in that particular area is carried out. Milk shed are generally denotes a district (or) from which area milk is procured~ and processed in the common plant located in the central part of that particular are The villages in the milk shed area should be preliminary survey is conducted as different aspects of milk production as detailed given below:

1. The existing cattle and buffalo population
2. The production and utilisation/disposal pattern of milk and milk product.
3. Marketing channels for surplus milk.
4. Returns from the sale of milk realised by the farmers.
5. Agricultural facilities and production patterns.
6. Basic amenities such as communications links, educational facilities etc.
7. Other sources of income.
8. Performance of other institutions including multipurpose cooperatives etc.,
9. Different communities living in a village and their interrelationship.
10. Other relevant information if any.

Once the milk potential areas are located detailed survey is conducted i.e. door to door survey about the milk production, surplus milk with the family, whether they are interested to sell the milk to the society or not, infrastructure needed for enhancement of milk production etc. After detailed survey possible milk roots are identified so as to cover all the milk potential areas. In selecting the roots the prime idea should be considered is that the vehicle from the starting point loading the milk from different collection centres, reaches milk chilling centers (or) processing plants within a reasonable time without allowing the milk for spoilage.

Systems of Milk Procurement

The success of any dairy project depends on a well planned an organised system of milk procurement. In the case where programme system is not well established dairy plants remains under utilised on the other hand, if systems is well planned the following advantages can be obtained.

- An assured market round the year to the milk producers.
- Full capacity utilisation of the dairy plant.
- Increase in the milk production through inputs at reasonable cost.
- Planning and scheduling of milk procurement.

Following two aspects.

- Policy decisions at top management level
- Scheduling the actions for smooth running

Policy Decisions at Top Management Level

Before starting milk procurement the following decision should be taken.

1) Price to be paid for raw milk in different seasons
2) The system and frequency of payment for milk—Daily Weekly, fortnight or Monthly.
3) Reserve funds required to carry milk procurement to avoid hard ships
4) Material, equipment, chemicals and stationary required of collection centres.
5) Transportation of milk—hiring of transporting vehicles better rather than owning the vehicle.
6) Technical inputs i.e. Veterinary aids, A.I, feeds and fodder to be given in advance to the producers to get the advantage of favour.
7) Man power required and training engazed in milk procurement needed to people

Scheduling the actions

Once the above policy sessions are taken, the milk procurement activities are planned. After preliminary and detailed survey of villages, village society's are started. Society staff is recruited and necessary training in the fields related to milk collection, testing, maintenance of records, bank transactions bye-laws etc. is given. Transport time table for milk root is prepared and the all society's are informed about the time of loading of milk cans and (or) unloading of empty cans. All the members of the society will be informed about the time of milk collection at the collection centers. Depending upon the quantity of milk collected indent for extra cans or information about the quantity of milk to be procured in future should be reported promptly to the concentrated authorities by the society organisers.

Systems of Milk Pricing

The pricing of any commodity is always based on its cost price and the price paid by the consumer. Working out the cost price of milk under field conditions is a complex subject any pricing system followed should be

1) Remunerative to the producers

2) Competitive to the local market prices.

3) Discourage adulteration and promote quality consciousness:

4) Based on milk constituents.

Methods of milk pricing

The old systems followed in India are volume basis and weight basis. The volume basis will encourage the adulteration of milk with water and also quantity of milk will be affected on, with formation of foam. The weight system will not be effected by foam but it also encourages adulteration of milk. The various other pricing systems are:

1. *Pricing on pro-rata fat basis:* In this system the price of milk is fixed proportional to the fat content of milk. This system will assign practically zero value for S.N.F content.

The advantage of this method are:

- easy to calculate the milk price
- easy to adopt as it required only fat estimation, farmer will easily understand the system and it can be adopted to any type of milk.

The disadvantages are:

- It encourages adulteration of milk with water, as there is not check on S.N.F. This system will encourage buffalo milk and do not provide remunerative price for cow milk.

Pricing on Two Axis Basis

This method is used in pricing cow as well as buffalo milk where both fat and SNF contents are taken into accounts. As the system is based on both fat and SNF, it is called as "Two access pricing". The prices of fat and SNF are fixed depending upon the market price of GHEE and skim milk powder. Normally the price of fat will be declared by the union for different seasons and the price of SNF will be 2/3 price of the fat. The price is calculated using the following formulae.

Ex: Price of 100 kgs milk = Kg fat rate x Fat percentage + kg SNF rate x SNF%

Ex: If the price of kg Fat is 100 then the price of 9% SNF be 100 x 2/3 = Rs.66.60

Then the cost of 100 kg of milk testing 6% fat and 9% SNF = (100 x 6) + (66.6 x 9) =600+599 = 1199 i.e. Rs. 11.99 per kg.

The advantages are:

No discrimination against cow or buffalo milk as cow milk is reasonably priced due to consideration of SNF contents which is well comparable to that of buffalo milk.

Pricing on Equivalent Fat Unit Basis

In this method the SNF unites are converted into equivalent fat units in proportion to the relative market prices of fat and SNF. The SNF is

Value at 2/3 units of fat. For example: The buffalo milk testing 6% fat and 9% SNF

The total number of Fat units = 6 + 9 x 2/3. = 6 + 6 = 12

If the fat price is Rs. 100/- than the cost of 100 kg of milk = 100 x 12 = 1200

Or Rs. 12 per kg of milk.

This method will leave the same advantage of two access pricing system.

Principles involved in Pricing of Milk Products

While finalising the price for milk products there are six steps to be followed.

1. *Selecting the pricing objectives*: Whether the pricing objectives should be or profit oriented service oriented. Normally government agencies, voluntary organisations or cooperative bodies objective will be service oriented with minimum profit, where as private people will aim on maximum profit. For any producer aiming at reasonable profit will have many advantages to have in market for longer period with maximum percentage of market share.
2. *Determining the demand:* By making market surveys the demand for individual product can be assessed. The heavy demand product should be prepared. The price of heavy demand product will be high.
3. *Estimating the cost:* The cost of the product at which it can be marketed can be calculated as follows
   a) Cost of raw materials used for the preparation of the product i.e. milk, sugar, species, salt etc.,
   b) Cost of processing the product: Normally in dairy industry the
   c) Processing costs will be around 20% of cost of raw packing cost:
   d) Depreciation on the cost of raw material.
   e) Distribution cost (i.e. transportation)
   f) Distribution margin (whole sales margin)
   g) Retailers margin.

The total of the above gives actual price for the product. For that add profit margin which may be 10-15% depending upon the demand.

4.. *Analysis of competitors price and offer:* The price of product should be competitive and attractive compared to competitors product. Some times extra quantity of product is offered with the same prices (Add 100 gms with 500 gms of product) by competitors. That should also be taken into account.

5. *Selecting the final price:* After deciding the above factors the final price of the products may be arrived.

   For any product price fixation other factors will also influence like.

   1) *Season:* During summer, demand for flavoured milk, butter milk, Ice cream, kulfi will be enormously increased. So the price of fast moving products in summer can be increased.

   2) *Area of marketing:* If the income of people is high, their purchase will be more.

Planning for Milk Collection and Transportation Routes

For efficient collection of milk, certain problems arising at the collection centre should be solved. The various problems faced at the collection centres are

1. Producers having vested interest—some persons will try to influence the staff and get undesirable things done to save their personal interest. This should not occur.
2. Some persons will supply adulterated or substandard milk. This should be discouraged.
3. Strict timings for milk procurement—Some producers will supply the milk very late, the society will not receive it resulting a direct conflict between the producers and staff. This can be sorted by explaining the farmers about the difficulties.
4. Some producers will think that sample of milk drawn is an extra quantity of milk which is not paid for. This can be explained to the farmer that all the samples are polled and sold which is distributed to all members as bonus.
5. Some farmers due to many reasons will supply evening milk in the next morning and morning milk in the evening which causes curdling of milk and loss to the society. Such producers should be carefully checked and explain about the quality of milk causing problems in processing of milk.
6. Some staff members will not following the timings for milk collection, so that the procedures will have to wait for hours together and loose their interest on society. Maintenance of the time by the staff is essential for improving the milk procurement.

Transportation of milk to the processing centre or chilling centre will be undertaken by the union. Some societies will not have proper roots, it's the responsible of the society to transport the milk from the collection centre to the near by truck pick-up point. In some societies there will be transportation root through that village, but the collection centre will be interior, in such case also it is the responsibility of the society.

At union level different roots are planned to get the milk from different places to the processing plant. Each root will be planned in such a manner that it will go through all the society villages or atleast nearer to the societies. The roots are so planned that if any damage to the road or traffic an alternative road is available to the processing centre.

The transport vehicles will deliver the empty cans for next collection and lift the can with milk. In case of any break to the transporting vehicles an alternative vehicle or atleast the other route vehicle may be diverted.

Measures to Enhance Milk Collection during Lean Season

During rainy and winter season, there will be, lot of green, roughages which will help in enormous milk production, where is in summer the' most of the, fields' including grazing lands become dry in a green fodder will be available adversely affecting the milk production. Moreover no farmer will plan to calve the animals just before or during, summer, which will adversely affect the lactation yield. Most of the cows will be in dry or late *lactation or late lactation with pregnancy. Recent studies indicate that the milk production during summer season will be decreased of the milk production during rainy and winter seasons. The summer season in which low production of milk is called lean season and flush season when high milk production exists.

As the output of milk production is decreased, the demand will be as such for the milk, there will be lot of completion for the collection of milk. The competitors of milk processors will start their own strategies to get maximum share of milk collection by any dairy in lean season. The following are the some of such steps.

1. The milk production during flush season will be surplus, the collection centres are unable to collect full quantity due to varied reason. The processors should regularly collect full quantities of milk from those producers who will be faithful and supply full quantity of milk to him during lean season. The producers are also remember the collection centers, who has helped them during flush season. Some processors even declare milk holidays once in a week, or so during flush season, which will cause economical loss to the producers. If farmers are tackled well during flush season, they will inturn help by giving whole quantity of milk during lean season.

2. Fixing of high price or giving bonus or extra payments for the milk supplied during lean season will also improve the milk collection. As the level of production drops during summer and also most of the dairy animals in dry/pregnant conditions, the cost of the milk production will generally high during summer season. To compensate this high cost of milk production, the processors should enhance the purchase price of milk.
3. Advance payment/prompt and regular payments for the purchased milk by the collection centers will definitely improve the milk collection during summer.
4. Supply of inputs like concentrate feeds, fodder seeds, fertilisers A.I facilities to the producers in advance and adjusting the cost for the price of milk collected.
5. Satisfying the producers by explaining about the cunning nature of competitors who will give high price of milk during lean season. The collection center people should explain to the producers, that the competitors would not collect the milk during flush season.
6. Especially during festival occasion, children school reopening, marriages time farmer need of money and they may come for agreement with milk collection center people, by supplying milk-during lean season, if they give any finance to them. Any processors should make advance payments during the above occasions to attract the producers.
7. Training programmes should be conducted on management of animals during summer season without affecting the milk production.
8. The collection centre persons should respect customs, of the local people and they should participate in a various social and cultural activities of the village so that the farmers think that these are one among them and definitely they sell milk to them only.
9. Out of their profits, the processors/milk collection centre persons should spent certain portion for social activities in the village, i.e. laying or repairing of roads, construction of school buildings. Maintenance of parks, donations to temples, or donation to any religious/other functions will have effect on milk collection.
10. Milk competitions, bull competitions, calves and other groups of animal competition regularly is the village will also increase the faith in the villagers. In addition to the above encouragement points, the processors/collection centre people should not do the following things.
    a) Cheating the producers by taking extra quantity by manipulating the weights and measures.

b) Showing less readings of fat and SNF levels in the milk.

c) Wrong calculation in the price fixation of milk.

d) Utilisation of money for personal use and delaying the payments to the producers.

e) Not paying the bonus after the year.

f) Not bothering about the collection of milk during flush season.

g) Not attending to the problems of animals.

DAIRY DEVELOPMENT PROGRAMMES

Milk has emerged as the second largest agricultural commodity next to rice production. India ranks world first in milk production in 1996. India's milk production is 70 million tones. Cross breeding of indigenous cows with exotic bulls/semen has encouraged for augmenting milk production.

Government Project/programme

1. All India key Village Scheme—1951
2. Intensive Cattle Development Projects (ICDPs)—1964—65.
3. Operation Flood phase I—1970.
4. IDA Assisted Dairy projects.
5. Operation Flood Phase II—1979
6. Operation Flood Phase III—1985.
7. Dairy Technology Mission—1987.

Key Village Scheme (KVS)

It was taken up in August, 1952. Under the scheme a "key village block" consists of one AI centre along with four key village units attached to it. Each key village unit is a compact area of contiguous village having a population of about 500 cows and/or she buffaloes fit for breeding and milk supply. Selection of pedigree bulls, proper administration and technical organisation consisting of one VAS, one milk recorder and three stockmen had been provided for every centre. During the third five year plan the KVS was considered to be the main programme for IDCP. The main activities are:

1. To intensify the construction programme in the key village areas.

2. Extending the PTS to the On gole breed in Andhra Pradesh and Kankrej breed in Gujarath. (PTS—Primary Testing Scheme)
3. Establishing bull-rearing farms
4. Development of grazing areas by setting up two fodder banks and also a grass land and Research Institute.

Intensive Cattle Development Projects (ICDP's)

During the third and fourth five year plan it gained its significance by its activities such as

(i) Formation of NDDB

(ii) Establishing progeny testing farms—IV plan

(iii) Establishing frozen semen stations—VI plan

(iv) Institute for Buffalo Research—VI plan

(v) Embryo transfer technology—VII plan.

Progress Review

By the end of 1965, there was an awareness about the success and failures of the Government's own programme. The review of above revealed the following.

Progress made under 5—year plans

- Dairying acquired national-level recognition.
- Concept of planned approach was introduced at all the levels.
- Organised marketing was adopted by private, public and cooperative sectors.
- The multi-national introduced new milk products.
- To overcome the economic barriers, toned milk, with less fat and at comparatively cheaper price, was formulated.
- India started developing its own cadre of trained technical personnel.
- The concept of intensive cattle development was introduced.

Unfortunate trends

Besides above contributions, some negative effects were also observed as listed below.

- modernisation and planning of dairy industry was consumer oriented.
- the package of inputs required for enhancing milk production was , left in the hands of State Animal Husbandry Department without Lilly correlation with milk industry. Those inputs hardly reached the producer. This made dairy fanning an unattractive preposition for rural milk ; producers as they were to bear entire burden of maintaining the milk animal.
- the private city dwellers/duhias exploited the consumer due to increased demand as a result of industrial development.
- Cattle colonies, housing large number of good cattle and buffaloes ' brought from the home tracts got established to meet cities demands. ' Maintenance of these animals in big cities was a problem, especially in dry periods. The best animals thus started finding way to slaughter ' houses, once these were found uneconomical. Old stocks were replaced: by the new ones from villages. This anti-dairy cycle perpetuated.

OPERATION FLOOD

Operation flood—the Indian white revolution was launched to over come the above mentioned unhealthy trends. It is designed to raise milk ~ producer's income by organising them into cooperatives and eliminating f middlemen; to increase milk production in rural areas creating a flood of milk to meet demand on a regular year-round basis; and to create a self-sufficient dairy industry in India.

Operation Flood I was launched in 1970, following an agreement with the United Nations World Food programme. The European Economic ~ Community was also closely associated with Operation Flood I provided much of the food aid to the World Food Programme.

To launch Operation Flood I and finance projects undertaken within its framework, the Delhi Government set up the Indian Dairy Corporation (IDC) in 1970. The actual implementation of the various projects is left to the village cooperative societies and milk unions which own dairies at district level.

Objectives of Operation Flood I

a) To increase the capacity of milk processing facilities.

b) To change urban markets from traditional milk supplies to modern dairy milk supplies.

c) To make provision for the resettlement of city based cattle in rural areas.

d) To develop long distance milk transport and storage facilities.

e) To develop Anand pattern of milk procurement system of improve dairy farming standards.

Operation Flood II

Operation flood II was started in April 1981 and ended in March 1985 with the expressed intention of creating a viable dairy industry to meet India's needs in milk and milk products.

India's White Revolution has not only received support from the European Community and the World bank, but also from a number of Western Governments, the United Nations food and Agriculture Organisation (F.A.O), the United Nations Children's Fund (UNICEF) and European NGOs such as the British Relief Agency OXFAM. It has also been regularly evaluated over the years.

IDA ASSISTED DAIRY PROJECTS

The world bank's assistance to dairy development started with the coverage of Karnataka, Madhya Pradesh and Rajasthan. The project comprises of:

i) establishment of about 7200 DCS and 12 milk producer's unions.

ii) Important and multiplication of pure bred exotic breeding stock and an associated A.I. programme of crossbreeding native cattle with high producing exotic breeds. Provisions of extension programme to encourage production of fodder, mixed farming and improved animal husbandry practice.

iii) Construction of 12 dairy plants and cattle feed mills.

iv) Establishment of one regional diagnostic laboratory and a plant for production of biological veterinary vaccines.

v) Provisions of a training centre for each union.

Objectives of Operation Flood II

a) To cover 10 million milk producer families in rural areas.

b) To create National Milk Herd of 14 million cross-bred graded buffaloes.

c) To strengthen national Milk and by linking milk supply and demand centres cows and

d) To construct a base structure for National Dairy Industry.

e) To increase percapita consumption of milk products at 144 gms/day

Operation Flood III

Operation Flood III was launched in April 1985 to run until March 1990. The results achieved in Operation Flood 11 justified the confidence faced by the Government in farmer's own organisations as instruments of dairy development and led to the initiation of Operation Flood III which was implemented, covering most of the Anand pattern milk sheds of the country.

Objectives of Operation Flood III

a) To increase the coverage of milk producers.

b) To establish an additional 15,500 village Milk co-operative societies in 173 Anand pattern milk sheds as constituents of the State Federation.

c) To increase milk animals in co-operative ambit.

d) To strengthen National milk Grid.

e) To better utilisation of technical inputs in co-operation with state governments.

f) To develop dairy co-operatives own system of improving health, environmental sanitation, nutrition etc.,

National Dairy Development Board (NDDB)

To replicate the Anand pattern throughout the country National Dairy Development Board (NDDB) was established in 1965. The dairy development programmes are being implemented through a network of milk co-operatives organised on the model existing in Gujrat state namely ANAND pattern dairy cooperatives. The three tier structure of the dairy development programme are:

1. Village level primary milk co-operative producers societies.
2. District level milk producers co-operative society unions.
3. State level federation of district co-operative milk producers unions.'

The main objectives are to assure remunerative price for the milk produced by the milk producers through a stable, steady and well organised market support, and distribution of milk and milk products at reasonable prices to consumers.

Milk and Milk Products Order (MMPO)

This programme has been issued by the Government of India during 1992 under the liberalisation policies. It empowers that those dairy plan exceeding its utilisation of 10,000 liters per day must register with Government for its modernisation, product manufacturing and to collect milk in specified area.

WHITE REVOLUTION

Just like 'green revolution' which is intended over all increase in agricultural produce., white revolution in the increase of milk production tremendously so that sufficient quantity of milk is available for all affordable price. To tune up the milk production the infrastructure required are

1. High yielding genetic potential dairy animals in India most of the dairy cattle are native breeds, in which majority are poor yielders of milk. It is not economical to raise the animals with 1-2 litres of milk production The milk potential of animals can be improved by

   a) *Introduction of Exotic cattle:* Exotic breeds like Jersey, Holstein Friesian, Browpswiss etc., are excellent milk producers. These breeds can be introduced to some extent through out the country to increase the milk production.

   b) *Cross breeding programme:* Purchase of exotic breeds are costly and mass introduction is not possible. The semen of exotic breeds can be utilised on native breeds to produce superior breeds which can be utilised on native breeds to produce superior offsprings. With little investment the future herd will be cross breds having good milk production capacity. Massive cross breeding programme should be undertaken.

   c) *Selective rearing of native breeds:* Under native breeds there are some breeds which are yielding optimum milk production. These breeds can be maintained by maintaining pure breeding, programme.

   d) *Upgrading native buffaloes:* Murrah buffalo breed is the good breed under buffalo which can be utilised for upgrading native buffaloes. Slowly the future stock will become graded murrah buffaloes.

2. *Animal Husbandry activities:* Veterinary doctor should be there in or around—at least within a reasonable distance who will take care of the animals in the following activities.

   – To maintain the health by doing vaccination. To treat the diseased animal

   – To inseminate the animals and confirming pregnancy diagnosis. Attending dystocia

   – Maintaining reproductive health.

- Advising on balanced nutrition and managemental tips.
- And many other activities concerned with animal husbandry.

Now a days trained personal are involved in door step Artificial insemination. Rural unemployed people will under go short duration training on artificial insemination and they will do door step A-I on payment.

3. *Improving the fodder:* the fodder crops development in India is not favourable. Most of the farmers are opting for commercial crops; not leaving any land for fodder crops. Green fodder is necessary to increase the milk production economically and also maintains good health and reproductive status. Those who are maintaining dairy animals they should allot some land for fodder production. High yielding fodder crops like Napier Bajra, Para grass, leucerne, cowpea, Berseem, and other grasses can be grown whose yield is more and also give cuttings. In India the grasses grown for grazing. These grazing lands can be improved by sowing with high yielding grass varieties.

4. *Establishing feed plants, 9:* The availability of good quality of concentrate feeds in India is not satisfying the needs. Modern feed plants, should be established especially under cooperative system, to produce well balanced rations for high milk production and also to keep the price of concentrate feed at minimum affordable level. As the human beings are competing for the most of the feed ingredients, much emphasis shot id be given for use of unconventional feed ingredients. Many agricultural by products and unconventional feed ingredients can be included without affecting palatability by using palletisation process. Molasses are used both as sweetening as well as energy supplements.

5. *Formation of Cooperative three tier system*: The development of milk production under government has not given boost. It is proved in our country in Gujarat, that only cooperatives will perform better to boost up milk production. Cooperatives system advantage is the milk producers will manage all the activities i.e. milk production, collection, disposal and providing basic requirements. Anand pattern of three tier system is successful system. In this in a village all the milk produces will farm village cooperative society. In a district all the village cooperative societies will form district milk producers union. All the district unions in the state will form state federation which is the apex body to take policy decision. Village societies will collect the milk and send to district union where milk is processed and milk products are prepared. Liquid milk and products are marketed by the district union. In all the villages village milk producer's cooperative societies should be formed to enhance the milk production.

6. *Providing inputs to the milk producers:* The district union should provide the inputs like artificial insemination facilities, supply balanced concentrate feeds, fodder seeds on subsidised rates, fertilisers and arranging for loans for the purchase of dairy animals. Training programmes should be conducted periodically in the subject of dairying, so that the farmers will get sufficient knowledge in the management of dairy animals and also in producing milk production economically.

7. *Improving the rural transport:* The roads are in very poor condiuons in the rural areas. The milk collected at rural cooperative societies should be transported to chilling centre/processing centre with in reasonable time, to keep up the quality of milk to withstand processing. If the roads are in bad condition, the milk will spoil when it reaches the destination.

8. *Processing centres/product factories':* The milk processing centres/products factories should have the /sufficient capacities and sufficient number to deal with surplus milk during flush season. The surplusmilk should be converted into products. If the processing centre are at long distance from collection points, chilling centres can be established in which the milk is chilled and transported to processing centres by refrigerated thermo packed road tankers.

9. *Marketing facilities*: For the sale of liquid milk and milk products marketing infrastructure should be developed. i.e. C & F agents, distributors, whole sale, retailers, Mobile quality checking teams should be provided to check the quality on the spot, if any complaint comes, to get consumer's satisfaction. A poor marketing structure, will easily damage the business. Now a days any body can produce any product, but ability depends on efficient marketing.

   - Other basic infrastructure includes
   - Electricity
   - Water supply In the village. Drainage

NATIONAL TECHNOLOGY MISSION FOR DAIRY DEVELOPMENT

The government of India has formed a body "Technology mission" to coordinate the activities of various institutes concerned with dairy development such as NDDB, IVRI, Agricultural universities, state government department working for dairy development with the ultimate objective to promote dairying on "Operation Flood" model for the welfare of millions of milk producers in the country. Most of the above institutions are working piece meal and in isolation. This body was established in 1988 to 1994 (7 years programme) with headquarters at Anand in Gujrat State. This body also sets targets, monitor the progress and advise government on policies and statues. This will help to promote institutional based dairying in India more rapidly during the nineties, in comparison to what we have achieved in the seventies and eighties.

The idea of mission was conceived by the then prime minister of India, Sri. Rajiv Gandhi during his visit to Anand, head quarter of National Dairy Development Board (NDDB) during 1986.

Mr. Gandhi felt that the pace of the dairy industry growth under operation flood was not fast enough and that there was a need for technological intervention. The mission would accelerate the pace of rural employment through Dairy development and bring about effective coordination among various government programmes and agencies for optimum use of resources. The mission was launched by the Advisor to the prime minister of India on Technology mission Mr. Sam Pitroda, Dr. V.Kurean Father of India's White revolution is the chairman of the mission. The main objectives are:

a) Under the Technology mission the milk production in the country is expected to go up from 44 million tonnes in 1987 to 61 mm by 1995.

b) To increase the percapita availability of milk from 158 to 186 gr/head/day.

c) The average lactation yield of the cow is expected to be increased from 390 to 640 lit. and in buffaloes from 900 to 1010 lit per lactation.

d) Number of districts covered by dairying would go up from 242 to 270.

e) Number of village milk co-operatives to increase from about 49000 to 50000. These include about 21,000 additional village cooperatives planned under of phase III.

f) Milk marketing facilities will go up along with processing capacity.

g) Various government Departments associated with the mission. Indian council of Agricultural research (ICAR) Central Scientific and industrial Research (CSIR) Agricultural universities and NDDB will be involved with the mission.

h) The mission plans to set up large energy efficient dairies and lactoperoidase system to preserve milk quality.

i) The mission would have a total outlay of about Rs. 1070 crores including 915 crores under OF—III.

Role in Voluntary Organisations in Dairy Development

Social institution may be defined as any voluntary, private, cooperative or sponsored organisation for poor people who are under below poverty. Social institutions are service oriented organisation and not aimed at profit making. Most of the social institutions are sponsored by voluntary organisations . Eg: Awane, Artic etc.

The various types of social institutions are:

1. *Voluntary Organisation*: The persons who are interested in rural development and social activities will form a social institution and registered with central Government under ministry of human resource development. The finance sources for these organisations are

   a) Funds from human resource development ministry.

   b) Foreign bodies donations

   c) Donation from Industrial/business/ individuals

   d) Income on donated properties.

The organisation is organised by a committee. They will take the help of any volunteers of different professionals, who will work voluntarily, or they will appoint persons on honorarium basis. The Govt. of India will audit the accounts and take necessary actions, if any miss happening occurs.

2. *Promoted by industrialists/business people:* Some of the industries/business people who are interested in rural development/social work will form a "trusty". The funds for these "trustes" a portion of the profit from their group of companies are diverted to it, for which tax exception is provided by the government. They will also collect donations for people, for which also tax is exempted. It is also managed by a committee. They will take the help of different professions and also employees of their group of companies to do the work.

3. *Promoted by Cooperatives:* Milk producers cooperatives or compound live stock feed manufacturers associations or Breeding associations etc. will organise social institutions. They fertiliser:

4. *Promoted by banks:* Nabard and other commercial/cooperative banks will sponsor service centres to promote rural development. Funds are financed by respective banks.

5. *Qiftas-Indo Swiss project:* Jointly organised by Switzerland and Indian governments. Some are organised by PJRI person etc.

Activities of social-institution concerned with dairying

1. They will adopt some villages where poor, people are dominated under poverty line.
2. They will identify the beneficiaries by their own surveys and gathered information.
3. They will select the people of 25-40 members per batch as beneficiaries.

4. They will provide training to these beneficiaries on dairying by professional experts, they
5. They will help in formulating dairy project.
6. They will assist in getting loans from commercial banks and subsidies from government.
7. They will develop community facilities which are useful for most of the beneficiaries. The cost for these facilities will be borned by them. Eg: Community fodder crops, water supply, vaccination programme.
8. They will supervise the dairy farms frequently to see that it is properly running.
9. They will provide veterinary aid freely /with law fee by appointing their own doctors.
10. They will help in marketing of milk and milk products. Some times they will take the marketing work to benefit milk producers.
11. They will supply inputs like concentrate feeds, fodder, seeds, fertilisers on actual cost which can be repaid in instalment.

Concept of Socio-economic and Cultural Changes

Society is a group of people in more or less permanent association who are organised for their collective activities and who feel that they belong together. Important aspects of society is not the structure, it is the system of relationship. Society exists only when the members known each other and possess common interest on subjects. The likeness, cooperation, interdependence are the important elements to constitute society.

Community is a social group that have some degrees of co-operation, likeness, interdependence and living in a specific area. Community is a natural group of people residing in a particular locality permanently with a feeling.

The society is heterogeneous in nature. These are rich, poor, industrialists, peasants, rulers, sweepers etc. Every where society is divided into various classes, economic, social, political and religious. The process by which individuals and groups ranked in a more or less enduring hierarchy of status is known as stratification. Every society is divided into more or less distinct groups. No society is unstratified. Where there is a social stratification, there is social inequality since social stratification means division of society into social classes.

Social classes are defined as abstract category of persons arranged in levels according to the social status they possess. There are no firm lines separating one category from the other. Social class is a culturally defined group that is accorded a particular position or status with in the population as a whole. A social class is the aggregate of persons having essentially the same social status in a given society. Each social class has its own particular social behaviour, its standards and occupations. The relative positions of the class in the society arises from the degree of prestige attached to the status. Status is the basic criterion of social class or in other words class is a status group.

In a social class there is, firstly a feeling of equality in relation to members of its own class in behaviour, standard of life, occupation etc. Secondly, there is a feeling of inferiority in relation to those, who stand above in a social class. Thirdly, there is a feeling of superiority to those below in social hierarchy.

Every class has its own distinctive ways of life. A social class is distinguished from other classes by certain customary modes of behaviour, which are taken to be characteristic of that class and may be concerned with such things as mode of dress, the type of conveyance, the way of recreation and expenditure. Thus the upper class members are masters rather than servants. Economic classes are the groups engaged in different economic activities or standing in different relationships to the means of production in a society eg. Business, service, farmer and other classes.

Cultural class as further social strata that have developed sub cultural patterns of behaviours. The patterns are distinguished from each other eg. Hindu and mohammedan cultural classes.

Farmers and their families are members of the society in which they live. In any society there are strong pressures on its to behave in certain ways. In all societies there are accepted ways of doing things and these ways are directly related to the culture of the society. The culture of society is the accepted way of doing things in that particular society. Sargent etc also defined "Culture is a pattern of learned behaviour shared by members of a society. It includes not only the way of making things and doing things, but the pattern of relationships of many people, the attitude they foster, the beliefs and ideas they have arid even the feelings with which they respond. Culture is not merely customs, though customs area part of culture. For culture, is the pattern of whole of responses, the more or less consistent unity that links the many diverse elements of living into the way of life. The culture of a society is learned by individual members of that society eg: children learn by seeing how elders behave.

The basic difference between society and culture is that society is people and culture is behaviour. Members of a society share to some extent at least a common culture, live with it, alter it, and transfer it to the next generation. Culture has a structure that is made of various units i.e.

a) *Culture trait*: Which may be material or non material trait Bullock cart, Doti, Sari are examples for material culture and vanakkam and namaskaram and also pulling the harm of sari over the head to cover a women's face in the presence of outsides are examples for nonmaterial. Certain cultural traits are essential to all are called as universal eg. Young people use to show extreme respect and obedience to the elders, dress, language etc., culture in which the individual has a choice among several forms of behaviour are called alternative traits eg: When a cow comes to heat the farmer can get inseminate his animal either taking it to veterinary dispensary or subcentre or milk producers cooperative society, which ever he chooses as most convenient or beneficial to him. Some traits are practised by some groups but not by all groups are called specialists traits. Individual peculiarities such as fears prejudices or capabilities are called individual traits

b) *Culture complex:* It is a group of cluster of related cultural traits eg. Mattu pongal festival in livestock farmers community, thread ceremony in brahmin community, a girl coming of age function (attaining puberty).

c) *Cultural pattern:* It is a group of cultural complexes eg: Cultural pattern of rural hindu society.

d) *Customs*: Customs are socially prescribed form of behaviour, transmitted by tradition and enforced by social disapproval of its violation. Customs are the accepted ways in which people do things together in personal contacts. Customs are interwoven with our social life, and are part and parcel of our society.

Customs can be classified as

a) *Unidentified acts:* eg: a farmer prefers goat milk, using a particular brand of products.

b) *Folk ways:* Are the customery way of behaving in a society in which society exerts some force for conformity. Eg: Removal of shoes before entering in to house.

   Vanakkam (greeting others with folded hands)

   Folk ways are the expected forms of behaviour but are not rigidly enforced.

c) *Superstitions:* Eg: in a farm a cow delivered a male calf on Friday and later the farmer fell ill and died. The farm women explains that the death was due to the birth of male calf on Friday.

d) *Mores:* Are the pattern of behaviour consider essential by society. It is strickly enforced eg: Halal method of slaughter in muslim society, standing up during the playing of the national anthem.

e) *Taboo:* Those things which persons ought not to do. Eg: prohibition of pork in Muslims society and beef in hindu religion.

d) *Acculturation:* It means contact between culture when people of two different cultures come in contact, they may influence each in different ways. The impact may be one side or reciprocal.

e) *Ethnocontrison:* It is the tendency of man to consider his own culture of high value and superior to all others and judge, other cultures in terms of standards and values that exists in ones own culture eg: Arranged Marriage, American father of lady would never sell his daughter in marriage to any man.

Social and cultural change

Social structure and cultures are never completely static, they can and do change. Cultural change in society has two major aspects.

a) Cultural change by discovery and invention.

b) Cultural change by diffusion and borrowing.

The first comes from within the society and culture, the second from another culture outside of the society. The extension worker will help to "seek up cultural change in farming. This may in turn contribute to wider social change. Eg:

a) Amul pattern of milk society: Cultural change, social change

b) Ox drawn plough to tractors.

Animal Husbandry Cooperatives as an instrument of social and economic change

The advent of dairy and other animal husbandry cooperatives has been a boon for farmers especially those who are traditionally weak. It provided year round income to the farmers 60-65% of income of the group from animal husbandry.

Social Impact

Membership is open to all regardless of caste and creed barrier. Untouchability reduced. Other impacts are

- Age old superstition of selling milk as a social evil is removed.
- Democratic election procedures of societies increased awareness of the farmers about their vote.
- Enables adoption of better managemental practices.

– Portion of cooperative profit can be spent for improvement of road conditions, establishment of small libraries and educational units, helping establishment of hospitals, schools etc.

Interaction with educated society improves the lives of farming community.

Economic Impact

(a) *Direct impact:* Large number of youth especially women, widows are given employment. Farmers have become self reliant by regular in flow of money from urban to rural areas.

(*b*) *Indirect impact:* Financial position of farmers is improved by increase milk yield, low expenses on veterinary aid. Middle man and exploit of farmers are checked. Gainful employment, family labour and agricultural by products are also utilised efficiently.

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Dairy Cooperatives and Economic Planning

India is a country of villages. Our farmers have small land holding. Intensive cropping therefore has been the way of farming. Use of production enhancement inputs went on increasing. Thus the input-output ratio started getting imbalanced. The need of cash was more felt to buy inputs. To meet these needs, farmers had to borrow money at a very high rate of interest. Money lenders exploited the farmers who were poor and in debt.

A large number of farmers at Pune and Ahmednagar area in Maharastra rose in open hostility against money tenders in 1879. Subsequently land improvement Loan Act in 1883 and Agriculture Loans Act in 1884 were passed to advance loans at reasonable rate of interest to the farmers. At this juncture, the Government realised that the cooperative movement could possibly solve the economic problems of farmers. The Government there fore appointed a committee under the chairmanship of Edward Law to make suitable proposals for enacting a separate legislature for cooperative societies. Thus in 1904. The Co-operative Credit Societies Act was enacted. The Act had however following short comings.

- Only credit societies could be registered
- Classification of societies into urban & rural was unscientific
- It was a silent about distribution of profit.

Thus another act, named 'The Cooperative Societies Act' of 1912 was enacted. The Act took care of following institutions like Central Banks, Supervising unions and other non-Credit societies.

In the year 1919, Cooperation became a state subject and fell within the scope of provincial legislature. Each province than started formulating their own Cooperative societies Acts to suit these requirements Bombay state had taken the lead by passing the Bombay Co-operative Society Act in 1925. Such as

- Madras Cooperative Societies Act of 1932

- Bihar and Orisa Cooperative Societies Act of 1935 Bengal Cooperative societies Act of 1940
- Cooperative Societies Act of 1936.

After Independence the Co-operative movement made rapid strides. Government adopted the policy of utilising the cooperative movement for establishing democratic economic order in the country. The government of India appointed a committee in 1956 to review cooperative Acts in different states and prepare a model bill on the basic of this model Bill these are:

- The Mysore Cooperative Societies Act of 1959
- The Jammu & Kashmir Cooperative Societies Act of 1960
- The Maharastra Cooperative Societies Act of 1960
- The Punjab Cooperative Societies Act of 1961
- The Gujarat Cooperative Societies Act of 1961
- The UP Cooperative Societies Act of 1965
- The Rajasthan Cooperative Societies Act of 1965 The A.P. Cooperative Societies Act of 1964.

COOPERATIVE MOVEMENT IN DAIRY INDUSTRY

Before Independence there is no system of organised milk collection and distribution. Which had major effect both on the milk producers as well as milk consumers on November 15th 1945.

Aarey milk colony was established by Bombay Government under greater Bombay milk scheme. This is the first scheme in India which benefited partly milk producers and milk consumers. In 1946 the farmers of Kaira district of Gujarat state has realised that they were exploited and had no choice but to sell their product (milk) at throw away to the government approved contractors. The trade was monopolised by contractors operating in district. The farmers approached Vallabhai Patel at his advice, decided to market their milk through the Co-operative Shri Morarji Desai one of the lieutenants of Sardar, moved the farmers to established village co-operatives.

Subsequently at a meeting held at Samarkha village on January 4 1946, it was resolved that the milk cooperatives could be organised. It was also decided that the government should arrange to buy their milk which could be processed at the dairy owned by the union. And in case it was not acceptable to the government the farmers would refuge to sell milk to any agency.

The government turned down this proposals and farmers went on 'Milk Strike' which lasted 15 days. During this fornight not a single drop of milk reached Bombay from Anand and the greater Bombay milk scheme virtually collapsed. The milk commissioner of Bombay then visited Anand. and after assessing the situation accepted the farmers demand. This marked the beginning of kaira district milk producers Ltd. union on October 26th 1946. First milk co-operative society formed in Hadgud village and on the same day First milk collection by Kaira district co-operative milk producers union Ltd. was started on 14-12-1946. Amul union was registered on 1-06-1948 milk processing unit was inaugurate at Anand by.

MILK COOPERATIVES - ANAND PATTERN

The foundation of Anand pattern of milk cooperatives was laid with the organisation of the kaira district. Co-operative Milk producer's Union limited at Anand. In this pattern all the functions of dairying - milk production, procurement, processing and marketing are controlled by the milk producers themselves. In addition to this all the facilities related to milk production and procurement are provided at farmers door steps. The ' anand pattern in three tier system i.e. village Cooperatives, District Unions and state Federation.

The basic unit in the Anand pattern is the Village milk producers co-operative—a voluntary association of milk; producers in a village, who wish to market their milk collectively. All the village milk producers cooperatives in a district are members of their district Co-operative milk producer's union. Every milk producer can become a member of society. At a general meeting of members representatives are elected to form a managing committee. Which manages the day-to-day affairs of milk collection, and its testing for fat content. Sale of cattle feed etc., Each society also provides Artificial Insemination Services and veterinary First-aid.

A key element in the Anand pattern of dairy co-operative is that all; registered village milk societies are members of a district co-operative milk producer's union which enable them jointly to own a dairy processing ; factory and a cattle feed plant. In order to become members of the union, a registered society must purchase at least one share of Rs. 100/ - and pay Rs. 5/ as entrance fee.

The District Dairy Cooperative unions became members of a cooperative milk marketing federation by Subscribing to it at least Rs. 20,000 each as L share capital. The federation is responsible for evolving and ' implementation of policies on cooperative marketing of all member unions liquid milk and milk products, deciding the product - price mix, ' cooperative provision of joint services and cooperatives ' marketing of technical inputs to members.

AIMS, AND FUNCTIONING OF VILLAGE MILK COOPERATIVE SOCIETY

After the complete survey of the village about milk production and related items, the supervisor / officer from the union organises Gramsabha. If the villagers decides to form society, an organiser is selected from amongst them. The organisers is authorised to collect the share money @ Rs. 101 each for share subscription and Rs. 1/- for entrance fee from all the milk producers who are interested in society will be registered with dept. of cooperation. One member will be elected as chairman and he appoints secretary who will look after day to day work.

Functions and Activities of the Society

The basic unit of Anand Pattern structure is village milk producers cooperative society. The Functions of a society can be classified in to:

- Managerial
- Operational and
- Input services.

*Managerial:*All the members of the society form the general body of the society which has supreme power, The society has managing committee of 9 members elected from amongst of member producers. The committee employs paid staff to run the day to day affairs of the society and this number of staff depends upon the size of the business. One third members of the committee retire every year by rotation. The rotational retirement helps bringing new faces and continuity in the management The chairman is elected every year in the management committee meeting. The committee decides policy matters and frames guide lines for efficient running of the society. The committee holds its monthly meeting to discuss issues pertaining to society, producers, guidelines provided by the union etc.

Operational: It can be classified into two groups.

a) Milk Trading

b) Marketing of inputs

a) Milk Trading: This involves the following works

1. *Reception of milk:* Milk is received from the producers both morning and evening. Sample of milk is collected for testing.
2. *Testing of milk:* The individual samples are tested for fat and SNF and recorded sample from pooled milk and tested.

3. *Dispatch of milk:* All milk cans are covered tightly by lids. Filled milk cans are loaded on the hired l own truck and empty cans are unloaded for society use for next milk collection.
4. *Payment for the milk:* The price of milk remains uniform throughout the district irrespective of village distance from union head quarters. Both quality and quantity for the basis for the payment. Price chart will be supplied by the union. The society pay the producers morning milk price evening and evening milk price next day morning.
5. *Accounting:* Separate account books are maintained for different transactions and the relevant postings are made on the same day of operation. A person from the same village is appointed as internal auditor to check the account.
6. *Distribution of profits:* The society from its profits distribute bonus to the producers in proportion to the value of milk supplied by g the year.
7. Other duties like sample milk disposal, local sales of milk, standardisation of testing equipment and chemicals etc., will all be undertaken.

Put Services

1. Providing artificial insemination services
2. Providing veterinary first aid.
3. Society purchase cattle feed from the union and se-Us it to the producers in retail at cost or subsidised.
4. Provides quality fodder seeds to the producers at cost or subsidised.
5. It also distributes news letters. Educational material, meetings organisations, tours to dairy plant, cattle feed plant etc.
6. It will also helps in cattle insurance and some strong societies will give subsidy on insurance of cattle.

STRUCTURE AND ACTIVITIES OF DISTRICT MILK UNION

Once sizeable number of societies (40 - 50) are organised and registered in a milk shed, the district level milk union can be started. The chairmans of all village milk cooperative societies forms are the members of the district milk producers unions. In order to become members of the union, a registered society must purchase at least one share of Rs. 100/ - and 5 /- as an entrance fee. They hold the meeting and resolves the formation of District Cooperative milk producers union. The union registered with the cooperative department. They elect the board of directors who will inturn elect chairman. One third of elected board members retire every year by rotation. Each district union is professionally managed by a managing director who reports to the elected chairman arid board of directors. The number of board of directors will be sixteen to seventeen of which* twelve are democratically elected from amongst the representatives of the village societies. The remaining five comprise managing director as a member secretary, one or two representatives of the financing institutions, a representative of-the registrar of cooperative societies and a representatives of the Federation. These five numbers are not eligible for contesting to the post of chairman. The general policy for the union is framed by the board. The board employees the managing Director/General manager, but his removal will be done by only general body. The board determines the number, type and scales of the posts and managing director/general manager makes appointment.

Functions and Activities of the District Milk Producers Union

In general union carries five important functions.

1. *Procurement of milk:* Milk will be collected from all the member societies of union by engaging hired vehicle. Different routes are framed to cover the societies so on to enable the milk to reach the union plant within reasonable time.

2. *Processing and marketing of milk and milk products:* The milk is processed and liquid milk is marketed in all demand places within the union milk shed area. Different milk products are produced and kept in sale through own or distributor outlets.

3. *Providing technical inputs:* The union appoints veterinarians who will provide Artificial insemination services, treatment of diseases etc. on free cost or charging subsidised rates. Emergency services will be provided. Liquid nitrogen will be supplied regularly to field AI Centres. Supply of feeds and fodder seeds to village societies on cost or subsidised rates. Establish the dairy and fodder demonstration farms.

4. *Strengthening of milk cooperative movement:* The union will formulate the strategies for strengthening of cooperative, in-dairy industry.

5. *Organisation of extension activities and rural development service:* Under this field visits will be arranged for milk producers to dairy plant, cattle feed plant, semen production stations etc. so that the producers will get some scientific and profitable methods in milk production. Milk yield competition will be organised to build competition among the producers. Screening of different educational films related to dairying will be undertaken.

6. *In addition to the above:* union carries research and other promotional activities for the over all benefit of farmers. The union owns and operates dairy plant, cattle feed plant, fodder and bull mother farms, semen collection station, head quarters centre

for animal husbandry activities. On the net profit earned by the union, 25% is carried 'to its reserve fund and not exceeding 12 % per annum is paid to the member societies as dividend on their paid up share capital and small contribution is made to education fund. Out of the remaining profits upto 80% is paid as bonus to the members in proportion to milk supplied and remaining for charity, cooperative propaganda and other funds.

ROLE OF STATE MILK COOPERATIVE FEDERATIONS

The district Dairy cooperative unions become members of a cooperative milk marketing, federation. Each union should subscribe at least Rs. 20,000/-as share capital. The federation is responsible for evolving and implementation of policies on cooperative marketing of all member unions liquid milk and milk products.

The federation board consists mainly of the elected chairman of all the all the members unions and the federations managing director. Other members are the representative of Registrar, Cooperative societies; a items are representative of financing agency, nominee of NDDB and one nominee union of the State Government. The members elect a chairman of the board. The board evolves the federation policies on all its functions. Members votes are weighted by the amount of milk procured by each union in the previous year and profit distribution is done him the on the same basis kept in.

The federation board is advised by its managing committee, which is composed of each member union chief executive, the federation chief quality control officer and one or more non voting cooped technical representatives of NDDB. The federation managing director is the committees chairman. The committee meets once monthly and is also responsible for day to day implementation of the board policies and plans. Out of the total profit earned by the federation 25% goes to reserve fund, not exceeding 12% as dividend, remaining as bonus to member unions and little to education fund and research and development.

RECORDS AND REGISTERS IN A MILK SOCIETY

Records to be Maintained

The society will be required to maintain and periodically update a number of records. The records would be in a bend form and initial supply would come from the client organisation. Their subsequent replenishment / replacement is discussed. The records can be classified in the following groups.

a) Organisational records

i) Membership record

- ii) Share ledger
- iii) Proceedings

b) Financial Records
- i) General Ledger
- ii) Cash Book

c) Procurement Records
- i) Milk Purchase register
- ii) Milk test record
- iii) Dairy register
- iv) Sample milk sales record

Membership record

1. *Purpose:* To record the membership details of each member of the primary milk producers cooperative society
2. *Originating form:* The secretary of the society
3. *Authorised by:* The Register, cooperative societies or the managing committee of the society.
4. *Distribution:* One copy to be retained at the society.
5. *Frequency of recording and updates:* Initially at the start of the society, subsequently whenever a member joins the society or levels the society.
6. *Information details*
   - i) Date of joining as member
   - ii) Date of paying in entrance fee
   - iii) Name and Address and member with father's name
   - iv) Age of the member
   - v) Occupation of member
   - vi) Heirs / Nominee's name and address
   - vii) Age and relation of the heir
   - viii) Member's signature or thumb impression.
   - ix) Date of leaving membership.
   - x) Remarks.

Share Ledger

1. *Purpose:* To record the details of shares purchased by each member of the primary milk procedure's cooperative society
2. *Originating from:* The secretary of the society
3. *Authorised by:* The Register cooperative department / Managing committee of society.
4. *Distribution:* One copy to be retained at the society
5. *Frequency of Recording:* Each time a share is purchased / returned / transferred by a member. It is recorded on record for each member.
6. *Information details*
   i) Name of the society
   ii) Name of the share holder
   iii) Date of purchase / return / transfer of share
   iv) Cash book folio no.
   v) The no. of shares issued to member along with serial number of share certificates.
   vi) The number of shares returned or transferred by the member along with serial number of share certificates returned transferred.
   vii) Balance number of shares hold.
   viii) Balance(Rs) deposited as share money.
   ix) Amount returned / transferred to member.
   x) Remarks.
7. *Processing details:* Information recorded here is used in completing individual records.

Bonus and Dividend Registers

1. *Purpose:* Detail of business transacted by an individual producer member over period of the one year.
2. *Organisation from:* The secretary of the society.
3. *Authorised by:* The managing Committee of the society
4. *Distribution:* One copy to be retained by the society Frequency of Recording:
5. *Frequency of recording:* At the end of every month for one year. One record of each member.

6. Information details
   i) Name of producer member and Address
   ii) Period of accounting - from (date and month) to (date and month)
   iii) Quantity of milk supplied and its value. The total for the accounting period to recorded here.
   iv) Rate of bonus declared.
   v) Bonus payable.
   vi) No. of shares held by the producer
   vii) *Dividend payable:* Amount payable is worked out according the number of shares held by the producer.
   viii) Signature of the secretary.
   ix) Signature of receiver on receipt of amount.
7. *Processing details:* Bonus amount and dividend amount payable; milk supplied and number of shares held by all members may be totalled while preparing 1 financial statements and the annual report of the working of society.

Cash Book

1. *Purpose:* To record the daily financial business transactions of the society
2. *Originating from:* The Secretary of the society
3. *Authorised by:* The Registrar cooperative department / Managing committee of the society.
4. *Distribution:* One copy to be retained at society.
5. *Frequency of recording:* Daily
6. *Information details:* This book will have both pages of the register (left and right) for one entry The page on left will have entries for the income (credit side) where all the right side will have the entries for the expenditure (debit side). Every day the first entry on the left side will start with opening balance and will close on the right side with cash in hand. The cash in hand on the close of the particular day should tally with the opening balance of the next day and the total income (total of all credit enters) and total of the expenditures and cash in hand should tally.

For any withdrawal or receipt through cheque the cheque no. and the date is to be entered.

i) Page no

ii) Date and month of transaction.

iii) Ledger folio no. of the head of account.

iv) Head of account and particulars of transaction.

v) Receipt no.

vi) Amount of money spent or received.

vii) Total

COORDINATION WITH OTHER INSTITUTIONS CONCERNED WITH DAIRY DEVELOPMENT

The dairy cooperative societies should have good cooperation with other departments which are fully or partially concerned with dairy development Any society or organisation cannot provide all the requirement. For some requirement it will be dependant on other organisation. Unless the good coordination is maintained with other organisation it is not possible to get the help. The dairy operative societies should have coordination with the following organisation.

1. *Dept. of animal husbandry:* Local veterinarian who is looking after the veterinary hospital is the key man in the maintenance, of health, reproduction and production aspects of the dairy animals. The local veterinarian will protect the health by doing vaccination, treat to the sick animals, maintains reproductive status, do artificial insemination, pregnancy diagnosis and advises on growing of fodder crops. In each mandal animal husbandry extension officer or mandal veterinarian will take animal husbandry activities in that mandal. He will assist in establishment of dairy farms. Animal husbandry department will provide subsidised fodder seeds.

2. *Commercial, Cooperative bank and cooperative societies:* The finance required for dairying will be provided by various commercial cooperative banks, and village cooperative societies. The milk producers cooperative society should maintain good report with these bank, to get loans for all its members. It the society has any dispute with these banks, getting of loan will become difficult.

3. *District Rural Development Agency:* The diary societies should maintain good relation with DRDA. DRDA will operate many rural development programmes i.e. Integrated rural development programme. Draught prone area programme. Small farmers development agency, marginal farmers and agricultural labour development agency, etc., which have dairy development activities. If the society maintains good relationships with DRDA, there is every possibility in getting above schemes, which will have even subsidy of 25-50% depending upon the class of beneficiary.

4. *Cooperative registrar office:* All the cooperative societies of any nature should be registered with cooperative registrar office present in the district head quarters. They will check the accounts and misdeeds if happens, regularly. They have to certify that the society is running as per the rules and regulations stipulated. Any misunderstanding with them creates problems.

5. *Revenue Department:* Most of the relief operations, matters dealing with lands, law and order will be normally dealt by revenue dept. Eg: village Asst. Mandal Revenue Officer, Revenue Divisional officer. Joint collector and collector. Most of the schemes beneficiaries will be selected by the revenue department. So coordination with revenue department is a must.

6. *Panchayat Raj System:* Gram panchayat is the most essential part of the panchayat raj system which is the base level of this system. Any dairy society is formed in the village. This society should fulfil and obey the rules and regulations of the Gram panchayat approach roads, drainage, water, electricity and other basic amenities will be provided by Gram panchayat. Sanitary milk collection can be checked by the Gram panchayat. At mandal level mandal development officer, Animal husbandry officer, Mandal cooperative officer are concerned with the dairy societies. So the dairy society should maintain coordination with panchayat raj system.

7. *Voluntary organisation:* In our country numerous voluntary organisations who are working for rural development. The funds for these organisation comes from abroad and partly provided by the central governments. Some of these organisations are taking up animal husbandry activities. These organisations will select the beneficiaries and provide training with experts on their cost and even bear expenses of farmers during training period. They will establish community fodder crops, for which initial expenses will be borne be them.

INSURANCE OF DAIRY ANIMAL

Insurance is a contract by two parties, where by the insurer under takes in consideration of certain periodical fixed amount called premium to indemnity the other called insured against a certain amount of risk or loss to life or property insured. Cattle insurance has gained importance in recent years. The country is heading for white revolution with introduction of massive cross breeding programme to increase the productivity of the animals. The financial institutions are pressing for security for loans for the purchase of animals, the land less labourer does not possess the necessary property to offer as security. The insurance of animals which are hypothecated to the financial institution is the only security, which encourages live stock loan's.

Inspite of its importance in national economy, cattle insurance has not, gained momentum in the country. The various causes for this are

- Enormous Cattle, population in India
- Cattle ownership is widely dispersed among millions of farmers.
- Low productivity of animals
- Acute shortage of feeds and fodders
- Lack of effective disease control

However increase, of cross breeding, scientific farming and dairy farming, and demand created by lending policy of financial agencies, cattle insurance has popularised. The following four subsidiaries of General, insurance corporation are providing cattle insurance.

- National Insurance Company
- New India assurance Company
- Oriented Insurance Company
- United India Insurance Company
- The premium for cattle insurance is 4% of the cost of animal insured.

Types of cattle covered

1. Milch Cows and Buffaloes
2. Calve/heifers
3. Stud Bulls
4. Bullocks and castrated male buffaloes.

Scope of cover: Policy provides indemnity in the event of death of insured cattle due to:

1. Accident (Inclusive of fire, lightning, flood, cyclone, famine)
2. Surgical operations.
3. Strike, Riot, Civil commotion.
4. Diseases, contracting or occurring during the period of policy, and shall be subject to exclusion as under:
    1) Theft and clandastive sale
    2) Partial disability
    3) Wax, inclusion

Age group covered

1. Milch cows 2 years (or age at 1" calving)
2. Milch buffaloes 3 years to 12 years.

3. Stud bulls 2 years to 8 years.
4. Bullocks 2 years to 8 years.
5. Indegeners Cross bred / Exotic female calves heifers from 4 months upto the date of 1st calving.

Premium rate

1. Cattle owned by individuals / institutions / Bank financed
2. Bullocks and male buffaloes
3. For all dairies operating under NDDB all over India

For extra covers and premium

1. Relaxation of maximum age limit for

Milch cattle and small bulls	By one year 0.5% Extra premium By 2 years 1.00% Extra premium.

2. Permanent total disability cover 1%.

   Under IRDP: Premium 2.25%

Claims: After the death of animal, the insured has to furnish duly, completed claim form and certificate of death given by qualified veterinarian for animals covered under market agreement scheme. In case of IRDP project cattle, claimant has to furnish information in the following forms:

i) Duly completed claim form.

ii) Certificate of death given jointly by any two of the following:
   1. Sarpanch of Village.
   2. President or any other officer of co-operative credit society.
   3. Official of milk collection centre.
   4. Supervisor / inspector of Central co-operative, bank.

iii) Post martem report if conducted.

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Economics of Dairy Marketing

The word 'market' comes from the Latin word 'Marcatus' which means merchandise or trade or a place where business is conducted. The various definitions for market are. A market is the area within which the forces or demand and supply coverage to establish single price.The term market means not a particular market place in which things are bought and sold, but the whole of any region in which buyers and sellers are in such a free intercourse with one another that the prices of the same goods tend to equality, easily and quickly.

Market means a social institution which performs activities and provides facilities for exchanging commodities between buyers and sellers) Economically interpreted the term market refers, not to a place but to a commodity or commodities and buyers and sellers in free inter course with one another.A market exists when buyers wishes to exchange the money for a good or service are in contact with the sellers, who are willing to exchange goods or services for money.

COMPONENTS OF DAIRY MARKET

For a market to exist, certain conditions must be satisfied. These conditions should be both necessary and sufficient. They may also be termed as the components of a market.

1. The existence of a good or a commodity for transactions.
2. The existence of a buyers and seller.
3. Business relationship or intercourse between buyers and sellers.
4. Demarcation of area as people, region, country or the whole of the world.

The existence of project competition or a uniform price is not necessary.

The dimensions of a market are:

1. Location

2. Area of coverage
3. Time span
4. Volume of transaction
5. Nature of transaction
6. Number of commodities
7. Degree of competition
8. Nature of commodities
9. Stage of marketing
10. Extent of public intervention
11. Type of population served
12. Accrual of marketing margins.

CLASSIFICATION OF MARKETS

1. *On the basis of Location:*
   a) Village market—Located in a small village
   b) Primary market—located in big town
   c) Secondary wholesale market—located in district head quarters I important trade centres/near railway stations and 'transactions takes place between villagers and wholesalers.
   d) Terminal markets—From where the produce is disposed to consumers.
   e) Seaboard market—located near seashore for import/export goods.
2. *On the basis of Area/Coverage:*
   a) Local/village markets—Buying and selling activities are confined among the local villages.
   b) Regional market—Buyers and sellers are drawn from longer area.
   c) National market—Buyers and sellers are at national level.
   d) World market- Buyers and sellers are drawn from the whole world.
3. *On the basis of volume of transactions:*
   a) Whole sale market—The commodities are bought and sold in large lots or bulk.

b) Retail market—The commodities are bought and sold to the consumers as per their requirement.

4. *On the basis of number of commodities in which transaction takes place:*

a) General market—All types of commodities are bought and sold

b) Specialised market—Transaction takes place only one or two commodities.

5. *On the basis of degree of competition:*

a) Perfect market—All buyers and sellers are knowledge people and there will be uniform price at any one time.

b) Imperfect market—Where conditions of perfect market are absent. Various types are there as

i) Monopoly market—Only one seller of a commodity monopoly on price.

ii) Duopoly market—Two sellers/buyers only for a commodity they may have some understanding on firm prices.

iii) Oligopoly market—More than two sellers of a commodity.

6. *On the basis of nature of commodities:*

a) Commodity market—Dealings -with goods and raw materials

b) Capital market—Dealings with bonds, shares etc.

7. *On the basis of nature of transactions:*

a) Spot or cash market: Goods are exchanged for money.

b) Forward market—Purchase and sate of a commodity will take place at time and exchange of the commodity takes place on some specified date.

8. *On the basis of Time span:*

a) Short period market—Market exists for short time/season.

b) Long-period market—held for longer period.

c) Secular market—permanent market.

MARKETING PROCESS

Marketing is a science which deals with the disposable of finished product through various channels and services that are essential for the disposal, until it reaches the consumer.Marketing also deals with the supply of raw materials used for the production of a product. It also deals with the working out the demand, fixation price and also producers to increase sales.

Difference of Marketing Milk Compared to Manufactured Goods

1. *Perishability of the product:* Life of milk is very less and so it should be marketed quickly, while maintaining acceptability to the consumer.
2. *Seasonal variation:* During winter (flush) season more milk will be produced and demand will be less, Why are as in summer production will be reduced and demand will be increaser
3. *Bulkiness of milk:* Due to bulkiness of packing and transportation problems.
4. *Variation in quality preference by the consumers:* Some favour whole milk where as others favour toned, double toned or standardised milk.
5. *Small size of holdings and scattered production:* In India still dairy is with small farmers with less number of animals, who are scattered over the village_ and it becomes problems in collection and transportation while maintaining the quality.
6. *Processing:* Milk have to be processed before marketing which increases the price for transportation, plant for processing and distribution costs.

The Services Required for Milk Marketing

1. Timely distribution of monthly milk cards/coupons
2. Distribution of milk at door steps
3. Collection back of bottles (If bottles are used).
4. Receiving complaints.
5. Establishing pick up booths.
6. Appropriate steps to prevent leakage's and pilferages.
7. Effective availability of market people to the consumers.

MARKETING OF DAIRY ANIMALS

Marketing of dairy animals is entirely different from marketing of any other product or items. Animals will be purchased from the popular dairy farms, individual farmers. The price of dairy animals are depending upon the individual animal.' No common price will be there for all animals. At important places animal markets are organised on specified days. The dairy animal owners will bring their animals to these markets which are popularly known as "thandas" or "santha". The animal purchasers will come to these markets and they will select the animals. For getting good price for the dairy animals, the records about the animals, ancestry particulars, production and other particulars. The animals displayed in the market for sale should be walk prepared so that it will give good look and appearance.

- The entire body should be washed to remove dung, dust, or dust using light detergent solution.
- Brushing may be done if the body is too dirty.
- If the hair on the body is lengthy, hair may be clipped.
- Horns are trimmed
- Blanketing: ie. Rubbing the body with blanket or cloth to bright look.
- Trimming of tail hair if too long.

Determination of the Value of the Animal

The value of the dairy animal will be dependent on the following factors.

- Breed
- Age
- Health
- Soundness: Sound body free from excess fat, dairy type, graceful look.
- Condition: Good flesh prior to calving in cows good growth and development in young animals.
- Present production.
- Past production
- Bred or open—pregnant will fetch more
- Calving time: Winter, rainy or summer. The time of calving which buyer needs gives more price.
- If pregnant service sire
- Ancestry
- Type and confirmation
- Typical of breed, good capacious udder, wedge shaped body, good size, chest and barrel well developed and balanced quarters.
- Disposition and others—Quite docile, good temperament, easy milker, free from vices, teats functioning, free from mastitis.
- Expected producing ability—should be high

The seller should furnish data of the animal as given below which serves while selling:

i) Breed

ii) Date of birth

iii) Health condition

iv) No. of lactation completed

v) Current lactation number.

While comparing the production of different animals with different fat percentage, the milk yield should be converted in to 4% or 3.5%. Fat corrected milk by the following formula.

4% FCM = 0.4 x milk production in the lactation + 15 x amount of butterfat in the lactation.

3.5% FCM = 0.4324 x milk production + 16.21.8 x amount of butter fat in the lactation.

The average rate of the animal is generally calculated as follows:

Cow Value = Average Amount of milk yield per day x 2000

Buffalo value = Average Yield of milk/day x 2500

In big dairy farms/research stations, once or twice in a year open auction will be conducted in their own campus. The price of the animal will depend on the competitive bidders.

vi) Average calving interval

vii) Peak yield and day recorded

viii) Total butter fat yield in a lactation

ix) Temperament of the animal

x) Vices in the animal

xi) Physical defects I abnormalities.

xii) Average service period.

xiii) Average dry period.

xiv) Average no. of services/conception.

xv) Age of first calving

xvi) Body weight at first calving

xvii) Major diseases affected so far.

Before purchase of any dairy. animal, its health, and reproductive status, pregnancy should be properly checked by a veterinarian. If the animal is suffering from any reproductive disorders, the animal may not conceive, if at all conceive it may abort.

MODE OF DISTRIBUTION OF MILK

Some factors which helps in deciding the mode of distribution of milk are:

- Keeping quality and kind of milk
- Perishable nature of milk and its products.
- Possible contamination
- Proper supervision and control in distribution
- Cost of distribution/delivery of milk

Distribution of Raw Milk

In planning of temperate climate and in sub-temperate conditions raw milk is distributed directly to consumers. Where carefully milk production is done and a short period lapses between production and consumption the raw milk may be distributed provided the temperature of milk does not go beyond 10°C at delivery.

Distribution of Pasteurised Milk

The deterioration of quality of pasteurised milk is mainly due to post pasteurisation contamination. The pattern of its distribution to public is affected by "the following factors.

1. Buildings density in particular locality
2. Topography of the area
3. Number of customers
4. Distance of the area from dairy plant
5. Temperature of milk at delivery
6. Type of delivery vehicles
7. Shop distribution vs home delivery

Containers for Milk Distributions

1. Dispensing in sealed cans.
2. Dispensing in bottles
3. Distribution by polythene bags or tetra packs

System of Distribution of Milk

Sound system of milk distribution is essential for:

a) Efficient well organised retail marketing of milk.
b) Simple, convenient for both farmer and customer.

There are three systems of distribution:

1) *Cash and carry system:* The customers are required to pay the cost of milk to venders of the time of delivery of milk.

Merits

Maintenance of account of sale proceeds of milk is easy:

- Commission of venders can be calculated easily and promptly
- Account of each calendar month can be closed in time.
- No extra cost involved in printing coupons/cards.

Demerits

Handling of huge amount of coins and currency is a problem

- Daily counting of money is cumbersome.
- Risk of embezzlement of money by venders
- Chances of loss of money due to theft or pick-pocketing.
- Non availability of coins poses difficulty for willing customers in purchase of milk.

2. *Coupon system:* In this system a set of coupons is issued to the customers on advance payment. Customers receive milk in exchange of coupons and purchase new booklet of coupons when they run short of it on advance payment.

Merits

- Chances of loss of money are eliminated

- Money on dairy farm is received much in advance which can be profitably utilised.
- Sale of milk in uniform even at the end of month.
- Counting of coupons is not cumbersome.

Demerits

- Value of unredeemed coupons cannot be ascertained easily.
- Account of sale proceeds of milk at the close of calendar month cannot be as clear.
- Chances of recirculation of redeemed coupons.
- Forged printing of similar coupons is eminent.

3. *Card system:* Milk cards are printed and sold to customers on advance payment. Validity of milk cards is limited to a month. Date of issue is not fixed but expiry of all sold cards is fixed. Customers who could ,not take milk for a day or days together are liable to get the cost of milk refunded. Immediately after supply of milk is made the quantity of milk is noticed at the back of card on each date. Card can be issued from the office of the dairy officer. One day time is allowed for customer to register. At the time of issue of card timings of milk delivery are notified. Usually yellow cards are issued for cow's milk and blue cards for buffalo milk.

Merits

- Cost of milk is received in advance which can be utilised advantageously.
- Trouble of dairy counting of money/coupons eliminated.
- Market of milk is assured.
- Chances of loss of money eliminated.

Demerits

- Refund for non supply of milk causes great inconvenience to both customers and organisation.
- Monthly accounts of actual sale proceeds of milk cannot be closed on account of refund.
- Vendors and booth men may sell out milk to non-bonafide customers other than card holders.
- Printing and issue of cards and refund involves ,a good deal of labour and time.
- Customers have to pick up milk only from assigned places.

4. *Push button mini dairy:* This is designed or installed on NDDB designed coin (TOKEN) operated milk vending machine, popularly known as "push mini dairy". The milk holding capacity of these machines varies from 1000 to 3000 litres each. The consumer is expected to bring his/her own containers large enough to hold the milk required by him/her.

For marketing of liquid milk, a market survey should be conducted about the following items

1. Total liquid milk demand.
2. Complaints about the competitive product
3. Type of milk the consumer prefer, i.e. Toned milk, Double toned milk, standardised milk, whole milk, low fat milk etc.
4. Income details of the consumers.
5. Selling points which will be more convenient to maximum people and trustworthiness on the seller.

After getting the survey results, the areas are divided into number of zones. In each zone milk distribution/selling points are located.

Points to be considered in marketing of liquid milk

1. Depending upon the income of consumers, type of milk should be prepared.
2. Depending upon the need, the size of pocket ie.. 200 ml , 500 ml, 1 litre etc. should be prepared.
3. The pick up/selling points should be convenient.
4. 24 hours availability of milk, will definitely increase the sales.
5. Receiving complaints about leakages, quality, availability, price, timings should be taken and necessary prompt action may be taken.

STRATEGY FOR MARKETING OF MILK PRODUCTS

For marketing of any product the following steps are followed.

1. *Market survey:* Marketing of any product requires market survey to produce a product. The market survey for the marketing of milk products should be based on the following points.
   a) Economic status of the people in the area.
   b) Purchase power of the people for the milk products.

c) Present consumption of different milk projects.

d) Packing size required:

e) The competitors in the market.

f) The price and offers of the competitors.

g) No. of dealers/retailers required.

h) Details of already established distributors/retailers.

i) Consumer's growth.

Marketing survey people will be appointed or survey work may be given to some firm to get the information about the above information.

2. *Market measurements:* By analysing the above demand and position can be analysed as followed.

   a) Present demand and supply of the product.

   b) Price existing.

   c) No. of consumers with quantity required in each area.

   d) Packing size required in area/consumer will.

   e) Effective distribution channels/sellers

   f) Weakness in competitors products

   g) Services given by competitor/service required.

3. *Selection of product:* After making survey and analysing the data of product which are in demand are selected the availability of raw materials (milk) and price of collection will be surveyed and these are favourable manufacturing of the products will be started.

4. *Price of the product:* Price of the product will directly influenced on the marketing of any product. The' price of the product will calculated as follows.

   a) Calculating the cost of production of the product.

   b) Distribution cost (Transportation cost) (1-2% of the product)

   c) Distribution margin (2-3% of cost of -product)

   d) Retailer margin (5-8% of the cost of product)

   e) Marketing expenses (sales personal) (1% of cost of products)

f) Advertisement expenses (2-5% of the cost of the products)

g) %.of profit desired. Generally aid at 10% .

While estimating for profit it should be reasonable. The reason for aiming a reasonable profit are:

1. It will prevent entry of competitors into the market.
2. It will project a favourable public image. Brand name image.
3. It will restrict the trade union demands.
4. It will maintain customer good will by getting reasonable quality at reasonable price by giving service facilities.

After calculating the production cost (including marketing, advertisement) the following price method is followed. I.e. 0 market method which is the price of the cost of production or competitors price or market + in which price is fixed above the production cost or competitors price or market—less than production cost or competitor price.

For a new firm, to compete the competition the products should be sold at market -ve price to get market share. After entering into market slowly switch over to market 0 and afterwards to market + price.

Forecast the sales volume of the product in the -market depending of the preliminary market survey and fix the target.

MARKETING STRATEGIES TO ACHIEVE TARGET

The marketing strategies are:

a) Appointing sates officers/marketing people to promote sales.

b) Advertisements in the form of pamphlets wall posters, holders and even in electronic media.

c) Offering discounts/offers.

d) Attending the complaints or any service required.

The marketing expenses will be high in the initial stage. One should not bother about initial marketing expenses. It is very difficult to enter in competitive market. Once the product is entered into the market, growing in market share will not be a problem.

REVIEW OF POLICIES

After entering into the market and gaining customers faith about the quality and services, the prices may be slowly increased and it should be comparable with the competitors price. Within a short time the price may be fixed to market + price .

SOCIAL ACTIVITIES

To gain confidence of the customers, some programmes in the localities of the people may be sponsored like cultural programmes, games and sports, offering scholarships to meritorious students, maintaining parks, roads, school etc. For these functions company logo can be utilised for sponsoring which will help in increasing the sales.

Marketing Systems

Producer—consumer

The producers directly sell the products to the consumer. No middle man in the marketing. In this any problem arises, the producers will get direct information, he will solve the problem immediately.

Producer—retailer--consumer

The producer will supply the products directly to the retailers, who will in turn will sell the products to the consumers. If the .business terms between the producers and retailers, he will take lead role in marketing. If any sales promotion benefits in the form of gifts, cash etc., will give boost to the retailer to improve the marketing.

ROLE OF ADVERTISEMENT FOR MARKET PROMOTION

In modern marketing system, there is stiff competition for any item in the market. To compete in the market with competitors advertisement is the main instrument. It is not uncommon in market, that many of the manufacturers spending lot of money on the advertisement. Even, the excellent quality product cannot reach the customer without much advertisement. For new producers lot of advertisement is needed to enter into the competitive market. The various means of advertising for promotion of sales.

1. *Pamphlets, bulletins etc:* Pomplets of different sizes, attractive colours are printed for distribution to the customers. The matter is so framed highlighting the worth of the product compared to other brands of competitors. A comparative statement can be prepare it containing extra quality in the product, keeping quality, effect on health, and under lining the cost comparing with other products in the market. Directly the competitors name or brand should not be mentioned, but only mentioning the other product containing 'x' composition, colour or any specific or separate qualities. The format may be like the character.

   Our products: Competitors/C X C Y C Z etc.

   1. Composition

2. Extra contents
3. Keeping quality
4. Taste flavour
5. Energy
6. Other nutrients
7. Price

In the pamphlet figures, cartoons etc can be printed which will give impression about the product. The running matter should be very less and only highlights should be mentioned. The matter should be in regional or popular language or one side national/ international language and other side regional language. These pamphlets can be distributed to all the houses through newspapers, or appointing boys. The pamphlets can be made available in popular shops or centres.

2. *Posters:* A poster is designed to make a public announcement of a special idea. It includes only a few words with an illustration. To catch the attention of the viewers and to pass a simple message at a glance. It should be attractive, brief and clear. If the poster is attractive, then only the people will look it for a longer time. It should have caption which should be as small as possible. It should be printed in bold letters. If necessary include the picture which can give eye catching to the people. ,Use attractive bright colour. Do not use-more than three colours. Normally the background colours mostly preferred as yellow, green, light blue and dark blue. Plenty of space between letters, words, lines and illustrations must be given. The layout of the poster should be well balanced so that viewers eye can smoothly travel. The style of giving message should be dependent on the type of customers, who will be customer.

3. *Holders:* Holders are permanent boards made of iron and placed on elevated heights with the help of strong stands or located on the top of the buildings. The advertising material is painted or poster is pasted to the board. These holders are place in important junctions or on highways or busy centres. Lighting facility can be there to facilitate night times. The matter/figures will be almost the same guideline followed for posters. These holders are easily eye catching type and give wide publicity about the product.

4. *News Papers, periodicals and Magazines:* Newspapers, periodicals and magazines are good media for advertising about the product. Most of the people will read newspaper. If not all, most of the people with read magazines and periodicals. If advertisements about the products are given in news papers and periodicals, people

will go through these information and definitely will increase the sales. These, advertisements should be captioned with interesting caption and the information about the product with photograph should give good opinion about the product over competitors product.

5. *Cutouts and banners:* Big size cutouts with product information can be kept at important places. Banners made of cloth or plastic materials containing the information about the products may be arranged facing main roads. These cut outs and banners will improve the sales.

6. *Railways and transport vehicles:* Railway bogies, Buses, lorries and other commercial vehicles can be painted with the information about the product. When the people are waiting for buses and trains, will definitely see the matter and will have some effect on the sales.

7. *Slides in cinema halls:* Slides can be prepared with the information about the products, which can be displayed in cinema halls at the beginning and interval timings.

8. *Electronic media*: In modern era electronic media plays an effective role in advertising about the products. The various electronic media are

   a) *Radio:* Advertisements can be played on radio during break time, before and after any programme. The advertisement programme prepared for radio should be preferably in songs style of popular songs or talk style of very important persons. The audio giving persons have clear and sweet voice.

   b) *Television:* Television advertisements films can be prepared and the advertisement material can be displayed. This can be prepared using popular figures, famous players and athletes or any other important People. These advertisement will have more impact on the people as it is seeing films. The famous personalities will be delivering the matter as they using that product with good results. These Television advertisements can be displayed either in Doordarshan or any con; local channels. The rates for these advertisements depends on the time of display, the programme in which it is displayed.

   c) *Electronic display boards:* Electronic display boards can be displayed in the railway platforms, Bus stations, important junctions, stadiums parks and public places. The features of the product will be displayed as running matter. In electronic media, audio—visuals are more effective than only audio or vedio separately.

9. *Sign boards on the road-dividers or traffic islands:* Sign boards can be placed in the place of road dividers. These boards will be painted with the information.

10. *Appointing advertisement persons:* Appointing advertisement people both men, women who will explain about good qualities of the product, at door step. They will

wear dresses and caps containing information about the product, which will definitely attract the customers. Friendly walk, run on the main roads wearing logos of the company and product will definitely have the impact on sales.

ANALYSIS OF CONSUMER DEMAND AND ACCEPTANCE

The term 'demand' refers to the quantity demand of a commodity per unit of time at a given price. It also implies a desire for whose fulfilment a person has ability and willingness to pay. Mere desire of a person to purchase or to consume a commodity is not his demand. He must possess adequate resource and willingness to pay for the commodity. The term demand for a commodity has always a reference to "a price" a period of time and 'a place' without these no meaning for demand. The term 'market' may refer to a particular section of consumers classified under age groups, sex, social status, income groups, geographical etc.

Types of Demand

1. *Individual and market demand for a commodity:* The quantity of commodity which an individual is willing to buy at a particular price of commodity during a specific time period, given his money income, his taste it is taste and prices of other commodities is known as individual demand for a commodity. Individual demand depends on price, income, taste and prices of the substitutes. The total quantity which all the consumers of any commodity are willing to but at a given price per time unit, given their on the money income, taste and prices of other commodities is known as "market demand'.

2. *Demand for firms products and Industry products:* The quantity of a firm products that can be disposed at a given price over a time period will be can denotes the demand for the firms product, where as the aggregate of demand for the product of all the firms of an industry is known as demand for industry product. It feels the share of a firm in the total demand for an industry's product.

3. *Autonomous and desired demand:* Autonomous is one that arises boards independent of the demand for any other commodity, where is derived is one that is tied to the demand for some parent product or some other product. The demand which arises directly from the biological or physical needs of the human beings may be considered as autonomous. Eg:Milk Demand that arises out of demand for some other commodity as derived of the demand eg. Cow, feed etc..

4. *Demand for durable and non durable goods:* Durable goods are it and those whose total utility not exhausted by single use and can be used repeated eg. Cloths, shoes; etc. non derivable goods eg. All food items.

5. *Short term and long term demand:* The commodity is demanded AND only over a short period. Eg. Woollen clothes, long term demand which is having continuous demand eg. Cloths.

   Law of demand: Gives the relationship between the price and quantity demand. It states that the quantity demand of a product/unit time increases when the price falls and decreases when the price increases, while other factors are constant. This assumption implies that all other factors include –

   – The income of the consumer

   – The price of the substitute.

   – Complimentary goods

   – Consumers taste and preference are constant.

   Eg: The demand for milk as per the milk is as follows,

2. *Substitution effect:* Any substituted product will decrease the demand.
3. *Utility maximising behaviour:* It can be studied by market surveys. Any commodity will be purchased upto maximum satisfaction.
4. Increase in the population/consumers will increase the demand.
5. Credit facility.

Analysis of consumer behaviour and acceptance: Consumer behaviour in physiological and psychological phenomenon.

Physiological—needs food, clothes.

Psychological—Luxury (false prestige), new modern designs of cloths, shoes etc.

The consumer acceptance depends upon psychology. It depends upon, customs, norms and values of consumers. A change in these factors like religious values, social habits, general lifestyles, age, sex, new fashions will change the behaviour and effects the acceptance by the consumer. The consumer will expert maximum satisfaction with spending least possible price. Some times the demand will be shifted due to

1. Fall in consumes income.
2. Advertisement influence.
3. Price of complimentary goods.
4. Change in the-technology of the products.

The elasticity, of demand is the degree of responsiveness of demand to the change in its determinants like price, income, advertisement, difference between original and inferior goods.

Market survey

Market survey in the survey conducted among consumes about their needs, income, purchase capacity. Present using product, their satisfaction about present products and its supply, their expectation, their life styles etc. Market people will be appointed to get the above information which on analysis gives about the consumes demand and also his acceptance or satisfaction about the product. These surveys are helpful in:

1. Knowing about the consumer demand about a particular product.
2. To know the price of product at which they can afford of purchase.
3. To know consumer expectation and requirements in the products.
4. Any improvement needed for the product.
5. To know any difficulties in distribution and selling persons.
6. To know about the quality of the products when it reaches the consumer.

ROLE OF SALESMAN AND MARKETING PERSONALITIES IN MARKETING OF DAIRY PRODUCTS

Any person who is employed to sell the product is known as Sales man. Now a days the art and profitability of business mainly depends upon the marketing. Any body can prepare any product, but the profitability and survivability depends upon effective marketing. For effective marketing sales -people are necessary. Depending upon the organisation and level of working they are named as salesman, Sales representatives, Sales officer, Marketing representative, marketing supervisor, marketing manager, sales coordinator etc. The art of selling in a person is termed as Salesmanship.

Activities of Sales man

1. He will be in touch with distributors/Wholesaler/retailers regularly to know about the movement of the stock
2. Sales people will approach the important and active people, who will influence others in purchase of particular brand of the product. He will explain with them, about all the good qualities of the product comparing other similar products.
3. Sales people will approach the individual customers, and explain the advantages of their product over other products available in the market.
4. After sales service is an important item in the marketing. The sales people will

highlighten about the after sales services by their company, which is not attempted by other or giving inferior services.

5. He should speak good language without any breaks. His talk should be very impressive and people should be attracted to hear his speech. 6 Directly he should not introduce the product to the consumers. He should give his introduction from which company names etc.
7. He should wish the customers is local and traditional types and he should enquire the welfare of the family members so that the as customers are satisfied.
8. Sales people will take samples of the product with them and they give the live demonstration before them. Which have much effect on the customers. They will carry other company's product with them and compare the qualities before customers.
9. Sales people will try to impress the customers by enquiring children education and giving best schools I colleges available in that area, best coaching centres. They will give best medical facilities available if any family members in sick. Then they will talk about their products.

Skills of a Sales Man

Any sales person should have the following skills to improve the sales of the product.

1. The sales man should wear well fitted and attractive dress and he will use tie and look trim so that he will look active and pleasing personality.
2. First he should start about the necessary of particular product and then he should introduce his company product which is superior than any other similar products available in the market.
3. He should patiently and interestingly hear, what the customers are feeling and he should not directly give controversy over their feeling. He should support their feelings and then slowly tie should tell them that the use of his company product will improve the condition or facilitates further.
4. If the customers offers any hospitality, he should agree for that and he should appreciate the hospitality repeatedly, so they show same inclination towards his product.
5. He should tell some interesting examples in the beginnings or about the famous personalities or jokes or any other interesting topics so that the customers will attract to salesman talks.

6. He should give a sample of the product to the customers and he can challenge about the good qualities of their product.
7. Sales people will attend the family functions, religious and cultural functions so that the customers impression sales people.

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Cost-effective Dairy Feeding Programmes

Dairy cattle require specific amounts of nutrients to support various levels of performance, so changes in feed intake can have a dramatic impact on the formulation of rations and nutrient intake. Dietary nutrient densities are minimised when feed consumption is maximised, making it easier to formulate rations that are adequate in nutrients. The amount of feed that a dairy cow consumes is highly correlated to its nutrient intake. Every effort should be made to maximise feed consumption when feeding dairy cattle. As feed consumption declines, dietary nutrient densities are increased. The higher the intake, the more forage that can be included in a dairy ration and the fewer concentrates that will be required.

The most cost-effective feeding programmes can be implemented when feed consumption is maximised. Maximised feed consumption minimises the cost of providing required nutrients because higher levels of forages and by-product feeds can be incorporated into the ration. When feed consumption is maximised there is more flexibility in the type of feeds that can be used in formulating the ration.

The quality of forage has a dramatic effect on feed consumption. Feeding the highest-quality forage will maximise feed consumption and nutrient intake and minimise dietary nutrient densities, ration cost and the quantities of concentrates that need to be incorporated into a ration. The feeding of roughages containing high fibre and low digestible energy levels is the primary cause of many dairy farms' failure to realise maximum dry matter intake. Higher forage levels also help to maintain a more stable and healthier rumen and reduce the animal's consumption of grain, which can then be put to other uses, including human consumption.

As forage quality declines, the digestive passage rate becomes slower, resulting in a greater fill factor and causing a reduction in feed intake. When low-quality forages have to be fed, they should be chopped to minimise their depressing effect on feed consumption. Care needs to be taken not to chop forage so fine that milk butterfat is depressed by the resulting low effective fibre level.

Every effort should be taken to minimise heat stress so that feed consumption is not depressed. Shade is very important in areas where cows are exposed to high levels of solar radiation. In hot dry climates, applying water or using misters or evaporative coolers can be effective ways of lowering ambient temperatures, cooling cows and reducing heat stress. Circulating air with fans increases evapotranspiration and increases the dissipation of a cow's body heat load. Opening housing facilities to increase air circulation during times of heat stress increases air movement, which will increase cooling and reduce heat stress. Providing a cool water supply can also help to reduce heat stress.

Adequate consumption of water is critical for maintaining feed consumption; there is a high correlation between feed and water consumption in dairy cattle. When dairy cattle are required to consume poor-quality water, water and feed consumption will be depressed. Maximum performance will only be achieved when cattle have ad libitum access to a good-quality water source.

Poor-quality water or an inadequate supply of water will depress an animal's performance more quickly and more dramatically than any other nutrient deficiency. Adequacy of watering space must also be considered. When cows have to wait too long to drink, their water and dry matter consumption are decreased. If water sources of variable qualities are available, the highest-producing cows should be given the best-quality water.

When developing feeding programmes for dairy cattle, the goal should be to maximise feed consumption by trying to minimise the various factors that depress it. When feed consumption is maximised, performance is optimised, and this should be the primary goal of a dairy feeding programme.

VERSATILITY OF DAIRY CATTLE

Dairy cattle are unique in having the ability to convert cellulytic feed resources (forages, by-products, etc.) that are not suitable for human and monogastric animal (swine, poultry, etc.) consumption into a highly nutritious product, which is milk. Milk is high in nutritive value which can be used directly by the people who own the cows, or be sold as a means of generating income. In some parts of the world, as few as one or two cows can provide a substantial source of daily income for a family for an extended period of time, if adequate feed resources are available and the cows are fed and managed properly. Dairy cattle are very adaptable since they have the ability to convert a wide range of feed resources into milk. They can be grazed on a wide range of forages or be maintained in partial or full confinement where they can be fed a wide range of harvested feeds; or crop residues (straw, maize stover, etc.). The manure produced by dairy cattle can also be a valuable resource and is used as either a fuel or a fertiliser in various parts of the world. The versatility of dairy cattle makes them unique among livestock species. They can be maintained in highly productive systems, where feeding and management inputs are very high, and in subsistence-type systems, where inputs are very low. Dairy farming provides a nutritious marketable product without sacrificing the animals.

CONSIDERATIONS FOR DEVELOPING A DAIRY FEEDING PROGRAMME

The ideal dairy feeding programme is one that optimises the use of available feed resources, so that profitability associated with milk production can be maximised. It has often been thought that one ideal feeding programme could be universally applied all over the world, and an example of such a supposedly universal programme would be the maize-soybean feeding programmes that have been developed and used extensively for swine. When maize and soybean meal are the most economic feed resources available, the maize-soybean programme would most likely be the feeding programme of choice but, for various reasons, it has often been used where maize and soybean meal are not the most economic feeds available.

Dairy cattle do not have a standard feeding programme that can or should be universally applied. In fact, dairy feeding programmes need to be customised for individual farms, and ideally for individual animals, so that they can take advantage of the feed resource that are available to individual producers. The feed resources available even to neighbours can vary dramatically: one farmer might have pasture to graze, while the neighbouring farmer does not; another farmer might have hay to feed, while the next farm has only straw. In areas or regions where feed resources are available at similar prices, similar feeding programmes can be used, but even then, if the production levels of individual cows vary, different amounts of forage and concentrate will need to be fed. This means that feeding programmes should be customised to individual producers or regions based on the prices of feeds, the availability of feed resources, the feeds' nutrient content and availability and the milk producing ability of the cows.

Fortunately, some basic nutritional principles can be applied to the development of dairy cattle feeding programmes that allow for a wide range of feed resources to be effectively utilised in the production of milk. The reason dairy cattle are so versatile is that they are ruminant animals and have the ability to convert a wide range of carbohydrate substrates (cellulose, starch, etc.) in their rumen into nutrient sources (volatile fatty acids, microbial proteins, vitamins, etc.) that the cow can then absorb and use to produce milk. A wide variety of feed resources can therefore be fed to dairy cattle, including forages, crop residues (straws), by-products (rice hulls, wheat bran, beet pulp, etc.), silages and concentrate feeds (cereal grains and oilseed meals). In developing countries where traditional feed resources such as forages (alfalfa, ryegrass, etc.) and concentrates (maize, sorghum, soybean meal, cottonseed meal, etc.) are not readily available or not economically feasible for feeding, a wide range of other feedstuffs can be used to provided the nutrients required to produce milk. The challenge in both developed and developing countries is to optimise milk production while using available feeds to provide the required nutrients in the most economic way possible.

When formulating rations, nutritionists have often aimed at increasing the efficiency of production. Simply stated, they have tried to formulate feeding programmes that would convert the highest amount of nutrients consumed by the dairy cow into milk components (butterfat, protein, etc.). Using this approach they have always tried to maximise production, because the higher the production the more efficiently the cow converts the nutrients that it consumes into milk components. As an example of efficient dietary nutrient conversion, three feeding programmes were developed for three milk production levels (40, 20 and 10 kg per day) for a healthy 600 kg cow that is maintained under ideal conditions and has the genetic potential to produce 40 kg of milk (containing 3.5 percent butterfat and 3.2 percent milk protein) a day. Table 1 shows the amounts of nutrients (in terms of total digestible nutrients, net energy of lactation and crude protein) required to support each of the three different levels of milk production, the milk's nutrient content and the percentage of the dietary nutrients consumed by the cow that are recovered in the milk produced.

Table 1. Conversion of dietary nutrients into milk components at three production levels (40 kg, 20 kg, 10 kg)

Dietary nutrient requirements (per cow/day)	*TDN*	*NE*	*CP*
For 40 kg milk/day	16.28 kg	35.3 Kcal	3.766 kg
For 20 kg milk/day	10.26 kg	22.5 Kcal	2.086 kg
For 10 kg milk/day	7.25 kg	16.1 Kcal	1.246 kg
Nutrients contained in milk			
At 40 kg milk/day	6.192 kg	14.592 Kcal	1.280 kg
At 20 kg milk/day	3.096 kg	7.296 Kcal	0.640 kg
At 10 kg milk/day	1.548 kg	3.648 Kcal	0.320 kg
Percentage of dietary nutrients converted into milk nutrients			
40 kg milk/day	38.03%	41.33%	34.03%
20 kg milk/day	30.18%	32.43%	30.72%
10 kg milk/day	21.35%	22.66%	25.71%

Table 1 shows that a cow producing 40 kg/day of milk converts an average of 38 percent of the dietary nutrients it consumes into milk components, compared with an average of only 23 percent for a cow of the same weight producing 10 kg/day of milk. There is an improvement of approximately 40 percent in feed nutrient utilisation efficiency between the 40 kg and the 10 kg milk production levels. It is often assumed that maximising a dairy cow's milk production is always desirable, and the terms "maximising" and "optimising" milk production are sometimes used interchangeably when talking about formulating feeding programmes for lactating dairy cattle. A ration that maximises milk production is one that maximises the expression of the genetic milk producing ability of the cow, while maintaining the health of the animal's digestive system. However, the feed resources available are often not suitable for maximising milk production because they do not contain the necessary nutrients, contain factors that limit nutrient availability or contain substances that cause nutrient intake to be depressed.

When the economics of milking production are being considered, maximising performance does not always equate to optimising profitability. In many situations, available feed resources are not suitable for maximising milk production. This is especially true in developing countries, where it is often not economically feasible to feed concentrates to dairy cattle and, therefore, it is not normally possible to provide the adequate levels of dietary nutrients for cows to express their full genetic milk producing ability. Under these conditions it becomes necessary to formulate feeding programmes that will produce milk in the most economic way and optimise milk production, but not maximise it.

The first question to ask when formulating a feeding programme is whether milk production should be maximised or optimised. If feed quality and price are not limiting, the objective should be to maximise production, while maintaining proper digestive tract health, but when feed quality or price are limiting, the goal should be to optimise milk production. Optimising production means producing the most milk for the least cost using the available feed resources.

Dairy cattle require specific amounts of nutrients to support various levels of performance, so changes in feed intake have a dramatic impact on the formulation of rations and nutrient intake. Table 2 shows the effect that changes in feed intake have on the nutrient specifications for a ration.

Specific amounts of a nutrient are required to support a specific level of performance. The requirements for producing 40 kg of milk are shown in Table 2a. When feed intake declines from 3.7 to 3.3 percent a significant increase in nutrient concentrations is required in the rations to provide the same amount of nutrients. In the Table 2 example, dry matter consumption declined by 2.4 kg (22.2—19.8 = 2.4 kg), which means that the required nutrients have to be provided by 2.4 kg less feed.

Table 2: Effect of intake on dietary nutrient density

	DM	CP	TDN
Nutrient requirements for producing 40 kg of milk	3.76 kg	16.28 kg	
Nutrient density of ration required for:			
DM intake of 3.3% BW	19.8 kg	19.02%	82.2%
DM intake of 3.5% BW	21.0 kg	17.93%	77.5%
DM intake of 3.7% BW	22.2 kg	16.96%	73.3%

The levels of dietary crude protein (CP) required to provide the same amount of CP increase from 16.96 to 19.02 percent, and total digestible nutrients from 73.3 to 82.2 percent. Changes in nutrient density of this magnitude can cause dramatic changes in the composition and amounts of concentrate feeds that need to be incorporated into a ration. Table 2b shows how the composition of the ration changes as the amount of dry matter being consumed changes. As intake declines nutrient density increases.

Table 2a: Nutrient specification of feeds (as percentage of total dry matter)

	CP	TDN
Alfalfa hay, early bloom	18.0%	60%
Maize grain, No. 2	10.1%	90%
For rations with DM intake of 3.7% BW		
Alfalfa 60	16.7 / 30 x100 = 55.7% alfalfa hay	
	73.3	
Maize 90	13.3 / 30 x 100 = 44.3% maize grain	
Total parts 30	22.2 kg	16.96%
At the 3.7 percent (DM basis) level of intake the composition of the ration would be 55.7 percent alfalfa hay and 44.7 percent maize grain.		
For rations with DM intake of 3.7% BW:		
Alfalfa 60	7.8 / 30 x 100 = 26 %	
	82.2	
Maize 90	22.2 / 30 x 100 = 74 %	
Total parts 30		

At the 3.3 percent level of intake the composition of the ration would be 26 percent alfalfa hay and 74 percent maize grain.

In terms of nutrient specifications only, both the rations shown in Table 2b would be satisfactory. They both provide the same amount of nutrients, but are dramatically different with respect to the amounts of forage and concentrate that they contain. The alfalfa level ranges from 55.7 to only 26 percent, and the maize content increases from 44.3 to 74 percent. The forage content of the ration decreases by approximately 50 percent (55.7—26/55.7 x 100 = 53.3 percent) and the concentrate content increases by approximately 40 percent (74—44.3/ 74 x 100 = 40.1 percent).

Table 2b: Cost per unit of dietary energy component (DM basis)

		Content				Cost		
	Cost	DM	TDN	NE	CP	TDN	NE	CP
	(US$/tonne)		(%)	(Mcal/kg)	(%)	($/kg)	($/Mcal)	($/kg)
Forages								
Alfalfa	$60	90	60	1.35	18.0	0.11	0.05	0.37
Wheat straw	$20	89	41	0.96	3.6	0.06	0.02	0.63
Energy feeds								
Barley grain	$105	89	86	1.99	10.8	0.14	0.06	1.09
Maize grain	$120	88	90	1.84	10.1	0.15	0.07	1.35
Maize silage	$25	33	70	1.60	8.1	0.11	0.05	0.94
Wheat millrun	$60	90	79	1.82	17.2	0.08	0.04	0.39
Soybean meal	$240	84	84	1.94	49.9	0.32	0.14	0.60

Unfortunately, however, in order to maintain the health of the digestive tract, when formulating rations for dairy cattle factors other than nutrient specifications need to be considered, such as roughage level. The minimum level of roughage in a lactating dairy cow ration is considered to be 40 percent, so only the ration that is consumed at the 3.7 percent of body weight level would be considered feasible. The other ration would cause digestive problems and would therefore not be suitable for feeding to lactating dairy cattle. This means that it would not be possible to maintain the production level if feed consumption were reduced to 3.3 percent of body weight.

Another factor that should be considered is the difference in the cost of the rations. Typical costs for alfalfa hay and maize grain might be US$60 and US$120 per tonne, respectively. Based on these costs the two rations would have the following costs:

- *Ration 1*
  - Alfalfa $60 x 0.557 = $33.42
  - Maize $120 x 0.443 = $53.16
  - Total $86.58/tonne

- *Ration 2*
  - Alfalfa \$60 x 0.26 = \$15.60
  - Maize \$120 x 0.74 = \$88.80
  - Total \$104.40/tonne

Based on alfalfa hay and maize grain prices the relative cost of each of the rations is computed (\$104.40—\$86.58 = \$17.82/\$104.40 x 100 = 17.07 percent) so the ration cost for the higher intake level would be approximately 17 percent cheaper than that for the lower intake level. Since dry matter intake is different between the rations, actual costs based on different levels of feed consumption are computed: 22.2 kg x \$0.0866/kg = \$1.92/head/day, compared with 19.8 kg x \$0.1044/kg = \$2.07/head/day. So in this example, there would be a saving of 7.8 percent (\$2.07—\$1.92 = \$0.15/1.92 x 100 = 7.8 percent) for the higher intake level. Typically, the cost of the forage component of the diet is approximately 50 percent or less of the concentrate (cereal grain, etc.) cost, so similar savings could be expected to occur. When the price of the forage increases to approximately two-thirds of that of cereal grain there would be no difference in the feed cost. The higher the dry matter intake level, the higher the amount of forage that can be used in the ration. Higher forage levels also aid in maintaining a more stable and healthier rumen and reduce the animals' grain need; the surplus grain could then be put to other uses, including human consumption. As feed consumption declines, the proportion of concentrate required increases, and this is a major cause of concern as regards the health of the digestive tract and in countries where the cereal grain supply is limited.

When least-cost rations are being formulated the first computation that is done is the relative cost of the nutrients provided by the available feedstuffs. Table 2b is an example of what the prices of various nutrients that are provided by feeds would be, based on typical prices.

In most situations, dietary energy and CP cost the least when they are provided by forages, so maximising the amount of forage in a ration, while still providing the other required nutrients, will usually minimise the cost. Typically, least-cost computerised ration formulation systems rank feedstuffs in terms of costs to provide a certain amount (1 kg, 100 kg, etc.) of a specific nutrient (total digestible nutrients, CP, calcium, phosphorus, etc.). Feeds are incorporated into the formulation on the basis of this ranking and starting with the least expensive source of a given nutrient. When the nutrient costs of forages and concentrates are similar, the cost of providing nutrients will not change as much as when feed intake is reduced and the ration needs to be reformulated.

In many developed and developing countries, energy often becomes cheaper when cereal grains are used. If the supply of cereal grains is limited and has to be used for human consumption (as is the case in some developing countries), such price considerations become irrelevant and the use of forages and locally available by-products will need to be maximised in dairy feeding programmes. The higher the feed intake, the more the forage that can be included in a dairy ration and the less the cereal grain that is required.

REGULATION OF FEED CONSUMPTION

The mechanisms involved in feed consumption and appetite regulation are complex. The following summaries briefly describe the factors that are involved in the regulation of feed consumption in dairy cattle. The two most important factors for dairy cattle that are not under any type of stress are the physiological and the chemostatic regulatory mechanisms of feed comsumption.

Physiological regulation normally occurs when less digestible feeds, such as low-quality forages or bulky feeds (hulls, etc.) are being fed. Chemostatic regulation occurs when less bulky feeds that contain higher digestible nutrient contents are used.

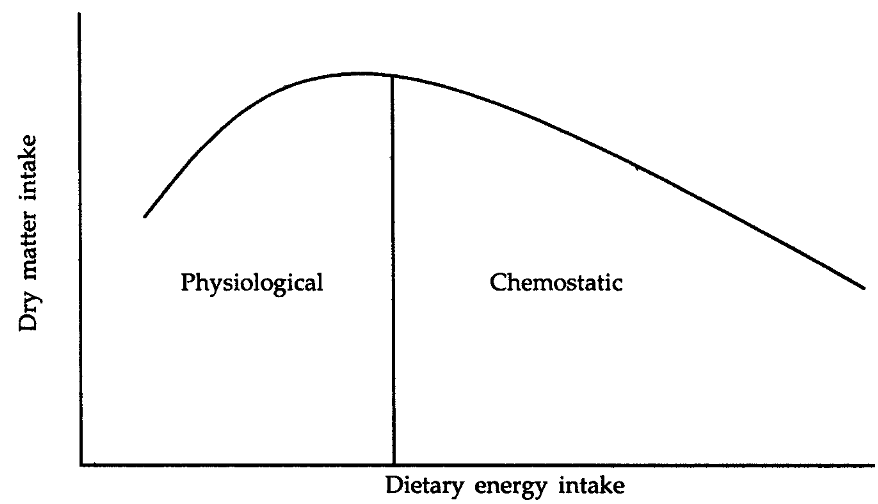

Figure 1: Regulation of Feed Consumption

Physiological Regulation

Physiological regulation is based on the volumetric capacity of the digestive tract, in dairy cattle this specifically relates to the capacity of the rumen. Sensors located in the rumen of the dairy cow sense when the rumen is distended (full), at which time a signal is sent that causes the animal to stop consuming feed. This type of regulation occurs with feeds that contain low digestible nutrient densities and are bulky (low weight per unit volume), such as straws and other low-quality forages. Dramatic reductions in consumption occur when these types of feeds are fed. These feeds normally have low digestibilities because they are high in lignin, silica and acid detergent fibre, which depress the digestibility of the nutrients that they contain. Table 3 shows the impact that forage quality can have on dry matter consumption in cattle.

Table 3: Expected dry matter intakes of various forage qualities

	Dry matter intake (% of body weight)
High-quality hay	2.5 to 3.3
Medium-quality hay	1.5 to 2.5
Low-quality hay	1.25 to 1.75
Straw	1.0 to 1.5

As forage quality declines, the digestive passage rate becomes slower, resulting in a greater fill factor and causing a reduction in feed intake. This same type of reduction in feed intake also occurs when low-bulk density feedstuffs are mixed into complete rations. In most cases, physiological fill is a factor only when dairy cattle are being fed very low-quality feeds.

Chemostatic Regulation

This mechanism functions when blood levels of specific metabolites rise, sending a signal that causes the animal's appetite to be depressed. In the case of dairy cattle, volatile fatty acids are the metabolites that cause the signal to be sent; a few hours after a cow has consumed a meal, the volatile fatty acid levels in the rumen start to rise as a result of rumen fermentation of the ingested substrates. The dietary digestible energy levels are directly related to the amounts of the metabolites that are produced. Peak volatile fatty acid production normally occurs in the rumen two to three hours after a high-concentrate (high in readily available carbohydrates) ration has been consumed and four to five hours after a high-forage (high in cellulose) ration has been fed. The volatile fatty acids that are produced in the rumen are then absorbed and the levels in the blood rise. Once a certain level of volatile fatty acids in the blood has been reached, the appetite of the animal will be depressed. The volatile fatty acids are continuously absorbed and metabolised by the cells, so when the blood volatile fatty acid level declines the animal's appetite will increase again.

RELATIONSHIP BETWEEN NUTRIENT CONSUMPTION AND MILK PRODUCTION

The amount of feed that a dairy cow consumes is highly correlated to its nutrient intake.

The level of available nutrients determines how much milk a dairy cow is able to produce. The available nutrients can either come from what the cow is consuming in its feed or be taken from its body reserves. If dietary nutrient consumption is not enough to satisfy the nutrient requirements for the animal's level of milk production, the animal will have to mobilise its body nutrient reserves in order to provide the missing nutrients. The nutrient reserves that an animal normally mobilises are energy (fat) and protein (tissue). When this happens, the animal loses body weight, which is normal in high-producing dairy cattle. The combination of nutrients provided by the diet and derived from body reserves must be sufficient to supply the required nutrients for the amount of milk being produced. If adequate nutrients cannot be derived from these two sources, the cow will reduce its milk production to match the available level of nutrients: nutrient input (diet + body reserves) = output (milk + body composition). When cows are being fed at a high nutrition level but do not have the genetic ability to produce the amount of milk that their feed would allow them to produce, they will deposit the excess energy that they consume as body fat, thus gaining weight. Care therefore should be taken to ensure that the proper amounts of nutrients are provided to support the level of milk production that a cow is genetically capable of producing.

Table 4: Dry matter intake in dairy cattle of different weights and milk production rates

Milk production	*Dry matter intake as percentage of body weight for*				
(4% FCM) (kg/cow/day)	*400 kg cow*	*500 kg cow*	*600 kg cow*	*700 kg cow*	*800 kg cow*
10	2.7 (10.8)	2.4 (12.0)	2.2 (13.2)	2.0(14.0)	1.9(15.2)
15	3.2 (12.8)	3.0 (15.0)	2.6 (15.6)	2.3 (16.1)	2.2 (17.6)
20	3.6 (14.4)	3.2 (16.0)	2.9 (17.4)	2.6 (18.2)	2.4 (19.2)
25	4.0 (16.0)	3.5 (17.5)	3.2 (19.2)	2.9 (20.3)	2.7 (21.6)
30	4.4 (17.6)	3.9 (19.5)	3.5 (21.0)	3.2 (22.4)	2.9 (23.2)
35	5.0 (20.0)	4.2 (21.0)	3.7 (22.2)	3.4 (23.8)	3.1 (24.8)
40	5.5 (22.0)	4.6 (23.0)	4.0 (24.0)	3.6 (25.2)	3.3 (26.4)
45	–	5.0 (25.0)	4.3 (25.8)	3.8 (26.5)	3.5 (28.0)
50	–	5.4 (27.0)	4.7 (28.2)	4.1 (28.7)	3.7 (29.6)
55	–	–	5.0 (30.0)	4.4 (30.8)	4.0 (32.0)
60	–	–	5.4 (32.4)	4.8 (33.6)	4.3 (34.4)

The feed consumption of dairy cattle changes as their productive status changes. They consume different amounts of feed during different stages of their lactation cycles, and different amounts when they are dry and not lactating. For example, dry matter consumption for a 600 kg dry cow that is 40 to 60 days from calving is 9 to 12 kg; when the same cow is ten to 15 days from calving, it will consume 11 to 13 kg of dry matter; rising to 24 to 27 kg when it is producing 45 kg of milk. When the milk production of a dairy cow increases, its feed consumption also increases. Table 4 shows how dry matter consumption increases as body weight and milk production increase. If this did not occur, it would be extremely difficult to formulate feeding programmes that would satisfy the nutrient needs of high-producing dairy cows.

IMPORTANCE OF FORAGE QUALITY

Forage is the most important component in the diet of dairy cattle because of the dramatic impact it has on dry matter and nutrient consumption. The quality and form of forage are two of the factors that have been shown to influence dry matter consumption and milk production in dairy cattle.

Forage Quality

Forage quality can be defined simply as the ability of the dairy cow to digest and utilise the nutrient components provided by the forage source. The higher the content and digestibility of the nutrients, the higher the quality of the forage. The highest-quality and most digestible forage is young herbage, because it contains the lowest amount of structural carbohydrates (cellulose, hemicellulose) and lignin. As a forage matures, its digestibility, rate of digestion and CP content decline, causing the cow to derive fewer nutrients from the forage. A decline in the quality of forage has an impact on the amount of other feedstuffs that the animal is able to consume. The slower passage time of the forage results in a reduction in intake of not only the forage but also other feeds that the animal is consuming.

Table 5: Effect of maturity of alfalfa on its digestibility

Milk production	*Dry matter intake as percentage of body weight for*			
	Digestibility	*Crude protein*	*Acid detergent fibre*	*Lignin*
	(%)	(%)	(%)	(%)
Prebud	66.8	24	23	4
Bud	65.0	22	25	5
Early bloom	63.1	20	28	6)
Mid-bloom	61.3	19	31	7
Full bloom	59.4	17	33	8
Late bloom	57.5	15	35	9
Mature	55.8	13	38	10

The quality of a forage declines as it matures. The primary reason for this arises from reduced digestibility, which is related to increases in acid detergent fibre and lignin. Table 5 shows that, as alfalfa matures, its digestibility and CP content decline, reducing the amounts of nutrients that the cow can obtain from the alfalfa and, thus, also reducing intake. Forage quality has also been shown to have an effect on dry matter consumption (Table 4), especially when low-quality forages are being fed.

The quality of the forage being fed to dairy cattle has a dramatic impact on not only dry matter consumption but also the proportion of nutrients that are being provided by other feedstuffs. Table 6 gives an example of the effect that changing forage quality has on nutrient consumption.

Table 6: Effects of different qualities of forage on forage and concentrate consumption

Nutrient requirements for producing 20 kg/day of milk		
Total digestible nutrients (TDN) = 10.26 kg		
Crude protein (CP) = 2.086 kg		
Dry matter (DM) intake = 16.2 kg		
Specifications for feedstuffs	*TDN*	*CP*
Good-quality alfalfa hay	60 %	18.0 %
Poor-alfalfa quality hay	50 %	13.0 %
Wheat straw	40 %	3.6 %
Wheat bran	70 %	17.1 %
Good-quality alfalfa hay	10.85 kg	
Wheat bran	5.35 kg	
(CP content	2.87 kg)	
Poor-quality alfalfa hay	5.35 kg	
Wheat bran	10.85 kg	
(CP content	2.55 kg)	
Wheat straw	3.61 kg	
Wheat bran	12.59 kg	
(CP content	2.28 kg)	

In the Table 6 example, the amount of concentrate (in this case wheat bran) required to maintain the same energy intake increases from 5.35 kg when good-quality alfalfa is fed, to 12.59 kg when straw is fed. Whenever the quality of the forage declines, the amount of concentrate required to be fed increases, if the same dietary energy level is to be maintained. In Table 6 the amount of dry matter consumption remains constant, but as forage quality declines, dry matter consumption also declines, so even greater quantities of concentrate will have to be fed.

In Table 6, the CP intake ranges from 2.87 kg down to 2.28 kg, which is still above the 2.09 kg minimum required to produce 20 kg of milk. As forage quality declines, the quantity declines and the amount of CP it provides decreases. Lower CP intakes also have a tendency to reduce feed intake because CP stimulates rumen fermentation, which increases dry matter intake.

Normally, 40 percent of roughage is considered the minimum level required when formulating ratios for lactating dairy cattle. The length of the dietary roughage component must also be considered. An inadequate amount of roughage or reducing the length of the roughage, so that there is not enough effective fibre, will cause butterfat depression and, often, digestive problems.

Visual Appraisal of Forage Quality

Visual appraisal of forage can be useful in assessing its quality. The maturity of a forage can be estimated quite accurately by the number of buds, blossoms or seed heads that are present. Proper curing during the haymaking process can be assessed by the colour of the hay. Colour can also be used to assess the extent of nutrient losses associated with leaching resulting from exposure to rain and weather. Bleached forages will have lower vitamin and CP contents. With legume-type forages, the leaf-stem ratio can provide a fairly accurate estimate of the nutrient content of the forage. When there are many leaves, the CP content is high; when there is more stem, the structural carbohydrates content will be higher and the digestible nutrients content lower. The CP content of a forage is closely correlated to its digestibility—the higher the CP content of a forage, the higher its digestibility will be.

Palatability of Forage

The palatability of a forage is affected by its taste (sweet, salty, bitter, acidic), olfactory and textural characteristics. Taste is normally the major factor affecting palatability. Dairy cattle are non-selective consumers and readily consume a wide range of feeds. Almost all livestock show a preference for sweet, so feed consumption can often be increased by adding molasses to a ration. Salt can also be used to increase the palatability of a feed but, once it reaches a certain level, increasing the salt content will depress feed consumption. Palatability can play a role in feed consumption when the animals have a choice, but dairy cattle do not usually have a choice, so palatability is not a major factor in feeding dairy cattle. Palatability normally becomes a factor only when attempts are made to feed spoiled feeds to dairy cattle.

Processing of Forage

The decrease in intake that occurs as a forage matures can be counteracted to some extent by reducing the physical size of the forage (through chopping or grinding), which will allow it to pass through the rumen at a faster rate. The passage rate out of the rumen is based on particle size and density. Small, dense particles are passed out of the rumen more quickly than larger forage particles (most of which are less dense and float), which are retained in the rumen. As the ruminal passage rate increases, exposure to the digestive processes decreases and the overall digestibility of the forage declines but, because more can pass through the digestive tract, the animal will increase its dry matter consumption and the net result is usually that the cow's digestible nutrient intake increases slightly. This is one of the reasons for chopping forages prior to feeding. Chopping is most beneficial when low-quality forages are fed, but forages should not be chopped into pieces that are too small, as this can result in a depression of milk butterfat.

INFLUENCES OF HEAT STRESS ON FEED CONSUMPTION

Heat stress is another factor that has been shown to have a major impact on the feed consumption of a dairy cow. Feed consumption decreases during hot weather and increases during cold weather. Several other factors have been found to be associated with, and have an influence on, heat stress, including humidity, air movement, shade and availability of water.

Temperature and Humidity

Factors that influence the body temperature of dairy cattle can cause stress and have been shown to have dramatic effects on feed consumption. Both low and high temperatures can cause temperature stress and both can have impacts on nutrient consumption and nutrient utilisation. As the core body temperature of an animal increases, the hypothalamus causes the cow's appetite to be depressed. This results in a depression of dry matter intake and can have a dramatic impact on nutrient intake and milk production. The effect that temperature has on feeding consumption is shown in Table 7.

Heat stress has a more dramatic impact than cool stress on feed consumption and milk production. It is not only related to ambient temperature, but also associated with humidity and air movement. When the humidity increases, the cow's evapotranspiration is reduced and the animal cannot cool itself, which increases its core body temperature and depresses feed intake. Temperature alone is not a good way of measuring heat stress, so various heat indexes have been developed which take into account such factors as temperature, humidity and evaporation rate. The rectal temperature of dairy cattle has been found to be one of the best indicators of heat stress.

Table 7: Intake adjustments for different environmental temperatures

Temperature	*Intake adjustment (%)*
> 35 °C, no night cooling	- 35
> 35 °C, with night cooling	- 10
25 to 35 °C	- 10
15 to 25 °C	None
5 to 15 °C	3
-5 to 5 °C	5
-15 to -5 °C	7
< -15 °C	16

The duration of heat stress also influences feed consumption. High daytime temperatures can be tolerated if cooling occurs at night and the cows are able to dissipate the body heat that has built up during the day. The most severe heat stress occurs when both humidity and temperature are high and the night-time temperature does not decrease, so the cows cannot dissipate their body heat. In addition to depressing feed consumption, heat stress has also been shown to have an effect on milk composition. Milk protein percentages have been shown to decrease during periods of heat stress, and some reduction in milk butterfat has also be observed in dairy cattle.

Ways to minimise heat stress

During periods of heat stress cows will consume more water, so an adequate supply of water needs to be provided. Providing a cool water supply can help to reduce heat stress. Cows will consume more cool water during periods of heat stress; although it is not the temperature of the water but rather the additional evapotranspiration that helps the cows to cool. Providing adequate shade will help reduce the cows' uptake of solar heat, and shade is particularly important in areas where cows are exposed to high levels of solar radiation. Cooling the cows with misters and evaporative coolers can also be an effective means of lowering ambient temperatures and reducing heat stress in hot, dry climates. Circulating air with fans will increase evapotranspiration and increase the dissipation of a cow's body heat load. Opening housing facilities during times of heat stress will increase air movement which will increase cooling and reduce heat stress.

WATER QUALITY

Water is one of the most important nutrients that an animal consumes. Numerous important biological processes require water, such as digestion, absorption, transport and excretion of nutrients and metabolites, components of milk, body temperature regulation and cellular metabolism. Death occurs about nine to ten times more quickly as a result of water deprivation than because of feed deprivation. Poor-quality water or the lack of an adequate supply will depresses an animal's performance more quickly and more dramatically than any other nutrient deficiency.

The amount of available water and the water quality are often overlooked when developing feeding programmes for dairy cattle. When the amount or quality of water becomes restrictive, an animal will not perform at the maximum of its genetic potential. If cows are only able to drink once or twice a day, they will produce less milk; and if adequate water is not available or the quality of the water is low, feed consumption will be reduced and performance will be depressed. Dry matter intake has been found to be highly correlated (at a ratio of 0.91) with water consumption.

Factors Influencing Water Intake

Water requirements vary considerably and are related to the type of diet being consumed and the environmental conditions under which the animal is being maintained. At 4 °C, a 545 kg non-lactating cow requires 30 kg/day of water, but at 32 °C the same cow will require 57 to 72 kg of water, depending on the humidity, because of increases in body water losses. The water content of the ration being fed can also have a dramatic effect on the amount of drinking-water that is required. For example, 20 kg of maize silage will provide 13.4 litres of water. In areas where water quality or supply is low, the use of feeds that contain water, such as wet brewers' grains or silage, can be an effective way of increasing milk production. Environmental conditions such as temperature, humidity, wind movement and exposure to sun all alter the water requirements of an animal, as shown in Table 8.

Table 8: Relationship between environmental temperature and water requirements of livestock

Environmental temperature	*Water requirements (kg/kg DM consumed)*
> 35 °C	8 to 15 kg
25 to 35 °C	4 to 10 kg
15 to 25 °C	3 to 5 kg
-5 to 15 °C	2 to 4 kg water
< -5 °C	2 to 3 kg

Performance will only be maximised when good-quality water is freely available. It is important to have an adequate supply of acceptable-quality water available to the animals at all times. Non-lactating cattle consume approximately two-and-a-half to three times as much water as dry matter, and lactating cattle consume 4.5 to 5 kg of water for each additional kilogram of milk produced. When water intake is reduced, dry matter intake will also be reduced, resulting in reduced milk production. Diets that are high in CP or salt increase water requirements further.

Water intake in lactating dairy cattle is influenced by milk production, ambient temperature, humidity, salt intake, dry matter intake and other factors. Elevated environmental temperatures increase the consumption of water because of the increased losses that the cow undergoes as a result of increased evapotranspiration. More water should therefore be provided during periods of elevated temperatures, or feed intake will be depressed. If water quality is marginal, the increase in water consumption can become problematic and consuming more water can put additional physiological stresses on the animals. Animals that do not have access to an adequate supply of water will consume less feed and produce less milk.

Factors Influencing Water Quality

The following factors can effect the quality of the water: alkalinity, total dissolved solids, specific minerals (nitrates, sulphates, etc.), and bacterial or algae content. Alkalinity is a measure of how much acid is required to neutralise the pH of a water supply. "Total dissolved solids" refers to the dissolved inorganic salts that are present in the water supply. Nitrates can be found in water supplies at levels that are toxic to dairy cattle because they are converted to nitrites in the rumen. Sulphates can cause diarrhoea, which will reduce the efficiency of nutrient absorption. A water supply that is too alkaline can cause physiological and digestive problems. Bacterial and algae contamination do not usually affect performance, except when they cause water palatability problems which lead to reduced water consumption. Some algae contain compounds that are toxic to animals if consumed in large quantities.

The most common minerals present in water include chlorine (Cl), sodium (Na), calcium (Ca), magnesium (Mg), sulphate (SO_4) and bicarbonate (HCO_3). The specific minerals that are present in the water depend on soil type and the source of the water. The tolerance of animals to alkaline (dissolved salt) water depends on several factors such as water intake, species, age, physiological condition, season of the year and salt content of the diet.

Several factors should be considered when assessing the quality of an available water source. Generally, water containing more than 1 percent NaCl (common salt) is not considered good quality because this is about the maximum salt content that cattle and sheep can tolerate without decreasing their productivity. If there is a question about the quality of a water source then the source should be tested. Mineral content is important, especially in arid areas. Depending on the type of minerals that are present, up to 15 000 mg/litre (1.5 percent) of dissolved solids may be tolerated by livestock, but normally the palatability of the water is reduced as the mineral content increases and the animal's performance will decline; a good-quality water source should therefore contain less than 2 500 mg/litre (0.25 percent) of dissolved solids.

Table 10: Water quality guidelines for livestock

Mineral element	*Maximum tolerances (mg/litre)*
Macrominerals	
Calcium	1 000
Nitrate and nitrite	100
Nitrite only	10
Sulphate	1 000
Total dissolved solids	3 000
Heavy and microminerals	
Aluminium	5
Arsenic	0.5
Boron	5
Cadmium	0.02
Chromium	1
Cobalt	1
Copper	5
Fluoride	2
Lead	0.1
Mercury	0.003
Molybdenum	0.5
Nickel	1.0
Selenium	0.05
Uranium	0.2
Vanadium	0.1
Zinc	50

Some salts, such as nitrates, fluorine and other heavy metals, may become toxic before the levels that affect palatability are reached. Levels of 100 to 200 parts per million (ppm) of nitrates are potentially toxic and 1 g of sulphate per litre may result in diarrhoea. Other materials that are sometimes found in water supplies and may affect palatability or be toxic include pathogenic microorganisms, algae and protozoa, hydrocarbons, pesticides and many industrial chemicals.

Ways to improve water quality

Water can be derived from various sources—wells, ponds, rivers/streams, springs, etc. The most commonly used source of water for livestock is surface water (streams, ponds, etc.). Rainwater that has been collected and stored can also be a good source of water in some areas. If water sources of different qualities are available, then the highest-producing cows should be given the best-quality water.

The adequacy of watering space must also be considered. If cows have to wait too long to drink, their water consumption and dry matter consumption will be decreased. The drinking-water source should be located near where the animals are being fed; if animals have to go long distances to water they will consume less. In order to achieve maximum performance, water sources need to be available in close proximity to grazing areas or the areas where cows are being housed. Cattle can be prevented from walking and defecating in the water by piping it into watering tanks. Maximum performance will only be achieved when cattle have *ad libitum* access to a good-quality water source.

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7

Economics of Sheep Production

Almost three billion people, or almost half of the world's population, live on less than US$2 per day. More than 1.2 billion of these, or about 20 percent of the world population, live on less than US$1 per day. Poverty is largely, but by no means only, a phenomenon of the rural areas. Effective poverty reduction measures can only be successful if the livelihoods of the rural poor can be improved.

Sheep and goats belong to the group of animals called small ruminants. Small-scale farmers keep small ruminants for both subsistence and economic reasons and, in either role, they generally improve household livelihoods, but they have the capability to do much more. Small ruminants contribute to landless, rural farming, peri-urban and increasingly to urban households by providing food, heat, income, socio-cultural wealth and clothing.

They also make important indirect contributions to households through the use of crop by-products, integration with other farming enterprises, use of household wastes and locally grown vegetation, soil fertility improvements and their roles in the social, cultural and religious aspects of everyday life. In particular they contribute to the empowerment of women and of children who often have responsibility for the management, production and health of small ruminants. At the regional and national level, sheep and goats contribute to supplying markets with food and non-food products with export-earning and import-saving potential.

Small ruminants, such as sheep and goats, fit well into smallholder farming systems. The species of animal reared (sheep or goats or both) in smallholder systems differ by region, country, and ethnic and religious groups. Their grazing preferences enable them to feed on weeds, shrubs and other plants that other species of domestic animals tend to refuse. Their small size means they require less space than larger animals and they are less likely to damage and compact soils. They are easier to work with than large ruminants and are cheaper to buy and maintain. Moreover, under the right conditions, they can be quite prolific, but this fact is not well known. The range of products produced by small ruminants is easy to market because demand is high, yet largely unfulfilled. Although these animals are distributed widely throughout the world, the potential of sheep and goats is often not realised. Policymakers and administration tend to overlook their contributions to the economy, rural and peri-urban livelihoods, the empowerment of women, other marginalised groups and food security. At the household level, they often survive by scavenging, thereby losing a lot of their productive potential. Hence, there are considerable opportunities for small livestock keepers to use their animals more effectively and efficiently, and thus increase their contribution to improved livelihoods, underpinned by a comprehensive range of support services. Hence the aim of this booklet is threefold:

- to highlight the benefits of keeping sheep and goats;
- to identify the key inputs into smallholder livestock systems to improve productivity;
- to identify the range of support services required and the challenges of service provision.

MARKET OPPORTUNITIES

The huge demand that is predicted to arise for livestock products in the first quarter of the 21st century, driven almost entirely by population growth, rising incomes and increasing urbanisation in developing countries, presents an opportunity for small livestock producers. They can exploit these markets in order to increase their income, employment and social development and to improve the sustainability of their farms. Most of the increased demand will be in the larger, and still expanding, towns and cities and this will be of particular benefit to peri-urban farmers. Wherever the farms are located, the successful marketing of products will be critical.

A key factor in any marketing chain, and often overlooked by farmers, is consumer needs and the choices available to them. Producers must provide what is required by consumers, otherwise prices are likely to be low or goods will remain unsold. Although this sounds obvious, it needs to be addressed in order to create more sustainable farming systems. The rise in demand for livestock products is commonly associated with higher levels of disposable income and an increasing level of sophistication amongst consumers. In such a situation, consumer demand for livestock products will increasingly be based on quality as well as supply regularity at a reasonable price. Low prices may not be so critical in success as disposable incomes rise. Successful small farm enterprises will need to know what the market requires and be able to respond to it. Traditional markets may well continue to exist, but these new markets represent a challenge to small farmers who will need to be well organised to capitalise on these additional opportunities. The ability to respond to market demands is an important factor in being able to make the most of new and expanding market outlets. This may be in terms of the type of product required or for the quality standards desired by new consumers of animal products. If small farmers want to respond to such consumer demands they may need to change the species of livestock they keep as well as the products derived from them. They may also need to change the methods of processing and marketing that they typically use. Farmers should be encouraged to adapt their farming systems to meet consumer needs, but will require policy and practical support to enable them to achieve these changes. This may take the form of training, credit, additional services or advice which should be delivered with the target group clearly identified.

While traditional markets in rural areas will continue to be important, more modern outlets including supermarkets are likely to be the prime mechanism for delivery to meet the increased urban demand. In these circumstances, it is unlikely that individual small farmers will be able to respond to demand on their own. The creation of cooperative or joint marketing ventures seems the most likely way forward. These may be owned by the farmers themselves or operated by entrepreneurs with the necessary infrastructure and experience to make them work. Farmer-owned cooperatives have the advantage that the farmers themselves are in control of the operation and will benefit directly from the increased income streams and increased sustainability that will follow.

If farmers lack the skills required to make such an operation work effectively, an entrepreneurial marketing system may be a more ef.cient and effective operation, but farmers will lose control over the pricing and marketing of their products once they leave the farm. Innovative forms of linking producers to markets, such as the formation of strategic alliances between farmers, processors and supermarket chains, are further options to be considered. The nature of the product will influence the type of marketing system needed. Highly perishable products transported to distant markets will require a much greater investment in infrastructure than less perishable products (for example, fresh milk in comparison with salted meat). Integrated marketing chains including food processing and supply to the retailer may be necessary for dairy and meat products. The more sophisticated the supply chain, the more removed farmers are likely to become from the selling process. Although well-trained professional staff may be more effective in such operations, it may represent additional risks to individual small farmers and may make their farms less sustainable in the long-term.

BENEFITS OF KEEPING

Outputs from Small Ruminant Production

The outputs from small ruminant animals can be grouped into products, by-products, and indirect and intangible benefits. Immediate products include meat and milk and their processed products such as cheese, wool and hair (including mohair) and skins and other minor ones. Economic and environmental benefits are derived from dung (which improves soil fertility and structure) and from nutrient recycling. Indirect benefits, representing those benefits that are not the primary purpose for keeping the animals, include weed control. Perhaps of equal importance are the notional outputs of wealth, status, security and the even less tangible social benefits of empowerment, selfesteem, pride and social interaction and inclusion which small stock can engender. In many societies livestock also have religious and cultural significance.

Dietary Contribution of Meat and Milk Products

Small ruminants (as indeed all animals) provide the potential for a more varied and healthier diet than that obtained from a pure crop system. Meat and milk and their processed products provide a more interesting nutritional regime for the household and also supply the minor but essential nutrients (minerals and vitamins) as well as the major nutrients (protein and energy) in the form of fats and carbohydrates.

Animal products that are edible can contribute significantly to the improvement of household health and are particularly valuable for children. Animal products provide the best quality protein in the human diet. Low animal protein intake can result in a high incidence of Kwashiorkor in children (malnutrition caused by inadequate protein intake despite a fairly good total calorie intake), high infant mortality, malnutrition in adults, and a general weakening of the body which predisposes it to disease. A restricted protein intake also leads to disturbances in growth and development in children that extend not only to physical but also to mental development.

The recommended total minimum protein intake for an adult is 85.9 grams daily of which 34 grams (40 percent) should be of animal origin. Animal products supply about 17 percent of the energy and 32 percent of the protein eaten by people. Although there are considerable regional differences regarding the role of animal products in the diet, the main source of future demand will come from developing countries as incomes increase and the demand for a more varied and higher quality diet intensifies.

Meat and Meat By-products

Meat and its products are sources of high quality protein. The composition of amino acids in meat usually compensates for deficiencies arising in staple diets relying largely on cereals. Meat also supplies iron that is easily absorbed and assists with the absorption of iron from other foods, in addition to assisting the absorption of zinc. These products are also rich sources of some group B vitamins.

Milk and Dairy Products

Milk is a fundamental product in human nutrition. It is the neonatal or 'baby' food of all mammal species. The milk of many species of domesticated animal is generally suitable for human consumption. Milk is an important source of dietary protein and calcium, which are important for growth and bone formation. Potassium, phosphorus and trace elements are also present in milk. Milk is also usually a good source of vitamin C, vitamin B12 and some other B complex vitamins (riboflavin and thiamine) and of carotene, which is the precursor of vitamin D.

In many nomadic societies and in many small mixed crop livestock systems, goats and sheep are the major source of milk for the family even though production per individual animal is small. Some people are intolerant of lactose, especially in bovine milk, but many are able to use the milk of other species. Goat milk is often a substitute for cow milk in these cases and is well tolerated by almost everyone.In addition to its value as a food, milk has (and is often considered to have) medicinal properties. In some societies, and for some species of animal, milk is also believed to have magical properties.

Benefits at Household Level

The presence of sheep and goats around the home or garden can provide immediate daily food particularly in the form of milk and its products. Small ruminants not only provide food security through ready accessibility, but they also increase the diversity of food and cash sources and thus reduce the risk that might otherwise be associated with limited food and cash supplies. Small livestock also improve household assets by providing fuel, clothing and additional sources of income. For example, value can be added to meat by preservation and making better use of by-products including the offal for food, intestines for sausage skins and various organs in cosmetics or as traditional or modern medical products.

Women and children are usually the managers, if not actually the owners, of small ruminants. They derive some socio-economic benefits from this activity, not only in terms of access to food and cash (this may be their only source of cash), but also through more subtle changes in their status. This may arise from the empowerment conferred on managers of livestock, and the sense of purpose and cultural identity that may follow, for example, through participating in training and extension activities.

Special Role in Poverty Alleviation

Small ruminants contribute to the livelihoods of all their owners, but particularly to the poor and otherwise marginalised groups including the chronically sick or families that have been affected by sickness. This is achieved by:

- providing food and other products directly to their owners;
- being one of the few assets readily available to the poor thus being crucial in maintaining household survival during crisis;

- acting as an important component of farming systems through increasing the diversity of production, lowering risk, and reducing fluctuations in cash flow especially in harsh environments;
- contributing to environmental objectives and the sustainable use of resources through the effect of manure on soil quality and water retention;
- assisting marginalised groups and the poor to obtain private benefits from common property resources;
- making the difference between survival and abject poverty for various types of producers including pastoralists, share croppers and part-time farmers;
- acting as a readily available 'current' account that can rapidly be sold when short term needs arise for small or medium accounts of cash and as a 'capital' account that can be accumulated for longer term and more substantial needs;
- allowing and encouraging access to social support networks and cultural and social well-being.

Many small ruminants exist on byproducts from crop production, on tree fodder (leaves, twigs and fruits) and on household wastes. The use of these by-products for livestock feed confers a value on them that they would not otherwise have. They also contribute to the production of food and other animal products from what would otherwise be waste. This increases the efficiency of the household and farm system and effectively recycles waste materials.

Benefits to the Farming System

Small ruminants play an important role in recycling nutrients in the soil. The use of crop wastes as feed facilitates the return of nutrients to the soil via the production of manure and urine. However, manure has to be treated carefully. If fresh manure has a high roughage content, micro-organisms will have difficulty in decomposting it, hence there will be a loss of nutrients caused by run-off or volatilisation. It is best that manure is composted over a period of time. This enables the breakdown of roughage and the decomposition of weed seeds that lose their germinative power. Harmful substances in the first stage of decomposition are also eliminated. The careful management and use of manure and urine can result in improved soil fertility, improved soil structure and higher humus levels, thereby increasing crop production.

Combinations of crops and livestock in the same farming system is usually mutually beneficial. This is caused by the recycling benefits mentioned previously, but also in part from the complementary requirements of crops and livestock in many situations. Arable rotations on the farm, relay cropping in the garden, or permanent tree crops frequently include stock grazing on crop material in the field for their deposits of manure and urine.

Input requirements

Where there is the potential for choice of possible uses of resources, small ruminants offer several advantages over many other enterprise options. The needs of sheep and goats are less than for larger livestock:

- the initial cost of the animals is small;
- they can use waste household resources;
- they can be kept near the home;
- they need less feed and water in cut-and-carry systems;
- they often do not require specialised housing;
- they are suited to a scavenging or partly scavenging production system.

Contribution to Peri-urban Livelihoods

The huge increase in the urban populations, many of whom have a rural background and have little cash to buy food, has led to a large number of peri-urban livestock keepers. The systems of production rely more on scavenger grazing, household waste, small gardens, with purchased feed as a source of nutrients. In this environment, farming is not the major occupation or source of income for the family but, nevertheless, the small livestock play an important supporting role.

Sheep and goats contribute to the national economy by, among other things, providing food. The collective contribution of many tens or perhaps hundreds of thousands of producers of small ruminants supply very large numbers of animals to home markets and thereby help reduce imports. These animals, in particular, provide further downstream opportunities for processing industries based on livestock products, such as milk processing or skins. There may also be the potential to export live animals and their products. This is an example of the win-win situation of the small ruminant sector whereby, not only is foreign exchange conserved by home production, but also gained through supplying export demand.

INPUTS TO SMALL RUMINANT

Production Systems

The basic unit of production in all livestock systems is the animal. Selecting or using the best genetic resource for the function the animal is expected to fulfil and for the production environment is of critical importance. The right balance between productivity and health, fitness and adaptive traits is vital. In most farming systems breeds or types have already been developed so that local livestock are adaptable to the local climate, system stresses and productivity requirements. Where natural or man-made disasters have devastated genetic resources or where new production requirements have become necessary, there may be a range of genetic resources suitable for these conditions.

The correct choice is crucial to future success and the correct balance between productivity and 'fitness' must be considered very carefully. The tendency to choose supposedly highly productive animals, while largely ignoring disease and climatic adaptation, is widespread, but the costs of coping with new disease or environmental conditions add considerably to the costs of production. The choice of a species, breed or type that is well adapted to the total environment (climate, management, disease and feed availability) saves considerably on the resources that may otherwise be needed to offset the choice of the wrong animal.

Sources for replenishing stock

All livestock systems require stock to be replaced at some time in the production cycle. It is important to arrange this replacement in the most appropriate and cost effective way. In many situations it is sensible to keep replacements from amongst the offspring produced on the farm. However, sometimes it is necessary to go outside the home environment, and the purchase of stock locally and of the same breed type may well be the 'best practice'.

Care must be taken not to use highly inbred stock that may result from the lack of introduction of new genes into the local population. The 'worst practice' may be the choice of exotic or imported stock because of their high production potential with no regard to their adaptation to local conditions.

Keeping livestock healthy

The maintenance of animals in a healthy state is an important factor in sustainable development. Animal health is a crucial aspect of production and it may also have implications for human health. An animal disease that affects or can be transferred to humans is known as a zoonose; examples include tuberculosis (most often transferred through drinking raw milk) and helminth infections that may involve animals and humans in alternative stages of a parasitic life cycle such as tapeworms.

The availability of affordable animal medicines and the routine (prophylactic) treatment of animals for diseases known to be present in an area are important aspects of livestock management. Hence producers need access to information and knowledge about the correct use of medicines.

Supplying adequate feed and water

A major objective of smallholder systems is to make them as selfsustaining as possible. This means that feeds and water as well as livestock resources are available. It may sometimes be necessary, however, to buy in feedstuffs from outside the farm that need to be appropriate in terms of quality and cost. If the local market does not supply appropriate feed resources, policies should be introduced or orientated towards providing locally grown and processed feed resources at a realistic cost. This will help provide a sustainable system for both growers and livestock keepers. Better still, small stock keepers should be encouraged to grow their own feeds by using such techniques as intercropping, alley cropping, forage and multipurpose trees or local processing of arable crop products. Protein sources such as the byproducts of oil extraction from arable crops could be developed locally and the growing of alternative feed sources should be encouraged.

Careful selection of plant species to provide the right balance of animal nutrients is crucial and might need to take into account the ecology of the rumen. Local roughage and carbohydrates are also important for ruminant systems for which byproducts and residues from arable crops are a useful source.

Grazing as a way of using local feeds

Livestock obtain much of their nutritional need through grazing. Not only are livestock able to harvest feeds that suit their nutrient requirements but they can also:

- harvest material and turn it into useful products that would otherwise be lost to agricultural production;
- use natural grassland or rangeland areas that would otherwise provide little or no economic benefit;
- encourage re-growth of beneficial plant species in pastures;
- discourage the growth or invasion of an area by unwanted plant species;
- maintain landscapes and particular agro-ecosystems in a way that would not otherwise be possible.

Grazing or herding is often carried out communally and in an organised fashion that brings collective benefits to the whole community. However, too many animals on an area may lead to overgrazing. Careful attention should be paid to achieving the correct balance between the needs of the animals and those of the ecosystem, since this is critical to long-term sustainability. In particular situations this may require attention to questions of land tenure and access rights at both local and national levels.

Using local materials to make livestock housing and equipment

Local materials should be used whenever possible. Methods from foreign production systems are not always appropriate and may lead to unsustainable practices if applied without adaptation.

Most smallholder livestock can be kept in buildings and pens made from local materials, such as wood or sun dried bricks, thatch from local grasses and bush poles. These materials are usually cheap and readily available at little more than the cost of farm labour. Indigenous does not necessarily mean basic and the scope for innovation in this area is considerable.

With regard to human health, less traditional materials may be necessary for surfaces that are in contact with food products and may harbour harmful bacteria or other pathogens if they are not cleaned properly.

Labour needs

Livestock can be labour demanding, even in extensive systems if they have to be guarded or herded. In more intensive systems, labour is required for cutting and carrying forage or other types of feed to the livestock each day. Children often undertake some of these tasks, but this may conflict with their formal education requirements.

In addition to feeding and tending animals, a regular supply of labour is required for milking. This is often carried out by women and may be combined with other domestic activities. Care is required to ensure that increased workloads do not conflict with women's other income earning activities or be detrimental to their health. For example, different methods of housing, fencing or tethering can assist in reducing labour requirements.

Preserving livestock products

Many animal products, particularly those intended for human food, are highly perishable. Damp conditions or poor storage lead to spoilage caused by bacterial infection. If the products are consumed immediately within the home, spoilage is not likely to be a problem. However, if they are marketed outside the household it may be necessary to convert them to a product that has a longer 'shelf-life', thus preventing deterioration.

In some areas, meat preservation is common, by drying, smoking or preserving as cooked products. Examples include hams, sausages, dried meat, etc. Refrigeration or freezing may be necessary for some products and is likely to become more necessary as consumer awareness of quality and health increases.

Fresh milk is a highly perishable product because it is an ideal medium for bacterial proliferation and deteriorates quickly especially in hot and unhygienic conditions. Many traditional and modern preservation processes can be employed to extend the shelf-life of milk in fresh form including refrigeration and sterilisation. These can be expensive but the value of the product, both to the consumer and to the health of the nation, justifies the cost. Milk is generally conserved by traditional methods in one of four groups of products: fermented milks; butter and butter oils; cheese and curds; and other milk products. Fermented products are often the result of natural souring; indeed this is such a common product that many people who rely on milk for much of their nutrition prefer soured to fresh milk. Unfortunately sour milk itself is susceptible to spoiling, if kept for long periods, and souring does not kill many potential pathogenic organisms, such as bacteria of tuberculosis.

Whatever method of preservation or transformation is used, all products have a maximum shelf-life, after which they may become unusable. Many processes can be carried out at the household level, but the development of local processing plants, perhaps on a cooperative or group basis is also an option and may be more economic if there is a concentration of production in the local area.

Adding value to livestock products

There are many opportunities at the household level to process edible and inedible livestock products in order to improve the income of livestock enterprises. Value can be added to fresh meat by traditional methods of preservation, including salting, drying and smoking. Under suitable climatic conditions of hot sun and a dry atmosphere, very good quality dry meat can be produced. Simple drying is suitable for small-scale production and avoids the high capital, operating and maintenance costs of more sophisticated equipment. For slightly larger lots simple solar driers, wood .red driers, etc. can be used. Flavour can be added to dry meat by the use of salt and spices.

Smoking is less satisfactory as a preservative method: light smoking delays the onset of spoilage by a relatively short period, whereas heavy smoking, although more satisfactory in terms of preservation, can have severe negative effects on the flavour and nutritional value of the final product. Consequently, smoking is often regarded as an emergency measure and other traditional methods of preservation are generally preferred. Modern methods of meat preservation include the use of refrigeration, for chilling and freezing, and canning.

Milk may be processed into a range of products such as cheese, yoghurt, butter and ghee. In some countries a multiplicity of products is made from raw milk. There is considerable indigenous knowledge about such processes, many of which are commonly carried out at household level. Such activities are valuable and can lead to the creation of products that can be marketed over a much wider distance.Adding value to non-food products can take many forms such as the production of handicrafts, for example: wool may be washed, spun and made into yarns or cloths; animal skins may be cured and made into clothes, belts, bags, shoes, carpets etc.; and animal by-products can be made into candles and soap. If possible, priority should be placed on empowering households to add value and market their own produce. The equipment used should be carefully considered, appropriately selected, and suitable for use by poor households with limited levels of education.

SUPPORT SERVICES

For Small Ruminant Production

Small stock farmers need access to a range of inputs and marketing services. When such services are planned, their long-term delivery and sustainability must be considered. A major aspect of sustainability is the involvement of smallholders, particularly women, in planning and managing the services.

In the past the general situation of extension and farmer support has been a broad sweep rather than a targeted promotion of interventions for particular groups. Livestock producers have usually had less support than crop producers and women are often neglected even though it is frequently recognised that they are extremely important to the agricultural sector and thus the national economy of many countries. The situation has changed in recent years in some areas and special services are now being provided for women producers.

One of the greatest deterrents to the growth of small stock production is the spread of animal diseases that result in a loss of production. The provision of resources to overcome this is essential through supplying appropriate breeds of livestock including exotic or cross breeds, improving levels of feeding, and ensuring timely and focused veterinary prophylaxis or treatment.

Once these aspects of livestock keeping have been addressed, other weaknesses in the sector may become apparent such as poor marketing and pricing arrangements, or the lack of indigenous knowledge. These issues may, however, be addressed more easily once animal health constraints have been overcome or reduced to an acceptable level.

Access to technical and commercial information, loans and credit

Small ruminant producers differ in many ways from keepers of intensive livestock or large stock. Because their enterprises are small, they are not very visible and their needs are often overlooked or underestimated. Many small stock keepers are women and children who are usually excluded from the regular channels of communication.

Consequently, sheep and goat keepers may find it difficult to gain access to technical information concerning livestock, livestock services, loans, credit facilities, savings mechanisms and marketing possibilities. As a result, the likelihood of making a success of their enterprise and achieving the potential benefits of their stock may be limited.

In view of the large number of small ruminants in many countries and their potential contribution to the local and national economy, it is essential that policy-makers address the issues that prevent access to such services by small stock keepers. It may be necessary to make special provision for the delivery of appropriate services designed for the different needs of small-scale livestock keepers.

The provision of services, credit and physical inputs must be sensitive to labour division between women and men in livestock production. Particular attention should be paid to the ability of women to access such services and steps taken to overcome any barriers they may face.

Veterinary services

Each species of small ruminant, country or region has its own set of prevalent animal diseases. Whatever the disease, it must be handled in a cost effective way in order to create the framework in which successful livestock keeping can flourish. This may involve a combination of national veterinary services, particularly for diseases that need a national or even a transnational eradication policy (for example, Rift Valley Fever and Peste des Petit Ruminants - also known as goat plague) coupled with locally delivered interventions.

There are many alternative forms of delivering veterinary services. The traditional approach of government veterinary service, comprising a topdown structure of regional and district offices, has generally been unable to deliver services to local farmers as a result of a combination of inadequate funding, poor motivation amongst staff, and a failure of trust between farmer and veterinarian. More successful health delivery strategies have involved the private sector, the use of para-vets, community animal health workers and pharmacy-based services.

There is no one size fits all solution. Governments need to examine the question of how best to deliver veterinary services to smallholders and should not assume that the historical top-down approach is either the best or the only way. The discussion often centres on the provision of such services by public or private services or by nongovernmental organisations (NGOs) and whether farmers should pay directly for these services.

The main need is often simple prophylaxis programmes that can be taught and delivered at the local level. More specialised veterinary knowledge may be needed in only a small number of cases. In each locality it should be possible to determine what are the most likely disease threats and train farmers and para-vets to deal with them. In view of the close involvement of women and of children in the management of small ruminants, policy-makers and extension managers should ensure that they are provided with training in primary animal health care.

Access to technologies and training

Factors to be considered when determining training needs of smallscale livestock keepers includes whether livestock keeping is a traditional enterprise or has been introduced recently, the choice of animal species, the use of indigenous and modern technologies, whether farmers are settled or migrants, the effects of social changes and new work patterns, market opportunities for livestock products, and the wider issues of community decision-making and community well-being.

Indigenous knowledge should be harnessed wherever it can be found. However, with newer techniques, particularly those associated with processing and marketing livestock and their products, training will be important to the success of such activities. This may take the form of training in techniques suitable for small-scale household use or suitable for somewhat larger but still local processing plants.

Training may be delivered by central or local government agencies, NGOs, private organisations or farmers' groups. The scale and nature of small farm production means that training is more likely to be delivered in a cost effective manner, if it is delivered face-to-face at community level or remotely by radio or television. The design of the training programmes and identification of potential trainees should take account of the gender roles in livestock production. For example, if women are involved in household processing and marketing of small ruminants and their products, much of the training could be targeted at women's groups. Skills development plays a crucial role in the empowerment process.

Input supply chains

Many options for processing livestock products require the provision of specialised equipment or inputs including fresh water, packaging, dyes and other chemicals. Supply mechanisms and the availability of local products are critical for the sustainability of this process.

Markets for produce

Much of the output from small-scale livestock production is consumed in the home or sold or bartered with friends and neighbours. Encouraging and supporting smallholder access to more formal markets is an additional means of generating cash and providing a wider outlet for surplus produce. Products need to be marketed in a reliable and cost-effective way. Assistance may take the form of market information about market opportunities, prices and quality requirements; transaction mechanisms between farmers and buyers; transport to more distant markets; transporting goods to market in smaller or larger lots; product advertising; the use of middlemen, the creation of local markets; and the provision of information to potential buyers about the existence of markets.

The creation of specialised markets, the use of agricultural shows, the setting up of food fairs, as well as the more traditional food markets, are possible outlets for surplus produce. More innovative methods to supply processing factories with bulk produce may be an option worth pursuing for farmer groups. A major factor for a successful operation of this kind is that as much control of the marketing process as possible remains in the hands of local livestock keepers.

Transport

could be a key factor in the success of realising the potential of sheep and goat resources. This relates to transporting the inputs required for processing livestock products as well as transporting the final products to a distant market or outlet. Existing local transport arrangements may be adequate or adaptable to the marketing needs of small farmers. However, there could be special needs for perishable food products including refrigerated containers for milk or meat. Investment in such facilities is critical to the success of the small stock keeper and must be considered in relation to the throughput and sustainability of the marketing operation.

Potential for establishing cooperatives and women's groups

Livestock producer cooperatives and women's groups can provide a range of benefits to members including delivering technological messages, sharing best practices, joint purchasing of inputs, collective value-adding activities, product differentiation through labelling, risk reduction, securing higher prices and economies of scale through collective marketing, and providing access to credit and savings mechanisms.

Food safety regulations

In many parts of the world, the commercialisation of small animal products, such as milk and meat, are becoming subject to food safety regulations which require approved facilities for processing, such as pasteurisation plants or licensed slaughterhouses. As consumers become increasingly focused on quality and safety attributes, it is expected that regulatory frameworks will become more widespread, more stringent and have to be applied more frequently and more rigorously. Under such a scenario, small livestock keepers wishing to market their products must be informed of the food safety legislation that may affect their activities. The national body responsible for food safety is responsible for setting such regulations, generally based on Codex Alimentarius standards, and it also controls their implementation and should give such information to farmers and processors.

CHALLENGES AND OPPORTUNITIES

There are four main technical constraints which work against successful improvements and sustainability in small ruminant production and productivity:

- the genetic potential of indigenous livestock in need of improvement;
- the widespread distribution of livestock diseases;
- inadequate feed supplies and poor animal nutrition;
- poor marketing infrastructure and arrangements.

Non-technical constraints, such as the balance of operations and management between central and local governments, an almost universal absence of clear livestock development policies and strategies, the pace of privatisation and the possibilities of cost recovery for goods and services, are also important factors constraining the development possibilities for sheep and goats.

Further disincentives to rapid development include a lack of rural services and infrastructure, a credit environment unsympathetic to smallholder borrowers, weak financial services, and unclear land tenure policies. Once external funding is withdrawn, the continuity and sustainability of projects is often frustrated by absence of government support and little beneficiary participation in the concept, design and implementation of development initiatives. Capital investment and the provision of recurrent expenditure for livestock development are very often low, particularly in relation to the size and importance of small ruminant populations. In many countries, government support has actually decreased in absolute and relative terms over recent years. Increasing population pressure, uncertain rainfall, declining soil fertility, and traditional techniques continue to inhibit increases in animal output.

Consequently, despite the large number of small ruminants in the developing world, almost nowhere do they produce to their potential. Nevertheless, small ruminants do make a substantial direct contribution to national and household economies, and to food security. High value essential dietary proteins for people are an important output of small ruminants. There is rapidly rising demand for livestock products especially from the urban populations that are escalating throughout the world. For small stock keepers in developing countries, there are specific markets for higher output of food products deriving from domestic animals in areas where the demand is greatest, the cost of production is lowest, and the potential for adding value is most favourable. Increased and more efficient production is therefore very important to overall development.

Small ruminants provide a very suitable base for increasing the supply of animal products. Comprehensive and coherent programmes for development of small ruminant production would seem to be the most appropriate way to confront the complex biological, technical and climatic factors, and associated policy issues with which these extremely useful animals have to contend. There is also the possibility of improving the genetic potential of indigenous livestock for the increased and more ef.cient production of milk, meat, wool and skins. These are areas where, given an appropriate enabling environment, there is likely to be increased producer interest. Current economic policies in many countries now allow for much greater private involvement in agriculture in general. There has been a rather slow private sector response to agricultural and especially livestock investment, because there are alternative attractive short-term opportunities in other sectors (especially transport, tourism and construction).

The challenges to guaranteeing food security and alleviating poverty require sustained increases in production and productivity. Farmers will respond to appropriate incentives, better market access and technology transfer. The possibilities of enhancing farm incomes from a high value product should not be overlooked. Strategic options to improve small ruminant production include:

- prioritising the development of the small-scale and traditional sector;
- continuing to re-orient the role of governments in creating an appropriate enabling environment;
- making more appropriate production technology available through research and extension;
- continued investment in human resources development, especially farmers;
- improving resource management by smallholder farmers;
- increasing beneficiary participation in efforts and rewards.

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8

Economics of Poultry Production

The agricultural subsector of animal production is part of a complex interdependent farming system. Analysis of livestock production cannot be based solely on input and output, but must also take into consideration other farming activities. The interaction between animal production and other subsectors can be complementary, as in the use of manure; or competitive, as in the allocation of land to crops or livestock grazing.

The farming system as a whole, and animal production in particular, is influenced by external factors (including government policy on rural development, livestock development programmes and marketing), which must be considered in any analysis or evaluation.The farming system is defined as the combination of all farm enterprises/ subsystems, management and farmer objectives and the interaction between them. It is a decision-making and land-use unit, comprising the farming household and the crop and livestock systems, which transforms land, labour, management and capital into products that can be consumed or sold.

Enterprises/subsystems are defined as the different subdivisions of the farming system, each producing one kind of crop or livestock product. In the case of family poultry, the products are poultry meat and eggs, with manure as a by-product. The harvesting of family poultry for home consumption and sale can be considered as the management of a standing resource for economic yield. In this respect, the economic principles applying to the management of fauna, parklands, fisheries, wood and timber forests and rangelands are more appropriate than the economic concepts more commonly applied to the labour and capital-dependent livestock production and other commercial farming industries.

METHODS AND CRITERIA FOR COST CALCULATION

The cost of production can be seen from various angles. The inputs may be external (Non-Factor costs) or internal (Factor costs). Internal input is under the control of the farming household, and includes land, labour, management and capital. The cash involved in production represents either Cash (Paid) Costs or Non-Cash (Calculated) Costs. Another way to categorise the costs is to distinguish Variable Costs from Fixed Costs. Variable costs rise and fall with the size of the output and the level of the operation. Variable costs (for items such as feed, vaccine and casual labour) can be controlled to some extent and are not incurred when there is no production. Fixed costs (for items such as taxes, insurance, interest, and depreciation on buildings and equipment), are incurred whether or not there is any output.

The Opportunity Cost principle is applied in farm cost accounting. Opportunity costs can be defined as the "income that would have been generated if the production resource/input/factor were put to the next best alternative use". Many farm enterprises/subsystems yield more than one product. Poultry produce eggs, meat and manure. When calculating the cost-price per unit of production, the cash value of the by-products (sold externally or used as a substitute in another enterprise/subsystem of the farm), must be subtracted from the Total Gross Costs. This will result in the Total Net Costs. For the cost-price per unit of production, the Total Net Costs must be divided by the total number of units of production.

The cost-price calculation model splits production costs into two categories: Paid Costs and Calculated Costs. Paid costs involve actual payment in cash or kind for inputs or services used. Calculated costs are determined using mathematical formulae, and include the following:

- depreciation on the poultry house and equipment;
- interest on cash in hand and personal capital used to construct the poultry house and purchase equipment, birds and feed;
- maintenance of the poultry house and equipment; and
- labour supplied by the farm family.

Calculated Costs include Opportunity Costs as related to the national economy: for example, unemployment and high rates of devaluation of the national currency. These form a part of the socio-economic reality for the smallholder, and influence the Opportunity Cost of labour and of capital. By making use of locally available and renewable materials for poultry housing and equipment, family poultry producers minimise the introduction of external capital into their enterprise.

Large-scale poultry production cannot really be compared with smallholder family poultry, because smallholders often face such constraints as the absence of organised marketing systems and the lack of price rewards for produce quality and uniformity. Therefore, the cost-price calculation for large-scale poultry production may not be applicable to smallholder family poultry systems without modifications.

Elson showed that for layers, production costs increased with space allowance per hen. The minimum stock density allowed in the EC is 22 birds/m^2 (450 cm^2/bird). The production cost for birds housed in laying cages at this density is used as a baseline. The percent increases in cost over this baseline are:

- 5 percent for aviaries;
- 7-12 percent for percheries (tiered wire floor aviaries) at 20 birds/m^2;
- 15 percent for cages at 20 birds/m^2 (750 cm^2/bird);
- 21 percent for deep litter systems at 7 birds/m^2;
- 30 percent for straw yards at 3 birds/m^2;
- 35 percent for semi-intensive systems at 0.1 birds/m^2 (1000 birds/ha);
- 50 percent for free-range systems at 0.04 birds/m^2 (400 birds/ha).

A comparison of the EC cage minimum as a base, with perchery and free-range alternatives, is shown in Table 1.

Table 1. Performance and production costs of three alternative systems in the United Kingdom

	System		
	Cage	*Perch*	*Free-range*
Performance			
Stock density	22	20	0.04
Eggs per hen housed	276	265	252
Feed intake, g/bird/day	115	116	135
Mortality, %	5	5	8
Old hen weight, kg	2.2	2.2	2.3
No of birds/worker	20 000	10 000	2 500
Production costs (pence per dozen eggs)			
Feed	25.5	27.8	32.8
Bird depreciation	7.9	8.4	8.6
Labour	1.5	3.2	13.3
Electricity	1.2	1.2	0.7
Medication	0.1	0.1	0.2
Other costs	1.1	1.2	1.3
Total	37.4	41.8	56.9

A BROADER ECONOMIC FRAMEWORK FOR ANALYSIS

All economic activity consists of transforming resources into goods and services which serve the needs and desires of people. Much of the quantitative assessment in cost-benefit analysis is simple accountancy: assigning monetary values to various measured or estimated physical quantities, categorising them under a cost or benefit heading, adding them up, and finally comparing the totals. Proper economic analysis should provide a framework by which the benefits of production are shown in the economic system, and how these benefits are valued by society. This can only be done with a "before and after" or "with or without" analysis. Benefits can be measured in two ways:

- by a technical component which represents the higher productivity of resources used in supplying poultry products; and
- an economic component which reflects the value placed by society on those supplies.

The technical effects are demonstrated in an economic analysis as a shift of the supply curve - the basic relationship showing the minimum price at which different levels of production can be made available to the market. This is shown in Figure 1 as the downward shift in the curve S_0 to S_1.

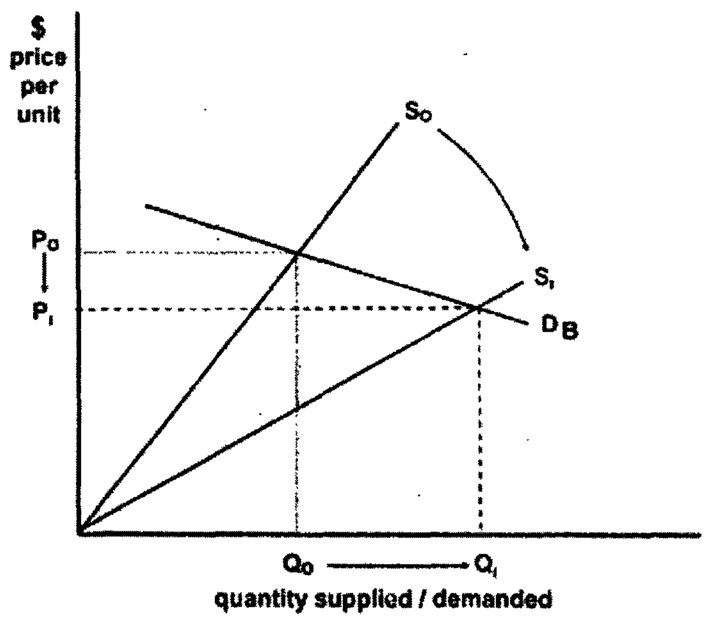

Figure 1. A Representation of the Market for Poultry Products from Smallholders

The value placed on this change in potential availability is then entirely dependent on the demand for poultry products. With rising demand for these products, additional supplies become expensive, and therefore the extra production translates into a substantial gain in benefits to the community. It can be argued that this usually happens in developing countries where, compared to the staple diet, poultry products are a luxury commodity with a relatively higher value. Hence, the demand curve D shows that the quantity demanded is highly responsive to price and income changes, with additional consumption causing little decrease in value. The demand for poultry products is price/ income elastic.

This simple model highlights the overall economic impact of higher poultry production as manifested on the market for poultry products. Production and consumption rise from Q_0 to Q_1 but the average price paid by consumers (and received by producers) falls from P_0 to P_1. Consumers gain significantly, reaping the benefits of both greater supplies and lower prices. Producers also gain. Although unit costs fall, the increase in production compensates for the price reduction and, as evident from the diagram, total revenue received by producers, (P_1Q_1) is greater than the previous P_0Q_0.

The overall net economic benefit from improved family poultry production technology is represented by the size of the shaded area. It is this net economic benefit that an economic analysis of family poultry development schemes and programmes should be seeking to estimate.

MARKETING

As a country develops, more of its consuming population lose touch with the village and food producers. Thus more specialised marketing services are needed. Farm produce must be collected, packed and transported in good condition to the cities and distributed to retailers near consumers' homes. This also calls for grading and storage of the product. The more developed the country becomes; the greater is the variety of products that can be economically produced. All this must be provided at a cost that consumers can afford.

A study of existing marketing systems in a country will often reveal how they have evolved to their present state. Many developing countries do not have refrigeration as a factor in their storage, either during transport, retail or consumer household stages. For this reason, poultry meat is purchased live, and slaughtered immediately before consumption. Also, eggs are often retailed with a means for the buyer to check their quality before buying, either by "candling" or a bucket of water. Both methods essentially test for the size of the air-cell situated at the blunt end of the egg, which increases in size as moisture is lost from the egg. With a bigger air-cell, there is more floatation.

In developing countries, transport of eggs and poultry from the village to the city usually begins with a purchase by a middleman dealer, direct from the household, or from small locally held weekly markets. Baskets with layers of straw protect the eggs from breakage, and other types of baskets are used to carry live birds. Bullock carts are still used in many countries for transport of both live poultry and eggs to larger community centres. The roofs of buses or trains replace these slower vehicles as transport systems develop. Marketing quality considerations for live birds are usually concerned with weight loss in the bird from dehydration during transport. These are easily resolved by providing drinking water during the trip, and travelling during the cool part of the day when possible.

Improved marketing programmes must add no more cost to the product than the consumer can afford. Important marketing improvements can often be simply made by making small corrections to already existing handling, transport, packaging, grading and storage methods.

Marketing organisations generally come into being very gradually, and must be appropriate for the background, character and education of the people concerned. Plans for radical changes, which do not take sufficient account of social and economic environments, are likely to fail. Thus any improvement programme should be designed to achieve desirable modifications in existing commercial facilities by a process of steady growth.

As a country develops, the task of marketing eggs and poultry will still involve the collection of live poultry and eggs from farmers, transporting them to a grading, packing or processing plant, grading and standardising the poultry meat and eggs, processing them and packaging them into more useful forms, storing them (preferably under refrigeration), moving them through wholesale and retail channels and delivering them to consumers at a convenient time and place.

FACTORS AFFECTING DEMAND FOR POULTRY MEAT AND EGGS

Ceremonial and Traditional Aspects

In traditional societies, poultry are often used for ceremonies, sacrifices and gifts. What follows are some traditional aspects of poultry keeping from the Mossi of Burkina Faso (West Africa), the Mamprusi of northern Ghana, and Bangladeshi and Malay farmers in South Asia.

Among the Mossi people when no poultry is available, to meet customary family obligations, the household must purchase or borrow a bird. Chickens are given to convey value to a relationship, or to offer thanks for a favour or help. For most socio-cultural and religious purposes, the required sex and colour of fowls are also prescribed. For example, a family will give a white cockerel when an agreement for marriage is reached.

The consumption of eggs in Mossi villages is uncommon. There is a strong belief that a child who regularly eats eggs will become a thief, reasoning that the good taste of eggs will make the child want to eat eggs often. The only eggs consumed are those that fail to hatch under broody hens. These are boiled and then eaten. Chicken eggs, unlike guinea fowl eggs, are not part of the trade in poultry products, since all eggs are required for hatching to maintain the flock. Dealers from urban areas reflect the demand for village eggs. The eggs are often bought by small food stall merchants who boil the eggs and resell them as snack food. A considerable number of guinea fowl eggs are collected by the Mossi for sale, most of which find their way to the cities via village markets, where dealers buy the eggs.

The Mamprusi society in northern Ghana has a variety of uses for poultry products. Chicken cocks are the most popular sacrificial animals. Guinea fowl cocks are not used. The colour of the bird is important. A red cock is sacrificed to ask for rain or a good harvest; a white cock is used to convey value in relationships, and a black cock is used to ask for protection against disease, war or quarrels. Because of these customs, red, white and black cocks have double the value of cocks of other colours.

The sale of young birds and eggs takes place in the Mamprusi village markets. Prices fluctuate during the year, and are low during the pre-harvest season, when the granaries are empty and the crops are still growing and thus cash is less available. At such times, traders from the south come to buy for resale in the cities. Sometimes, middlemen dealers are involved. They buy the birds in the villages and sell them at markets or to city-based traders. The sale of poultry products from Mamprusi households contributes about 15 percent to Mamprusi annual cash income.

Poultry consumption by the household is rare, as most birds are sold for income generation. In Mamprusi society, women, circumcised girls and first-born children do not consume eggs or meat. These products are only eaten by elderly men, male visitors and young children. The reasons are not fully understood. Some Mamprusi women believe that during pregnancy, their behaviour can affect their unborn child.

In Bangladesh, eggs and meat are consumed mainly by men and boys, and very rarely by women and girls. Low-income groups generally do not consume eggs or meat. These products are sold, and from the proceeds, essential items are purchased, such as carbohydrate and low-cost vegetable protein foods.

Guinea fowl, more than chicken, are given as gifts to visitors. To give a gift is considered to be a wealth-increasing action as well as an act that conveys value on the receiver. Farmers often save for agricultural equipment or other materials and small livestock is used as a savings account. The offspring, like chicks, are considered to be the interest on the savings.

In many parts of Africa, birds are sold to meet unforeseen expenses, for example, to buy the beer and kola-nuts customarily given to gravediggers when a family member dies. The birds usually sold from the village flock are: surplus males (cockerels and cocks); pullets; old hens; non-productive hens; large-sized birds and sick birds. Young birds are often sold just before the onset of the high-risk period for Newcastle Disease.

Traditional Taste Values Placed on Poultry Meat

It is important to understand traditional taste values and their effect on market demand. The market price for free-range birds for meat is usually stable because:

- the meat is considered tastier and stronger flavoured than commercial broiler meat;
- the meat (muscle tissue) is tougher, and retains its texture when prepared in dishes requiring longer cooking; and
- the birds are not fed with compounded feed which may contain antibiotics, anti-mould compounds, enzymes, sulpha drugs and other medicines or synthetic chemicals.

In eastern Asia, it is believed that chickens fed with chemicals and drugs have poorer therapeutic value, as they do not combine well with ginseng and other oriental herbs used in making soups, especially steamed types. For this type of soup, younger pullets are preferred and thus they fetch a higher price than do the cockerels. The female is said to be more beneficial and the meat tastier. Steamed chicken soup is believed to provide virility and vigour. It is commonly recommended in Malaysia for pregnant women and for those recovering from sickness.

In the case of large-scale commercial *ayam kampung* production in Malaysia, local birds are confined and fed on commercial rations but they fetch lower prices than free-range local birds. Such large-scale production has an affect on the market value of all local birds, as purchasers have difficulty distinguishing between genuine free-range and commercially fed local birds. However, the price of *ayam kampung* continues to hold a margin above that of commercial meat chickens. The introduction of more appropriate methods of Newcastle Disease vaccination in Malaysia will reduce mortality at the village level which may also stimulate further interest in family poultry production. If this happens, there will be an increase in the supply of local free-range poultry products to the market, and the price of the *ayam kampung* product may fall further.

Carcass Parts and Organ Meats

The value of birds for sale in developing countries depends firstly on the available supply, secondly on the age and sex of the birds, and thirdly on their size or weight. Young birds, especially cockerels up to six months of age (weighing up to one kilogram live weight), are usually preferred by consumers. This is because larger birds are more expensive for most households, and smaller birds are more tender and have the same preferred portions. Table 2 shows carcass characteristics of the local village chicken in Bangladesh.

Table 2. Product characteristics of indigenous scavenging chickens in Bangladesh

Characteristic	*Mean*
Live weight, kg	1.14
Carcass weight, %	55
Eggs/hen/year	35 - 45
Egg weight, g	35 - 39
Hatchability of eggs, %	84 - 87

Whatever the size of bird, all chickens have an equal number of high-demand portions (such as breasts and drumsticks), and a similar proportion of gizzards and other desirable organ parts (Table 3).

Table 3. Organ weights and carcass composition of Ethiopian local chickens at different ages

	Slaughter age (months)			
Body part weight (grams)	3	4	5	6
Total body	502	674	892	1006
Gizzard	19.9	24.1	27.7	30.9
Heart	2.6	3.1	3.8	4.1
Intestine	60.9	67.0	77.4	81.8
Kidneys	4.6	5.4	5.6	6.4
Liver	15.8	20.0	22.9	25.9
Lung	4.0	5.1	6.2	6.6
Pancreas	1.8	2.0	2.3	2.9
Total organs	109.6	126.7	145.9	158.6
Body weight %	21.8	18.8	16.3	15.3
Carcass				
Bone	87	113	123	138
Meat	197	267	331	406
Skin	36	49	59	68
Total Carcass	320	429	513	612
Body weight %	63.7	63.6	57.5	60.8

Buying small birds supplies the same number of the desirable parts for a lower price. Together with the tenderness of the meat, this explains the heavier trade in young birds, which are also bought for replacement stock in depleted flocks.

SUPPLY MECHANISMS FOR POULTRY MEAT AND EGGS

Depending on the location of the farm dwelling, birds and eggs are sold from the household to traders, direct to consumers, or carried by the farmer to the local market. The role of traders in the marketing of poultry products is an important one. Traders from urban areas buy eggs in villages to sell in cities. Where transport is an important consideration, guinea fowl eggs, with their stronger shells, are preferred to chicken eggs. Prices of eggs are related to supply and demand, to the higher risk of spoilage and lower use for hatching in hot and humid seasons, and to the availability of alternative protein foods such as fish. There is a tendency to hatch less in the hot season, due to low hatchability and diseases of young chickens, and there is also less hatching in the cold season, due to the risk of chilling stress to the young chicks.

Birds are either brought to the local market once or twice a week for sale to local consumers, to other local markets, or to local traders. Chickens are transported to the market in open-weave baskets or wooden crates. They need not be fed on the day of sale, but should receive drinking water. If the trip to the market takes eight hours or more, stops should be made to supply water to the birds. In hot seasons, it is better to transport birds at night or in the cooler early morning. While the price of live birds depends on their size, the price of eggs depends more on number.

It is often assumed that for poultry and eggs, producers get 60 to 65 percent of the market price but this has been found to be false in Bangladesh, where they receive less than this. The role of traders or hawkers is very important, as it makes selling from the house possible, but these traders take up to 35 percent of the market value, with a consequent lower profit for the farmers who are responsible for production. This loss of income has stimulated farmers in many places to organise sales through their own marketing groups or formal cooperatives.

Supply Channels

A study by Adeyanju *et al.* of the marketing of poultry products in Ondo State revealed a large number of transactions and participants. The local channel begins with the producer selling poultry products to retailers who serve the needs of local consumers. In most areas, local consumers also buy directly from producers. The other marketing channel involves wholesalers. They buy poultry products directly from producers and sell to retailers inside and outside the State, and are based in urban centres where urban-based consumers are located.

Odi found that marketing channels for family poultry often cross international boundaries and can generate significant foreign exchange for the producing countries.

Planning

Forming a marketing plan means identifying where and when birds and eggs will be sold to receive the best possible prices. Putting large numbers of birds up for sale in a small community may depress the price.

Even the sale of small numbers of intensively managed layers needs advance planning. A flock of 20 hens may produce 1 200 eggs in a year, even at the low production rate of 35 percent. The plans of other farmers must also be considered. If they all expand their flocks and have good years, prices will almost inevitably fall. Seasonal considerations enter into market plans as well. In India for instance, eggs are thought of as a heat-producing food and are eaten in the cool, rainy season. Many factors affect the quality of eggs and hence the price that consumers are willing to pay for them in the market.

Table 4. Length of lay and egg quality in Nigerian indigenous chicken

Traits	*Months of Lay*					
	2	3	4	5	6	7
Egg wt, g	35.8	37.2	36.9	37.1	39.0	38.6
Yolk wt, g	14.9	14.7	14.5	14.2	14.0	14.2
% Albumen	47.9	50.8	51.5	52.0	52.0	53.5
Shell thickness, mm	0.39	0.39	0.36	0.32	0.36	0.35

Table 5. Quality of eggs of different shell colour of the Nigerian indigenous chicken

Trait	*Brown*	*Light Brown*	*White*
Egg wt., g	38.9	37.1	37.0
Yolk wt., g	14.5	14.0	14.8
Shell wt., g	3.78	3.58	3.51
Albumen wt., g	20.6	19.6	18.8
Shell, %	9.77	9.67	9.49
Yolk, %	37.4	37.8	39.9
Albumen, %	52.3	52.8	50.8
Shell thickness, mm	0.37	0.37	0.35
Surface area, cm^2	52.6	50.9	50.8

EGG QUALITY CONSIDERATIONS

Quality determines the acceptability of a product to potential purchasers. The quality of eggs and the preservation of this quality during storage is a function of their physical structure and chemical composition. A basic outline of the most important factors of concern in egg quality is presented below.

Egg Composition

The egg consists of shell, two shell membranes, the white and the yolk. The shell is quite porous to air and water vapour but is very resistant to invasion by micro-organisms as long as it is clean and dry. A thin outer covering on the shell called the "bloom" or "cuticle", assists this process. After the egg is laid, its contents shrink, both from cooling and water evaporation. Air is drawn in through the pores in the shell to replace this loss. A gap opens up between the two membranes because the outer one is attached to the shell and the inner one is attached to the egg white. This gap is known as the "air cell" and is usually found at the large blunt end of the egg. The egg white takes the form of a "thick" albumin sack enclosing the yolk, with a more fluid "thin" albumin between this sack and the yolk to the inside, and again between the sack and the shell to the outside. These layers provide a barrier to prevent the yolk touching the shell and to provide food for the embryo. Egg white has specific antibiotic effects, which further protect the yolk. Egg white also contains two fibrous cords, which are attached to the yolk and to either end of the egg, which help hold the yolk in the centre and assist in preventing the yolk from touching the shell.

The weight of an egg laid by a local village breed of hen is about 35 g. Commercial hybrids lay eggs of about 58 g weight. The shell comprises approximately 11 percent of the weight of an egg, the remainder being the edible portion. By weight of edible portion, the yolk is 36 percent and the white is 64 percent.

Shell Quality

Eggs of unusual shape are more likely to be damaged during the marketing process, and consumers do not like them. Small thin cracks in the shell, which do not leak, are called "checks". These are usually detected by candling. "Checked" eggs should be sold for immediate consumption, as their storage life is limited. The household usually consumes eggs with leaking cracks, where the eggshell membranes are broken as well as the shell. Brittle, thin-shelled eggs are also unsuitable for transport to market. Dirty eggs must be cleaned by dry or wet methods, and thus have a higher marketing risk because of the removal of the cuticle. Shell colour is not a guide to egg quality, but there is usually a consumer bias to either white or brown, which must be considered in marketing.

Egg Yolk and Egg White Quality

Consumers prefer the odour and flavour of normal fresh eggs. The yolk should be round, firm and yellow in colour. Local yolk colour preferences may vary and can be easily adjusted by raising or lowering the amount of green leaf material included in the poultry ration or supplement. Egg white normally has a slightly yellow-green tinge and the thick white is slightly cloudy.

Consumers are usually critical of blood or meat spots, which can vary in colour from red to grey, and in size from small specks up to one square centimetre. Blood spots are caused by slight bleeding at the time of release of the ovule (yolk) from the ovary of the hen. They may be found in the white or adhering to the yolk.

Deterioration

The interior quality of eggs deteriorates after laying at a rate depending on time and conditions of storage, such as temperature, relative humidity (RH), and the presence of strong smelling substances or other food items in the storage place. Eggs stored at 27 to 29 °C for 7 to 10 days will show deterioration changes similar to the same eggs stored at minus 1 °C and 85 percent RH for several months. The changes are due to water loss, carbon dioxide (CO_2) and the absorption of volatile odours from the environment.

Moisture loss

Since an egg contains about 74 percent water and the shell is porous, eggs readily lose moisture. A weight loss of 2 to 3 percent is common in marketing and is seldom noticed by the consumer. When losses exceed this level, the air cell is noticeably enlarged by shrinkage in the contents of the egg. This loss is reduced if the storage humidity is high and the temperature is reduced. Coating the eggs with oil and other substances can also reduce the loss. The ideal conditions for egg storage are about minus 1 °C and between 80 to 85 percent RH. At storage temperatures of 10 °C and above, the optimum RH is 80 percent. There is a risk of mould spoilage when the RH is too high. Paper pulp egg trays or other packing materials that readily absorb moisture will accelerate moisture losses from eggs. A temperature as low as 10 °C is unlikely to be practical in rural areas of many developing countries. Temperatures between 10 and 15 °C are more practical, but even then, care should be taken when moving the eggs from cool storage into the outside air with its higher temperature, which often causes condensation to form on the shell, with consequent risks of mould and "rot" growth.

Microbiological spoilage

The contents of the egg are usually sterile when the egg is laid. The main cause of contamination is the washing of eggs. Wetting the shell allows micro-organisms on the shell to penetrate and multiply inside. Common indications are green, black and red "rots", mustiness and sourness. The bacteria causing these effects cannot penetrate the shell if it is kept dry. If eggs do become wet through condensation, for example after removal from a cool store into a warmer room, bacteria may then be able to penetrate the shell.

Tainting

Eggs, especially yolks, are easily tainted by strong odours, from such sources as disinfectants, soaps, diesel, kerosene, petrol, paint, varnish and wood preservatives. Other foods, such as onions and citrus products, can taint eggs after only a few days of exposure.

EGG QUALITY CONTROL AND MAINTENANCE

Maintenance of egg quality is a major problem for those involved in egg marketing.

Eggs soiled by droppings or the contents of leaking or broken eggs spoil faster than clean eggs. Only good quality eggs should be sent to the market. The simplest way of sorting is to divide the eggs into three categories: cracked, dirty and clean. The cracked eggs should be eaten or sold locally for immediate consumption. The dirty ones should be cleaned and sold locally for consumption within a few days, while the clean eggs can be sent to the major marketing outlet. In some areas, eggs of certain colour or sizes are preferred, and the eggs should be sorted for these qualities.

Production Factors Affecting Egg Quality

The main production factors affecting egg quality are:

- breed and age of the flock;
- type of feed;
- incidence of disease;
- management control of the laying flock; and
- management control of the handling of eggs.

Breed and age of the laying flock

The effect of breed on the egg is inherent in many aspects, including the colour, thickness and texture of the shell, the incidence of blood spots, and the amount of thick albumin. While commercial breeders pay constant attention to these factors, there is little that farmers can do to control them.

After the first season of egg production, hens produce eggs of poorer shell quality and poorer egg white thickness, even though the eggs are larger in size. The rate of egg production is also lower. For these reasons as well as the high meat value of the carcass of the older hen in most developing countries, it is advisable to replace the hens after 12 to 18 months of lay.

Type of feed

A balanced diet supplied to intensively housed chickens must supply sufficient nutrients to enable the hen to produce an egg with a good shell thickness and good egg yolk colour. A high level of yellow maize, leaf or grass meal will ensure a good yolk colour. Calcium carbonate in some form (limestone or shell) must be supplied. This is either mixed in the ration or fed as a separate supplement on a free-choice basis. It is often quite practicable to have a separate container in a pen with shell or limestone inside.

Fish meal with a high fish oil content fed in the diet can give fishy flavours to eggs produced by hens on those diets.

Incidence of disease

The diseases Infectious Bronchitis (IB) and Newcastle Disease both affect egg quality. They cause the hens to lay eggs with misshapen shells and poor quality thick white. IB induces groove-like marks along the long axis of the eggshell.

Management control over the laying flock

In many developing countries, there is a belief that a rooster is necessary to stimulate hens to lay. This is not true. The presence of an active male causes the eggs to be laid as fertile eggs (containing an embryo chick), and this reduces the storage stability of the egg. Even after the male is removed, all eggs laid are fertile for up to six weeks because sperm is stored and released from specialised cavities in the hen's oviduct. If fertile eggs are in demand, then cocks should be placed with the hens. Non-fertilised eggs have a much longer shelf life than fertilised eggs and are more suitable for the market.

Dirty eggs can be reduced in number. For hens in deep litter systems, the nest box litter must be clean and replaced regularly. Frequent collection of eggs under any housing management system, and at least four times a day in the hot humid tropics, will reduce the incidence of dirty eggs.

Management control over egg handling

Temperature control

The most effective way to preserve egg quality is to store eggs between 10 and 15 °C during all handling, transport and marketing phases. Insulated containers and/or vehicles can maintain cool temperatures during long-distance transport. Even an outer layer of straw in a basket will help. In hot weather, and where there is no cool storage system, eggs should be transported to market at least every third day. Eggs should never be left standing in the sun or in a very hot room. Air conditioning or even an electric fan is advised whenever practicable. However, as air conditioning has the negative effect of drying out the egg contents as well as the advantageous effect of cooling, wet sacks should be placed as curtains in the cool store to alleviate this dehydrating effect. If fans or air conditioning are not available, then shaded well-ventilated rooms or underground cellars should be used.

Treatment of dirty eggs

An egg's shell has a natural protective coating (cuticle) that resists the entrance of bacteria and retains moisture inside. Washing eggs with water removes this protection, and thus washed eggs should be eaten as soon as possible. Whether eggs are wet- or dry- cleaned, they should be sold separately from naturally clean eggs, as their storage life is shorter. The cuticle from the shell is a protein-fat substance, and the lack of a cuticle can therefore be detected with a simple ultraviolet (UV) lamp. Washed eggs (without a cuticle) are red in colour under UV-light, while a blue colour indicates that the cuticle is still present.

Dry cleaning

Even with good flock management, some eggs will get dirty. The risks of allowing water to touch the shell have already been mentioned. Dry cleaning systems are preferred. Rubbing lightly with fine sandpaper or a rough cloth is better than wet cleaning. Cloth-backed sandpaper or emery paper can be wrapped around a block of foam rubber for dry cleaning by hand. Steel wool and nylon dishwashing or bathroom scrubbing aids are also quite suitable. Care should be taken not to remove too much of the protective cuticle layer which covers the shell. Only the dirty patches should be cleaned. There are also motor-driven dry-cleaners commercially available. The simplest model consists of a spinning wheel of foam rubber. A mixture of glue and sand is applied periodically to the foam wheel. The operator holds the egg against the spinning foam wheel to clean it.

Wet cleaning

Washing of eggs is only suggested under very well-controlled conditions. The concern is to ensure that the washing water temperature (38 to 43 °C) is never below that of the egg. This avoids the wash water being sucked into the egg through the shell pores by the action of the egg contents shrinking (as happens if the egg is in contact with cooler water). In addition, the washing machine must be able to monitor the detergent/sanitiser/disinfectant/antiseptic levels in the water to ensure that they are optimal. Only special types of non-tainting chemicals can be used. The water itself must be changed frequently. After washing, the shell should be pasteurised by dipping the eggs in water at 82 °C for a few seconds, then dried quickly with warm air before packing. The eggs must also be clearly labelled as "washed". Washing done in this way is complex and expensive, and is therefore only justified in large operations, although even then it involves risks.

EGG QUALITY GRADING

Interior Quality

Candling

Opening the egg by breaking it is the only accurate way to fully check the interior quality. This can only be done on a limited sample basis. "Candling" can show some aspects of internal quality without breaking the shell. It consists of inspecting the egg in a beam of light strong enough to penetrate the shell and illuminate the contents. Various types of lamps can be used but the essential features are similar. An incandescent-type bulb of 25 to 50 watts is enclosed in a casing with light exiting through a round hole about 3 cm in diameter against which the egg is held and turned. The casing usually has another hole to provide light for the operator to see the egg container if the room is very dark. By rotating the hand-held egg close to the hole in the candler, the yolk and egg white quality can be estimated by their movement. Experienced operators can candle 24 eggs per minute. The main points to observe are summarised in the following paragraphs.

White

Egg white (albumin) characteristics showing good egg quality are thick albumin fullness and albumin transparency. When the thick albumin sack is strong and healthy, it is full and confines the yolk within the various layers of egg white. As the thick albumin sack deteriorates, its contents leak into the thin albumin cavity. The yolk then moves more freely, increasing the risk that it might touch the shell and be contaminated by micro-organisms from outside the shell. A healthy albumin is also transparent. It can become discoloured or cloudy due to rot or overexposure to hot water (partial coagulation) in washing.

Yolk

Yolk characteristics showing good egg quality are confinement within the thick albumin, a small spherical shape, orange-yellow colour and the absence of spots. As described in the above paragraph, yolk confinement within the albumin protects the yolk from outside contaminants. A small spherical shape indicates a strong yolk membrane. When the egg is exposed to high temperatures and dehydration, the yolk deteriorates and grows larger and flatter. Consumers prefer yolks of orange-yellow colour without spots. Spots on the yolk can indicate: embryo development (reddish colour); blood from the hen's ovary and "meat" bits from the oviduct released during egg formation (red and brown, respectively); moulds (grey or black); or bacterial rots (blue, violet, green or red). Although consumers prefer yolks with no spots, the only spots that pose any health risk are mould and rot spots.

Air cell

Air cell characteristics showing good egg quality are small size, shallow depth and fixed position at the blunt end of the egg. Small size and shallow depth indicate very little loss of moisture from the egg contents, which in turn indicates freshness. A fixed position at the blunt end of the egg indicates that the membranes surrounding the air cell have not been damaged.

There is usually a correlation between the depth of the air cell and other quality aspects. However an egg stored at high temperature and high humidity may show a good air cell depth but it may have deteriorated otherwise.

Air cells can be deflated completely or become unfixed and mobile within the egg. The air cell can become filled with albumin if part of the inner shell membrane is broken. If the membrane is merely weakened, the air cell may move freely around the egg. These mobile air cells are often caused by transporting eggs on rough roads or by the egg being stored small end upwards. The egg could be otherwise quite fresh.

Shell Quality

Before candling, eggshell quality is assessed, and eggs that are dirty, cracked, thin, rough or misshapen are processed accordingly.

EGGS SALE OPTIONS

Eggs can be sold by graded size or by total package weight. Selling by graded size involves weighing each egg individually and grading the eggs within certain weight ranges. They are then packed in cartons of 10 or 12 eggs, and sold according to a price per graded size. Selling by total package weight involves packing the eggs without size grading, and selling the package according to a price per kilogram.

Consumers in the more developed countries are accustomed to buying eggs graded by size and boxed into cartons. Grading eggs by size requires complex machinery for grading and packaging, as well as monitoring and testing of all grading machines, and sample monitoring of the various grades at retail outlets.

In developing countries without the capital or administrative capacity to undertake such extensive monitoring tasks, the better option is to sell eggs by total package weight. If a market weighing scale is used to weigh foods such as rice or maize, then it can also be used to weigh eggs so that they can be sold by package weight. Selling eggs by package weight also simplifies the situation where standardisation of containers and grades has not yet been developed. It also makes price comparisons between different types of food items much easier for the consumer.

Eggs in most developing countries are sold by quantity rather than by weight, which penalises the producer of larger eggs. As local breeds of hens usually lay uniformly small eggs, this is not a significant problem. However, as the market grows and a demand develops for different sized eggs based on the availability of commercial hybrids in peri-urban areas, the decision to sell eggs by graded size or by total package weight must be faced.

EGG TRANSPORT

The four concerns regarding egg transport are:

- Protection against mechanical damage, which can be achieved by avoiding excessive shaking, especially where roads are bad, and by using spring suspensions on bicycle carriers.
- Protection against poor egg handling, which can be achieved by providing convenient loading levels to make lifting easier.
- Protection against tainting odours.
- Protection against exposure to high temperatures in transport.

Egg Packing Methods

Eggs can be packed with a padding of rice husks, wheat chaff or chopped straw in firm-walled baskets or crates. This greatly reduces the risk of shell damage in transport. In Iran, long flat boxes, each containing about 1,000 eggs cushioned in chopped straw, are commonly used for the transport of eggs to the capital from a distance of up to 1 000 km. The boxes are transported in trucks over rough roads, but breakages seldom exceed five percent. The main difficulty with such systems is in standardising the number of eggs per container. Consignors and receivers will otherwise spend much time counting eggs and repacking to ensure that the correct number has been received for payment.

The standard type of transport egg packing container is the 30-egg tray, which is made of paper pulp holding six rows of five eggs each. The trays are stackable either when full or empty. A standard box of 360 eggs (30 dozen) is made up of two stacks, each comprised of six trays. Washable plastic reusable trays are also available. Cases are usually made of wood. Half-cases to hold 180 eggs (15 dozen) are also common and are usually made of corrugated cardboard.

Quality preservation during transport

Permissible temperature ranges depend on the duration of transport time. In Europe, the temperature recommendation for two to three day transport in refrigerated vehicles is between -1 °C to 3 °C. In developing countries, however, refrigerated vehicles are not widely available. Even when available, precautions are needed to avoid moisture condensation on eggs removed from the cool container to the warm moist air of the retailing environment.

Fans blowing air towards the eggs across a container of salt and ice is a cooling system that has been used in Pakistan for egg transport by rail for the 1 600 km trip from Peshawar to Karachi, where outside summer temperatures can range from 38 °C to 47 °C.

Refrigerated transport is expensive. In estimating the costs of establishing such a system, the volume of trade for refrigerated goods is an important consideration. The capital cost may be spread over five years to prepare the costing. Transport of other taint-compatible produce with the eggs should be considered; as should the prospect of back-loading with other goods, which may not necessarily require refrigeration.

Public transport such as rail or bus is the most common means of transport in developing countries. Awareness of the special needs for egg transport as addressed above will assist the operator in preserving the quality of the eggs no matter what the type of transport.

EGG STORAGE

All egg storage systems must meet the following requirements:

- Water loss by evaporation to be minimised.
- Mould and bacteria growth to be minimised.
- Interior quality to be maintained.

The first two requirements can be met by: coating eggs with oil or waterglass; immersing eggs in limewater; or putting eggs in dry storage. However, all three of the above requirements can only be met by refrigeration, which is the best storage method, if available.

Following below are descriptions of some of the traditional egg storage methods used in the absence of refrigeration. The first two systems rely on evaporative cooling, which is only effective in the hot dry tropics. The hot humid tropics do not allow sufficient evaporation to occur, and thus there is much less of a cooling effect. Where none of these storage systems can be used, there is no way to slow the inevitable drop in egg quality, and the eggs should therefore be transported to the consumer as quickly as possible.

Clay pot

Eggs are placed in a clay pot buried in the ground up to its neck, in a shaded area. The pot is covered tightly so that no water gets into the pot. The ground around the pot is watered, but without leaving puddles of water. Straw or a mat is placed in the pot to cushion the eggs and to keep them above any water that seeps into the container. The eggs are put in the pot as soon as they are collected, and covered with a cloth and damp straw. Due to the evaporative cooling effect, the inside of the pot is often five to six Celsius degrees cooler than the outside air temperature. A variation of this method, used in the Sudan, is to bury an earthenware pot in the ground to half its height. A 7 cm layer of mixed sand and clay is packed around the pot up to its neck, and kept wet by sprinkling water on it. The inside of the pot is lined with grass. The eggs inside are covered with a thin cloth to allow air circulation. Evaporative cooling in Sudan's hot dry climate often reduces the egg temperature to up to eight-Celsius degrees below that of the air outside. Eggs are turned daily to prevent the yolks touching the shell, which would accelerate the decaying process.

Wet sack cooler

This is another method utilising the evaporative cooling principle. The sack material is kept wet by having a tray of water above the hanging sack, into which the neck-edge of the sack material is dipped, keeping the sack wet. A slightly more sophisticated system uses perforated pipes connected to a water tank. To prevent mould formation, the sacking is pre-soaked in a solution of copper sulphate ($CuSO_4$), using 60 g of crystals in four litres of water.

Oil coating

A thin film of oil on an eggshell fills its pores and reduces evaporation and thus spoilage of the egg contents. Using a wire basket, the eggs are dipped into slightly heated oil, about 11 °C warmer than the eggs. Special odourless, colourless, low viscosity mineral oils can be used. If these are not available, then any light mineral oil or almost any cooking oil that doesn't easily turn rancid serves the purpose. To reuse the oil, it is cleaned through a filter and heated to 116 °C to sterilise it. Four litres of oil coats about 7,000 eggs. Oiled eggs last for at least three weeks. For high temperature storage, eggs should be oiled four to six hours after laying.

Waterglass paste

Waterglass is a paste or ointment of sodium silicate in water. It is rubbed onto the hands and then the egg is rolled between the two waterglass-coated hands to transfer a waterproof coating of waterglass paste to the eggshell.

Waterglass solution

For 100 eggs, a 25-litre pot or jar is used, and 5.3 litres of previously boiled (and then cooled) water are mixed with 0.5 litres of waterglass. The eggs are placed in the pot and covered with the waterglass solution. The pot is covered and kept in a cool, shaded place. The eggs keep for one to six months.

Limewater solution

Limewater is a solution of calcium hydroxide [$Ca(OH)_2$], a mild alkali. The main ingredient is burnt lime (also known as quicklime). The chemical name of this is calcium oxide (CaO). It is also known as *choon* in Bangladesh, and is a common ingredient of the betel nut mixture chewed by people in many tropical countries. Calcium oxide is made by burning limestone ($CaCO_3$) in a hot fire. Carbon dioxide (CO_2) is driven off from the limestone, leaving CaO behind as a white powder. Dissolving this calcium oxide in water makes limewater. The resultant solution of calcium hydroxide is only partly soluble, and the insoluble portion will settle to the bottom of the container.

Six litres of limewater is made by stirring 2.3 kg of calcium oxide into six litres of boiled (then cooled) water. It is allowed to stand overnight so that the insoluble portion settles. The eggs and the clear part of the limewater solution are placed in a pot, covered and kept cool. The eggs last more than a month. In the years prior to 1970, eggs were commonly transported from Bangladesh (formerly East Pakistan) to Pakistan (formerly West Pakistan) on a train journey of about a month, in high temperatures. The eggs were stored in earthenware jars containing limewater and maintained their quality well.

Hot water immersion

Immersion in hot water for carefully controlled lengths of time has a pasteurising effect, which kills the embryo in fertile eggs, destroys some of the bacteria on the shell and stabilises the quality of the egg white. The difficulty is to achieve this without coagulating some of the egg white. Equivalent effects are achieved with any of the following temperature-time combinations:

35 minutes at	49 °C
15	54 °C
10	59 °C
5	60 °C

This method requires special equipment and supervision.

Salt and wet clay or ashes

Eggs are coated in a mixture of salt and wet clay or ashes which allows them to keep for one month. This method has been practised for centuries in China.

Cooked rice and salt

Eggs are covered with a mixture of cooked rice and salt, which allows them to keep for six months. This method has been practised for centuries in China.

Lime, salt, wood ashes and tea

Eggs are covered with a layer of lime, salt and wood ashes mixed with a tea infusion, which allows them to keep for several years. This method has been practised for centuries in China.

RESEARCH AND DEVELOPMENT FOR FAMILY POULTRY

Research and development in the field of Family Poultry (FP) must first examine the social, cultural and technical constraints faced by this sector, and then observe how these have been addressed in past efforts and whether the lessons are being applied in currently ongoing efforts. While holding this perspective, the need for further research, training and extension must then be assessed in the light of a clear understanding of what the overall development objectives are, and what place FP has in achieving them.

SOCIO-CULTURAL CONSTRAINTS TO DEVELOPMENT

A sociological appraisal is essential in determining strategies for development. Technical and economic appraisals are also necessary, but are insufficient on their own. Socio-cultural factors contribute to the wide variety of response of livestock keepers even under identical economic conditions. Many socio-cultural factors affect livestock production. For example, some communities ban ducks, as they are presumed dirty and destructive to drinking water supplies. Some communities regard pigeons as a sign of peace and concord. In such communities, the presence of pigeons is regarded as a good omen, and their departure would presage disaster. In other communities, pigeons are regarded as an evil omen, since they are used by native doctors in sinister rituals.

Another socio-cultural constraint to poultry development is the value placed upon poultry for use at ceremonies and festivals or even as a source of income in times of need but not as a source of daily food nor as a regular source of income. Some regard chickens as their pets or part of the family, thus it is only the arrival of an important unexpected visitor that could allow their use as food, although they can be sold without regret and the money utilised.

Another major constraint to poultry production is the high value placed upon crop production rather than livestock production. This affects the willingness to put much time, expense and effort into livestock production. Theft is also a great constraint. Villagers who have lost all their poultry to theft may be reluctant to face the expense of starting again.

Another constraint is the social norm that determines ownership of livestock. Typically, where crop farming is the men's main activity, keeping livestock is perceived as a peripheral activity relegated to women and children. However, when the number of livestock increases, men usually take over the activity.

It should not be assumed that socio-cultural factors can be changed. However, by incorporating socio-cultural factors into development strategies, the programmes and technologies may encounter less resistance. Development programmes, which combine local knowledge with western science, yield strategies which are culturally more acceptable. Socio-cultural factors are thus not seen as a problem, but rather as a factor to be considered or used in finding a solution.

TECHNICAL CONSTRAINTS TO DEVELOPMENT

The most common FP flock size of between 5 to 20 birds seems to be the limit that can be kept by a family without special inputs in terms of feeding, housing and labour. These small flocks scavenge sufficient feed in the surroundings of the homestead to survive and to reproduce. Any significant increase in flock size often leads to malnutrition if no feed supplement is provided. In addition, larger flock sizes must forage at greater distances, which may involve damage to neighbours' vegetable gardens. Any move to fence in or enclose the poultry then involves the need to provide a balanced ration. Larger flock sizes can easily arise once mortality is reduced through vaccination and improved hygiene. Flock size can rapidly increase to the point where the feed requirement exceeds the available Scavengable Feed Resource Base (SFRB) in the area around the dwelling. At this stage, either supplementary feeding or a semi-intensive system of management is required. If balanced feed, day-old hybrid chick and vaccine input supplies are available and well organised, and then intensive poultry management systems may be a viable option. There have been many attempts to take short cuts to development and to start immediately with the semi-intensive system.

FAO Consultation 1987

A wide range of approaches to improve FP production has been tried. An FAO Expert Consultation on Rural Poultry Development in Asia was held in Bangladesh in March 1987, to review these approaches in order to identify the reasons for success or failure. A major issue during the workshop was to clearly define the different systems of rural poultry production. There was confusion in terminology between the low-technology scavenging systems of Bangladesh, Myanmar and Bhutan, and the small semi-intensive or intensive production systems kept in India, Malaysia and Indonesia.

Perhaps because of the variety of understandings of rural poultry development, many of the methods suggested seem more suited to the development of small units of intensive poultry production. The methods reflect the procedures required for transfer of new technology or total replacement of existing practices. For instance, incentives were required to encourage farmers to participate in the programmes, perhaps indicating that the programmes were not consistent with the priorities of the farmers. Selection of farmers was also identified as a major factor in determining the success or failure of a development programme. Incentives can often lead to the selection of farmers not genuinely interested in poultry production. To ensure the selection of authentic candidates, the following procedure was recommended:

- The extension service should select farmers already known to be particularly interested in poultry production.
- Incentives should never be given in cash.
- Incentives should always be associated with certain commitments by the farmers (for example, equipment for poultry houses should be provided only if the farmer has constructed the poultry shed at his own cost).
- Supplies of inputs such as day-old chicks, fertile eggs, feed and vaccines should be made at cost price.

The pilot farm method risks failure if a large amount of foreign input is needed to establish it because neighbouring farms can become discouraged by the fact that they are unable to procure the same equipment.

Table 6. Technical constraints and training requirements for family poultry development

Constraint	*Training Measures required*
Disease risk	Advice on sanitation and health; training vaccinators.
Predators	Advice on predator control.
Housing	Advice on improved poultry housing.
Feed and water	Advice on locally available feed ingredients and their combinations; making of feeders and drinkers; regular provision of feed and water.
Genetic potential	Introduction of improved indigenous (and if necessary, exotic) breeds and advice on special management.
Marketing	Advice on egg handling and storage, and training of farmers in group management and marketing.

In order to be effective in the process of technology and information transfer, pilot farms should be charged with special duties, which bring them obligatorily in contact with the other poultry keepers. Pilot poultry farmers have been successfully trained in Bangladesh and Burkina Faso to vaccinate chickens and guinea fowls, respectively. Pilot farmers can also be used to provide improved lines or to raise pullets for distribution so that a number of farms in the surrounding area will be regularly served with inputs and information.

Attempts to by-pass the phases as described by Bessei usually fail, and it appears that the transitory phases are important if the development is starting from the traditional scavenging system. It has been noted that even in successful poultry development programmes, the supply of feed and veterinary products often lags behind the increase in flock size, especially if it is organised by the government extension service. The use of non-governmental organisations (NGOs) and private entrepreneurs is a better alternative.

INFPD and the 1998 FAO e-conference

The International Network for Family Poultry Development (INFPD) started as the African Network for Rural Poultry Development (ANRPD), and was established during an international workshop on rural poultry development held in November 1989 in Ile-Ife, Nigeria. The name was changed to INFPD at a meeting that took place in M'Bour, Senegal, in December 1997. INFPD is mainly an information exchange network. One of its objectives is to encourage higher standards of research and development that can sustainably increase the productivity of the FP subsector. This is achieved through providing advice and collecting data and detailed information about FP production systems. Information is disseminated through a trilingual newsletter, produced twice yearly and distributed electronically with the assistance of FAO.

In December 1998, FAO held the first INFPD/FAO electronic conference on FP, which proved so popular and interactive that it was extended until July 1999. The introductory paper to this conference addressed the issue of research and development options for FP. The layout of this important introductory paper was:

- Research options for family poultry development.
- Prospects for development.
- Development approaches.
- Breeding and reproduction (evaluation and selection of indigenous breeds).
- Evaluation and adaptation of imported breeds to hot climates.

- Feed research and development.
- Health management.
- Entrepreneur development.
- Information management.

All papers, comments and discussions are available on the FAO/INFPD website. The constraints and issues facing FP that were recognised by the e-conference are:

Disease

Newcastle disease (ND) constitutes the most serious epizootic poultry disease in the world, particularly in developing countries. No progress has been made in controlling ND in free-ranging village flocks, which represent more than 80 percent of the total poultry population. Several recent surveys in Africa showed high rates of seropositivity in the absence of vaccination. In developing countries, ND occurs every year and kills an average of 70 to 80 percent of the unvaccinated village hens. It is very difficult to organise vaccination campaigns covering free-range birds. The main constraints are:

- the difficulty of grouping together an adequately large number of birds in order to obtain an efficient vaccination rate;
- the possibility of disease cross-contamination arising from birds of various ages being raised together; and
- the difficulty of maintaining an efficient cold chain for proper vaccine quality preservation.

Diseases make poultry production a risky venture. FP producers using the free-range extensive system acknowledge this risk, and reduce its impact on the household economy by having small flocks. ND is a major disease problem for all FP producers wherever the disease exists. Vaccination of the flock against ND is very important and provides a basis for further development.

It is worth repeating that the reluctance of farmers to invest in poultry production is not due to a lack of resources but to the risk of disease outbreaks and mortality. Killer diseases like ND regularly decimate village flocks. In traditional farming systems, farmers often live close to the survival limit, so they naturally avoid risks. Minimising risk ranks higher than increasing output. A key component of FP development is the control of the most important diseases. Regular vaccination is a prerequisite for any improvement in FP production.

Although the control of ND is the key constraint, there are other disease constraints, which rise in importance as soon as higher-ranking constraints are eliminated. Many poultry development projects have failed because only one constraint was tackled or, when more than one constraint was considered, the importance of other problems was poorly understood. Many projects concentrated either on disease control or on genetic improvement. There is no doubt that vaccination reduces mortality, but in one particular project, in certain periods, mortality due to predation was as high as 70 percent and the effect of vaccination was further negated by a secondary constraint of poor housing. Generally, the costs of an isolated vaccination campaign cannot be justified unless actions to improve housing and feeding are also taken.

Predators

Predators such as snakes, rats, dogs, cats, foxes, racoons and birds of prey represent the main causes of predator losses, especially in young birds. Human beings can also represent another important predator for adult birds. Proper shelter should be constructed using locally available materials, and predators should be trapped, hunted or repelled by specific plants. For example, in Nigeria, sliced garlic (*Allium sativum*) is placed around poultry houses to repel snakes.

Analysis of mortality in FP flocks in Thailand showed that the first four months of life are critical for the growing chicks. The mortality of chicks during this period often rose to 60 percent even in flocks vaccinated for ND. In Africa, while various other diseases such as Salmonellosis or coccidiosis affected the chicks during the first two months of age, the most important cause of mortality between two and four months of age was predation, by dogs, cats, hawks and snakes, which caused up to 70 percent mortality. Overnight housing is an important way to reduce this loss, and can utilise locally available materials of reasonable cost.

Feeding

Feed is also an input of major concern and the supply of adequate feed supplement is critical. The nutrient intake of scavenging birds varies from place to place according to the seasons, the crops grown and the natural vegetation available. In field experiments, feed supplements, including household waste, and oilseed cakes, have a positive effect on egg production and body weight of scavenging birds.

Careful attention should be given to ensuring adequate feed resources. Feed represents 60 to 80 percent of the input cost in the intensive commercial poultry sector. In Low Income, Food-Deficient Countries (LIFDCs), a surplus of cereals is generally not available. It is therefore not advisable to develop a wholly grain-based feeding system. The recommended policy is to identify and use locally available feed resources to formulate diets that are as balanced as possible.

Full *ad libitum* feeding of a balanced ration is essential for poultry intensively managed in confinement, even on a small scale. The usual recommendation is for commercially manufactured feed, but many farmers find it too costly and not in regular supply. The by-products of processing of local crops can be used as both energy and protein sources but on their own cannot make a balanced ration. More research is needed on local feed resources as sources of trace elements, minerals and vitamins, especially from leaves, fruits, algae, fungi and other available materials. However, even with this knowledge, the skills of a well-equipped and experienced nutritionist are needed to formulate least-cost balanced rations.

Breeding (genetic potential)

Indigenous or local breeds are generally raised in FP production systems. These birds are exposed to natural selection from the environment for hardiness, running and flight skills, but not for egg production. Hens are thus poor layers, but good mothers. When farmers contemplate the adoption of a more intensive poultry production system, they are eager to purchase more productive birds. There is a need to find the best method to provide them with such birds, and the options are:

- to supply hybrid strains, which requires the presence of well-managed hatchery facilities and (grand) parent stock, or
- to supply pure-bred breeds, which allows the farmer to renew his flock and to remain independent from external suppliers. Unfortunately, pure-bred breeds are becoming more difficult and more expensive to purchase, and produce fewer eggs than hybrids.

Genetic improvement has been considered a high priority in poultry development projects. Usually vaccination programmes are carried out during genetic upgrading programmes, but feed supply to the improved birds has not received sufficient attention. Thus it has not been possible to exploit the superior genetic potential of the improved birds.

Marketing

Poultry products in most developing countries, especially in Africa, are still expensive. The marketing system is generally informal and poorly developed. Unlike eggs and meat from commercial hybrid birds (derived from imported stock), local consumers generally prefer those from indigenous stocks. The existence of a local market offering good sales opportunities and adequate transport facilities are obvious prerequisites for FP development. As most consumers with greater purchasing power live in and around cities, intensification of poultry production should be initiated in peri-urban areas or, at least, in areas having a good road network.

Traditional dealers and middlemen, who collect eggs and birds from the villages, facilitate the marketing of FP products in most developing countries. Such traditional marketing structures are often overlooked, bypassed or criticised. There has been a regrettable tendency in some countries to use government extension services or parastatals to market family poultry products. This practice should be discouraged as it is not sustainable.

Farmer Organisations

Organising FP farmers is not an easy task, for several reasons. Flock sizes are small and birds are maintained with minimal land, labour and capital inputs. Thus farmers generally consider FP a secondary activity compared with other agricultural activities. Nevertheless, it is essential to develop producer groups, which give members easier access to essential inputs and to credit, training, transportation and the marketing of poultry products. Producer groups also encourage more educated people to initiate FP farming as a secondary activity, as well as facilitating the development of associated activities such as market gardening, which can utilise poultry manure and help to reduce or remove household waste and pests.

Farmers should be allowed to develop the market structures most suitable for them. Often women's groups prove to be effective in marketing eggs along with other products at local markets. Such groups should be encouraged and supported if they exist, but their establishment solely for FP may be unnecessary and unviable.

In a case study in the region of Niamey, Niger, it was shown that smallholdings of layers, which were situated beyond 2.5 km from a main paved road, could supply eggs and meat to the city market at competitive prices. Villages much farther from the main routes could supply live birds competitively but not eggs. Eggs are not an important food item at the village level, as it is a relatively high-priced protein food, and thus marketing may require cooperative efforts by producers to transport eggs to larger towns. Possibilities for this include using existing commercial trading channels or opening new channels such as those through producer associations, cooperatives, women's groups or young farmer associations. The establishment of specialised poultry production cooperatives has proved difficult in many places, and socio-economic factors play an important part in this.

Training and Management

Technical skills need to be considered at both farmer and extension officer levels. Training is essential in the areas of disease control, housing, equipment, feeding, genetic improvement and marketing. A basic knowledge of specific features of poultry anatomy and physiology is also important, to provide a basis for understanding the above topics.

Housing and management could be improved through appropriate farmer training, preferably conducted on-farm. Local craftsmen could be trained to manufacture small equipment, such as feeders and drinkers.

RESEARCH LESSONS LEARNED FROM COMPLETED PROJECTS

Genetic Upgrading

This was the earliest and most commonly favoured FP development strategy, and has been adopted and supported by many donors from the 1960s onwards. It has usually involved substantial investment in government infrastructure, and less investment in training village farmers or developing distribution networks for vaccine and medicine. The Cockerel Exchange Programme (CEP) represented the traditional approach, in which cockerels from exotic strains were reared up to 15 to 20 weeks of age, usually in government poultry farms, and then exchanged with local cockerels owned by FP households, which kept small flocks and were requested to remove or exchange all local cockerels. In addition, sometimes the flocks of the farmers, were vaccinated against ND, and the farmers were given advice on poultry feeding and housing.

In the Machakos district of Kenya, an evaluation by Ballard of the performance of hens upgraded through a CEP in 1977 showed an increase in egg production of about 30 eggs per hen in a flock of nine hens and one cock (Table 7).

Table 7. Production increase per hen of a nine-hen flock in Kenya

Per hen, per year	*Local hens (before)*	*Improved hens (after)*
Eggs per hen	57	87
Eggs for consumption and sale	41	63
Eggs for hatching	16	24
Chicks hatched	11	17
Birds for consumption and sale	3.2	4.9

The CEP method is criticised mainly because the raising of cockerels in government farms is costly, and exposure of the intensively raised cockerels to village conditions leads to considerable adaptation problems with resulting mortalities of 50 percent or more. Also, local cockerels are not always removed, as the farmer (quite rightly in many cases) distrusts the survival and mating ability of the exotic cockerel. The presence of the local cocks reduces the effectiveness of the attempt at genetic improvement, as they are easily able to compete for the favours of the local hens against the exotic breed cocks.

In view of the problems of the CEP, other methods have been developed, including the distribution of chicks, pullets and hatching eggs of improved breeds. A comparison of the relative efficiency of these upgrading methods, based on the number of "improved" day-old chicks produced in the village over three years, showed that the distribution of hatching eggs was the most cost-effective method (Table 8).

Table 8. Efficiency of strategies for improving poultry production

Strategy	*Percent increase*
Distribution of pullets	15
Exchange of cockerels	17
Distribution of day-old chicks	67
Distribution of hatching eggs	100

In operation, hatching eggs of selected lines are sold to families raising poultry. Local broody hens hatch the eggs. The chicks are raised by the hens and adapt easily to the environment. The distribution of hatching eggs is thus the least costly and most efficient method of genetic upgrading. This method has the following advantages and disadvantages.

Advantages of distributing hatching eggs

- The eggs represent a low project cost, compared with pullets or cockerels.
- The eggs convey 100 percent of genetic improvement, compared with cockerels or pullets, which contribute only 50 percent when crossed with local birds.
- The young chicks are raised under natural conditions from day-old age, and develop or learn scavenging ability.

Disadvantages of distributing hatching eggs

- Cockerels are generally more appreciated and accepted by the poultry farmers. This hampers the introduction of improved breeds through distribution of hatching eggs in the same area.
- Transport of hatching eggs under rough conditions and with unsuitable packaging reduces hatchability.
- The total replacement of local chickens by improved birds of exotic origin leads to: a loss of biodiversity of the local poultry population; a loss of brooding and hatching ability in the hen; and a breakdown of the self-sustained system of reproduction at the village level. These are serious problems and must also be considered.

The words that follow come from a prominent Nigerian livestock expert, but they reflect the growing appreciation of the genetic and environmental resources placed in the care of all people of all countries: "Perhaps the time has come for us to redefine the ideology for the development of African agriculture and indeed the entire economy. African agricultural ideology appears to be based on the premise that the genetic resources indigenous to the continent are inferior to those found elsewhere and as such they must be replaced or diluted to a large extent by genetic materials foreign to the continent. Similarly, we have viewed our environment as hostile and, in fact, a direct threat to our existence. These postures have prevented us from capitalising on the strengths of our genetic and environmental resource endowments. We must move from a position of emphasizing the weaknesses of our resource endowments to one of amplifying their positive aspects, while seeking to overcome the weaknesses inherent in them."

Vaccination

Protection against Newcastle Disease requires three vaccinations during the six-month growing phase of pullets and cockerels. Depending on local conditions, between two and three vaccinations per year are needed for adult birds. Because of the limited resources of government veterinary services, it is necessary to build networks of private veterinarians, veterinary assistants and vaccinators to provide preventive veterinary care in remote rural areas, and to ensure a reliable supply of vaccines. In Bangladesh, the Department of Livestock Services established such a cold chain from the vaccine production laboratory to the village level in 1984. Within three years, 4 500 poultry farmers were trained as village poultry vaccinators. The full cost of vaccination was charged to poultry producers in order to sustain the full cost of vaccine production and distribution. When it is possible to extend this fee to partly cover an extension service, it can result in the creation of a partly privatised poultry extension service. Such a system, financed by vaccination fees and the sale of exotic birds to farmers, was established in Sao Tome and Principe.

Strategy Combinations

A combined approach, including vaccination against ND, the provision of a regular water supply and feed supplements and special care for the young chicks during the first weeks of life, increases the number of eggs laid by about 100 percent as well as increasing the number of chickens raised per hen/year to between 10 and 12.The introduction of genetic improvement, in combination with further improvement in feeding, housing and health, will again increase egg production by approximately 50 percent and egg weight by 60 percent.

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9

Economics of Rabbit Rearing

The domestication of the major livestock species (cattle, sheep, pigs) and the small species (poultry) is lost in the dawn of prehistory. But rabbit domestication dates back no further than the present millenium. Indeed the wild rabbit Oryctolagus cuniculus of southern Europe and North Africa is thought to have been discovered by Phoenicians when they reached the shores of Spain about 1000 BC. In Roman times the rabbit was still emblematic of Spain. The Romans apparently spread the rabbit throughout the Roman Empire as a game animal. Like the Spaniards of that time, they ate foetuses or newborn rabbits, which they called laurices.

Rabbits had still not been domesticated, but Varron suggested that rabbits be kept in leporaria, stone-walled pens or parks, with hares and other wild species for hunting. These leporaria were the origin of the warrens or game parks that subsequently developed in the Middle Ages. It is known that monks were in the habit of eating laurices during Lent as they were "an aquatic dish". In France, it became the sole right of the lord of the manor to keep warrens. Rabbits were hunted little, and were captured with snares, nooses or nets.

Several breeds of rabbit were known in the 16th century and this is the first record we have of controlled breeding. Domestication can therefore be traced to the date Middle Ages. This was probably the work mainly of monks, since it provided them with a more delectable dish than the tougher wild rabbit. In the 16th century breeding seems to have spread across France, Italy, Flanders and England. In 1595, Agricola mentions the existence of graybrown (wild), white, black, piebald (black and white) and ash grey rabbits. In 1606, Olivier de Serres classified 3 types of rabbit: the wild rabbit, the semiwild or "warren" rabbit raised inside walls or ditches, and the domesticated or hutch-bred rabbit. The meat of the last is described as insipid, and that of the wild or semiwild type as delicate.

At the beginning of the 19th century, after the abolition of seigneurial privileges, rabbit rearing in hutches sprang up all over rural western Europe and also in city suburbs. During the same period, European colonial expansion saw the introduction of the rabbit in many countries where it was unknown, such as Australia and New Zealand.

In Europe, breeders usually had a few does and a stock of fattening animals, from which they took according to their needs, as from a larder.The animals were fed mainly on green forage picked daily. In winter the breeders supplemented forage with hay, beetroots and even grains, often from the stocks intended for large livestock. Rabbits were kept in the backyard, with the poultry. Reproduction was extensive (2-3 litters a year). From that time on there is frequent mention of the fur as a byproduct, and the already long-existing Angora mutant was recorded.

FROM TRADITIONAL TO RATIONAL PRODUCTION

Beginning in the late 19th century and picking up speed in the 20th, hutch rearing led to a rabbit population explosion made possible by the selection, protection and multiplication of breeds and mutants unadapted to the wild. Breeders formed associations. Breeding techniques were rationalised and hutch hygiene improved.

Breeding standards were laid down: each adult breeding animal was raised in a separate hutch because rabbits kept in a confined space became aggressive. Young rabbits for fattening were left together, but in this case the males were castrated. Feeding was the same as in the previous century, green fodder and grains, but the first feeding trials produced certain guidelines. The second world war saw the extensive development of rabbit production throughout Europe and Japan to cope with meat shortages. Under these demanding conditions, rabbits demonstrated their highly efficient feed conversion capacity.

In the 1950s, production slumped in Japan and the northern European countries as other meats with more flavour became available, such as frozen beef from the Southern Hemisphere. But in the Latin countries of Europe where people know how to cook rabbit, particularly in France, rabbits were Still produced. In the late 1950s, New Zealand rabbits, wiremesh cages and balanced pelleted feeds were all introduced into

France and Italy from the United States. At the same time, diseases hitherto unknown and apparently linked with the new production techniques (mucoid enteritis and respiratory ailments) appeared, and others disappeared (cenuriasis) or tapered off (coccidiosis).

These new techniques, originally better adapted to the climate of California than to that of northern Italy or France, demanded many modifications in production which were often discovered by trial and error. The hutches especially, which had always been kept outside, were put in closed buildings. Ventilation and lighting problems had to be solved.

The time spent on cleaning cages and collecting food shrank abruptly. This freed breeders to spend more time on the animals themselves. In the late 1960s and early 1970s, the work of authors such as Prud'hon et al. led to a sharp drop in weaning age, from eight weeks to four weeks. Post-kindling matings replaced post-weaning matings. Breeders were able to put into practice Hammond's early observations about postkindling fertilisation of does because feeds were so much improved as to obviate the danger of abortion in lactating pregnant does through malnutrition.

At the same time came the explosion of the New Zealand White rabbit and its offshoot, the Californian. The traditional European breeds underwent a regression. As adults it is difficult for these breeds to live on the mesh floors of the cages-the pads of their paws not being adapted like those of the New Zealand White and Californian rabbits.

French and Italian breeders worked to improve substantially the first New Zealand White and Californian rabbits imported from the United States. In France, the 2 breeds were combined to produce specialised hybrid strains according to the design conceived by the French National Agricultural Research Institute (INRA). In the late 1970s, these strains crossed the French borders to Italy, Spain, Belgium and the Federal Republic of Germany, where in large commercial production units they tended to supplant the traditional breeds. Other hybrid strains were produced at the same time, especially in Hungary and the United Kingdom, but in almost every case new strains were bred from these original 2 breeds.

Traditional varicoloured rabbits were gradually replaced by white rabbits. This is having a considerable impact on the market for skins. Before the 1970s, furriers tended to favour the easy-to-dye white skins. Today the reverse is true-white skins are too common. At the same time, improved production techniques have lowered the slaughter age of rabbits in Europe which has reduced the value of the fur. The hair of the skins is "loose" because the animals are too young.

Industrial rabbit production in Europe today is typically in units of 200-1 000 hybrid does reared in buildings with artificial or controlled ventilation. The breeding females are under artificial lighting for 15-16 hours a day and produce all through the year. All animals are reared in 1-4 storey mesh cages. Male and female breeding animals are raised in separate cages. Young animals for slaughter are raised in cages in groups of 5-10 or 1-3. Young males are not castrated because they are sold for slaughter before or just at puberty. All the animals are fed exclusively with balanced pelleted feed. Drinking water is automatically distributed to every cage.

At the same time there is a sizable increase in private and producer group investments. Typically, rational production consists of a very quick succession of all phases of the reproduction cycle. This demands extremely close and time-consuming supervision by the breeder. The technical adviser, not being directly involved in these day-to-day tasks, is of great assistance in the medium- and long-term running of a unit. His salary and ancillary costs amount to a sizable investment for a group of producers.

In many countries of eastern and western Europe, a more traditional production system, very similar to that of the first 40 or 50 years of this century, still contributes a considerable part of the national output: over 90 percent in Hungary and nearly 40 percent in France. These traditional units are usually very small, with 2-12 breeding females.

World Production

National statistics generally do not include rabbit production. But a few basic statistics from an FAO survey and various personal contacts suggest a possible world output of roughly 1 million tonnes of carcasses. This would mean an annual consumption of approximately 200 g of rabbit meat per person. But this is theoretical, as in many countries most people eat no rabbit meat whereas rural people in France eat nearly 10 kg a year.

Table 1. Major rabbit producing countires in 1980

Country	*Estimated production (carcass weight)* *Thousand tonnes*
USSR	210
France	180
Italy	160
Spain	120
China	60
Hungary	40
Poland	25
Portugal	20
German Dem Rep	20
Germany (Fed Rep of)	15
United Kingdom	15
United States	15
Total	880
Other countries	120
Grand total	1000

Table 2. Estimated annual rabbit meat production in selected countires, per caput, (kg of carcass per person per year)

Country	*Carcass weight kg*	*Country kg*	*Carcass weigh*
Malta	4.30	Germany (Fed. Rep. of)	0.33
Hungary	4.00	United Kingdom	0.27
France	3.60	Egypt	0.22
Spain	3.60	Ghana	0.20
Italy	2.80	Peru	0.13
Portugal	2.00	Algeria	0.12
USSR	0.96	Colombia	0.12
Cyprus	0.89	United States	0.07
German Dem. Rep	0.88	Mexico	0.06
Poland	0.76	South Africa	0.04

Europe is indeed the centre of world rabbit production. The foremost world producers, far surpassing all other countries, are the USSR, France, Italy and Spain. In all, Europe accounts for 85 percent of total world output. Production areas outside Europe are mainly in Central America, a few regions of Africa and in the Republic of Korea and China. Rabbits are not reared in most Arab countries.

European Trends, 1960-80

National production in the USSR is difficult to estimate as home consumption is not taken into account. But over the last 20 years there certainly seems to have been an increase in overall output: a probable rise of 20 000 tonnes to the present figure of 200 000-220 000 tonnes. In fact, sizable research efforts are made in the USSR to adapt western European methods and especially to develop systems and techniques suited to the country's potential.

The situation in France is somewhat different. Output stabilised at about 270 000 tonnes a year from 1965 to 1972, then slumped abruptly and now stands at roughly 180 000 tonnes. This situation is in line with the rapid drop in the number of very small producers who themselves used most of their production but who, because there were so many of them, supplied an appreciable share of the rabbits marketed. During this same period many newly established rational units of 50-500 does not only closed the small-scale producer gap, but also managed to increase slightly the tonnage of rabbits marketed, which rose from 110 000-120 000 tonnes in the years 1960-65 to 130 000-140 000 tonnes at present. A considerable research effort aimed at improving production techniques was responsible for this increase.

The traditional production sector in Spain produced little during the 1960s. The many rational units set up from 1970 onwards made possible a spectacular leap in the output and marketing of rabbit meat. The present total is 120 000 tonnes. The production models were transposed directly from France. Italy is between these two countries: it is unable to meet domestic demand and has to import sizable tonnages. But here again, newly established units are mostly large (500-1 000 breeder does).

Rabbit meat production and consumption in other western European countries are still low. However, there seems to be a slight increase in consumption in the Federal Republic of Germany, where breeders are being encouraged to increase their output. There is a large number of fancy breeders in the Federal Republic who raise a few pedigree animals as a hobby, and also eat a small proportion of the rabbits produced for this purpose. Production and consumption in Sweden and Norway are very low. Rabbit breeding is still a tradition in Denmark, though the national output, once exported mostly to the Federal Republic of Germany, has now dropped.

Among eastern European countries Hungary is the biggest producer. In this predominantly agricultural country family-scale rabbit production is encouraged. At the same time large production complexes with 10 000-15 000 breeding females have been set up. The young fattened animals from both systems are collected and the great majority exported to Italy. In the early 1970s, exports to Italy consisted mainly of live animals. The rabbits were slaughtered in the Milan area. Most rabbits from Hungary are now exported as fresh carcasses.

In Poland, small backyard rabbitries (5-20 breeding females) are still the rule. The rabbits produced are expected to provide good quality meat as well as fur for marketing. Therefore they are usually slaughtered late (4-6 months) for better skin quality. Some animals are collected as in Hungary, but exported as frozen carcasses (generally heavy). Recently rabbit production units of 5 000 breeding females have been established in Romania using French techniques and equipment.

North and South America

Rabbit production and consumption in the United States are concentrated mainly in the three Pacific States. Young rabbits of approximately 1.8 kg liveweight are eaten as "fryers". On the East Coast there is virtually no market and the only rabbits are pets. Rabbit production in Canada is modest, mainly concentrated in the Quebec province where it is subsidised by the provincial government. The slaughtered carcasses are a little heavier than in the United States.

In Mexico, the promotion of backyard rabbitries in rural areas has led to a total annual output of over 7 000 tonnes from these backyard units and commercial units combined.

The latter are small and use balanced concentrate feeds almost exclusively. The family units rely on forage and kitchen wastes.

In the Caribbean area, rabbit production is basically family style, using forage. The rabbits are often small local breeds, descended from animals imported some hundreds of years ago. However, notable efforts have been made in Cuba to develop improved breeds and use more intensive production methods. In Guadeloupe and Martinique, intensive commercial production in small units of 15-20 does has grown side by side with traditional production in the last decade. This development is based on animals and concentrate feeds imported from France. Output is good: does produce 30-40 young a year and these are sold at 2.2-2.4 kg, at about 80 days.

In South America the biggest producers are Brazil and Uruguay. In both countries the commercial units are large, with thousands of breeding females. The animals are raised intensively and fed locally manufactured balanced concentrate feeds.

Asia

Rabbit production does not seem to have developed in Asia except in the Republic of Korea and, minimally, in Japan. The exception is China. No official statistics are published in China on the production and consumption of rabbit meat and it is difficult to approach the question of production in a country of a thousand million inhabitants without official statistics. However, it does appear that rabbits for export are raised in a very special manner.

About 20 million Angora rabbits are farmed. They are usually slaughtered very young, after the second or third clipping at most. Production is therefore mixed, Angora wool plus meat. Thus, financially, meat appears to be the byproduct and Angora wool the main product, fetching 55-70 percent of the gross return for each animal. The animals are fed forage and a little grain and grain byproducts. Production units do not appear to be spread throughout China, but rather concentrated in certain villages. This enables better support facilities to be provided and facilitates the organising and marketing of a production which remains, in principle, at a traditional level.

Africa

The two main African producers are Ghana and Egypt both with 7 000-8 000 tonnes of carcasses a year. Far behind come Algeria and the Sudan, with 1 000-2 000 tonnes a year. Although commercial production exists in these countries most rabbitries are family owned, with a part of the output going to the market. The national rabbit production development programme in Ghana, for example, proposes a system where small family units keep only 3-6 breeding animals, so they can be fed on what is growing locally-forage, cassava, etc.-and produce surplus animals for sale.

THE RABBIT MEAT MARKET

The tonnages of rabbit meat involved in international trade are not negligible in relation to national outputs. Almost every country in western Europe regularly imports several thousand tonnes of rabbit meat a year, and the trend is upwards. The biggest producer, the USSR, neither imports nor exports rabbit meat. The two biggest import markets are Italy (16 000 tonnes) and France (14 000 tonnes), followed by the United Kingdom and the Federal Republic of Germany (5 000-8 000 tonnes) and finally the Benelux countries (4 000-5 000 tonnes). Denmark and Ireland import practically no rabbit meat. In Europe outside the EEC, Switzerland imports 2 000 tonnes and Austria barely 400 tonnes. Eastern European countries do not usually import rabbit meat.

From 1972 to 1980, imports in the EEC rose from about 24 000 to over 52 000 tonnes-more than double (+ 117 percent). The share covered by intra-EEC trading remains around 5 000-7 000 tonnes. France, the Netherlands and, very recently the United Kingdom are involved in this trade of which a small part consists of reexports.

In this period China has increased its sales of rabbit meat to EEC countries by 228 percent and eastern European countries, especially Hungary and Poland, have doubled theirs. In 1980, China covered 48 percent of EEC imports and eastern European countries 35 percent (Hungary 24 percent). Globally, net imports at present account for approximately 12 percent of total EEC rabbit meat consumption, estimated at 420 000 tonnes.

With the exception of the flow of rabbit meat from China to Europe, the trade outside Europe is very small. There are some Chinese exports to Japan and, in small quantities, to the United States and Canada. African countries import some 30-40 tonnes, often as fresh rabbit meat airfreighted from Europe (France' Italy). In 1980, Jordan imported a hundred tonnes. Apart from China, the foremost exporter of rabbit meat, Uruguay is the only trader outside Europe of any significance. and it exports only about 40 tonnes.

Market for Rabbit Skins

Data on skin marketing are scanty. France appears to be the main producer of raw skins, but the practice of reimportation after partial treatment rather complicates the figures. France uses 56 percent of the skins it produces, about 70 million. About 60 percent of these are poor quality skins from which only the hair is recovered. The best quality skins are used after tanning for garments (5-8 percent) and linings, gloves, and so on.

Most other producers also market rabbit skins, but the USSR and Poland, for example, apparently make domestic use of all the skins they produce. Australia must be considered a producer, as it exports the skins of wild rabbits killed in extermination campaigns.

The main importers of raw skins are developing countries such as the Republic of Korea and the Philippines, which have low-priced manpower to do the dressing. After fairly complete processing, these skins are reexported to developed countries such as the United States, Japan, the Federal Republic of Germany and Italy.

ANGORA WOOL

Used mainly in textiles, the wool of the Angora rabbit forms a special sector of the international wool trade. World production is modest but the value per unit of weight is high: 40 to 50 times that of greasy wool.

Europe's share of the ever-growing world output, now estimated at 2 750 tonnes, is at present about 350-400 tonnes a year. Production is mainly concentrated in Czechoslovakia (80-120 tonnes a year), France (100 tonnes) and the Federal Republic of Germany (30-40 tonnes). A small amount is also produced in the United Kingdom, Spain, Switzerland, Poland and Belgium. For the rest of the world, Chinese production is highest, at 1 500-2 000 tonnes a year. Japan produces 50-60 tonnes a year. Small quantities are also produced in Argentina, the Republic of Korea and India.

There is brisk trading in both raw Angora wool and the spun yarn. The main end-users are Japan, the United States and the Federal Republic of Germany. The trade is characterised by regular 4-year cycles, due not to production, which is in fact regular, but to fluctuations in demand dictated by fashion.

RABBIT MEAT QUALITY

Carcasses Composition

Carcasses are presented in different ways in different countries. Traditionally in Italy and certain African countries, rabbits for the market are simply bled and gutted. In France until recently the carcasses were sold skinned, with the thoracic viscera, liver and kidneys, and the head and paws still covered with fur. This changed in 1980, and now the paws must be removed.

In Canada and the United Kingdom the carcasses are dressed much as beef carcasses: no head, no viscera, and of course no paws. So slaughter yields can vary greatly from one country to another. Yields also vary among breeds, and according to age and diet. Slaughter yield improves with age: for a given carcass weight, animals with a high growth rate, receiving more balanced feed, generally have a better carcass yield. Too much roughage in the diet tends to overdevelop the digestive tract and thereby lower yield.

Table 3. Slaughter yield of New Zealand Whites, by Age

	Age in weeks			
	9	*11*	*13*	*15*
Liveweight at slaughter (kg)	1.70	2.12	2.47	2.67
Carcass weight (kg)	1.18	1.48	1.76	1.93
Slaughter yield (%)	69.2	69.8	71.6	72.1

Meat Composition

Compared with the meat of other species, rabbit meat is richer in proteins and certain vitamins and minerals. However, it has less fat. Rabbit fat contains less stearic and oleic acids than other species and higher proportions of the essential polyunsaturated linolenic and linoleic fatty acids. The anatomical composition of the rabbit varies with age. The proportion of muscle mass to body weight remains constant: over 2 kg liveweight for a strain weighing 4 kg (adult animal). But the proportion of fatty tissue tends to increase. This ratio shows up in meat composition.

Table 4. Effect of feed type on slaughter yield: Role of Supplementary Bulk Feed

	Low-bulk feed		*High-bulk feed*	
Straw content (%)	0 4		20 12	
Crude fibre content (%)				
Presentation (choice)	alone	+ straw	alone	+ straw
% of straw in free choice (% DM)	-	15.9	-	16.1
Liveweight at 70 days (kg)	1.52	1.72	1.96	1.88
Carcass weight (kg)	0.94	1.0	1 20	1.14
Slaughter yield (%)	61.4	57.7	61.3	60.6

Table 5. Impact of balanced feed on slaughter yield of burgundy fawn rabbits average liveweight at slaughter 2.2 KG

	Balanced feed	*Alfa!fa+maize*	*Dehydrated alfalfa only*
Age at 2.2 kg (days)	78	88	96
Conversion rate (DM)	3.92	4.80	6.90
Slaughter yield (%)	63.7	59.7	56.8
Fattening cost for 1 kg Carcass (index)	100	89.8	123.9

ORGANOLEPTIC PROPERTIES

The organoleptic properties of rabbit meat, like those of other species, are tenderness, juiciness and flavour. Rabbit meat does not have a very strong flavour. It is comparable to, but not identical with chicken.

Table 6. Proportion of the Principal fatty acids in fat deposits of different animal species

	C14:0	*C16:0*	*C16:1*	*C18:0*	*C18: 1*	*C:18:2*	*C18:3*
Ruminants	4	27	2	24	42	2.5	-
Pigs	1	27	3	12.5	45	8	0.5
Poultry	0.1	26	7	7	40	20	-
Rabbits	3.1	29	6	6.1	28	17.9	6.5

Tenderness varies with muscle age, and depends on changes in the proportion and type of conjunctive tissue supporting the muscle fibres. The younger rabbits are slaughtered, the more tender the meat will be. On the other hand, flavour tends to develop with age. Although little research has been done on this it is known that flavour improves with the quantity of internal fat in the muscle. In the same way, juiciness depends largely on the fat content of the carcass. The fatter the carcass the lower its water content, but the better it retains what juice it does have.

Table 7. Changes in Hindleg muscle tissue composition in New Zealand whites, according to age

	30 days	*70 days Percent*	*181 days*
Degree of maturity			
(% of adult weight)	17	55	100
Water	77.7	74.9	72.7
Proteins (N X 6.25)	18.2	20.2	21.3
Fats	2.8	3.7	4.8
Mineral salts	1.2	1.2	1.2

Slaughter conditions, especially the onset of rigor mortis, can modify the tenderness and juiciness of rabbit carcasses. Selection for growth rate combined with confined rearing favour the anaerobic metabolism of rabbit muscle tissue. Animals raised in rational rabbitries therefore have a higher proportion of white muscle fibre, which gives the meat a lighter colour.

CUSTOMER APPEAL

In Latin countries, which are traditional rabbit consumers, customer appeal is no problem. Rabbit meat is even classified as "sought after" and is eaten on special occasions. However, it is less frequently served when a guest is invited to join the family at table. In Anglo-Saxon countries, rabbit meat is not a traditional food. It is thought of as wartime fare, conjuring up memories of food shortages. A century ago, however, tens of thousands of rabbits were imported every week from the Netherlands for the London market. In other countries the situation varies greatly. Whereas the Koran in no way prohibits rabbit meat, production and consumption are virtually nil in most Arab countries. Yet rabbits are a traditional food in certain Maghreb countries such as Egypt and the Sudan. In Mexíco, rabbit meat was almost unknown, but an advertising campaign boosted consumption. A reverse example is offered by Greece. A rational development programme of large-scale commercial production was implemented in mainland Greece in the late 1960s with relative success in technical terms. But marketing made no real headway as Greeks were not in the habit of eating this meat. There had been no advertising campaign to promote it so consumers did not buy it. Paradoxically, on the island of Crete, consumption is 4 kg per person per year.

Table 8. Water losses from cooking (Grilling) Rabbit meat, according 10 age and fat content

	Age of rabbits (days)		
	86	*96*	*105*
Carcass weight (kg)	1.40	1.54	1.63
Kidney fat (% carcass)	1.5	2.2	3 4
Loss from cooking hind leg (%)	30.9	27.6	27.3
Loss from cooking back (%)	34.1	30.9	30.8
Fat content			
Leg (%)	4.8	4.9	6.0
Back (%)	1.5	1.7	1.6

The only religious bans concern Jews. Formerly there was also a religious ban in force in Japan which forbade the eating of meat from four-legged animals. When rabbits were introduced into Japan in about 1350 by a Dutchman, the meat was sold as chicken. In modern Japan rabbit meat is eaten, though the total amount is still modest (750 tonnes from domestic production plus 3 000 tonnes imported from China).

In the 1981 INRA-FAO survey of 64 developing countries reporting on the development potential for rabbit production in their countries, 70 percent thought it possible and only 22 percent considered that social customs would not favour it. The remaining 8 percent were against it for religious or other reasons.

Rabbit meat consumption is much easier to develop where people are already used to eating widely different kinds of meat, as from hunting. This would be generally true of black Africa. Peoples with monotonous diets will find it harder to accept this new product. However' the example of Mexico, with its traditional diet of maize and kidney beans, shows that a well-planned development campaign can do much to promote necessary changes in eating habits.

RABBITRY MANAGEMENT

Production Cycle

As ovulation in does is provoked by mating, and the females are generally kept in different cages from the males, it is the breeder who determines the reproduction rate of the unit. These rates vary from 1 or 2 litters a year under the most extensive management to 8-10 litters in an intensive management system. In rational European rabbitries does are remated either immediately after kindling (intensive system) or about 10 days later (semi-intensive). European backyard rabbitries use a more extensive system, presenting the doe to the buck 1-2 months after kindling. Young does are first presented for mating at 4-7 months, depending on the breed (lighter breeds are usually more precocious) and especially on the diet.

In the semi-intensive system, the does are first presented to the buck at 41/2 months. They are then mated 10-12 days after the birth of each litter. Weaning (separation of doe and young) takes place at 28-30 days. Many European breeders (France, Italy, Spain) manage intensively: mating does within 48 hours of kindling and weaning the young at 26-28 days. This, however, requires very good feeding and a producer with a fairly high level of expertise. Extensive systems are characterised by a long delay between kindling and mating, and perhaps even until weaning. For example, the young may be weaned at 56 days and the doe mated after weaning. This system is still practiced in France in farm rabbitries, where breeding does are fed fodder and grain. At weaning the young are separated from the doe. The duration of fattening varies, depending on the carcass weight required and the growth rate possible in the feeding and production conditions of the rabbitry.

In intensive European production, where weaning takes place at 1 month, the fattening period is 7 weeks. The rabbits weigh 2.3-2.4 kg (liveweight) when they are ready for the market. Some African breeding units where weaning takes place at 2 months are reported to need a 4-month fattening period, because balanced concentrates are not available. European and North American countries which market rabbits at liveweights of 1.7-1.8 kg use a different system. The young are not weaned. They are left with their doe up to the age of 2 months, when they are sold. The mother is remated 3 weeks before that. This latter system can produce 5-6 litters a year.

Reproduction

Mating

Servicing is always done in the buck's cage. The breeder checks the doe's health at this time to make sure she has no respiratory disorder, sore hocks, etc. or that she is not too thin. A red vulva is a promising but not infallible sign. A buck can fertilise a doe with a white vulva. When the doe has accepted mounting and the buck has serviced her the breeder removes the doe and puts her back in her own cage. Altogether this should not take more than 5 minutes.

While the doe is being handled the producer can carry out any treatment necessary-anti-mange, for example. If the doe refuses to mate,the breeder can try to present her to another buck. As a last resort he can leave her for 24 hours in the buck's cage but then he cannot be sure that mating has taken place. It is better to mate the animals in the morning or evening, to avoid the hottest hours of the day.

In intensive breeding 1 buck can serve 7 or 8 does. In the extensive system 1 buck can serve 10-15 does. The buck, however, should not be used more than 3 or 4 days a week, and not more than 2 or 3 times a day. So even if there are only, say, 10 does in the unit, there should be at least 2 bucks so that successful mating is not dependent on 1 buck alone. When the size of the unit permits (at least 50 does), 1-2 reserve bucks are kept. If a balanced pelleted feed is used the bucks should be fed from 120 to 180 g a day, depending on their weight.

The first mating of medium-size, properly fed does takes place around 4 months. Bucks are first mated at about 5 months. If production conditions are not optimum the first mating will be delayed until the animals reach 80 percent of their adult weight. There is no advantage in delaying it further. The breeder should carefully supervise the first mating. For the first month the young buck should not be mated as often as an adult.

Determining pregnancy

The only effective way of determining pregnancy is to detect the embryos in the doe's uterus by palpating the abdomen. This operation should be carried out between 10 and 14 days after mating. It is not effective if performed earlier (before the 9th day), while after the 14th day the operation is more delicate and there is a risk of provoking abortion. The breeder must palpate the doe gently and expertly in order not to cause an abortion.

If palpation shows the doe to be empty she is presented to the buck again as soon as possible. Presentation of the doe to the buck as a test of pregnancy is pointless, though not dangerous. Indeed a large proportion of pregnant does accept mating and some empty does refuse. Nor is doe liveweight an indication of pregnancy because weight fluctuations depend on too many factors.

Preparations for kindling (supervision, nest box, changing bedding material, etc) should be made for all the mated does from the 27th to the 28th day after mating if they have not been palpated' but where palpation has been practiced regularly the preparations are restricted to the does found to be pregnant.

A pregnant doe that is not nursing a litter will be rationed if the breeder uses balanced concentrates. The daily ration for medium-size does will be about 150 g. If the doe is nursing a litter at the same time she will be fed ad lib.

Kindling

Kindling should take place in quiet, hygienic surroundings. The breeder's presence is not required, but the nests should be checked as soon as possible after kindling. This operation is easy and there is no risk to the young. It can be performed right after kindling, provided the mother is removed. The breeder should remove any dead animals, and any foetal sacs the doe has not eaten.

A nursing doe needs considerable nutrition and from the time of parturition she should be fed ad lib. Drinking water is very important in the days leading up to and following parturition. The doe will nurse her young once a day, usually in the early morning.

The mortality rate between birth and weaning is still high (20 percent today in European rabbitries). A mortality figure of less than 12 percent is very difficult to achieve. Therefore the nests have to be inspected daily and any dead animals removed. Strict preventive hygiene is more important than ever at this period.

Fostering

The breeder may decide it is necessary to eliminate excess newborn rabbits in a large litter. or they may be fostered to a smaller litter, if certain rules are respected:

- no more than 3 young rabbits should be given to a foster mother;
- the maximum age difference between the foster doe's litter and the fostered young should be 48 hours;
- fostering should take place within 5 days of kindling.

Weaning

During the weaning period the young gradually give up milk for solid feed. Weaning is also the time when the breeder separates the young from the doe. All the young of a litter are taken away at the same time and placed 6-8 per cage in the area set aside for fattening. The cages must be clean and the groups should be fairly uniform , with a maximum age difference of 1 week between them. During the transfer operation the breeder checks the health of the young rabbits culling any that are undersized or sick.

Weaning can take place when the rabbit's liveweight tops 500 g (after approximately 26-30 days in rational European production). The young rabbits begin to eat solid feed at 18-20 days, and when they reach 30 days the doe's milk provides no more than 20 percent of the daily feed intake.

Stock reduction and renewal of breeding does

One of the apparent drawbacks of intensive reproduction is the rapid turnover of breeding stock. Monthly culling rates of 8-10 percent are not uncommon. In fact, where reproduction is intensive the breeder soon learns the value of each doe and can thus keep the best. The total number of rabbits produced by each doe during her working life is fairly independent of the rate of reproduction imposed by the breeder. Whatever the reproduction and the monthly stock renewal rates, to avoid having empty cages in the nursery there should be a constant reserve of does available that are ready for mating.

The breeder has several means of renewing breeding does. The most practical solution, applicable to both pure breeds and °Common" strains, is to select the best young from the best does. To avoid inbreeding, the bucks and even the does should be obtained from another breeder (selector). If production is intensive, the producer can buy breeding animals from a selection programme of specialised strains for crossbreeding-the system of stock renewal to follow will be advised by the supplier.

FATTENING AND SLAUGHTER

During the weaning-to-slaughter growth period the rabbit should always be fed ad lib. If the breeder uses balanced concentrates, the average daily consumption will be 100-130 g for medium-size animals. In good conditions the rabbits will gain 3(1-40 g a day, which means an intake of 33.5 kg feed will produce a I kg gain in liveweight. Young fattening rabbits can also be fed cereals and fodder, with or without the supplement of a suitable concentrate.

During this period mortality should be very low-only a traction of the fattening stock-but it is often far higher. Preventive hygiene (cleaning, disinfecting) is essential in the fattening station, but the breeder will often pay less attention to this area than he will to the nursery.

The animals are sold alive or as carcasses. Rabbits raised in rational production systems are sold at about 70-90 days at weights of 2.3-2.5 kg for strains like the New Zealand White and Californian. In extensive production systems with less-well-balanced feeding the rabbits may be sold much later (4 to 6 months, maximum). Fattening animals that have passed the usual age for sale can form a reserve from which the breeder can draw for home consumption or stock renewal. In farm rabbitries, the mortality risk from accidents, epidemics and so forth is still high, and any delay in the regular slaughtering age for whatever reason, such as keeping the rabbits alive for gradual home consumption, can end in catastrophe, with the death of all the animals. The higher the mortality rate during fattening, the more the breeder will tend to shorten the length of this production phase.

If rabbits are to be kept beyond 3 months the bucks must be either put in individual cages or castrated, so that they can continue to be colony reared. The females may remain in groups, but will need more cage space than they did before 3 months. Castration is a simple operation, though it usually requires 2 people.

The breeder may wish to slaughter his animals himself. The necessary installations are relatively expensive if the proper standards of hygiene and conservation (cold storage, etc) are to be respected. He will also need labour for a few hours a week to help with the slaughter.

Handling Rabbits

Rabbits should be handled gently. They must never be lifted by their ears. Several techniques can be used to pick them up and hold them.

A rabbit can always be picked up by the skin of the shoulders. For animals weighing under 1 kg, one method is to pick them up and carry them by the saddle just above the hindquarters, using thumb and index finger. If the animals are heavier it is best to take them by the skin of the shoulders, but if they have to be transported or shifted for more than 5 or 10 seconds they must either be supported with the other hand or be carried on the forearm with the head in the bend of the elbow.

If an animal struggles and the producer feels he cannot control it, it is best to just drop it so it will fall on all fours, and then pick it up again correctly within 2-3 seconds. If the breeder keeps his hold on a struggling rabbit he risks some nastry scratches, and can even break the rabbit's backbone.

ORGANISING A RABBITRY

First Operation Identification

Identification can be made in 2 ways: by individuals and by cages. The first method is necessary for all producers who intend to select. The second is important for the economic management of the rabbitry.

Individual identification

Each animal is assigned a number. This number will appear on all documents concerning the rabbit and on the rabbit itself. There are 3 main ways of identifying rabbits on a lasting basis. Not all are equally good.

- *rings:* a numbered ring is attached to the hind leg just above the hock. Risk of losing the ring is high;
- *clips:* numbered clips are attached to the rabbits' ears. These clips are made of metal or plastic, and risk of loss is again high;
- *tattooing:* small holes are punched in the rabbit's ear spelling out numbers or letters, and these are filled by rubbing in a special ink. A well-made tattoo lasts throughout the rabbit's lifetime. Although this method takes longer, it is the only one that is really sure. It can be done at weaning using special rabbit pincers, or on adult rabbits with sheep pincers.

Cage identification

The management unit of a rabbitry is the mother-cage. All the cages in the nursery section should be numbered, and this is the figure that will appear on the records. This method is much easier than individual identification, so it is used in rabbitries which keep records but do not breed selectively.

An identification system is essential even in small rabbitries. It will form the basis of the technical records that will serve for both the organisation of the work and the economic management of the rabbitry.

Technical Records and Organisation of Work

In the nursery

A daily record book is essential in almost every kind of production. The producer notes the chief operations simply and clearly:

- mating days for each doe, indicating sire (used to check buck fertility);
- outcome of palpation, where performed;
- numerical size of each litter at birth;
- numerical size of each litter at weaning.

The young does selected for replacement are identified at weaning. This list is far from complete. Litter weight at weaning could be added, for instance. If the producer uses balanced concentrates he will enter the amounts fed in the nursery to compute the average feeding cost per weaned rabbit. This is an important item in calculating net profit. A similar entry would be equally helpful for other types of feeding, but these are far more difficult to estimate.

The record book system is often inadequate. One improvement is a doe card hooked to each cage, for calculating individual doe productivity.

The next step is to put the data together to get an overview of the unit for efficient organisation of the work. This is essential in any rabbitry with more than a few dozen does. Planning pigeonholes offer a virtually foolproof way of monitoring all events in the nursery. Assuming that does are remated and litters are weaned no later than 1 month after kindling, the system involves a large box with 4 horizontal rows of 31 compartments. Each corresponds to a day of the month. The first row is for matings, the second for pregnancy checks, the third for births and the last for weanings. If weaning takes place between 1 and 2 months, which is common in extensive production, there will be 2 rows for weaning, for even months and odd months.

Every morning the producer sees in his work book what operations are to be carried out. As each is completed, the card of the doe concerned is moved into the pigeonhole corresponding to the next operation and the day for which it is scheduled.

In a rabbitry where mating takes place 10 days after kindling and rabbits are weaned at 35 days, the doe record could be as follows: Let us suppose the doe is mated on the third day of an odd month. Her card is then placed in the palpation row. This operation is performed on the 16th of the same month (+ 13 days). If the result is positive, the doe card is placed in the kindling row under the second day of the following month (+ 15 days). If it is negative, her card will go back to the mating row. After kindling the doe card returns to the mating row under the 1 2th day of the same month (+ 10 days). At the same time, a card with the doe's individual and cage numbers will be placed in the weaning row, in space , of the second, odd month (+35 days). There are other planning systems. The important thing is to use one system consistently.

Scheduling several matings, a few palpations and the weaning of several litters all for the same day adds up to a lot of wasted time. Using a weekly work plan I man working 8 hours a day can manage 250-300 does. With this method batches of litters at weaning are close to the same age. It also sets the time for activities the producer always tends to postpone, such as recording data and carrying out preventive hygiene measures. In a rational production unit the following average times must be set aside for the main nursery activities for 100 does:

- mating: 4 hours a week;
- nest supervision: 3 hours a week;
- handling young, nest boxes: 2 hours a week;
- palpation: 1 hour a week;
- hygiene: 4 hours a week.

Fattening records

Here again the daily record book is essential. It will list the first and last fattening days of the animals in each cage, any mortality and the apparent causes. Liveweight when sold and the number of animals marketed weekly could also be added. In large-scale production, production checks will be done by batches. The batch will be the core reference point of all technical data.

If the breeder uses balanced concentrates he will record the amount of feed eaten by fattening rabbits. Feed conversion efficiency (the amount of feed needed to produce a weight gain of I kg) is a sound economic criterion. If the producer wants to breed his stock selectively he can use a litter card listing the weaning weight and date, the weight and date at sale or slaughter, and the individual identification number of each rabbit.

Some production targets

The basic technical criterion in the nursery is the number of young weaned per doe per year. Economically, the tendency is to calculate this in terms of the mother-cage and include the amount of feed consumed. The young weaned per doe depend on the number of kindlings a year, the number of young weaned per litter and the real rate of occupancy of the nursery cages.

Several analytical factors are important in the fattening stage- growth rate, feed efficiency, age at slaughter, carcass yield, mortality. Global criteria such as overall feed efficiency cover the range of production and feeding activities. The number of rabbits sold per week in reference to a fixed number of does is another global criterion.

To help producers with this work, outside organisations can collect the main technical data of their production units every week and make an estimation of these parameters. With this information a breeder knows what results to expect. A comparison with other rabbit production units will reveal any weak points in his system.

ECONOMIC MANAGEMENT

As with keeping technical records, not all producers have the same needs in economic management, which mainly concerns those whose purpose is to make a good profit.

Operating costs, which can vary with the production system, here amount to more than 70 percent of the cost of production. Feed is the main item under this heading (65 percent of the total outlay). This is why feed efficiency is so important. Depreciation of the building and equipment together with financial charges amount to more than 25 percent of the total. These figures are closely linked with the French socioeconomic situation. As always, the higher the level of investment the greater the unit's productivity must be to write off these debts.

Improvement in overall production has a substantial impact on producer income. Feed consumption is here again of considerable importance. The objective in raising rabbits is meat production. The exceptions are rabbits raised for their fur only-a rare exception this and the Angora rabbit for textile wool.

The outcome is that the rabbit pelt is a byproduct, imposing no special constraints on meat production methods. But wool is the main target of Angora rabbit production and the need to produce a quality fur has led Angora breeders to develop methods quite different from those used in meat rabbit production.

These two production systems should therefore be dealt with separately because of their different natures, destinations, markets and production techniques. There is only one point they have in common: hair shorn from lower-grade skins that cannot be used in fur manufacture is partly used by the textile industry.

Rabbit Skins

Rabbit fur production is not comparable with the production of other fur species. Mink, which tops the list of species bred essentially for their fur, supplies a world total of about 25 million pelts a year. In France alone annual rabbit skin production tops the 70 million mark. But mink is bred for its fur and rabbits for meat, so rabbit fur is just a byproduct to which breeders give scant attention.

Intensive meat rabbit production techniques in Europe are usually incompatible with production standards for quality fur pelts. In fact, the raw skin represents only a small percentage of the value of the living animal. So more and more frequently rabbits are slaughtered at an age or time of year when their coats have not fully developed. This is usually at 10-12 weeks when they still have an infant coat or are beginning the sub-adult moult. These thin, unstable coats are not suitable for furs.

The only season when the adult coat is stable and homogeneous is winter. This is true of any animal over 5 months of age. The rest of the year there are always moult areas of greater or lesser size, so the coat is uneven and the hair is not firmly attached to the skin. Some summer coats can be homogeneous, especially those of rabbits that have completed the sub-adult moult, but the rabbits must be at least 5 months old. The summer coat is also thinner than the winter coat.

This rather inflexible growth cycle and seasonal changes in the coat create the problem of simultaneous fur and meat production. Fur can therefore only constitute a byproduct, especially in intensive production. However, no research has been done on moulting patterns in hot climates; the figures given here only really apply to temperate regions. In extensive production, rabbits are slaughtered at 4-6 months, and this is the situation in many tropical countries. So quality skins could be produced in the tropics assuming the proper skinning and preserving techniques were used.

Sorting and Grading Pelts

In an unsorted batch of rabbit skins valuable pelts can be found side by side with useless waste, so sorting and grading should be done as early as possible. Sorting is the first operation and determines the future use of the skin. Skins are sorted into 3 grades.

1. *Pelts for dressing.* These are the best skins, with regular shape, intact, homogeneous, dense, a well-formed coat, a flawless skin. Their price may be 20 times that of ordinary-quality skins.
2. *Pelts for shorn hair.* These usually lack the proper shape or are not homogeneous enough for fur products. The hair, however, is sufficiently long and healthy. It is therefore machine shorn and used for textiles or felting. The skin is cut into fine strips and made into glue or fertiliser. This technique allows much of the pelt to be recycled.
3. *Waste, unusable except for fertiliser.* These skins push up the costs of labour, processing and transport.

In France, one of the foremost rabbit producing countries, the proportion of pelts suitable for dressing is less than a half of those collected.

The figure differs from one author to another, which is not surprising in view of the difficulty in getting exact data on this product.

The customer buys the skins in commercial lots of matching quality. The following grading system is used in France. For pelts for shorn hair: rejects-hair weight 10-18 percent of the dry pelt weight; ordinary-hair weight more than 18 percent of dry pelt weight; good quality, with guard hair removed-for glovemaking. For fur pelts:

Grading is more complex for fur pelts, as colour, size and quality are all considered. The colours are white, range of grey, range of red (nankin), mixed and black.

Size is assessed by the weight per 100 dry pelts:

- entre-deux: 12-13 kg/100 pelts (100-140 g per pelt);
- cage: 13-20 kg/100 pelts (150-210 g per pelt);
- heavy: 26-40 kg/100 pelts (250-350 g per pelt).

The gap between grades and the difference between weight per IOU pelts and unit weight stem from fluctuations in assessment.

Quality assessment covers the integrity of the pelt (proper cut, good fleshing, no knife marks or holes from skinning) and its structure (height of guard hair, compactness and height of downy undercoat and the homogeneity of the coat):

- pelts 4: poorest;

- pelts 3, 2 bis: medium;
- pelts 2 and 1: best.

This classification, which at first sight looks complex, is in actual fact relatively simple: traders and clients know exactly what merchandise is in question when they speak of a "Cage 2 grey" or an "entre-deux 4 nankin".

The system, with slight variations, is the same in every country, understandably so considering rabbit pelts are an international trade item. In the United States, where rabbit production is not widespread and is undertaken by amateurs, US Department of Agriculture grades are:

- *firsts:* no defects, thick and regular sub-hair. Used for furs;
- *seconds:* some hair defects and a certain lack of thickness, short sub
- *hair.* For inferior fur and cutting;
- *thirds:* for cutting (felt) or toys;
- *hatters:* rejects, the best of which are used for cutting.

Firsts and seconds include 5 colours: white; red; blue; chinchilla; mixed.

Sorting and grading clearly show that it is in the interest of the breeder and the general economy of the country to produce the highest possible proportion of quality pelts or at least reduce the proportion of those which are unusable. It is also important to be able to constitute homogeneous commercial lots. This means that if production is low in a region the range of colours should be limited. The choice is not simple, given the ups and downs of fashion. The wisest choice would normally be white, as it generally commands a good price and once dyed can easily follow colour fashion trends. However, this is not the best advice at present' with longhaired fur in vogue and dyeing virtually in disuse.

The Production of Quality Pelts

Moulting

The main barrier to quality pelt production is slaughter age: the pelt must be big enough, and the whole coat mature. The crucial times are moulting-juvenile moults for growing rabbits and seasonal moults for adults.

The seasonal moults in adults are ruled by seasonal photoperiodicity and occur in spring and autumn. The spring moults are spectacular, with visible loss of winter hair, but they are slow and irregular and rarely give an entirely stable coat in summer. This summer coat, thin and short, is not among the most prized-it weighs only 60 g. The autumn moult on the other hand reactivates all the hair follicles in a relatively short time. It gives longer hairs and above all multiplies the secondary hair follicles which produce a part of the undercoat. The winter coat, which remains stable for several months, weighs approximately 90 g. It is this coat which is the most highly prized of all, if not the only one used. In addition, the network of collagen fibres of the derma is contracted, and produces a finer and stronger skin.

It is obviously preferable in a temperate climate to slaughter the animal at the onset of winter, as soon as the coat is mature, to ensure the least possible deterioration of the hair. Unfortunately no detailed study has been made in tropical or equatorial climates.

There are 3 types of juvenile coat: that of the newborn rabbit, infant coats, and sub-adult coats. The first two are unusable because they are too small. The coat of the newborn rabbit stops growing when the animal reaches 0.4 kg (for an average size breed); it weighs only 8-10 g. The infant coat is mature at around 9 weeks and its weight depends on the rabbit's weight, since the number of hair follicles in development depends on the size of the skin area of the growing animal. If a rabbit weighs 0.5 kg at 9 weeks it carries 15 g of hair, against 30 g for a rabbit weighing 1.1 kg. The coat is thus still light in weight and the hair is fine.

The sub-adult coat becomes more interesting but the moult which produces it is long (4-5 weeks) and only begins when the rabbit reaches 1.71.9 kg. It matures at the earliest at 4 to 5 months, usually after 5 months. The weight of the coat, and hence the length of the hair and its density, also depends on the season in which the hair develops: 40 g in summer, 60 g in autumn or in winter, which is acceptable. The sub-adult coat is therefore the first coat that could provide a fur.

It is very difficult to obtain pelts for fur in intensive production systems (slaughter at 11 weeks). However, a breeder might attempt to produce acceptable pelts for shorn hair by using simple measures (animal housing, precautions at slaughter and skinning).

It is not impossible to produce pelts for fur in a rational extensive production system (an extensive system in which production techniques are strictly adhered to, especially with regard to hygiene, habitat and feeding). In fact, with a low investment, not forcing the animals' growth and using an economical but balanced feed regime, it should be possible to slaughter the animals at around 5 months.

Environment

Sub-adult and adult moults are ruled by seasonal photoperiodicity. They can therefore be induced by artificial lighting, but this calls for sophisticated installations (windowless housing) and the technique is complex (interference with reproduction). At present, natural photoperiodicity seems to offer the greatest security for the production of quality pelts, which argues in favour of rational, extensive production.

Temperature does not influence moults, but it does seem to affect the structure of the coat: a greater number of downy hairs and longer hair in cold zones, and a shorter, thinner coat in hot zones. As a consequence, cold or temperate countries are more likely to provide pelts for fur production.

Rearing rabbits in colonies leads to fighting and possibly trichophagy (the rabbits eat one another's hair for lack of roughage in the diet). Individual cage rearing, at least during the month preceding slaughter, is to be preferred. The cage with straw litter, as will be seen with the

Angora rabbit, gives a completely defect-free and clean coat, but individual mesh cages can also give good results. In this area too, extensive production is more likely to provide pelts for fur production.

A wholesome, balanced diet is required-the question is whether to aim at a rapid growth, or a slightly moderated growth rate using economical rations from the farm's own produce. For fur production, slaughter should be delayed to 5 months, or 41/2 months at the earliest, and this also argues in favour of rational extensive production.

Any physiological imbalance or pathological disorder has immediate repercussions on the coat, even if it has reached maturity. It becomes dull and unkempt, the secretion of the sebaceous glands is disturbed and the rabbit neglects its grooming. A skin collected in this condition will never make a good fur. Normal hygienic procedures, valid whatever the production system, also favour the production of a quality pelt and help to avoid diseases which specifically affect the skin. This will be one of the most difficult problems for developing countries.

Choice of breed and selection

In making this choice there are two factors above all to be considered with relation to grading pelts: colour and size. Colour is a question of fashion but, as mentioned earlier, white is the most suitable as it is impervious to fashion changes; it can be dyed. It must be remembered that the trader is interested only in lots of 4 or 5 tonnes. Large pelts are the most prized; without going so far as to produce giant rabbits this means that midget breeds should be set aside. Lastly there is the structure of the coat: it should be homogeneous, with long hair and a thick undercoat well covered with silky guard hair.

The Collection, Preservation and Storage of Pelts

Skinning

Skinning should be carried out in a manner that ensures the largest possible skin surface, which is an important part of its value. The first cut is usually an incision at the hind feet, passing from one thigh to the other. The skin is then pulled off. The skin on the head is of no commercial value so it can be discarded, which facilitates the drying.This operation should be done with care to avoid mutilation, knife marks, grease or bloodstains. All these defects reduce the value of the pelt, especially when the coat is originally of good quality.

Rabbit pelts are preserved only by drying. This is a simple operation which can be done anywhere, and costs little. Drying should start immediately after the skin has been removed. It must cool off quickly and dry out to prevent the action of enzymes in the derma which attack the hair root and cause the hair to fall. If fresh pelts are left in a pile for even a short time a rapid bacterial fermentation will set in and cause the hair to fall out in patches. Many pelts are lost this way for a lack of elementary care.

The skins are shaped on a frame. They should not be excessively stretched, not should there be any creases. The frame can be a board, a steel wire frame, or even a fairly supple stem with no branches. Straw should not be used as padding as it can deform the pelt.

During drying, air should circulate freely, and the skins should not come into contact with one another. It is out of the question to accelerate drying by exposing the skins to the sun or to hot air, above 50°C the collagen of the derma is altered irreversibly and the skin cannot be processed. They should be dried in the shade in a well-aired place.

Storage

The pelts are arranged in piles when they are perfectly dry in a cool airy room, with insecticide (naphthaline) between each layer of skin. It is best to grade the pelts without delay, the grading being more or less elaborate according to the size of the stock in question. At least the different qualities should be separated immediately, and the white skins from the coloured.

Whether the destination of the pelt is fur or hair production, all operations from skinning to storage must be carried out with care and attention. The slightest fault in handling results in a lowering of grade, which is all the more serious when a high-quality skin is involved and all the work carried out previously is lost. The greater the homogeneity and quality of the pelts the more attractive they will be to the trader, which is particularly important at times of market depression. If it is intended to extend rabbit production in a country for the profitable sale of the pelts, the training required should not be underestimated. It will be needed not only in production, particularly in teaching producers how to recognise the state of maturity, but also in the care needed in skinning the animal and in preserving and storing the pelt. Experience with hides and skins of other species shows the extent of losses due to negligence (in some countries only 1 pelt remains from every 3 animals slaughtered). Perhaps bad habits can more easily be avoided with the introduction of new husbandry methods.

Curing and Glossing

Developing countries are increasingly processing the cattle hides and sheep skins they produce. The first step is to turn out semifinished products, for which the technology is simpler and more uniform, albeit demanding, and for which there is a wider market. Finished leather is a specialised product whose manufacture is far more delicate to undertake as experience and imagination are both essential.

This is why developing countries are holding back their rough pelts to make semifinished products such as wet-blues and hides (India, Pakistan). This system obviously has the advantage of using the local labour available and giving greater value to the exported product. Is the same development possible for rabbit pelts? This is difficult enough to answer with regard to other fur, which must always be perfect, and even more difficult for rabbit fur, towards which there is some consumer resistance, and because European output, though of medium quality, is so high. On the other hand, shearing the pelt for the hair does not seem to pose any particular problem any more than does the utilisation of the remainder of the skin, even if only for fertiliser. There is also the possible manufacture of small objects such as toys with pieces of low-quality fur; however, this is of relatively small economic importance and may involve difficulties with the hygiene regulations of importing countries.

Curing

Processing the pelt to the semifinished stage requires a series of operations:

- *dipping:* rehydration of the pelts with water, salt and possibly soap, followed by rinsing;
- *fleshing:* the rabbit skin has a peculiarity-a thin collagenous film on the flesh side. This membrane, which is impervious to curing products, should be removed. This is a delicate, labour-intensive operation, carried out on the rehydrated skins;
- *dressing:* the special tanning for rabbit skins generally uses a special blend of salt, alum and formol;
- *thinning:* it is necessary to thin down the thicker skins. This is highly specialised work, demanding great precision to avoid holes in the skin, cutting hair follicles, causing hair loss. A second dressing is carried out on the thinned skins;
- *greasing:* nourishing the skin with oil. This operation is labour intensive;
- *finishing:* this gives the skin a pleasing appearance by removing grease, beating, lifting the hair to set it in place. Machines can be used for all 3 finishing stages.

Glossing

This is a complicated finishing operation, with variations such as shaving or colouring according to the final product required. It calls for much handling, expertise and imagination (mixing of dyes, special effects, etc). These operations are too complex to describe here. However, it is often the furrier who, having chosen his lot of rough furs, decides on the final appearance they will be given. For a coat, 20-30 skins will be needed. The making up of "bodies", which is labour intensive and not highly automated, can be done in developing countries or in countries where the labour is less expensive.

Hair production

It would be mistaken to assume that the pelt for shorn hair is a negligible product. Depending on quality its value can be very high-80F in France in 1978, againt 300F for an Angora pelt. The fluctuations in value, however, are vertiginous because demand is not constant: a pelt for hair can be worth between 1 and 20F according to the quality and the demand of the moment. This figure is multiplied by 5 to arrive at the price of the hair.

THE ANGORA

In the matter of textiles, "angora" without any other qualification refers solely to the hair produced by Angora rabbits. Its ISO (International Organisation for Standardisation) symbol is WA: W for wool, reserved for noble textile hair, as opposed to H used for ordinary hair. The letter A is for the Angora rabbit, and distinguishes it from the mohair goat, M (the term Angora goat is no longer used). The symbol for mohair is thus WM. The short hair of the ordinary rabbit is designated HK (K = Kaninchen in German).

Angora hair is unusually long owing to the prolongation of the active phase of the hair follicle cycle: the hair grows for approximately 14 weeks? whereas that of the rabbit with ordinary hair grows at the same rate but for only 5 weeks. Apart from this great length, there is no other modification either in the hair's structure or in the composition of the coat, which contains the 3 classic types of rabbit hair:

- guide hairs; the longest (12-15 cm) and the roughest; they cover and guide the coat;
- guard hairs ("barbes"); shorter than guide hairs (8-10 cm); their rough points lie on the coat and hermetically seal it (covering hair): 4 to each guide hair;
- down: shortest hair (6 cm); rounded point, hardly visible, very fine body (13.5 ~m). Very numerous, 60 to a guide hair, they constitute the thermic isolation undercoat.

It is the length of angora hair which gives it its textile value as it permits cohesion in the thread.

The rabbit's hair is characterised by an extremely low friction coefficient which is due to the very slight relief of the cuticle scales. This results in a particular softness to the touch, but also an exceptional capacity for slipping. This is why the length of angora is important; the hair is twisted and stays in the thread. The use of ordinary rabbit hair to replace angora produces threads of bad quality which spread everywhere: this is a fraudulent process which reflects badly on the angora industry.

Because of its softness angora hair is used for the manufacture of insulating underclothes (keratin). Ten percent angora in a mixture of wool, cotton and synthetic fibres makes an extemely soft fabric, very easy on the skin.

The kemp points and the covering hairs, which are more rigid rise from the fabric, giving it a fluffy appearance which is much prized. Whole angora hairs obtained by depilation are the most suited for this purpose.

Though the Angora rabbit exists in all colours, only the albino strain is produced now. Its coat is entirely white, which is an advantage for dyeing. The hairs are all modulated, which makes them lighter than wool (density 1.1 against 1.3) and increases their insulating properties. They have all the properties of keratin, notably insulation, water absorption and good dyeing quality.

The Angora rabbit's coat is 98.5 percent pure as cutaneous secretions (restricted to those of the sebaceous glands) are very slight and the animal grooms itself frequently (a sheep's fleece is 50 percent pure). Angora wool goes straight to the card without previous washing: it is imperative that the producer keep constant control over the cleanliness of the animals.

Commercial Qualities

There are several grades of hair, identified by length, type of animal and cleanliness. For first-quality hair 80 percent of the coat must be over 6 cm in length, and clean. This grade was worth US$50 a kg in 1981, but only $10 a kg in 1971. Second-quality hair is clean but too short (under 6 cm) or too woolly. It is grown on the belly and extremities, and is worth about 20 percent less than the first quality wool.

The hair of the young Angora is shorter and softer. It is the product of the first and sometimes the second collection. The clean but felled hairs collected on the necks of females or breeding animals are worth only 15 percent of the value of first quality hair.

Dirty hair of any length is virtually worthless. At best, it is worth less than shorn hair from ordinary rabbit breeds. Its value would be no more than 5-6 percent of the first quality. Clean hair is therefore absolutely essential in angora wool production.

Raising Angora

Angora rabbits are reared primarily for their hair. The production of this hair calls for an entirely different set of techniques from those used in meat rabbit production. These techniques have reached the pinnacle of specialisation in France, where the sole target is wool production.

The adult female produces the hair: adult, because top quality Angora is only produced from the third collection at 9 months, and female because the female produces more hair than the male-an average of 1 kg against 700-800 g for the male. So the hair-producing stock is made up of adult females that are maintained as long as possible, with reproduction kept at a minimum. Gestation and lactation reduce hair production by one third.

The number of breeding bucks is kept to a proportion of only 5 percent. In France the males not destined for breeding are culled at birth.

The hair is collected every 90-100 days, when the follicles reach the resting stage and before hair starts falling, which would cause felting and reduce the value. The hair is cut with scissors or electric or manual shears, or collected by depilation. The hair from each rabbit is sorted into its separate grades as soon as it is removed. The summer collection is smaller, up to a third less than that of autumn and winter. The spring collection is between the two.

Collection takes a skilled operator about half an hour per rabbit. Shearing is a little quicker than depilation, but the hair is of slightly poorer quality. In addition, with certain strains of Angora rabbits the hair grows back unevenly after shearing, while it is more regular after depilation.

The Angora rabbit is raised in an individual cage on straw litter for two reasons: to keep the hair clean and to avoid the formation of scabs on the paws, which eventually happens on mesh floors as Angora rabbits are heavy (4 kg) and their pads are unusually delicate. Damaged paws will cause production to drop by 25 percent compared to litter reared animals, and the rabbits may die. Raising the animals in cages, a feature of the extensive system, does not require costly investment and allows a gradual increase of production. One person working full time (2 400 working hours a year) can care for 500 rabbits-feeding, care, collection of wool, etc.

Feeding and hygiene

Feeding Angora rabbits involves several peculiarities. Indeed the Angora at peak production is an adult rabbit from the physiological standpoint. Its growth is complete and reproduction is limited to a few animals. It must, however, produce over 2 kg of dry proteins a year- more than 1 kg of keratin (hair) and the same amount from the internal sheath of the hair follicle. This is the equivalent of 7 kg of muscle.

This explains the need for a high-protein diet-17 percent. The keratin in the hair is rich in sulphur amino acids, exporting 35 g of sulphur a year, so the proper intake of these amino acids (0.6 percent in the ration) must be ensured. French breeders give their animals top quality alfalfa hay supplemented by oats, which are preferred to other cereals. For a high production of hair 200 g of alfalfa hay and 100 g of oats are needed per rabbit per day. If the amount or quality of alfalfa hay is inadequate the diet should be supplemented by mixed concentrates, including feed cakes, dehydrated alfalfa meal, cereals, and vitamin, mineral and methionine supplements. Most Angora breeding units use this diet now. Some use solely the balanced pelleted feed designed for nursing does. In this case an average 170-180 g should be fed to each rabbit daily.

The Angora rabbit's feed requirements follow the cycle of collection (every 3 months) and hair regrowth. Requirements increase after depilation as the animal is then hairless and energy losses by radiation are very great. By the second month the animal is again well covered, but this is when the hair grows fastest so the ration must of course remain adequate. In the third month, requirements decrease because the hair grows more slowly and, as collection time approaches, starts to fall. Daily rations need to be adjusted carefully to these variable requirements.

It is now the practice to give 190-210 g per day of dry matter during the first month, 170-180 g during the second month and 140-150 g during the third month. If really necessary, in the 4 weeks after depilation a rabbit could be fed ad lib., but after this it must be rationed daily. It is also recommended that the rabbits not be fed 1 day a week so the stomach can empty, preventing or at least diminishing the risk of hair balls from self-grooming. The hair forms very hard balls (trichobezoars) which obstruct the pylorus and usually cause the animal's death.

The collection of the animals' hair poses problems of heat regulation for them. Just before collection the rabbit has an insulating mantle 6-10 cm thick, but after it is quite bare. The rabbits must therefore be kept at a temperature between 10 and 25°C (30°C at most). Most losses of adult Angoras occur during the days following hair collection as the animals then have problems maintaining thermal balance.. They become particularly sensitive to respiratory germs (pasteurella, coryza, etc). The breeder must therefore be constantly on the alert regarding their general hygiene (frequent litter renewal, cleaning, disinfecting). Having to replace working females with young does lowers average production levels because first year Angora output is appreciably lower. Even more important, dirty hair is virtually worthless.

Angora in Developing Countries

A point to be considered very carefully is that Angora rabbit production is labour intensive and also requires great expertise. The slightest mistake can mean the loss of productive adults-the animals have to be over a year old to return a profit. Carelessness downgrades the product.

Not all climates are suitable: excessive heat and intense light (albinos) are very bad elements. In cold countries the solution is to use buildings that shelter the animals against the rigours of the winter. Housing should in any case provide Angoras with a clean, hygienic environment, and this is not possible everywhere. Feed is also costly, unless a producer is content to provide a meagre feed which will keep the animal alive but will halve hair production.

Angoras can be raised for both hair and meat. A considerable reduction in the hair yield will result. German breeders use this system, but production techniques are very strictly adhered to. Chinese breeders probably also produce Angora hair from dual-purpose animals slaughtered relatively young for meat.

A last point to remember, and probably the most important: Angora hair prices fluctuate according to fashion, with a cycle of 3 to 5 years. In 1971 many units disappeared in France because Angora hair dropped to US$10 a kg, compared with $20 in 1965. The world market is so small that any considerable increase in output would cause a price slump.

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10

Costs of Livestock Feed Resources

There are many feed resources in the tropics that can be used as alternatives to cereal grains for feeding to monogastric animals. Most of these are rich in either carbohydrate or oil. Almost all are low in protein. The total allowance of protein can be reduced by some 35% when the dietary protein is mainly derived from oilseed meals and animal and fish by-products, since the amino acid profile of these feeds is better balanced than that in cereal grains. There are also opportunities to provide part of the protein from water plants and leaves of trees and crop plants. Research that leads to the identification and appropriate processing of new protein sources from plants with high productive potential will facilitate the adoption of non-cereal grain feeding systems for monogastric animals.

SUSTAINABLE PRODUCTION SYSTEMS

The first step must be to examine the role of non-ruminant livestock in the overall farming system, so that from the beginning the issues of sustainability in its broadest sense are addressed. The following guidelines are proposed:

- The feed should be grown and processed, the animals raised,and the excreta recycled, on the farm where the enterprise is situated.
- The feed should be derived from a crop that is part of an environmentally sustainable farming system which optimises biomass productivity per unit of solar energy, minimises inputs of agro-chemicals, and maintains soil fertility and biodiversity.
- The production system should be integrated with other farming activities so as to optimise (i) use of family labour and; (ii) recycling of excreta as nutrients for ruminants and fish or as substrate for biogas production and as fertiliser for crops raised in both soil and water.
- Maximum advantage should be taken of the animal's innate ability to: (i) select what is good for it; and (ii) process natural feeds.

It is assumed at the outset that future feed resources for monogastric animals in the tropics will not be cereals, but rather locally available feed resources that can be produced on the farm with comparative advantage in sustainable, non-subsidised production systems. This hypothesis gives rise to a series of consequences the outcome of which is that the husbandry of monogastric livestock in the tropics will increasingly differ from that practised in temperate countries. The available and potentially available non-cereal grain feed resources can be divided in to two categories:

- Feeds low in fibre and rich in oil, sugars or starch.
- Feeds rich in protein.

In the category of energy-rich feeds are:

- The products and by-products derived from sugar cane.
- The products and by-products derived from the African oil palm.
- Fruits from mainly leguminous trees.
- The by-products from certain food and cash crops.
- Recycled organic food waste recovered from homes and institutions and from points of storage and sale of agricultural food crops.

Almost without exception all these feed resources are very low in protein. Most have a high moisture content at the point of harvest or production. By way of contrast, the cereal grains used in temperate pig production are relatively high in protein (8–10%) and are harvested with relatively low moisture content.

Since it is expensive in time and energy to dry plant material, feeding systems using tropical resources will increasingly require transport, storage and distribution of the feed in the fresh state, ensiled, or as liquids or slurries.

The soluble fractions of sugar cane, which are rich in sugars, are the feed resources which are steadily having increased impact in pig production in the tropics. However, new possibilities are seen in the African oil palm tree - which combines high productivity, a perennial growth habit and products and by-products of high energy density - and the sugar palm tree. Most of the research with cassava has been directed towards producing a dry meal which could be exported or incorporated into mixed feeds. Less attention has been given to developing systems for the small-scale farmer.

SUGAR CANE FOR PIGS

The two most important feeds derived from sugar cane are sugar cane juice and molasses. They have special characteristics which must be taken into account when using them as the basis of feeding systems.

- They have a lower energy concentration, compared with cereals, and the main energetic substrate is not starch but a mixture of sucrose, glucose and fructose. Fructose is a poorly studied substrate in pig metabolism.
- They contain no fibre and no lipids, and are practically free of true protein. Additionally they contain variable and imbalanced amounts of minerals and vitamins.
- Molasses has physical properties which have consequences from the nutritional and physiological points of view and also in its technological manipulation.

The agro-industrial process of extraction of sucrose results in the production of substances whose chemical composition is not well characterised for convenience they are described as "non-identified organic matter" (NIOM) and, in the light of practical findings, are not well metabolised by pigs. These substances appear in the sugar cane molasses in proportions which may be as high as 30% in final molasses. Older pigs are able to extract the juice from chopped sugar cane stems and even from whole stems. However, growth rates are only some 60% of what can be achieved when the pigs are fed with juice extracted mechanically. There is probably a role for chopped cane stalks for pregnant sows that will benefit from being offered low-energy-density feeds. The principle of fractionating sugar cane to secure its most efficient use by livestock and for production of fuel can be applied at a practical level in three ways:

- in the industrial sugar mill,
- in a "trapiche" dedicated to making "gur" or "panela", or
- in a "trapiche" crusher dedicated to livestock production.

High test, "A", "B" and final ("C") Molasses

The grinding of the cane stalk, filtering, clarifying and concentrating the juice and crystallising the sucrose, are the processes which give rise to molasses. There are four types of molasses in the sugar cane industry:

- Concentrated cane syrup (high-test molasses) which has been partially inverted to avoid crystallisation of sucrose during storage and distribution.
- "A" molasses produced after extracting 75% of the total recoverable sucrose.
- "B" molasses produced after some 85% of crystallisable sucrose has been recovered.
- "C" or final molasses considered as a by-product in view of the fact that further sucrose recuperation is not feasible.

Normally "A" and "B" molasses are not produced as products; they are re-processed in order to extract more sucrose. The chemical composition of the different types of molasses is essentially the same as the cane juice differing in that, as the technological flux to crystallisation and sucrose separation advances, the biomass is submitted to alkali and steam treatments which increase the percentage of reducing sugars. In these processes, non-sugar organic substances are produced and concentrated. The other important difference between molasses and sugar cane juice is that the former has a high dry matter percentage (approximately 80%), which facilitates storage and distribution.

Table 1. Chemical composition of different types of Cuban sugar cane molasses

	Hightest	*Molasses*		
		A	*B*	*Final*
DM	85.0	77.8	78.1	83.5
(As % DM)				
Nitrogen	0.26	0.29	0.38	0.44
Ash	2.8	4.6	7.2	9.8
Total sugars	86.1	75.9	69.5	58.3
Sucrose	28.6	63.4	57.1	40.2
Glucose	29.3	6.4	5.2	8.9
Fructose	28.2	6.1	7.2	9.2
NFE	95.6	93.0	90.4	87.4
Non-identified OM	9.5	17.1	20.9	29.1
Gross energy				
(MJ/kg DM)	15.0	14.9	14.7	13.5

In Table 1 is the typical composition of the different types of molasses. It should be noted that the concentration of total sugars decreases, and the ash and non-sugar organic matter increases, in the progression from high-test to final molasses. In a sugar cane mill where the efficiency of sucrose crystallisation is low, the final molasses may resemble in composition the "B" molasses in Table 1. Molasses characterisation is an essential step in deciding on the strategy for using it. In fact, it is precisely the composition of molasses which determines animal performance and which indicates whether it is best fed to monogastric or ruminant animals.

The different grades of molasses are essentially similar in their chemical composition. They contain sugars, nitrogenous substances and a "non-identified organic matter" fraction. This latter fraction varies significantly between the types of molasses. The other important characteristics of molasses are:

- It contains neither lipids nor fibre.
- The nitrogen content is low.
- The ash varies from approximately 3% for high-test molasses to 10% for final molasses.

- The principal energetic source is a mixture of soluble sugars, the concentration of which increases from <58% in final molasses to 86% in high-test molasses.
- The proportion of total sugars to reducing sugar varies. It is less in high-test molasses due to a process of partial inversion to avoid sucrose crystallisation.
- The gross energy of molasses is approximately 20% lower than that of any typical cereal grain.

The soluble fractions of sugar cane which are rich in energetic compounds are the feed resources which are finding increasing application in the feeding of pigs in the tropics. Their nutritive value in the pig diet will be determined by:

- Adequate protein supplementation.
- The efficiency with which the soluble sugars are utilised.
- The mineral and vitamin content with the need to provide supplements to balance those in molasses.
- The role in digestion and metabolism played by the fraction of non-identified organic matter.

Typical results with growing-fattening pigs fed "C", "B" or "high-test" molasses or a cereal grain control diet are given in Table 2. Growth rates on high test molasses were comparable with those obtained on cereal grain; results for the "B" molasses were slightly inferior and more so when "C" molasses was used. Feed intakes were always higher on the molasses diets and therefore feed conversion rate was always poorer than with cereals. But this is not so critical when the price of molasses is less than that of grain.

Table 2. Pig performance on high-test, "B" or final molasses compared with a maize/soya bean control; initial weight was 30 kg.

	Maize		*Molasses*	
	SBM	*H-test*	*"B"*	*"C"*
Final wt (kg)	104	103	98	96
LWt gain (g/d)	643	682	635	619
DM intake (kg/d)	2.21	2.55	2.61	2.56
DM conversion	3.19	3.74	4.11	4.14

Similar results have been obtained with molasses-based diets in pregnant and lactating pigs. In the case of lactating sows however, there are indications of better performance on high-test molasses than on cereal grain (Table 3).

Table 3. Performance of lactating sows fed high-test molasses and torula yeast

	Cereal	*Molasses*
Feed intake:		
Dry matter (kg/d)	4.1	4.5
ME (MJ/d)	56.0	53.8
Energy output in milk (MJ/d)	26.0	30.8
Litter weight (kg)	58.5	63.2
Sow weight loss lactation (kg)	20.5	14.5

The differences between raw cane juice and "B" and final molasses in trials done in Colombia were much more pronounced. The poorer performance on the two sources of molasses possibly reflecting the advantages of higher purity cane juice in Colombia and higher factory extraction rates of sucrose, with correspondingly less sugar in the molasses.

It is evident that the energy concentration and the nutritive value of the molasses are favoured as long as it is a major product and not simply a by-product. But such "higher" grades of molasses compete with sugar production. In the traditional sugar industry which produces sucrose for local and preferential export markets, it will rarely be economical to produce high-test or "A" molasses but under some circumstances, it could be economically feasible to modify the normal industrial process to produce "B" molasses and "A" and "B" sugar. The economics of this will depend on the relative value of the "C" sugar for human use and of the "B" molasses for livestock feed.

Sugar Cane Juice

The soluble fraction of sugar cane is easily extracted at farm level by passing the stalk through a "trapiche" or crusher. In these machines, the maximum extraction rate is between 60 and 80% equivalent to 40 to 53% of juice as a percentage of the weight of the cane stalk. In the industrial mill, with repeated washing and crushing (up to 5 times), extraction can be as high as 97% of the total sugars.

This soluble fraction, called "sugar cane juice" will contain from 16 to 23% of soluble solids (DM), mainly consisting of sucrose and reducing sugars. It is thus a liquid, energy-rich feed and difficult to conserve due to its rapid fermentation.

Sugar cane juice contains between 15 and 23% of total solids of which approximately 80% are soluble sugars, mainly sucrose. Sugar cane juice is not exposed to prolonged drastic alkali treatments and high temperatures. As a result the original chemical composition of the soluble sugars is preserved without the appearance of undesirable secondary chemical compounds, especially non-sugar polymers. Furthermore, there is no flocculation and extraction of the plant proteins as occurs during the clarification process in the sugar factory so the juice is richer in amino acids, minerals and vitamins than is molasses. The low solids content facilitates decomposition by a very rapid fermentation (8–12 hr), which can cause difficulties in the management and distribution of the cane juice in the piggery. The inclusion of formaldehyde, ammonium hydroxide or sodium benzoate permits the preservation of sugar cane juice for periods of from 3 to 7 days. However, this has rarely been used in practice.

The research leading up to the development of this technology has been described by Mena and Sarria *et al.* The most important step was the demonstration that, when the protein was provided by soya bean meal, the levels could be reduced to 200 g/day with minimal effects on performance but important economic advantages.

Cane juice is now employed commercially as the basis of pig feeding on farms in Colombia, Cuba, Vietnam and Philippines.

Sugar Palm as a Source of Feed for Pigs

It is estimated there are about 1 million trees of sugar palm (*Borassus flabellifer*) in Cambodia where it is traditional practice to make palm sugar from the juice. The tree is also found in neighbouring countries: in Thailand, Vietnam, Myanmar, India and Bangladesh. The season of production of palm sugar is for 6 months and the rate of production is 5, 15, 25, 30, 20, 5 for months 1 though 6. The juice is collected twice daily in the morning and again overnight from the flower of both male and female trees. It begins to invert quite quickly. Traditionally a piece of wood is used that produces an extract that slows down the inversion.

The juice contains about 13% of sucrose and production of "*masse cuite*" is on average 150g per litre of juice. Average yield is 4 litres juice/tree/day=600g of *masse cuite*. A serious constraint is the need for fuel. 1 kg of crude sugar (*masse cuite*) requires: 3–4.5 kg wood or 4.2–5 kg of rice husks.

An average household in Cambodia will harvest the juice from 20 trees giving a total production in 180 days of 3600 kg. This is equivalent to a production of 1 kg of *masse cuite* per tree per day. Potential feed sources for pigs are the scums skimmed off the boiling juice. The scums are composed of the juice enriched with the proteins and minerals which flocculate and float to the surface due to denaturing of the protein when the juice is heated. From 20 trees, the daily production of scums from the evaporation of the palm juice is likely to be about 5 to 10 litres. This would supply the energy needs of 1 pig. The fresh juice can also be used. The daily yield from two trees would be sufficient to feed one pig. There is increasing interest in Cambodia in this option due to the shortage and increasing price of firewood needed to make the sugar.

African Oil Palm as the Basis of Intensive Pig Production

The first attempts to use the products and by-products of the African oil palm (*Eleais guinensis*) in pig feeding were focussed on incorporating the dried sludge in relatively low concentrations in conventional mixed feeds. Ocampo *et al.* were the first to show that the oil-pressed fibre (30% oil) could completely replace cereals in diets for growing-finishing pigs. These researchers subsequently extended their studies to the use of both the crude oil, and the fresh fruit, as complete replacements for cereal grain in all phases of the production cycle.

The by-products

The three by-products of potential use in livestock production are:

- The oil-impregnated fibre (oil-press fibre) recovered after filtration of the crude oil.
- The mud which remains after the oil has been clarified and centrifuged.
- The palm kernel cake.

Table 4. Mean values for performance traits of pigs fattened with oil-press fibre and reduced levels of protein

	Supplementary protein level (g/day)			
	280	*256*	*230*	*200*
Number days	121	126	124	135
Liveweight, kg				
Initial	22.7	22.8	22.8	22.1
Final	90.2	90.0	90.4	90.3
Daily gain	0.56	0.53	0.55	0.51
Intake, kg/day				
Soybean meal	0.70	0.64	0.57	0.50
Oil residue	2.33	2.44	2.22	2.56
Conversion (DM)	4.8	5.2	4.6	5.4

The first product has only 5% moisture, 24% of oil and 15% fibre (dry matter basis). In contrast, the mud contains over 90% moisture although the dry matter is rich in oil (51%) and relatively low in fibre (12%). Yields are 5 and 29% respectively of the weight of fresh fruit harvested. The palm kernel cake is relatively high in fibre and has only 20–25% protein. It has a limited role as a protein supplement for monogastric animals. With a fruit yield of 15 tonnes/ha/yr, the availability of the oil-press fibre and the mud is 0.76 and 0.44 tonnes dry matter equivalent/ ha/year, respectively. It has been demonstrated that:

- The oil-press fibre can be a complete replacement for cereal grain in the diet of the growing-finishing pig.
- There is no advantage of giving more than 200 g/day of supplementary protein for fattening pigs in the range of 20 to 90 kg liveweight.

The effect of supplementary protein level on performance of pigs fed the oil-press fibre is shown in Table 4. With a dry matter intake of palm oil residue of 2.6 kg/animal/day, it takes 135 days to fatten a pig from 20 to 90 kg liveweight and uses 350 kg dry residue equivalent. Thus 1 ha of oil palm plantation should generate, on average, enough oil-rich residue that potentially could grow and finish 3 pigs. However, there are no reports on the use of the mud or "sludge" as the basis of the diet for pigs. This is an obvious area for further research.

Crude palm oil

The African oil palm has become an important crop in Colombia now established on approximately 120,000 ha of which 80% is currently in production. The recent removal of guaranteed producer-support prices, and the reduction of import tariffs in Colombia, led to a fall in the internal price of crude palm oil to close to the world free market price. This made the crude oil competitive on an energy basis with imported cereal grain, and was the stimulus for initiating research with the crude oil as the basis of the diet of growing-fattening pigs. An advantage from using oil as the energy resource is its high caloric density and the absence of fibre. This creates opportunities for using unconventional sources of protein such as tree leaves and water plants whose fibre content would normally be a limitation in a conventional cereal grain diet.

The data in Table 5 show the effect of feeding a diet with 50% of the dry matter in the form of oil to growing-fattening pigs, and of replacing up to 30% of the soya bean meal protein with *Azolla filiculoides*. The results for growth and feed conversion suggest that, even at such high levels in the diet, the oil is efficiently utilised, and that there are apparently no detrimental effects on carcass quality.The results also indicate that *Azolla* can replace successfully up to 20% of the soya bean protein in oil-based diets. Practical observations suggested that the presence of a small amount of carbohydrate in an oil-based diet was beneficial. A trial to evaluate the effect of level showed that there was no advantage inexceeding 100 g/day of rice polishings. Several commercial producers in Colombia are now using the crude palm oil, supplemented with soya bean meal and rice polishings, as a replacement for cereals in all phases of the pig production cycle.

Fresh oil palm fruit as the basis of pig diets

The use of the fresh whole fruit of the oil palm as the basis of intensive pig production makes it possible for the farmer-producer to diversify the end-uses of the crop through integration with pig production. This will have favourable effects on the sustainability of the farming system, since the manure from the pigs will serve as fertiliser for the trees. Farmer self-reliance will be increased by the creation of alternative end uses for the fruits thus reducing dependence on sale to the oil palm processing factories. The hypothesis that the pig would be able to extract the oil and other nutrients from the whole fruit was confirmed as can be seen from the data in Table 6. However, there was a reduction in growth rate, apparently related with a fall in intake, when the replacement of sorghum by the palm fruit exceeded 50%.

Table 6. Performance of pigs fed whole fruit of oil palm as replacement for sorghum grain

	Replacement of sorghum, %			
	25	*50*	*75*	*100*
Duration trial, d	98	98	126	126
Liveweight, kg				
Initial	26.1	27.0	26.7	27.0
Final	89.3	85.7	90.2	85.7
Daily gain	0.625	0.596	0.503	0.466
Intake, kg/d				
Supplement	0.5	0.5	0.5	0.5
Sorghum	1.3	0.86	0.20	0.0
Palm fruit	0.54	0.97	1.68	1.59
Total DM	2.02	1.94	1.68	1.59
Conversion (DM)	3.2	3.2	3.3	3.4

Part of the reduced intake on the 100% fruit treatment was thought to be due to deterioration in fruit quality, when occasionally it had to be stored for periods exceeding the recommended 7 days. Despite the slower growth rate, the economic analysis favoured the treatment with complete replacement of the sorghum by the palm fruit. This latter treatment would also be favoured by an analysis taking into account the indicators of sustainability.

SURPLUS AND REJECT BANANAS AND PLANTAINS

In his review of bananas and plantains as animal feed, Batabunde pointed out that these would almost never be grown as a specialist crop for livestock, in view of their role as a staple in the human diet in most tropical countries. The exceptions to this rule are the commercial banana plantations producing fruit for export, where grading of the produce often results in rejections rates of 20–30% because of unsuitable characteristics. Many studies have been made on ways of using this material mainly for pig feedmg. However, these rejects increasingly find their way into local markets and there are few instances of producers setting up livestock units to use these resources. The fruit of both plantains and bananas is largely composed of starch which gradually is converted to sugars during ripening. Because the fruits are low in protein (>4% in dry matter), the principle of the feeding system is the same as with sugar cane juice. A protein supplement is required but, as in the cane juice system, the amount can be restricted to approximately 60% of the levels recommended by NRC, assuming that the supplement chosen has a well-balanced array of essential amino acids. Ripe bananas generally support faster growth than green bananas, due it is believed to high "free" tannins in the unripe fruit. Cooking slightly improved the feeding value of the green bananas, but ensiling may be a more appropriate option. The fact that there has been little rescarch on bananas and plantains as animal feed during the past 20–30 years confirms Babatunde's statement that these resources will almost always find a better market as human food.

Plantains are often grown as shade for coffee and, because of the short shelf-life of the fruit and the distance from markets, their use as animal feed in these circumstances may be feasible. However, economic success will generally be obtained by minimising costs rather than maximising performance. Restricting the protein supply is an important strategy in this case.

CASSAVA

Both the roots and the leaves can be used as feed for monogastric animals.

Cassava Roots

Processing of the roots to produce cassava chips for animal feed is a major industry in several tropical countries, chiefly Thailand, Indonesia, Brazil and to a lesser extent in Colombia.

As with bananas and plantains, the decades of the 60's and 70's were the periods of active research into uses of cassava products in pig feeding when it was shown that fresh, ensiled or dried cassava root chips could completely replace cereal grains in diets for pigs. Poultry appear to be less tolerant of cassava products, mainly because of the adverse effects of hydrocyanic acid (HCN) on intake and requirements for the sulphur-containing amino acids. Inclusion levels of dried root meal of less than 50% are recommended for broilers and no more than 40% in rations of layers.

The direction of the work eventually focussed almost exclusively on production of dried cassava root chips for export to Europe for mixed feed manufacture where, because they were classified as a by-product, they were subjected to a much lower tariff than imported cereal grain.

Some promising work on the feeding of fresh and ensiled cassava root chips, along with a protein supplement, a system that is appropriate for small-scale farmers, was unfortunately never followed up presumably because of the higher profits to be made in the short term from exports of the dried chips. The recent revision of the Common Agricultural Policy in the European Union and the consequences of the recently approved World Trade Agreement will almost certainly result in the market for cassava chips becoming less attractive. This will create opportunities for more sustainable mixed farming systems in which the cassava will be consumed by livestock on the farm where it is grown.

There are indications that this approach is being adopted in the tropical region of Mexico, using ensiling as the the method of conservation. Manipulation of the protein supply will be an important feature of research to popularise cassava feeding at the small farm level. When livestock are treated primarily as components of farming systems and not as specialised activities, emphasis shifts to optimising the role of the animal in the system rather than maximising individual performance. This has important economic consequences since it is in striving for maximum performance that creates requirements for expensive ingredients such as essential amino acids and vitamins. An example of this interaction can be seen in the work of Ospina *et al.* where performance of growing finishing pigs on a basal diet of cassava root meal increased linearly with protein supply (from soya bean). The maximum biological response was obtained with a daily intake of 350 g protein, but the economic optimum was with levels of only 200 g/day.

The advantage of cassava is that it can be grown in areas with extended dry periods. Where there are better conditions for plant growth, other crops are usually more profitable as sources of animal feed. Certainly, cassava is an exploitive crop and growing it in monoculture leads to declines in soil fertility. Thus it should be grown in rotation with other fertility-restoring crops, and this is usually what is practised by small-scale farmers.

An attractive end-use for cassava is for manufacture of starch. This can be done at an artisan level with minimum infrastructure; chippers/ grinders to peel and break up the roots into chips and a washing machine to extract the starch. The bran contains: 1% protein, 15% fibre and 60% starch; corresponding data for the fines are 5,1 and 64%. Cassava bran and fines are low in protein and thus the total protein in the diet, provided it is well balanced in essential amino acids, can usually be reduced. Typical results using these feed resources for growing-finishing pigs are given in The results are similar to what would be expected with traditional diets of cereal grains. There is an obvious potential in cassava starch by-products as feed particularly for pigs. However, the way forward will be to encourage farmers close to the plants to engage in pig production. This will avoid the need for sun-drying the cassava by-products. The pig excreta could then be combined with the organic-matter-rich wash waters from the plant to feed biodigesters and ponds which in turn could provide fuel for the families and protein to be recycled to the pigs.

Cassava Leaves

When leaves are harvested at the same time as the roots, yields are in the range of 1 to 4 tonnes dry matter/ha. Leaf production can be enhanced by partial defoliation during the growing season. Ravindran and Rajaguru obtained almost 7 tonnes of leaf dry matter/ha by defoliating once during a 7-month growing season and reported a reduction in root yield of only 12%. It was claimed that, with adequate irrigation and fertilisation, cassava cultivated only for leaf production will persist over several years with average annual dry matter yields of over 20 tonnes/ha. However, there are no reports of this practice being adopted by commercial farmers.

Fresh cassava leaves can be fed directly to ruminants but must be dried or ensiled for monogastric animals. The effects of drying and ensiling on the HCN content are shown in Table 7. Ensiling appears to be the best method for reducing HCN content. However, little is known about the effect of this process on the digestibility and availability of the amino acids. The nutritive value of the leaves is similar to that of alfalfa with respect to fibre levels and the amino acid profile.

Table 7. Effect of drying and ensilling cassava leaf meal on HCN content

	HCN (mg/kg DM)
Fresh	863
Dried in shade 2 days	274
Sun-dried for 4 hours	261
Sun-dried meal	80
Ensiled	33

Sweet Potatoes

An advantage of the sweet potato crop is its short growing season. Both the tubers and the vines are traditionally fed to pigs by small-scale farmers. There is evidence that cooking improves the feeding value of the tubers for pigs and especially poultry as it reduces trypsin inhibitors and improves starch digestibility. As with other tropical carbohydrates sources, the economics of using sweet potato tubers in pig feeding will depend on the source and quantity of protein that is given. There appear to be no data on growth responses to varying protein levels which makes this a priority area for research. Soya bean meal levels were reduced to 390 g/day when the fresh vines of sweet potato were also fed in a pig diet based on cooked sweet potato tubers (Table 8). However, little is known about the digestibility of the protein in the sweet potato vines.

Table 8. Sweet potato vines as replacement for soya bean meal in diets based on cooked sweet potato tubers

Intake, kg/d				
Soya bean meal	0.72	0.54	0.39	0.54
SP vines	0.0	2.4	5.1	0.0
Cooked SP	9.5	8.6	8.1	0.0
Maize	0.0	0.0	0.0	2.8
Liveweight gain, kg/d				
Feed conversion	0.77	0.69	0.64	0.77
(DM basis)	3.81	3.01	3.51	3.55

PIG PRODUCTION SYSTEMS BASED ON RECYCLED HOUSEHOLD AND INDUSTRIAL ORGANIC WASTE

Cuba developed an unconventional model for its national pig production strategy based on the integration of its principal agricultural crop - sugar cane - with the utilisation of wastes and by-products from restaurants and canteens and from agricultural and industrial activities. In this way, the traditional dependence on cereal grains for the pig industry was avoided.

Collection and Utilisation of Organic Wastes

All organic wastes with potential for use in pig feeding are collected and transformed into a liquid feed termed "processed wastes". The recovery of these materials is done systematically in tanker trucks which follow established routes throughout the country. In 1990, there were 205 such routes and the average amount of organic waste collected on each one was 7.7 tonnes, giving a total of 1,578 tonnes daily, or nearly half a million tonnes annually. The wastes are delivered to industrial plants designed specifically for the purpose of processing the wastes, where they are submitted to selection, grinding, sterilisation and mixing with sugar cane molasses, before being conveyed by pipeline to pig fattening units situated adjacent to the processing plant.

Analysis of this processed organic waste, prior to mixing it with molasses, shows that it contains: 13.5–18.8% dry matter, 7.9–16.7% ash, 18.6–22.2% protein, 6.6–10.8% lipids and 6.5–12.6% fibre.

The protein is highly digestible but low in biological value at 58% compared with casein at 91%. It appears that the sulphur amino acidsmethionine and cystine - are the most lacking. In view of the relatively high level of protein in the processed wastes, it has been standard practice in Cuba to mix them with molasses, initially with final "C" molasses and more recently with molasses "B".

It is apparent that the optimum limit of either type of molasses is of the order of 30% and that performance is always better with "B" molasses. It appeared that pig performance on the processed wastes was improved when supplements of minerals, vitamins and methionine were added. Liveweight gains in one trial were increased by more than 100 g daily by the supplements irrespective of the type of molasses used Dominguez. However, this refinement never became commercial.

Incorporation of citrus wastes

Ensiling citrus wastes following extraction of the juice has advantages over traditional drying, in that less energy is used and there are improvements in the palatability, probably due to destruction of certain secondary plant compounds which give a bitter taste to both the dried and fresh product.

Results from using ensiled orange wastes as a replacement for final "C" molasses are shown in Table 9. Liveweight gains were unchanged but feed conversion was improved when the citrus silage replaced the final molasses. These results show that the organic wastes from the citrus industry can be incorporated satisfactorily with other processed organic wastes for pig production, and can replace molasses.

Table 9. Performance of fattening pigs given a basal diet of processed organic wastes and different proportions of final molasses and ensiled citrus pulp

Ensiled orange waste	0	12	25	40
Final molasses	49	37	24	9
Dry matter intake (kg/d)	2.8	2.9	2.6	2.45
Weight gain (kg/d)	0.62	0.62	0.59	0.60
Feed conversion	4.54	4.64	4.37	4.08

Thermal destruction of animal and vegetable wastes

Another feature of the Cuban programme of waste utilisation has been the design and development of an autoclave with mechanical agitation which processes adequately not only vegetable wastes but also wastes from abattoirs and even dead animals. The advantage of this system compared with dehydration is the saving in fuel oil and the lower investment cost of the equipment.

Conservation of the paste-like product has not proved to be a problem since addition of molasses has proved to be both effective and convenient. In any event the molasses is usually added to the final mixture of processed wastes. It is planned to equip all new waste processing units with the thermal-disintegrator system in view of lower investment costs and simpler operating procedures.

ENSILED ANIMAL AND FISH WASTES

The ensiling of the animal and fish by-products, using molasses and crude syrups derived from sugar cane, is a simple and appropriate method of conservation. The shrimp heads were mixed with blood and molasses in the ratio of 5:3:2 and ensiled for 3 weeks. The pH fell to 4.5 at the end of the first week and remained at this level for the remainder of the ensiling period. The silage was used to replace fish meal at levels of 5 and 10% in a diet based on maize and rice bran in a fattening diet for pigs. There were indications that the palatability of the silage was a constraint affecting intake and feed conversion at the 10% replacement level. It would be interesting to test the silage in completely mixed diets based on molasses or juice from sugar cane or sugar palm.

SUGAR CANE DERIVATIVES FOR POULTRY

Research in Cuba twenty years ago showed that raw sugar could replace the cereal grain in diets for all classes of poultry. However, the technology never became truly commercial. Raw sugar is almost always too expensive to use in animal feeds. Molasses and cane juice are economically competitive with cereals but there are many factors that mitigate against their use for fattening and laying birds other than water fowl. For example:

- Large scale poultry systems are designed to use complete mixed and dry diets.
- The productive life of broilers is too short to permit them to adapt adequately to liquid diets.
- The mouth parts of birds are not designed for consuming liquid feeds. There is considerable wastage and the feed sticks to the plumage which is an inducement for cannibalism.

LAYING AND FATTENING HENS

Sugar Cane Juice

Use of the cane juice as a substitute for grain in broiler and laying hen diets has not been successful due mainly to the physical difficulties experienced by chickens in consuming a low-density liquid diet, and the stress caused by splashing of the sugar-rich juice on the feathers which can lead to cannibalism. Rates of growth and feed conversion have rarely exceeded 60–70% of genetic potential. Laying hens, particularly the heavier dual purpose strains, which have been raised on cane juice, have been maintained through complete laying cycles with satisfactory, although lower, egg production than would be expected with cereal diets.

Molasses

An interesting development has been reported from Cuba. It was found that ground sun-dried tropical forages, especially the leaves of sugar cane, were able to absorb up to twice their weight of "B" molasses. The molasses is first diluted with 20% of its weight of water, then mixed with the dry leaf meal and the mixture left to dry in the sun for 48 hr. The final product contains: 70% "B" molasses and 30% dried sugar cane leaf meal. It is friable and easily mixed with other dry ingredients. Its true metabolisable energy value was found to be 2.87 Mcal/kg DM. Up to 40% of this feed has been included in diets of laying hens with no loss of performance. The aim now is to replace the whole of the cereal grain with this alternative tropical feed resource.

Ducks and Geese

Recent developments in the feeding of cane juice to ducks are much more promising. Ducks are well adapted to consuming liquid diets and, provided they have access to water for swimming, have no problems with the sugar juice falling on their plumage. It appears to be possible to reach at least 80–90% of genetic potential for growth. As with pigs, the absence of fibre in the cane juice permits partial stitution of conventional protein sources with water plants such as *Azolla filiculoides*. There appears to be real potential here to develop low-cost, farm-based commercial feeding systems.

OTHER TROPICAL NON-CEREAL FEED RESOURCES FOR POULTRY

Reject cassava roots, sweet potato tubers and banana and plantain fruits, have long been fed to poultry managed as scavengers around the farm holding. There appears to be no reported research on the use of these feed resources as the basis of the diet in intensive on-farm feeding systems.

Scavenging for their feed continues to be the predominant system in the less-developed tropical countries. Nutritional improvements to this system have not been researched very well as it has not been a priority for most NARIs and not all for the CGIAR centres. In contrast, from the sociological standpoint, poultry are the most widely owned species of livestock and are particularly important for income generation for women. There are reports from Bangladesh of economic gains by supplementing scavenging chickens with 25 g of by-product feeds such as rice polishings. It is likely that the choice of supplement will depend on the human and livestock pressure on available natural resources. Where pressure is high, protein is likely to be the first limiting factor as was shown in a study in Bangladesh where the contents of the crops of birds and ducks were found to have in the region of 9–10% crude protein in dry matter. Where human and animal pressure is low, there may well be benefits from an energy-rich supplement. All of these observations indicate that there is need for much more research in this area.

TROPICAL NON-CEREAL FEED RESOURCES FOR RABBITS

Sugar Cane

The digestive system of rabbits requires that they be fed preformed amino acids (protein) that should preferentially be released in the small intestine. Although most non-ruminant small herbivores practise coprophagy, it is not efficient for protein to be recycled in this way since the pathway involves first fermentation to microbial protein. On the other hand the practice does permit cell wall carbohydrates to contribute energy as volatile fatty acids. Rabbits also like to use their teeth to bite and chew their feed. The two approaches to replacement of cereal grains by sugar cane products which promise to have impact in farm practice are:

- Use of molasses incorporated into solid blocks along with other by-products.
- Use of sugar cane juice as an integral component of the fresh sugar cane stalk.

Molasses

The idea of preparing molasses-rich solid blocks for rabbits was first proposed by Perez. It was further developed in Italy and Vietnam, where it was shown that adequate growth and reproductive rates could be obtained with blocks containing 50% final molasses. In one trial, urea was incorporated at low levels (4%) but had no apparent effect. More recently in Colombia, blocks made with 30% of final molasses and complemented with legume bean foliage have supported growth rates post weaning of 20g/day. This is comparable with what can be achieved in the tropics with pelleted complete diets based on cereal grains.

Sugar cane juice and fresh "split" stalk

Early attempts to replace cereal grains with sugar cane juice showed that it was technically feasible to adapt rabbits to consume liquid cane juice, but growth rates were well below the genetic potential of the animals. More promising results have been obtained in Vietnam using lightly peeled cane stalk split down the middle.

The rabbits relished the peeled, split cane stalk which was cut into lengths of about 15cm. For fattening of young rabbits, growth and feed conversion were best on the sugar cane stalk. Reproductive performance was the same with the peeled sugar stalk as with the control fed cereal-based concentrates. Feed costs were less for the sugar cane diet in both trials. It has since been found that peeling of the stalk is not necessary and it is enough simply to cut into short lengths and split these longitudinally.

THE INDIAN FEED INDUSTRY

Feed manufacturing on a commercial and scientific basis started around 1965 with the setting up of medium-sized feed plants in northern and western India. Feed was produced mainly to cater to the needs of dairy cattle. The poultry sector was not developed at that time and was restricted to backyard production, with the *desi* kept mainly for the production of eggs. The poultry industry is now growing in importance. Today, the Indian feed industry is worth approximately Rs 45 billion, that is about US$1 billion.

India's animal wealth is quite large in terms of its populations of cattle, poultry, sheep and goats, camels, horses and pets (Table 10). Recently, aquaculture has also been growing in importance in India.

Table 10. Livestock population in India

Livestock type	*Population (millions)*
Cattle	204.5
Buffaloes	84.2
Sheep	50.8
Goats	115.3
Pigs	12.8
Horses/ponies	0.8
Mules	0.2
Donkeys	0.9
Camels	1.0
Yaks	0.06
Mithuns	0.15
Total livestock	470.86

Worldwide, India is number one in milk production, at 78.0 million tonnes *per annum*, and the dairy industry is spread across the whole country. India has one of the largest populations of cattle and buffalo in the world. In a total of 288 million head, there are 10 million cross-bred cows, 15 million good milch cows of local varieties and 36 million buffaloes of good milch varieties. The remainder of the cattle population is of a non-descript variety and a sizeable proportion consists of bullocks. The cross-bred population is either Jersey or Holstein-Friesian, crossed with local cows. Cross-breeding was a natural solution to upgrading the milk yield in the absence of high-value imported varieties of pure-bred animals. The buffalo breeds are unique to India, and produce milk with a fat content of 7 to 8 percent. Milk is seen as a health drink and a variety of Indian sweets are prepared from milk. The ice-cream market is growing. Farms are located on the outskirts of cities and within cities. Almost all villages have a number of cattle, but there are only a few organised dairy farms. In India, dairy is not so much an industry as a smallholder farming activity.

Growth in the milk sector has occurred mainly through cooperative efforts. Cooperatives started by supplying milk collection centres, where milk was collected from villagers in quantities as small as 1 litre, and gradually started to provide other services to farmers, including education, artificial insemination, veterinary health support and feeding. The small farmers became prosperous, loan facilities were made available through banks, and member farmers started to share the profits from cooperatives. Cooperatives also set up their own modern computerised feed plants. They have modern milk processing plants from which they produce and market pasteurised milk, butter, butter oil, chocolate, ice-cream and milk sweets, which are very popular with Indian consumers. Today, the feed production from cooperatives is about 0.6 million tonnes per year.

The National Dairy Development Board (NDDB), which has excellent facilities for research on breeding, nutrition and health care, has played a pivotal role in setting up cooperatives. Without NDDB and several of the existing dairy cooperatives, the milk sector in India would have suffered. The dairy industry in India is expected to grow, but growth will be restricted to individual small farmers. It is unlikely that India will see the advent of large, organised dairy farming in the near future.

Compared with the rest of the livestock sector, the poultry industry in India is more scientific, better organised and continuously progressing towards modernisation. Breeding and feeding management has improved through education, training, competition, expansion and survival instincts. India is the world's fifth largest egg producer, with a total production of 40 billion eggs per year. The broiler industry is growing at the rate of 10 percent *per annum.*

India has 150 million layers and 650 million broilers. Annual per capita consumption of eggs is 40, and that of broiler meat is 1 000 g. Although these figures are low in comparison with those for developed countries, the industry has great potential to expand because 30 percent of the country's population (about 300 million people) is developing economically and the demand for poultry products is therefore likely to grow.

The poultry industry has witnessed several ups and downs in the last 25 years as a result of unplanned growth and a lack of government regulation. Currently, it is growing at the rate of 10 percent in broilers and 6 to 7 percent in layers and is going through a phase of integration in broilers which is likely to change the face of the industry. Although the phenomenon is new, it is expected that there will be very rapid changes towards integration as more farmers find it increasingly difficult to run farms with marginal profits or negative margins. The poultry industry is very modern, with pure-line breeding, the latest vaccines and medicines, environmentally controlled poultry houses, up-to-date processing units, the latest management practices, chicken processing, exports of hatching eggs and excellent feed quality.

The sheep and goat sector is mostly in the hands of nomadic tribes and no significant scientific husbandry, rearing and management practices are implemented. Research on breeding and nutrition is being conducted at research institutes and agricultural universities.Most of the country's camels are located in the desert area of the western part of India, in the states of Rajasthan and Gujarat, bordering Pakistan. Camels are reared by individuals who feed them local ingredients. There is a lack of scientific management practices, genetic studies and scientific feeding practices in camel rearing and the industry survives mostly on the basis of local, long-established knowledge of feeding and breeding. There is, however, a fairly good disease diagnosis and treatment system, with modern medicines and vaccines.

India is a multilingual, multiracial country whose people hold various religious beliefs. Although the majority of the population is Hindu, there are sizeable minorities of Muslims, Christians, Sikhs, Buddhists, Jains, Parsees and others. India also has a large tribal population and is a plural society in which the sentiments of each social and religious group need to be respected for harmony and peaceful coexistence. Thus, most states in India have banned cow slaughter and the beef industry is therefore non-existent. The majority of people disapprove of pork consumption, maybe because of the lack of scientific management on swine farms. Swine reared on the streets are very unhygienic and buyers are always suspicious about the source of pork, so there is no organised pork industry.

The aquaculture industry is relatively young. Prawns and fish are grown in both fresh and brackish water, the latter being located mostly in the southeast and southwest coasts. Aquaculture feed is manufactured with highly scientific methods and modern plants that use new technologies and are highly efficient. Multinational companies from Thailand and Taiwan Province of China have invested in this business. India exports most of its aquaculture products.

The Indian equine industry goes back more than 50 years and is considered modern, scientific and very well equipped in terms of every aspect of animal husbandry practices. The equine industry is spread across India and is restricted to horse racing. Imports of good genetic material are quite common in this industry. The feeding of these valuable animals is mostly at the farm level under the supervision of experienced people following traditional practices. What innovation there is tends to be closely guarded by the companies concerned.

The Indian pet industry is in a nascent stage, with the main focus being on dogs rather than cats and the emphasis on breeding and training. Regular dog shows are held by enthusiastic dog owners to increase awareness of the rearing of good-quality pure-breds; dogs are a source of pride for households. In many cities, animal health care systems are run by qualified vets with well-equipped facilities such as X-ray machines, surgical facilities, imported vaccines and the latest drugs. The feeding of pets is however, left to the household. Some commercial preparations are available in the form of dog biscuits, chews, etc., but dogs are fed mostly on home-cooked food. One of the reasons for this could be the high cost of commercial pet food.

Feedstuffs and Ingredients in Animal Feeds

India is currently self-sufficient in livestock feeds and does not depend on imports. Instead, the country exports large quantities of solvent extracted meals, which are a major source of foreign exchange earning.

Cereals and grains

Maize, sorghum and *bajra* (a type of millet) are commonly used in animal feeds. Wheat and rice are mainly retained for human consumption.

Cakes and meals

Commonly used commodities of this kind are soybean, groundnut, rapeseed, sesame and sunflower meals in poultry feed. In cattle feed, in addition to these meals, others such as cottonseed and copra are used as premium ingredients.

Feeds of animal origin

Meat-meal, fishmeal, bone-meal and dicalcium phosphate of bone origin are the common raw materials available for animal feeding. It is interesting to note that, with the exception of some bone-based dicalcium phosphate, the Indian feed industry does not use materials of animal origin in dairy cattle feed. This was not out of fear of any zoonotic problems but the result of deep-rooted beliefs that the cow is sacred and must therefore be vegetarian. Now even the use of bone-based dicalcium phosphate has been banned and mineral-based dicalcium phosphate is used instead.

Fishmeal and meat-meal were popularly used in poultry feed, but the increased production, improved availability and better awareness of soybean meal has led to its replacing fishmeal and meat-meal in most poultry rations. It should be mentioned that farmers have faced production problems owing to the bacterial contamination of fishmeal and meat-meal. The quality of fishmeal is also very poor.

Popular by-products

Some by-products are very nutritious and palatable to cattle, and these products form the bulk of cattle feed. They include wheat bran, rice bran and oil-extracted rice bran, tapioca, guar meal, safflower meal, maize gluten and molasses. A special mention should be made of Indian cattle feed's unique use of hulls or shells, popularly known as *chunis* in the local language. These shells come from pulses: horse gram, black gram, mung bean and pigeon pea.

Minerals and vitamins

Cattle feed is necessarily enriched with vitamins A and D3, and trace minerals such as iron, zinc, manganese, copper, cobalt and iodine. Calcium and phosphorus are also included. Poultry feed is enriched with all of these and all of the B complex vitamins.

Feed additives and supplements

Feed additives and supplements have played a very important role in enhancing the performance of dairy animals and, even more so, poultry. Today they are necessary in any feed formulation and essential for the formulation of a balanced diet. The additives and supplements used are antibiotic growth promoters (their usage is not banned in India), prebiotics, probiotics, enzymes, mould inhibitors, toxin binders, anti-coccidial supplements, acidifiers, amino acids, by-pass fat, by-pass protein, non-antibiotic growth promoters, milk boosters, antioxidants, feed flavours and herbal preparations of Indian origin. A number of these products are imported from developed countries.

Animal Feed Commodity Production

Maize and sorghum

Maize is one of the most important cereals used in animal feed. The annual production of maize is about 10.5 million tonnes; about 4 million tonnes of which are used in the starch industry, 4.5 million tonnes in animal feeds and 2.5 million tonnes in human consumption and seed production. Maize production has remained almost static in the past three years while demand is increasing. The major crop is during the Kharif season (June to October), which accounts for 90 percent of the total. The remaining 10 percent is harvested in the Rabi season (November to February).

The import of maize used to be restricted but, since April 2000, imports have been approved under open general licence (OGL). There are, however, 15 percent duty and a grain inspection fee to be paid, so there is no price parity between imported and domestically produced maize. There is no subsidy or minimum price index for maize, and the price varies with the market demand. Maize cannot be exported. Sorghum and *bajra* are very sturdy varieties of millet that can grow under limited rainfall conditions and are popularly used in animal feeds. Production of sorghum has remained static. There is no export of sorghum and *bajra* (millet).

Rice bran and solvent-extracted rice bran

Rice bran and solvent-extracted rice bran are by-products. India is one of the world's largest producers of rice, producing 87 million tonnes during 1998/99 (1.7 percent more than in the previous year), and India produces approximately 2.95 million tonnes of solvent-extracted rice bran, which is regularly exported.

Oilseed meals

India produces soybean, groundnut, rapeseed, sunflower, sesame and cotton meals and these are used as major ingredients in animal feeds. For animal feeds, soybean is the most frequently used oilseed meal and has completely replaced fishmeal in poultry feeds. Cottonseed cake and meal are often used in cattle feed throughout the country. Groundnut meal is less popular because of the aflatoxin problem. Rapeseed meal is second to soybean meal in production and second to cottonseed cake and meal for cattle feed. Sunflower meal is commonly used in both cattle and poultry feed.

India regularly imports edible oil and imported 4.4 million tonnes in 1998-1999. These imports have created problems for the country's crushers and, although India has about 600 solvent extraction units, they are running at only 50 percent of capacity. India's economy is agro-based but the yield per hectare is a cause of major concern to the country's farmers and agriculture. The government recognises this and there are subsidies on fertilisers and power tariffs. The government also assures base prices for many agro-based commodities. With a population of 1 billion people, the demand for agroproducts is great and India will have to augment its agricultural production by several hundred percent if the country is to remain self-sufficient.

Feed Standards and Specifications

For cattle and poultry, nutritional standards have been prepared with respect to the genotype, environment, quality of available raw materials, maintenance methods, production and reproduction requirements, production capacity and phase of production.

The Bureau of Indian Standards (BIS) is a central government organisation that facilitates discussion between scientists and industry and prepares guidelines and specifications.

Research and Development in Animal Feed

Given the importance of feed ingredients, Indian scientists have worked on various aspects of research and development in the field of animal feeds and feeding. In the 1960s, all Indian raw materials were analysed for their proximate composition, metabolisable energy values and deleterious factors. During the 1970s, the government sanctioned special projects to study the use of by-products in animal feeds. Various by-products were considered and their nutritional parameters studied. Indian scientists analysed ingredients for their chemical values and studied their biological values, and this information was useful to the industry in the initial stages of growth. In the 1970s and 1980s subsequent research was conducted on the energy-protein and energy-amino acid ratios and the vitamin and mineral requirements of animals. During the next phase of research, the main focus was on bypass fat and bypass protein utilisation in ruminants, and on the role of various feed additives in enhancing milk, egg and broiler meat production. Research and development work has been conducted on least-cost formulations and usage of synthetic amino acids.

Issues in the Animal Feed Industry

As already mentioned, BIS has produced guideline feed standards and the industry also has its own guidelines. Currently there is no compulsion to use BIS standards, but the central government has been advising states to introduce their own regulatory standards. The industry, however, is resisting this move. One of the major reasons for opposition is that the government wants to legislate regulation under the Essential Commodities Act 1955 which is considered draconian and totally inappropriate in this context.

There is no shortage of compound animal feeds anywhere in the country. In fact, the organised sector of the compound feed industry is facing serious problems resulting from a huge idle capacity, to the extent of 50 percent or more. New capacities are being added by global players in the feed business and by national as well as multinational integrators. The nature of animal feeds and the animal feed industry has completely changed.

Increasingly, products, including new products, are being excluded from the purview of the Essential Commodities Act 1955. Major raw materials for compound animal feeds, such as groundnut, soybean, rapeseed and sunflower meals and cottonseed and rice bran extract, which are exported, are not covered by the Act. There is therefore no reason for it to cover the animal feed manufactured with these raw materials.

Furthermore, the industry has several reservations about implementing BIS standards. There is a lack of flexibility in these standards and they are lagging far behind the industry's products. For cattle, they have not been revised for 30 years, while the BIS standards for poultry are obsolete.

Another feed standards issue that worries both the government and industry is that any changes to existing standards will be slow and difficult to arrive at because of participative conflicts and various lobbying groups. However, the industry's principal concern about compulsory standards is that they will disturb efforts to innovate and upgrade feed production in order to improve the productivity of the animals. This is because all innovations would have to be passed by BIS, and such a process is likely to take several years to complete.

Classifications of animal feed supplements

The classification of feed additives is a major hindrance to the Indian feed industry. Worldwide, animal feed supplements and additives are covered under chapter 23.09 of the Harmonised System of Nomenclature (HSN), to which India is a signatory. In the HSN, all feed ingredients are listed under the "free" category for import, but the Indian Government put them into the "restricted" category in October 1995. Since then, there have been continuous discussions among the drug control authorities, the Director-General of Foreign Trade and the Central Excise Department, all of which want to bring feed additives under their administration so as to increase their own revenues. The industry, represented by CLFMA, has made several representations to the government, but these have been round various government departments, appellate tribunals, the High Court and the Supreme Court without providing any useful results for the industry.

Countervailing duty on amino acids

The essential amino acids, such as DL-methionine, L-lysine and L-threonine, are not manufactured in India. These products are vital ingredients of compound animal feed for improving the quality of the final feed and making it conversion-efficient. With a view to bringing about the rapid development of animal husbandry in India, the government reduced the import duty on essential amino acids to the present level of 10 percent customs duty, so that the feed price to livestock farmers would be economic. However, with the imposition of countervailing duty (CVD) and other duties, the objective of helping to promote animal husbandry has been defeated.

FUTURE OF THE INDIAN FEED INDUSTRY

At the beginning of the twenty-first century, India has a population of 1 billion people. Although the annual growth rate has slowed from 2 to 1.8 percent, the base is so broad that changes in population dynamics are not perceptible. The population may stabilise by sometime between 2030 and 2040 if all sections of society support family planning wholeheartedly. The purchasing power of the middle class is growing and food habits are also changing.

The Indian economy is growing at the rate of 6 to 8 percent per annum. The livestock industry in India is the second largest contributor to gross domestic product (GDP), after agriculture, and accounts for 9 percent of the total. Consumption is likely to increase as follows: *per capita* milk from 240 to 450 g per year; *per capita* eggs from 40 to 100 per year; and *per capita* broiler meat from 1 000 to 2 000 g per year.

A major change is occurring in India on the economic front. The country has adopted a model that lies midway between liberal and public sector production, but growth has been affected by the poor performance of most of the public sector units, rising government costs and fiscal deficit, and the economy has suffered. A process of liberalisation was set in motion by the government and has been implemented for the last eight to ten years. This has caused India to open up and invite investment from multinationals, liberalise imports, reduce government expenditure and remove public sector businesses. It also means that the days of nationalisation, unnecessary government controls and restrictions will soon be over thanks to progress in the country's economy.

India has entered into an agreement with its trade partners under the World Trade Organisation (WTO). The changes brought about by the liberalisation process will be slow but certain. The government is opening up imports in a phased manner, and it is expected that this process will be completed by April 2003. In the meantime, about 930 items, including agricultural products, will be open for import under open general licence from April 2001, making it possible to import dressed chicken, milk and milk products.

Various livestock industry associations have taken issue with such imports in an attempt to protect their members. If the livestock industry is affected, the feed industry will also be affected. The Government of India has raised the tariff on all poultry and poultry products from 35 *percent* to the WTO boundary level of 100 *percent*. It therefore appears that there will be a level playing field.

In view of the expected rise in *per capita* consumption of chicken meat, eggs and milk, livestock production and productivity will grow. The dairy industry, which is cooperative-based, is growing with the increased capacities of milk processing units. The population of cross-bred cattle and buffaloes is also growing. Milk is very popular in India. The poultry industry is developing towards vertical integration and a few multinational companies have already entered the Indian poultry business. Although the live bird market currently accounts for about 90 percent of the total market, it is expected that the consumption of dressed chicken will grow in the next five years, from the existing 10 percent to 25 percent or more. This would mean establishing very hygienic and scientific processing units. Cold chains, branded chicken, chicken cuts, etc. will be introduced and, depending on the success and consistent quality, consumer preference for dressed meat will grow.

The next decade will see significant changes in restructuring, mergers, acquisitions, amalgamations, joint ventures, diversification, integration and efficient service chains, e-commerce and use of the latest information technology in global tenders, trading, export/import and other commercial activities. At the root of all these developments will be the scientific development of feed manufacturing technology. The Indian feed industry will increasingly use biotechnology, more scientific formulations, new molecules and natural and herbal products to improve animal productivity. Indian agriculture will also use biotechnology and genetically modified organisms (GMOs) to support the feed industry, which is entering a very exciting phase of growth for the next decade.

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Economics of Livestock Disease Control

Economics is a social science dealing with the production and distribution of goods and hence of wealth. It analyses how scarce resources are allocated between different uses and groups within the economy. Originally, economic thought was developed under the name "political economy" and examined the production and distribution of wealth in a society composed of landlords, peasants and artisans With the advent of industrialisation, thinkers looked at the economic relationship between capitalists, workers and landlords. This approach was the one taken by Marx and underlies Marxist economics. Modern economies in the "capitalist" societies looks at the economic interactions between producers and consumers, who meet in the market place and try to satisfy their needs. Its aim is to analyst objectively the "positive" i.e. the verifiable or factual aspects of the economic relationships in society, and thus to derive generally applicable theories. It does not concern itself directly with the "normative" aspects which relate to value judgements about how the economic process ought to function.

The study of economics is conventionally divided into two areas. *Micro-economics* analyses the behaviour of individual producers and consumers, focusing on the factors influencing their levels of production and consumption and the mix of goods involved. *Macro-economics* analyses the economy as a whole, and deals with such topics as national income, balance of payments, overall savings and investment.

Development economics has emerged as a branch dealing with the specific problems of the less developed countries. It tries to analyse and explain the particular situation of these countries and to examine economic policies, such as price control, subsidies and taxes, and the channelling of investment funds into certain areas, which can help overcome their problems and improve their people's standard of living. The topics covered include an analysis of the causes and symptoms of poverty, of the dichotomy between the agricultural and the industrial sector in Third World countries, and of the extent of the bias in actual development towards urban areas. Development economics examines the questions of choice of technology, unemployment and underemployment, migration and land reform, from an economic point of view and also studies the roles of trade and commodity markets.

Project appraisal, the economic analysis of projects before they are undertaken, and *project evaluation,* the assessment of projects after they have been undertaken, are practical applications of economic principles to decision-making based on a social benefit-cost analysis. This consists of setting out costs and benefits over a number of years and comparing them according to certain prescribed conventions so as to determine whether the project would be profitable. Budgeting and accounting are also techniques of applied economics.

APPLICATION OF ECONOMICS DISEASE CONTROL POLICY

Economics contributes to the improvement of policy formulation and decision-making for animal health projects and programmes at four levels:

- Economic theory explains the behaviour of producers and consumers, and the effect of this on the price structure and on the output of the economy as a whole. In the livestock sector, it explains how economic factors influence producers, how they decide what and how much to produce, what prices are acceptable to them, why production is expanded or contracted, how much they invest etc. It also explains the economic factors underlying demand for livestock products, how these affect the amount and mix of products bought, and how prices are fixed in different circumstances. The economic aspects of the different livestock production systems can be described by collecting relevant information and using it as well as the knowledge derived from economic theory to analyse how producers and consumers interact. A particular livestock production system can be described in economic terms by looking at the value of output, the cost of the inputs, calculating the income received by the producers, butchers, traders and other middlemen, and examining the final price paid by the consumers.
- Having characterised the production systems involved, as well as the interactions between the consumers and producers, it becomes possible to examine and predict the likely economic effects of any changes introduced into the sector. Such changes would include both changes affecting prices of inputs or outputs, which would affect the incomes of consumers and, therefore, demand, and changes in the technical coefficients of output due to introducing improved inputs, changing the animal health picture etc.
- Finally, the techniques of economic analysis make it possible to arrange this information so as to provide the basic yardsticks for ranking and hence comparing different programmes, projects or measures, and assessing their overall economic feasibility.

Thus, for an animal health project, economic theory can help explain producers' behaviour, describe the production systems involved, then help to predict and quantify the effect of the project on output, prices, demand and incomes, and, finally, provide a framework for arranging this information in the form of a *benefit-cost* analysis. Then, having ranked and compared the alternatives, a decision can be made whether to implement the project or not.

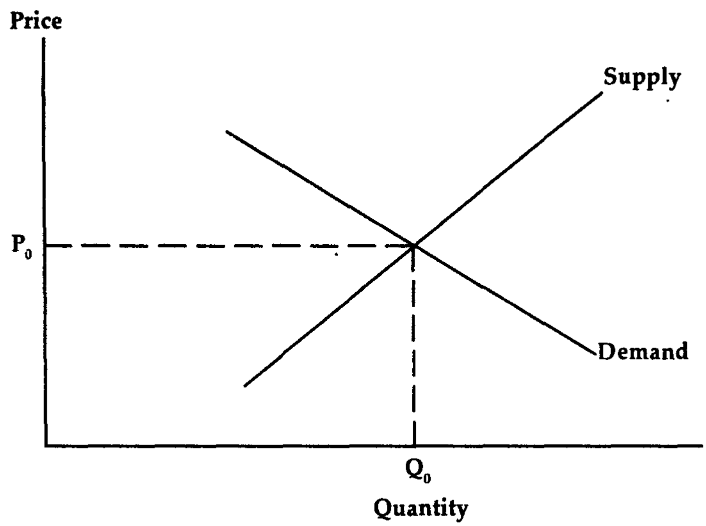
Obviously, decisions cannot be taken on the basis of economic considerations alone. First, the technical feasibility of any proposed measure must be examined by the relevant specialists. Second, its overall compatibility with the stated policies and goals of the livestock sector must be ensured, and, third, its feasibility from an organisational and social point of view needs to be verified.

PRICES APPROPRIATE FOR USE IN ECONOMIC ANALYSES

Prices are the "labels" or weights used in economic decision-making. As such, an understanding of how they are derived and what they represent is crucial. Money is the "unit" in terms of which prices of goods are given in a cash economy, although barter can fix their relative values. For example, if a kilogram of meat costs US$ 3 and a yard of cloth US$ 1.50, 2 yards of cloth could be exchanged for 1 kg of meat in the absence of money, or both could be paid for in cowries, manillas or some other acceptable currency.

Historically, price theory began with the concept of goods having either a scarcity value or a value because of the labour needed to produce them. Modern economies sees prices as being determined by the interaction of supply and demand, reflecting both the balance of the price producers are willing to accept, taking into account their production costs, and the price consumers are willing to pay for a certain quantity of goods. For most goods, the quantity offered increases with increasing price, but the quantity demanded decreases.

If supply equals demand, the market is said to be "in equilibrium" at price P_0. This price is also referred to as the *market-clearing* price, and it represents the point at which all that is offered is bought. At a higher price, supply exceeds demand, since producers are willing to offer more and consumers are reluctant to purchase. The converse is true if the price is lower than the market-clearing price, in which case consumers are eager to buy but producers are reluctant to sell or produce, and, consequently, the quantity demanded exceeds that supplied. If the individuals were bargaining in a real market place, they would continue to offer each other prices until they arrived at a mutually agreeable price, or else the consumer would decide not to buy or the producer not to sell.



Example: Suppose that a government fixes a maximum price for meat with the objective of ensuring that low-income consumers can afford the commodity. If this price is below the market-clearing price, producers would like to charge more, demand outstrips supply, and a black market develops where meat is sold at prices nearer to, or even exceeding, the market-clearing price to those consumers who can afford it. Conversely, if a government fixes a minimum price which is above the market-clearing price, supply will tend to outstrip demand at that price and suppliers will be forced to sell off their goods cheaply, avoiding the government regulations. This commonly happens when there is a fixed minimum wage for labour: if many people are looking for employment, a large number will end up accepting jobs below the minimum wage.

In fact, if a government wants its price-setting policies to be effective, it will often need to pay a subsidy to compensate producers, if the price is too low, or consumers, if it is too high. The government would need sufficient knowledge of the supply and demand curves for the product, i.e. the lines illustrating what quantity is demanded or supplied at which price, in order to work out at what price (P_1) the quantity supplied would be equal to that demanded at a minimum price (P_2) and representing the amount the government would like people to consume. The government can then pay producers a subsidy equivalent to the difference between P_1 and P_2, so that the supply rises to the level equal to the quantity demanded at the minimum price, and the market clears.

The discussion of price theory has raised several points which need to be considered when deciding which prices to use in various economic studies. These can be summarised as follows:

- Since for most goods the quantity demanded falls as the price rises, governments can stimulate demand for an item by setting a low price. Conversely, they can lower demand by setting a high price. A low price can be supported by a subsidy, a high price may be enforced by a purchase tax. For example, the consumption of milk may be encouraged by setting a low price for consumers, backed up by a subsidy to producers. Similarly, new inputs into production systems, such as fertilisers, improved breeds of liverstock, ploughs etc, may be encouraged by subsidising their cost to whoever is prepared to use them. In the absence of a support for artificially high or low prices, black markets tend to emerge.

- Different consumers may pay different prices for the same goods. For example, because of the costs of transport, goods may cost more in isolated rural areas or if they are imported from another region or country. Products may be more expensive when bought in retail outlets with high overheads, while items sold in large quantities are usually cheaper. If a good passes through many hands before it is sold to the final consumer, it will be more expensive since every middleman on the way expects to make some profit. These are all concrete reasons for price variations.
- A more subtle effect is that of the individual consumer's bargaining power. In the market, one person may be better or worse at negotiating a price than another. On a wider scale, the price an individual will pay may depend on such things as his or her influence in society, whether the seller wishes to gain favour, or considers the purchaser rich and capable of paying a good price. All these effects are intensified in a black market.
- A variety of prices exists for each item affected by a government subsidy or tax. These include:
  - The price paid by the consumer, which may include a purchase tax or is the portion of the cost after the subsidy has been removed.
  - The price received by the producer, which is the price before purchase tax is added or, in the case of a subsidy, the equivalent to the price paid by the consumer plus the government subsidy.
  - The cost to the government of the subsidy or the revenue brought in by the tax.
  - The cost to the nation, which is roughly equivalent to the price paid to the producer. A government tax or subsidy is a transfer between tax payers who pay the subsidy or tax and those who benefit from it, either by receiving the subsidy or using the facilities financed with the money collected from the tax.

Prices of Factors of Production

So far we have analysed prices as though they were for consumer goods that were purchased outright. Prices for durable goods and the various inputs of production are slightly more complex. There are three factors of production to be considered:

- Labour, which can be divided into various grades;
- Land, which includes natural resources; and
- Capital, which covers both money itself and production goods such as livestock and machinery.

A fourth factor, entrepreneurship or management, is sometimes added to cover management and risk taking.

The factors of production are subject to the laws of supply and demand in the same way as other goods, but the demand for them is described as *derived demand,* since it depends on the demand for the products the factors are used to make. Given sufficient information about the production conditions, prices and the demand for final products, input-output models can be constructed for the whole economy to determine the demand for the different factors of production.

The many inputs of production and most durable goods can usually be bought in two ways:

- Outright purchase, which confers on the owner all the incomes that can be earned from using a particular input or all the benefits from a particular durable good.
- Renting or hiring, which enables the purchaser to use the item for a stated period of time.

Thus a durable consumer good, such as a television, can be owned or rented. Machines used for production can be hired or owned. Labour is usually rented out by an individual by the hour or week against a fixed wage. Capital in the sense of machinery and buildings can be owned or rented. Money in the sense of cash can either be owned, in which case the owner reaps the income it can earn, or rented in return for a payment per unit of the time that it is used. This "rental" is conventionally referred to as borrowing and the payment per unit of time is the interest. Similarly, land or mineral rights can be owned or rented for a period of time.

Underlying all investment or project appraisals is the concept that the various inputs or factors of production at the disposal of an individual or a nation should be used so as to earn that individual or nation the highest possible income. Thus, just as an individual should not borrow money at an interest of 10% per annum to finance an investment from which he expects a profit of 8% per annum, a nation should not invest resources in projects with a return of 8% when alternatives yielding 10% exist.

Choice of Prices in Economic Analysis

In a project appraisal or budget, the main economic input lies in the choice of prices, since it is assumed that the technical inputs which give the main physical components of costs and benefits have been derived by the professionals responsible for ensuring the technical feasibility of the project. In the same way as all the assumptions necessary for deriving the physical parameters must be clearly stated, so the *origin* or *derivation* of every price or group of prices chosen must be given as well as *the justification* for using them. A simple rule determining which prices can be used in a particular analysis is that the prices chosen should approximate, as far as possible, to the *opportunity cost* of the relevant items to the individual, firm, institution or country from whose point of view the analysis is being made.

Opportunity Cost and Shadow Prices

The opportunity cost of making a particular economic choice is given by the cost of whatever alternative production or consumption had to be foregone as a result of that choice. The allocation of labour in a village production system means that new projects introducing new work patterns need to take into account opportunity costs.

Example: The labour needed to grow fodder crops could be valued at the government's minimum wage rate of, say, US$ 5 a day. After consideration, this rate might be found artificially high, so a black market wage rate of US$ 3 per day might be applied. We may also look at the problem from the point of view of opportunity cost and ask the question, What would the farmer be doing with his time if he were not cultivating his fodder crop? If the answer is that he would be doing nothing but lying in the shade sleeping, the opportunity cost - unless he is very tired - may be nil. If the answer is that he would be drinking beer with his friends, it may be that the opportunity cost is negative - by not drinking he saves money and has fewer hangovers. Alternatively, his drinking may be a way of finding out information on marketing issues, pasture availability, local politics etc. Most often, however, the opportunity cost will be expressed in terms of another crop or of time spent trading or on craftwork or some other remunerative occupation. In order to assess the true cost of transferring the farmer's labour to fodder crop production, the cost of the *income foregone* from the alternative occupation must be estimated.

The opportunity cost of capital, i.e. of using money or investment funds, is the rate of return or interest rate that can be earned in alternative uses.

From the concept of opportunity cost, the idea of *shadow prices* can be derived. Shadow prices are used with the broad objective of bringing prices to values nearer their true opportunity cost and thus, in project analysis, they lead to the selection of projects which use up the different resources at rates reflecting the real cost to society. Shadow prices can be defined as artificial prices calculated for certain items in order to ensure that their real opportunity cost is taken into consideration when making decisions. These shadow prices may be different from the money actually received or paid for the items at the time they are used.

Shadow prices are generally used in the following circumstances:

- Where market prices do not reflect real opportunity costs. This is often the case when prices are fixed by the government or are affected by speculators indulging in monopolistic trading.
- To accomplish particular policy objectives by encouraging the use of some items by setting artificially low prices for them and discouraging that of others by setting artificially high prices.

Thus, in project appraisal, shadow prices will present the costs and benefits of the projects at prices that: a) reflect, as far as possible, the real opportunity costs of the choices being made and the policies being proposed; and b) follow government policy by making those projects that use a higher proportion of the inputs whose use or production the government wishes to encourage, seem relatively more profitable. This is because shadow prices give such inputs an artificially low cost and such outputs an artificially high value.

Shadow prices are most commonly used in the case of two commodities:

- Labour, which can be rather difficult to value in monetary terms, as was illustrated by the example given above. Moreover, governments often want to encourage projects that use a high proportion of local labour while maintaining a relatively high minimum wage rate. A low shadow price for labour would make such projects appear relatively cheaper compared to projects substituting other inputs for local labour.
- *Foreign exchange.* Foreign exchange is a market commodity just like any other. It is accumulated by exporting and receiving aid in hard currencies and spent on imports, foreign debt repayments etc. A low price for foreign exchange means that the value of the local currency is high. This is often felt to give the country prestige and to imply a strong economy. It also makes the repayment of international loans artificially cheap. As with any other market, an artificially low price will lead to demand exceeding supply. Imports are artificially cheap, but exports are artificially expensive and hence not competitive, resulting in a shortage of foreign exchange. So governments end up restricting imports by imposing quotas, licences or banning certain commodities. One way to ensure the selection of a project that saves foreign exchange is to use a high shadow price for it.

Shadow prices can be used for any commodity if the need arises. For instance, if the objective of government policy is to raise the living standard of a particular group of people in a country, shadow prices can be used to give a higher value to incomes gained by that group as compared to those of another group. A comprehensive system of shadow pricing based on world market prices has been devised by Little and Mirrlees.

Individuals working within a government framework attempt to use a variety of shadow prices that they have calculated themselves. Ideally, the ministry in charge of planning and appraisal should give clear guidelines as to which shadow prices are acceptable. In the absence of this, individuals should make their initial calculations at market prices, and only if they feel that there is a strong case, should they apply their own shadow prices, stating clearly what these are and how they have been derived. Because the issue of shadow pricing is a complex one, the advice of a professional economist should be sought before attempting to assign shadow prices to goods and resources.

Choice of Prices for Financial and Economic Analyses

In economic studies, a distinction is made between financial and *economic* analyses. Financial analyses examine the monetary implications of any particular activity by an individual person, enterprise or institution, looking at the actual expenses and receipts from the point of view of the individual or firm concerned. The prices used in these analyses are usually market prices.

Economic analyses study the effect of a particular activity on the whole economy. The prices used should approximate to their opportunity cost, so they may be shadow prices. Since the analysis is undertaken from the point of view of the whole economy, all prices are net of purchase taxes and subsidies.

As a study undertaken from the point of view of an individual person (firm or institution) examines the implications of a particular activity to that individual, the prices used must be those that the individual faces. Thus to a farmer who ends up buying all the supplementary feed for his cattle on the black market, the application of the government's subsidised price makes no sense. Supplying supplementary feed at subsidised prices costs the government the handling and distribution expenses plus the value of the subsidy. Whereas if a trader is involved, the feed brings him a profit if he sells it at a higher price, less his own costs of transport, handling, storage etc. These are all *financial* viewpoints.

From the nation's point of view, the cost of the supplementary feed is probably best estimated using the price paid by the livestock producer, if the feed is sold on the open market. In economic evaluations involving most agricultural and livestock products, the so called "farm-gate price", which is the price paid to the producer, should be used. The retail price paid by consumers includes the profits of middlemen, transport and handling charges etc. which do not form part of the real value of the product. Where the farm-gate price is artificially fixed, a shadow price reflecting the black market price may be used. World market prices for particular items should only be applied if these prices are being used throughout and if the government or agency for whom the evaluation is being undertaken desires this. The distinction between economic and financial analyses will be used throughout the rest of this manual. Up to now, the word "economic" has been used to cover both aspects. Used on its own without contrasting it to the word "financial", it will continue to be the general term covering all studies of this nature.

Adjusting for Inflation -

For the purposes of project appraisal, making budgets or other economic or financial activities, it is often necessary to convert prices at current levels (i.e. for the year in which they occur) to constant values i.e. to those in a chosen base year.

Since any cost (C) is obtained by multiplying the quantity (Q) by the price (P) i.e.

$$C = P \times Q$$

it follows that, if for any year two out of the three items (C, P or Q) are known, and the price for the base year is known, costs can be converted to their value in the base year. Most commonly, it will be necessary to convert the cost of a particular item or undertaking in year n to that in the base year 0. Since the item or undertaking is the same, it follows that:

$$Q_0 = Q_n$$

so that

$$C_0 = C_n \times P_0/P_n$$

i.e. the costs in the year n are converted to costs in the base year by multiplying them by the ratio obtained when prices in the base year (P_0) are divided by those in year n (P_n). Sometimes this ratio is given in the form of a *price index* for a fixed quantity of goods.

Usually the price level in the base year 0 is assigned the number 100, so that price changes will show up as percentages of prices in year 0. Thus as the price changes, the price ratio for each year n (P_n/P_0) is calculated and multiplied by 100. Similarly, to convert costs from year n to a base year, they should be divided by the price index and multiplied by 100.

Example: Suppose that milk cost F 180 per litre in 1981 and F 250 in 1983, then the ratio 250/180 multiplied by 100 will give a price index of 139 if the base year is 1981. To create this index a constant quantity (1 litre) was used. Thus the quantity of milk bought for F 15 000 in 1981 would cost 15 000 x 139/100 or F 20 850 in 1983. Conversely, expenditure on milk of F 25 000 in 1983 would have cost 25 000/39 x 100 or F 17 986 in

1981. Often price indices are presented in a series for a fixed quantity. Thus if the 1982 price was given as F 215, the complete series would be as follows:

	Base year 1981	*Base year 1983*
1981	100	72
1982	119	84
1983	139	100

The base year in this series is given by 100. Using such a series makes it possible to convert costs from any year to those of any other, but most conveniently to the base year. Frequently an economist evaluating a project will be confronted with a series of expenditure figures extending over many years. If detailed information is not available, price indices published by government statistical services can be used in the analysis or else such indices can be--put together from the existing information on prices and quantities. Until costs over a numbeı of years have been converted to constant prices, it is meaningless to compare them, since any decreases or increases could be due to price changes.

Any project manager, planner or individual planning his finances must make it a priority to collect not only information on costs but also on prices. Ideally all quantities, prices and expenses should be recorded. In fact, since the objective is to compare expenditure or receipts at constant prices, a record of total costs and unit prices would be sufficient. Expenditure and receipts could then be converted to the base year by making price indices out of the price series. This is the most practical approach. An alternative approach is to note all quantities purchased or sold. When the moment for comparing expenditure and receipts comes, these can converted to current costs for all items since the quantities and current prices are known.

In many eases price indices actually cover a mixed sample of goods of a particular category. Examples of these include consumer price indices, share indices, construction goods indices, industrial price indices etc. In each case, the same principle applies. As before, the quantity must be fixed, but this quantity is a fixed selection of goods, usually called a "basket".

COSTS OF DISEASES AND THE BENEFITS OF THEIR CONTROL

Disease is only one of the many factors influencing the level of productivity in a production system and often cannot be considered in isolation. In order, therefore, to evaluate effectively animal disease control programmed the economics of the livestock production systems involved must be clearly understood.

Economic Aspects of Livestock Production Systems

Inputs and outputs

Describing the economic aspects of a livestock production system essentially involves the determination of the costs and quantities of the various inputs and outputs of that system. Two distinctions can usefully be made in the analysis of inputs or costs. Firstly, costs can be listed by item and the various factors of production (land, labour, capital) they apply to and, secondly, they can be classified by their degree of variability into variable and fixed costs.

Variable costs vary in the short run and directly with the amount of output produced, declining to zero if the output is zero.

Fixed costs vary only in the long run and are still incurred if output is nil. They are sometimes called overheads and cover such annual cost items as permanent labour, rent and rates, maintenance and running, and depreciation on durable goods which last for more than 1 year.

Sometimes an intermediate category of items is defined. These are integer costs, which vary with output in the medium term, such as large capital items.

A great deal of literature exists on the use of farm budgets for planning, control, analysis, and decision-making at the producer level. In farm budgets a distinction is made not only between economic and financial analyses, but also between financial and cash-flow analyses. In financial *analyses,* the actual financial position of the farmer is analysed. Depreciation, which reflects the annual reduction in value of durable goods or capital items, must be calculated. Several formulae exist, of which the simplest is:

Annual depreciation =(Replacement cost - Salvage value) / Years of productive kite

Here salvage value refers to the residual value of the machine when it is scrapped. A similar approach can be used in calculating the replacement cost of livestock. The cull value is the salvage value. The replacement cost is the price of a new animal. The formula above gives the so-called "straight-line depreciation" and must be included in fixed costs in a financial budget. A financial budget also includes the value of produce consumed at the farm.

Cash-flow budgets cover cash depreciation receipts and payments. They exclude home consumption, and depreciation but include loan receipts and repayments. If the latter were included in financial budgets as well as depreciation on equipment, for whose purchase loans had to be taken out, there would be an element of double counting. Distinguishing between the variable and the fixed costs of production is important in the analysis of disease control projects, because changes in production levels due to disease losses or the removal of production constraints affect costs at different levels as well as output. Usually a reduction in mortality and morbidity will affect only the producer's variable costs, since these vary with the levels of output and thus usually with the number of animals. The variable costs most often affected are feed and veterinary costs.

Theoretically these are variable, but are often included with maintenance in fixed costs in farm budgets, since, unlike other variable costs, it is difficult to allocate them to individual crop or livestock enterprises.

Factors Influencing Output and Offtake

In most herd- or flock-based production systems where farmers rear their own replacement stock the choice between *present* and future consumption, between current *income* and *investment,* presents itself clearly. All producers choose to some extent between saving and investing for future consumption or consuming now. The livestock producer can make this choice at two levels:

- Livestock products, such as eggs, meat or milk, can be sold or consumed by the family or, in the case of milk, given to young animals, thus increasing their nutritional intake and probably having an effect on their survival.
- Animals can be kept or slaughtered. Females are almost always retained, though, in some systems, some are sold for meat before culling becomes necessary. Males can be retained for breeding, sold or kept in the herd as a reserve of cash, or to assist in maintaining a balanced herd.

The choice between keeping or slaughtering animals can be illustrated using the following production parameters (expressed throughout as percentages):

- GP - gross productivity per 100 animals
- AF - proportion (%) of adult females in herd
- O - annual offtake rate
- CR - calving rate
- G - annual rate of growth
- LB - live births (AF x CR x 100) per 100 animals
- CM - calf mortality
- CS - calf survivals (LB - CM)
- AM - adult mortality

Gross productivity can be expressed as births minus deaths. This gives the increase in numbers which can then be allocated between growth and offtake, i.e.:

$$GP = CS - AM = O + G$$

Without making any distinction between sexes in the surviving calves, this equation gives a rough estimate of the growth potential (from GP) of the herd at different offtake rates. It emphasises the trade-off between offtake now (O) and investment leading to growth (G) and hence offtake later i.e. the choice between present and future consumption. At this level gross productivity is fixed by the basic production parameters of calving rates and mortality. How the increase in numbers is allocated between offtake and growth is decided by the producer.

Relationship between Livestock Prices and Output

The prices which consumers or producers find acceptable for a particular item are related to the incomes or other benefits that buyers expect to gain from that item. In theoretical terms it can be stated that, in a free market the *price* of any input item which lasts for several years will approximate to the present value of the incomes expected from the use of that item over the years of its working life.

For livestock this explains, for example, why a female calf generally has a higher value than a male calf A heifer's price rises as soon as she is in calf and her fertility is proven. As a cow ages, its value declines.

In the nomadic production system in Mali the purchased inputs are nil, so the price in each year can be seen as the product of both the expected probability of an animal surviving until it is slaughtered at 7 years and the present value in each year of the slaughter prices. This gives a good approximation to the actual price and helps explain the ob xxxserved fact that prices, even per kilogram liveweight, are considerably lower for young animals.

Estimating the Cost of Disease

The quantification of the losses due to individual animal diseases follows on from the disease investigation work undertaken. Once the actual disease prevalence and/or incidence and the nature and magnitude of the losses experienced in infected herds at the regional and national levels have been defined, the economic portion of the analysis proceeds to:

- Organise, classify and present the information on disease losses.
- Quantify losses in monetary terms, choosing prices that reflect the economic or financial nature of the analysis being undertaken.
- Identify and attempt to quantify the indirect losses attributable to a disease.

Quantifying the Direct Losses Due to Disease

Direct losses are those production losses directly attributable to the presence of disease. Depending on the information available, and the needs of the study, these losses can be estimated at various levels of detail, matching the complexity of the methods used to the sophistication of the data. Two main approaches exist for quantifying disease losses:

· Given a knowledge of the production parameters of the livestock systems, and the effect of disease on them, a livestock model can be built which looks at the values of output when the disease is present and when it is absent. Such a model would, by its nature, either involve projections over a number of years or the calculation of losses for a static livestock population in equilibrium.

A dynamic evaluation, either in the context of a static herd of fixed size or of a growing livestock population, will give the most accurate estimate of disease losses. For a given disease, the values of all production parameters in the absence and presence of that disease can be entered. The difference in output with and without the disease is then calculated using the model. This type of evaluation relies on a detailed knowledge of the production system and of the effects of the disease. Small differences in the various parameters can then be estimated and valued.

- Estimates can be made of the annual level of losses associated with the disease. These can then be extrapolated over the period being studied, in line with the expected changes in livestock populations in the affected production systems and with the expected behaviour of the disease.

Methods for Estimating Annual Losses

Method 1: Losses estimated as a function of the value of the animal

Mortality: Since Method I is based on the concept that price reflects the expected future income from an animal, the cost of mortality can be calculated by applying the price by age/sex category to the number of animals in each category, and to the percentage mortality in each category, if it is known how this varies between different age/sex categories.

Morbidity: Similarly, if there are no detailed data on the effects of morbidity, its cost can be estimated as an overall lowering of output, expressed as a percentage of

- all future output from the affected animal, by using its price; or
- annual output from the average animal or the herd, in terms of milk, meat etc.

The morbidity and mortality losses can be calculated on an annual basis and adjusted for future years to reflect:

- The growth of the animal population affected.
- Any change in the animal population away from or towards more susceptible animals.
- Any change in the disease picture, following from animal health measures, changes in management practices, cycles of disease occurrence etc.

Method II: Losses itemised in terms of the effect of disease on the final output of milk, wool, meat, young animals and draught power

Mortality: This can either be calculated as above, or the present value of expected output less costs is calculated for the age/sex group or for the average animal.

Morbidity: If this is known, the losses due to disease can be calculated via the observed effects of disease, such as:

- infertility
- abortion
- delays in reaching maturity (for reproduction or sale)
- lowered production of milk, eggs, wool etc.
- lowered draught power
- lowered weight of fattened or culled animals etc.

The majority of the effects are most conveniently calculated in terms of lowered output. In some cases the loss may be more easily evaluated in terms of wasted inputs. A more sophisticated estimate would include the time value of the delay in reaching maturity calculated by discounting to obtain the present value of the costs and receipts involved. Losses in the final output can be evaluated on an annual basis and then adjusted for changes in animal numbers or in the disease picture as outlined above.

In the following example this approach was used to evaluate a sheep scab control project in Lesotho in terms of meat and wool lost. The prices quoted are in maloti (M). The total number of sheep in Lesotho is 1 200 000. The value of wool produced per sheep per year is 2.1 kg at M 1.74/kg = M 3.65. The cost of mortality per sheep is M 40 and the price received for an average animal slaughtered is M 50.

Losses due to Disease Acting as a Constraint on Production

As well as causing *direct* losses, diseases can act as constraints on production by partly determining the producer's efforts to avoid as far as possible the risks of disease in his animals. Disease control policy may bring about changes in the location of production or in the production methods used.

If a disease control policy removes a constraint, the benefits resulting from such changes are called *indirect benefits*. The losses thus avoided are called *indirect losses*. Indirect losses are particularly important in cases where the existence of a disease poses an almost absolute constraint on certain types of production or on the use of certain animals in particular areas. For example in eastern Africa, tick-transmitted diseases, particularly East Coast fever, may prohibit the introduction of improved, exotic breeds of cattle except under extremely efficient control programmed Tsetse-transmitted trypanosomiasis poses a constraint on both agricultural and livestock production tat several levels, often by limiting access to, and the full exploitation of, valuable land resources. Quantifying such effects can be complex, but it is possible. It principally involves the estimation of *changes* in the income of the producer groups involved, which would arise if the disease threat were removed and the producers were able to improve existing systems of production or adopt new ones. These *income changes* can then be related to the effects of the disease control policy.

Other losses due to animal diseases

Zoonoses. While the effects of zoonoses on human production or output in terms of lost income and the costs of treatments can be quantified, the costs of mortality and human suffering are difficult to evaluate. As well as these direct losses, indirect losses may exist where the fear of contracting a disease limits human activity.

Trade effects. Outbreaks of some diseases, particularly foot-and-mouth disease, will have a major effect on the availability of export markets to a country. An estimate of costs can be made by assuming that after an initial loss of exports, an alternative market offering lower prices can be found.

Secondary Effects

Secondary effects are effects arising upstream or downstream of the affected production process, as the dependent industries also expand. These effects are seldom evaluated, and should be reflected in the prices of the products directly affected. They can be quantified by calculating the value added at every stage of the production process affected. This "method of effects" is widely used in francophone countries and, from the theoretical point of view, is analogous to calculating and using shadow prices to estimate the opportunity cost.

Externalities occur when the production or consumption activities of one group of individuals affect another without the results being reflected in the market, in costs or m receipts. For example, pollution of a river by effluent from a firm causes damage which is not paid for by that firm. The shade given by a tree planted and owned by one individual is shared by others free of cost. One farmer's failure to vaccinate his livestock may put at risk the livestock of the whole community. Externalities are said to be "internalised" when the costs or benefits involved are paid for in some way. For example, the firm could be required by law to install a plant for treating its effluent and rendering it harmless. The owner of the tree could charge people for sitting under it. Failure to vaccinate livestock could be subject to fines imposed by the community. In a financial analysis, if the externalities are not "internalised", they are not reflected in the costs to individuals, since no one actually pays for them. In an economic analysis some estimate of their effect should be attempted where possible. For example, the cost of pollution of a river can be measured in terms of its effect on fish mortality or on human health. Failure to vaccinate has a quantifiable effect on the direct losses due to the disease.

Intangible of disease are effects that exist but are very difficult to quantify. An example is the effect of a disease risk to people and animals on the quality of human life. People's welfare and behaviour may be modified if they no longer need fear certain diseases or losing their whole herd to rinderpest. Some aspects of this could perhaps be quantified, but generally it is acceptable to state that such effects exist and that they should be taken into consideration. This approach may also be the most practical way of dealing with some externalities.

COSTS OF CONTROLLING DISEASE

The costs of animal disease control will obviously vary not only with the disease and the type of control policy adopted, but also with the country and region in which the programme is being implemented. The reasons for this are easy to identify: different institutional frameworks, different salaries of those involved, different terrain and different production systems leading to very different transport costs. Nevertheless, it is possible to make some generalisations about the types of cost incurred and the components of these costs.

Non-medicinal Prevention

This covers preventive care within the daily routine of an animal production system. The cost is the producer's time spent observing the animals, ensuring that they have a clean environment etc. Non-medicinal prevention can include attempts to contain particular diseases by controlling livestock movements, policing borders and building fences. At a more modest level, they include the costs of protective measures undertaken at markets, the disinfection of vehicles used for transporting livestock and their products etc.

Medicinal Measures

The direct actions taken against a particular disease may include:

— Identification of a disease through diagnosis and surveys.

- Treatment of the disease, which usually entails diagnosis, treatment and follow-up. Treatment is a function of the reported incidence of the disease, which in itself often reflects the distribution of veterinary facilities and personnel, and the capacity of the veterinary service to treat a particular problem. Treatments continue to be necessary for as long as the disease remains in the population.
- Prophylaxis or vaccination. This is repeated at specified intervals once the population to be protected has been determined, either as a result of an epidemiological study and/or the producer's decision as to which animals he can afford to protect.
- Vector control, which may be repeated at determined intervals if necessary.
- Use of disease-resistant animals, which may be considered a form of disease control policy requiring experimentation, surveys and follow-up. The costs continue over the whole period during which the animals are used and are calculated in terms of the difference in productivity between resistant animals and the alternative which would have been used.

Eradication normally involves an intensification of one or more of the methods outlined above, which may be combined with a test and slaughter programme. It always involves intensive surveillance and investigative work. The initial costs of eradication are high but should be substantially reduced once the objective has been achieved. In examining and comparing different disease control policies, two aspects should be emphasised:

- The overall level of costs and their relation to the funds available.
- The *timing* of expenditures over the years. Treatments and prophylaxis typically involve costs over a number of years, while eradication demands a much higher level of expenditure but for a much shorter period. Surveillance and diagnostic work must accompany all policies. In all cases the present values of the costs.

Components of Disease Control Costs

The major components of general costs usually are:

- staff costs, including administrative costs,
- labour costs, and
- vehicle depreciation and running costs.

Added to this are costs linked to the specific nature of the project, such as:

- dip tanks and dipping chemicals,
- insecticides,

- vaccines or drug treatments,
- syringes, needles, cool boxes etc. and
- incentive payments or compensation.

In the case of more routine work, especially vaccination, it is often useful to distinguish between:

- The cost of *administering* the treatment or vaccination, sometimes called the *cost of intervention,* which includes all the costs involved in running the veterinary service and of the facilities used for the relevant treatments or vaccinations.
- The cost of *specific equipment,* such as drugs, syringes, needles etc. necessary for a particular treatment or vaccination.

Importance of Fixed and Variable Costs

As in any costing exercise, in costing disease control measures it is essential to distinguish clearly between variable and fixed costs. Variable costs include the cost of:

- drugs for treatments, vaccinations, insecticides or acaricides;
- syringes, needles and other small equipment; and
- staff travel and subsistence allowances.

Fixed costs or overheads in disease control include:

- vehicle running (this can be regarded as a semi-variable);
- permanent staff salaries;
- office running and administration;
- depreciation on vehicles, equipment and buildings; and
- office rents, rates, water and electricity.

The main objective in allocating costs into these categories is to make sure that the elements that contribute to the fixed costs are used to their maximum capacity. Projects frequently waste enormous sums of money because highly paid staff or expensive equipment are not fully utilised.

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Sustainable Livestock Production

Farming is a complex, multicomponent, interactive process that is dependent on land, animal, human and water resources as well as capital investment. Throughout the developing world it is practiced in many different ways and environments and with differing degrees of intensity and biological efficiency. Animals play an integral role in many of these farming systems. Unlike the specialized and intensified livestock systems in the developed world, animal production in developing countries utilizes the full range of animal outputs, many of which are returned as essential inputs to the farm production system. Manure, for example, is an important - and often the only - source of plant nutrients and, unlike chemical fertilizers, provides the organic matter necessary for maintaining soil structure, which is an important factor in erosion control.

Animal traction is another major farm input, especially in Asia, and there are an estimated 300 million draught animals of various species in the developing world. Land preparation immediately comes to mind when considering animal traction but the important contribution of animals in transporting both goods and humans should not be underestimated. Livestock also provide income on a regular basis, such as from the sale of milk, and serve as a strategic source of cash that may be drawn on as required, since animal ownership is also a rational means of storing and accumulating wealth. This function has important implications in that it finances other essential farm inputs, such as seeds and agrochemicals, while providing cash during the critical periods of the year and thereby alleviating the poverty trap as well as increasing household food security.

Food production in many developing countries is insufficient for current requirements and the situation will be further exacerbated by rapidly expanding human populations. Countries in this position cannot allow food production to stagnate. Nor can they afford, in the longer term, to produce food at the expense of the environment or their natural resource base. There is clearly a need for more sustainable increases in agricultural output in order to balance the adverse effects of intensive production and the exploitation of the resource base while, at the same time, optimizing food production.

Livestock serves as a means for recycling nutrients and as a source of energy and value-added production. Their complementary role within the farming system is unique and needs to be fully exploited.

However, there is a growing consensus among politicians, planners and scientists that livestock production in the developing countries is not expanding at a sufficient pace to meet the needs of the increasing world population. Growth in the output of animal products from these countries has largely been the result of increased animal populations rather than increased productivity. While the higher outputs are welcome, they do not necessarily equate with sustainable productive growth. On the contrary, in many cases they may lead to the lowering of productivity and degradation of the natural resource base. Despite the many development projects implemented over the years by national, bilateral and multilateral agencies - often with substantial capital investment - the sobering reality is that there has been little change in either the efficiency or sustainability of animal production in the developing world.

Technologies clearly need to be designed, taking full account of the multifaceted role of livestock in agriculture. For such technologies to be acceptable to the producer, they must be appropriate, affordable and give tangible benefits. There are already promising technologies available which optimize local feed resources, particularly crop residues, agro-industrial byproducts and productive, multipurpose crops such as sugar cane and cassava. The optimal use of the many different types of legume and their incorporation into existing farming practices will be a crucial factor in achieving sustainable agriculture. Two important animal products, manure and draught power, are grossly underutilized at present and specific programmes will be required to maximize their use.

LIVESTOCK PRODUCTION AT THE CROSSROADS

Since the inception of international aid, the goal of development projects in agriculture has been to increase productivity. Only now is it being realized that the production systems shaped by this narrow objective are not sustainable. The drawbacks are many and complex: high costs, contamination of the environment, soil erosion and animal and human stress are the consequences of modern agricultural practices. Many of these are the result of the intensification process *per se*. Thus, the increasing emissions of methane, perhaps the most damaging of the greenhouse gases, can be traced back to intensive rice culture and the expanding population of ruminant animals, especially in developing countries. It also appears that the effectiveness of important methane sinks, which are present in natural soil-based ecosystems, has been reduced by the burning of crop residues and heavy application of synthetic chemical fertilizers.

Chemical contamination of water and soil is a consequence of the increased use of agrochemicals in cropping. Soil erosion in both arid and humid tropical zones is largely the result of overstocking with grazing animals. Deforestation in the Amazon and in other tropical regions of Latin America is closely linked to the expansion of cattle ranching.

The industrialized countries' growing concern for animal welfare is partly a reaction to the stress caused by the intensification of housing and resource management. Consumer preference for "naturally" produced food can be partially interpreted as an expression of dissatisfaction with production systems that use an excess of additives, such as antibiotics and hormones in animals and chemicals in crop production.

The pressures to liberalize world trade predicate profound changes in agricultural production systems in industrialized countries as subsidies and tariffs are gradually withdrawn. The need to restrain the use of fossil fuels in order to combat global warming will force oil prices up which, in turn, will encourage the practice of organic agriculture and add value to biomass grown for fuel and chemical substrate.

These trends add up to an impending major crisis for agriculture in the industrialized countries. They also create a unique opportunity for the tropical regions of developing countries to capitalize on the comparative advantages inherent in their rural-based economies, including their capacity to produce year-round high yields of biomass for conversion into fuel, food and feed.

In the past, livestock production schemes in tropical developing countries were characterized more by failures than successes, largely because they attempted to transfer inappropriate (industrial) technologies, requiring expensive and often imported inputs, instead of exploiting locally available resources.

Recognition of these past errors and appreciation of the new scenarios offered by changing world climates, in both biological and economic terms, provide the rationale behind the hypothesis that future agricultural production systems in the tropics must be based on the following two principles:

- exploiting local comparative advantages in order to produce biomass competitively and transform it into food, feed and fuel for local consumption and sale on world markets;
- ensuring that the systems selected are economically, ecologically, sociologically and ethologically sustainable.

BIOMASS FOR FOOD, FEED AND FUEL

The identification of high-yielding sustainable ecosystems must be the first step in any attempt to design new interventions. The products of such ecosystems must be able to serve as the principal inputs for integrated activities aimed at furnishing food, feed and fuel for immediate sale or consumption, while the by-products and residues should serve as inputs for livestock husbandry. This activity will then contribute to earnings by providing milk and meat, farm power and, from the recycled manure, fuel and fertilizer.

The Biomass Subsystem

Sugar cane varieties, chosen for high biomass yield, are planted at twice the normal density in row widths of 75 cm, *vis-à-vis* industrial sugar production. The stalks and tops are harvested for animal feed at 12-month intervals. The dead leaves (trash) are left on the soil as mulch. The interface between the decaying mulch and the soil is where a symbiotic combination of bacteria and fungi fix up to 100 kg N/ha/year. It should be noted that, in most countries, in industrial sugar production both the tops and trash are burned to facilitate harvesting. Apart from the waste of a valuable resource, this practice pollutes the environment.

At least three multipurpose tree species are now being used commercially to produce feed protein (leaves) and fuel (branches): *Gliricidia septum*, *Trichantera gigantea* and *Erythrina fusca*. The two former species adapt to a wide range of soil types and elevations (up to 1 800 m above sea level). The niche for which these species are not suitable (heavy clay soils with a high water-table) is the ideal habitat for *Erythrina fusca*. Leucaena is not recommended because of its high cost of harvesting in cut-and-carry systems. Both *Gliricidia* sp. and *Trichantera* sp. are planted at densities of 20 000 plants/ha, the former from seed and the latter from cuttings. A lower density (1 000 plants/ha) is recommended for *Erythrina* sp. which can be established from seed or stakes.

Two ha of sugar cane are estimated to have an annual yield of 240 tonnes of stalk which, fractionated in a three-roll mill, produces 120 tonnes of juice and 120 tonnes of bagasse (816 MJ of fuel energy). *G. septum* and/or *T. gigantea*, planted on 0.14 ha, yield an annual 8.2 tonnes of edible foliage which is fed to the sheep.

The Pig and Duck Subsystem

The technologies for feeding pigs sugar cane juice were developed in Mexico, the Dominican Republic and Colombia. The feeding system for ducks was developed in Viet Nam. One pig fattened from 25 to 90 kg of liveweight consumes 1 200 kg of cane juice, 53 kg of whole soybean grain and 560 kg of fresh azolla water fern (*Azolla filiculoides*). It also produces 0.5 kg of methane.

A duck fattened on cane juice from brooding (700 g of liveweight at 21 days of age) to 2.5 kg of liveweight consumes about 18 l juice (20° Brix) and 3.2 kg of supplement.

Assuming that 1 200 ducks (four batches of 300) are to be fattened, they will consume 21 600 l of juice and the remaining 98 400 l from a total of 120 000 l will fatten 80 pigs.

The Sheep Subsystem

Two ha of sugar cane also produce 60 tonnes of tops. The cane tops, together with the gliricidia foliage, are sufficient to provide the basic diet for 29 African hair sheep (adult ewes), one ram and their progeny. In addition, the sheep consume 1 280 kg of molasses-urea blocks, 2 160 kg poultry litter and 222 kg rice polishings, inputs which must be purchased. The annual lambing rate is 1.9 (the average litter size is 1.22 with 1.53 parturitions per year) and the weaning rate is 1.7. With an average growth rate of 100 g/day up to weaning and 80 g/day from weaning to a slaughter liveweight of 25 kg, the lambs are sold at 255 days of age. Annual sales of liveweight are 972 kg. Annual methane production from the sheep is estimated to be 100 kg.

The Biodigestor and Pond Subsystem

The cost of materials (tubular polythene sheet and accessories) needed to construct a biodigestor that will supply a family of six in cooking fuel is about US$100. The ponds that receive the effluent are also used to grow water ferns (*Azolla filiculoides*) which can provide up to 50 percent of the protein needs for the final growth stage of pigs, i.e. from 50 to 90 kg of liveweight. At any one time, a farm has about 30 pigs, requiring 240 kg of azolla daily. This quantity can be produced from a pond surface area of 1 500 m^2.

The Earthworm Subsystem

This subsystem is still in the development stage; nevertheless, preliminary results are encouraging. From 1 m^3 of cattle manure, over one year the production of California red worms was 6 kg (211 g of protein). Fresh worms have proved to be an excellent complement to the azolla. The combination of the two feeds (50:50 protein basis) has been used successfully to replace 50 percent of the soybean meal in a cane juice diet for fattening chickens. Ducks consume azolla even more readily than chickens and it can therefore be expected that similar rates of substitution of the protein supplement can be achieved. Research to demonstrate this is currently in progress.

Inputs and Outputs of an Integrated Ffarming System

The overall level of livestock productivity using sugar cane is high. In addition, there is a considerable quantity of biomass (consisting of bagasse) which is a potential source of farm-based energy. Even if the sugar cane yield were no higher than the world average (about 55 tonnes/ha/year), the livestock output would still be more than 2 000 kg of liveweight/ha/year.

The system as a whole is environmentally friendly and sustainable, building on the concepts of ecodevelopment and self-reliance. Almost all needs are farm-grown with a minimum of fossil fuel-derived inputs, and a surplus of biomass energy is provided. Based on estimates taken from Crutzen, Aselman and Seiler, it is calculated that the pig/duck and sheep units will produce, respectively, 52 and 100 kg of methane per year. This results in a methane:meat ratio of 0.017, compared with an average of 0.75 for pastoral systems.

Agrochemicals are not used: biodigestor effluent, manure from the sheep and humus from the earthworms supply all the required plant nutrients. Dead leaves from the cane and trees form a continuous mulch over the soil surface, thereby improving fertility, fixing atmospheric nitrogen, probably oxidizing atmospheric methane and certainly preventing erosion.

The system is directed at, and has the greatest impact on, resource-poor farmers whose family members may all be provided employment. It is not a package, but rather a series of subsystems which can be introduced independently. The innovative feature of the system is that it is integrated in such a way as to maximize utilization of available natural resources and minimize inputs. The technologies themselves are not innovative. All are known and have been applied commercially in other contexts. Many farmers in Colombia are introducing or using either some or all of the elements that make up this integrated farming system. FAO-assisted projects to transfer the technology are-under way in the Philippines and Viet Nam while others are being planned for El Salvador, Barbados and Trinidad and Tobago. Elements of the technology are already being applied on a large scale in Cuba (Figueroa, personal communication) and are in the development phase in Mexico (Alvarez, personal communication) and Honduras (Esnaola, personal communication).

The "self-reliant" feature of the technology is that it has given a comparative advantage to small, as opposed to large-scale, producers by virtue of using farm-produced resources derived from a rational and sustainable exploitation of the natural riches of the tropical environment - solar energy, soil, water, biological diversity and people.

STRATEGIES FOR DEVELOPMENT OF ANIMAL AGRICULTURE

Most scientists believe that research will support the development of animal agriculture. Unfortunately, this belief is not always shared by the decision-makers who allocate the resources. It is therefore of importance to demonstrate that research is justified by more effective development. An important element of a successful research strategy is to ensure favourable impacts social, economic and environmental.

Demonstrating the economic importance of animal agriculture, particularly in developed regions, is not difficult. Livestock products, such as meat, milk, eggs and hides, account for more than one-half of the value of total agricultural production, including tobacco and other non-food crops. In most developing regions, the proportional value of livestock products is lower but still appreciable. As a proportion of total agricultural production, livestock products amount to about 22 percent for Southeast Asia, 25 percent for sub-Saharan Africa (not including the Republic of South Africa), 26 percent for China, 31 percent for West Asia and North Africa and 38 percent for South America.

These values do not include animal traction and manure for fertilizer and fuel, which partially substitute for the fossil fuel-powered tractors and chemical fertilizers used in developed regions. For sub-Saharan Africa, the value of animal traction and manure as fertilizer was estimated to be about one-half of the combined value of meat, milk and eggs. Using this proportional value for traction and manure, the combined contributions from animal agriculture are approximately 35 percent of total agriculture production in sub-Saharan Africa (compared with 25 percent for meat, milk, eggs and hides alone). For other developing regions - especially Asia - the values of traction and manure are likely to be equally important.

Research supports the development of animal agriculture in many ways, perhaps the most important being the enhancement of livestock productivity which leads to a more efficient utilization of available resources. This potential for improving productivity is dramatically illustrated by the differences in meat and milk productivity of cattle in developed and developing regions.

One-third of the world's cattle, which are found in developed regions, currently produce 70 and 80 percent of the global beef and milk supplies, respectively. These impressive differences in meat and milk production primarily result from the greater productivity of cattle per head in developed regions. The average yield per cow milked in developed regions is 3 605 kg compared with only 820 kg in developing regions. Similarly, the annual beef offtake per head of inventory in developed regions is about double that in developing countries - 35 kg compared with 18 kg.

Improved productivity benefits economic development both at the household and national levels. Livestock products improve the nutritional status of both farm and urban families. Sales of live animals, meat, milk, eggs and fibre are often the major income source for farmers of developing countries. Sales of milk and eggs provide a continuing flow of cash, a particularly important factor as farm families move from subsistence to cash-based economies.

Research can provide dramatic demonstrations of what is achievable and may thereby encourage development. Farmers, who are understandably averse to risks, are reluctant to make a major investment in their livestock when there is a high probability of losses through deaths. However, research that leads to effective vaccines and genetically resistant breeds can encourage farmers to invest in improved nutrition, management and other livestock interventions.

In recent years, global attention regarding environmental concerns has intensified. Too often and mistakenly, the development of animal agriculture is seen as being harmful to the environment. Research-based improvements in livestock productivity, on the contrary, should actually result in a more efficient and sustainable use of natural resources.

The central problem is that demand for food and fibre by the rapidly expanding human populations places great pressure on the often fragile natural resource base. This demand will increase, especially with regard to the food requirements of urban-based populations. The population of sub-Saharan Africa, for example, is expected to increase from the present 500 million to nearly 1 300 million by the year 2025.

Currently, only 145 million people are urban dwellers but, by 2025, more than 700 million people will be living in sub-Saharan cities and towns. Urbanization will cause a sharp increase in demand for nutrient-rich, easy-to-prepare livestock products. Meeting this demand will not be easy but, fortunately, research-based interventions should help.

Such interventions include increasing feed and residue yields from crops grown on arable lands, reducing losses from disease and parasites and improving the genetic potential for milk and meat yields. These improvements should have positive ramifications for long-term sustainability - both environmental and economic.

Research Strategies

Strategies for research were given particular attention in the recent study, *Assessment of animal agriculture in sub-Saharan Africa*. Research is but one essential element along with extension, education and investment for the successful development of animal agriculture. In many cases, however, research can also act as a catalyst to expedite and ensure the success of development activities.

Although the Winrock study focused on sub-Saharan Africa, the general principles and priorities mentioned are broadly applicable to animal agricultural research throughout developing regions. A successful strategy must be based on the assumption that animal agriculture is a positive factor in long-term, sustainable agriculture and that research will enhance the contribution of livestock to sustainable agricultural development. Strategies should thus embody the following concepts: adequate economic returns to livestock farmers; maintenance of natural resources and productivity; minimal adverse environmental effects; optimal production with minimal external inputs; and satisfaction of human food and income needs as well as of rural families' social needs.

Farm systems approach. Given the complexity of animal agricultural management, a farm systems approach to developing and implementing research strategies is essential. To ensure that the research undertaken addresses farmers' perceived needs, such an approach must: characterize the farming system - identifying inputs, outputs, potentials, constraints and interactions of components; develop interventions to resolve constraints and exploit potentials; design alternative systems; evaluate interventions and alternative systems; and elaborate on alternatives that have proven to be technically practical, economically feasible and socially acceptable.

The research process should begin with the careful identification of problems. Systems description and constraint analysis are particularly valuable for informing scientists about the real problems faced by farmers.

An interdisciplinary team effort, combining efforts of socio-economic and biological scientists, is required to ensure that the full benefits are realized from the research to the development stage. In the planning and priority-setting stage, the social scientists can provide ex ante projections of costs and benefits while helping to address equity issues that may arise, such as gender and reconciling the interests of the poorer farmers with those of the more prosperous producers. As research progresses, the monitoring of socio-economic factors improves the probability of favourable social and economic impacts.

Since the objective of farm systems research is to improve traditional systems and, consequently, production, it follows that there wild be circumstances calling for major changes. For example, the six-fold increase in pig and poultry meat production envisioned for sub-Saharan Africa over the next 35 years, will require the adaptation of high-input, industrialized production systems to the environmental conditions of sub-Saharan Africa. This adaptive research will have little relevance to the problems and constraints of traditional backyard, scavenger poultry production.

Research Priorities

The research strategy recommended for sub-Saharan Africa identified the following priorities: feed supply, animal health, genetic improvement, livestock management, crop/livestock farming systems, natural resources and policy. Priorities for research were based on agro-ecological, biophysical and socioeconomic constraints and potentials. Criteria for establishing research priorities included: potential for achieving substantial gains in production and/or income; probability research to resolve constraints and/or exploit potentials in order that substantial benefits be realized; availability of readily applicable technology to resolve constraints and exploit development potentials; and the expected social and environmental impacts of research.

Feed Supply

The primary constraint to livestock production in sub-Saharan Africa is the fluctuating quantity and quality of the year-round feed supply. Ruminants will continue to depend primarily on forages and crop residues. However, energy and protein concentrates are required for the expansion of poultry and pig production while concentrate feeds will also be needed to supplement the diets of high-yielding dairy cattle. In the drier regions, seasonal shortages of forage are common while, in wetter regions, the nutritive value of forages varies seasonally and the failure to preserve surpluses therefore limits year-round carrying capacities.

Arid zones. Low, erratic rainfalls preclude any significant increase in feed production without irrigation. Thus, research priorities concentrate on the more effective utilization and maintenance of natural vegetation for which the requirements include monitoring systems to facilitate early warning and drought relief measures as well as grazing management schemes with an emphasis on social and organizational prerequisites for long-term sustainability.

Semi-arid and subhumid zones. These zones offer the greatest opportunities for research-based improvements in feed supply. However, care must be taken to match interventions to specific ecological characteristics in order to ensure long-term environmental sustainability. Fortunately, feed production options such as forage legumes and multiple-purpose trees (MPTs) are often environmentally beneficial. Their use by livestock brings economic benefits to farmers as well as improving soil fertility and controlling erosion. Rain-fed cropping systems will expand in these zones in response to population growth and food demand and the better grazing lands that are not already cultivated soon will be. Therefore, research should be directed towards forage production on marginal lands; forage legumes and MPTs as rotational and complementary crops; improved utilization of crop residues; strategic protein, energy and mineral supplementation to correct nutrient deficiencies and promote efficiency; and conservation of seasonal surpluses to compensate seasonal feed shortages.

Highlands. Since human and livestock populations are nearing the maximum carrying capacity of most African highlands, research should concentrate on more intensive systems that produce higher yields of protein and energy. Most crop/livestock farmers are small-scale with limited access to grazing lands, a situation that calls for integrated cropping systems combining food, cash and forage crops (including MPTs) to meet the needs both of livestock and humans while sustaining the soil and water resource base. Coarse grains, roots and agricultural by-products will be increasingly used for semi-intensive dairying; the feeding of cattle, sheep and goats for slaughter; and intensive pig and poultry systems. Ways to enhance and preserve feed values of crops must be sought, an endeavour that could involve collaboration between plant breeders, agronomists and animal scientists.

Humid zones. Human population expansion and the subsequent growth in food and feed demand will encourage agricultural development in humid zones. There is concern about the implications this might have for the often fragile natural resource base (discussed later) and research efforts to increase and improve feed supply must have full cognizance of such environmental issues. Alley farming with MPTs is an example of a research-based alternative which can enhance crop productivity, protect the resource base and provide high-quality forage for livestock.

Poultry and pigs. Industrialized commercial production of poultry and pig-meat will provide nearly one-half of the meat requirements for sub-Saharan Africa, estimated to be 8 million of the total 19 million tonnes of meat that will be required annually by the year 2025. The demand for feed grains is predicted to increase from 3 million tonnes in 1990 to 25 million tonnes by the year 2025, and for protein meals from 0.2 to 6 million tonnes. If past experiences are repeated here, these concentrate requirements will be met from coarse grains, root crops and oilseed meals produced as cash crops over and above human requirements. Research must aim to fulfil a similar demand for food crops, but with a predominant emphasis on increasing yields under prevailing environmental conditions; rainfall, plant diseases and soil fertility, for example.

Animal Health

Diseases and parasites seriously limit live stock productivity throughout sub-Saharan Africa. Research is needed to improve the efficacy of existing preventive and therapeutic treatments and to develop new diagnostics and vaccines. For some health problems, resistant genotypes and preventive management offer cost-effective alternatives to treatment.

Trypanosomiasis, tick-borne diseases (theileriosis, cowdriosis, anaplasmosis and babesiosis) and the tick-associated disease, dermatophilosis, were identified as major constraints to livestock production in sub-Saharan Africa (Winrock International, 1992). Priority was given to genertic engineering research into the development of highly potent and thermostable multivalent vaccines. Diagnostics, based on monoclonal antibodies and recombinant DNA technologies, must aim to identify infectious agents and ensure efficient epidemiological monitoring, while research on immune responses will provide the basis for developing effective vaccines and delivery systems. Similar research on diagnostics, vaccines and delivery systems is needed to improve the control of major epidemic diseases such as rinderpest, contagious bovine pleuropneumonia (CBPP) and peste des petite ruminants (PPR).

Economic losses from diseases aggravated by intensified farming systems, including losses from abortions, pre-weaning mortality, internal parasites and mastitis, will become increasingly important. Integrated disease control strategies will therefore need to be devised while research should concentrate on diagnostic techniques, preventive management and genetically mediated resistance. The traditional emphasis of veterinary research on major epidemic and tick-borne diseases is gradually changing as the cumulative economic losses from less dramatic animal health problems become apparent. A greater understanding of the epidemiology and economics of animal health would assist in the appropriate allocation of resources and the delivery of health services.

Genetic Improvement

Global concern about loss of biodiversity applies to domestic as well as wild populations. Genetic resources must be characterized and preserved and their diversity used to improve livestock productivity. Under the harsh production conditions of many developing regions, genetic adaptations to disease and climatic stresses are particularly important.

The need for research ranges from genetic manipulation at the molecular level to the crossing of high-yielding "exotic" breeds with well-adapted indigenous genetic resources. Fortunately, basic research at the molecular level, which is now under way in developed countries, can establish a basis for future applied research in developing regions. In addition, the principles of quantitative genetic theory may be transferred to genetic improvement programmes involving selection, cross-breeding and multiplication for example, multiple ovulation embryo transfer (MOET) and open nucleus breeding schemes. Thus, the identification, characterization and development of indigenous genetic material should take priority in the allocation of the scarce resources available for genetic research. In Africa, these include the unusual, perhaps unique, genotypes of *Bos taurus* cattle in West Africa, African hair sheep, camels and donkeys. Major research initiatives with indigenous populations are being developed by ILCA and FAO. These will be largely implemented under contracts with scientists of national agricultural research systems (NARS) through the collaborative research networks discussed later.

Resource Management

The need for expanded agricultural production to provide food for today's population is increasingly affected by the fear that the eroding natural resource base will not meet the food needs of future generations. Farmers are already cultivating the better grazing lands, thereby limiting pastoral herds to marginal lands - even these marginal lands are increasingly threatened by the expansion of cultivation. If agricultural development is to be sustainable, research is needed to intensify and increase productivity from the better endowed and more robust lands and to improve the management of soil, water and vegetative resources on the more fragile lands.

Although environmental consciousness is high - regarding global warming, desertification, deforestation, for example - knowledge of causal relationships and their management is poor, especially in the case of animal agriculture. Long-term monitoring studies incorporating geographic information systems, remote sensing and modelling have become research priorities for most developing country environments supporting animal agriculture, especially as the inadequacies of paradigms derived from experience in temperate environments are increasingly evident .

Development of livestock production in the humid forest regions of sub-Saharan Africa is not recommended by the Winrock study. The adverse effects of tropical deforestation, such as climate change, loss of biodiversity and soil degradation have been well publicized. However, livestock production systems based on humid savannahs can be quite productive, providing control of major diseases, especially trypanosomiasis, is effected. Increased population pressure will almost certainly expand exploitation of the humid zone. The fallow period of traditional slash-and-burn farming systems is already being shortened in many regions, leading to the pernicious loss of soil resources. Research on nutrient cycling involving the use of animal manures, usually in combination with chemical fertilizer, may offer alternatives to slash-and-burn practices in the humid zone.

Policy Research

The policy environment can have either positive or negative effects on investment and innovation in animal agriculture. The absence of sound economic policies in support of animal agriculture will impede:

- investment in infrastructure;
- proper incentives to farmers;
- adequate supplies of production inputs and the delivery of animal health services;
- effective marketing and credit facilities;
- increased animal productivity through biological research.

Milk is a major source of income for smallholders. Traditional management practices gradually evolve as the growing demand for milk justifies investments in improved feeding, health, breeding and processing hygiene. Policy research could improve data bases and provide analyses to help policy-makers anticipate and understand the probable consequences of their actions. The Winrock study identified policy research needs in the general areas of fragile land use, institutional policies and fiscal incentive and trade policies. During a recent planning workshop, Livestock and Resource Management Policy, convened by ILCA, an international group of policy analysts and researchers identified the following research priorities: resource management; trade and macro-economics; technology policy, markets and institutions.

A major constraint to the adoption of improved innovations in animal agriculture is the nature of various communities' claims to the natural resource base. Insecure tenure, multiple ownership, common property and a lack of clearly defined and secure property rights result in the overexploitation, underinvestment in and general mismanagement of resources. This is fuelled by a poor understanding of the appropriate role for institutions that govern the use of land, water, rangelands and other resources. There is therefore a need to study how resource management policies, including land-use rights, affect resource use and how changes in policies might advance environmental objectives.

For the mixed production systems of the semi-arid and subhumid zones, these studies might examine resource competition and complementarily between different land uses and enterprises. For the humid areas, analysis of the relationships between disease control, livestock development, resource use and the environment are required. For the pastoral production systems of the arid zone, the linkages between pastoral societies, rangeland tenure and rangeland ecology should be studied.

Farmer support for resource conservation has been shown to depend greatly on government policies. The effects of credit, pricing, and monetary policies on resource use and the environment, especially for the mixed production systems, are therefore important points to consider. Policy-induced distortions in financial markets, for example, result in small farmers having to pay high real interest rates. Many farmers who are unable to borrow or meet the repayments on borrowed funds seek refuge in common access areas, which are often susceptible to environmental degradation. Policy-induced distortions in agricultural commodity markets also result in farmers receiving low prices for their livestock, thereby discouraging them from investing in natural resource management. There is a similar linkage between resource management and exchange rate policy. Setting official exchange rates above market exchange rates discourages agricultural exports, including livestock. This in turn decreases the derived demand for land, which discourages farmers from managing existing farmland and developing new land in a responsible manner.

The macro-economic environment plays a crucial role in the development of the national livestock sector. Macro-economic policy affects opportunities for trade and may, therefore, affect expansion of the livestock sector. Among areas which merit attention for research are: the effects of structural adjustment or liberalization on livestock production, concentrating on supply and demand changes resulting from economic incentives and constraints; the effects of and impediments to regional trade via economic integration; and the structure of demand for animal products.

Structural adjustment is already a reality for many sub-Saharan African countries, but while general impacts on the public sector may have been documented, specific effects on the livestock sector have not. There is a renewed interest in regional trade agreements and economic communities (such as the Economic Community of West African States and the Preferential Trade Area covering East and southern Africa).

Beneficial integration will require informed policy decisions, hence policy research is needed. Priorities include projecting changes in national comparative advantages for livestock production enterprises over time and identifying the "winners and losers" when existing trade impediments are removed. Although considerable work has been undertaken on food demand in sub-Saharan Africa, relatively little attention has been devoted specifically to demand for animal products. Understanding the effects of macro-economic policy adjustments on the livestock sector requires a knowledge of demand structures.

Research topics identified in this area include how price and non-price factors influence technological change. For the factor markets, issues of interest include the effects of land tenure, credit and labour policies. For the output markets, issues include the effects of input and product prices together with non-price factors such as quality and infrastructure. Policies to strengthen NARS and extension systems will benefit from research on institutional change, government expenditures and their allocation, institutional structures and linkages and the efficiency of public services in the livestock sector.

Research Institutions

A comprehensive research strategy should utilize basic, strategic, applied and adaptive methods as deemed appropriate. The comparative advantage for undertaking these types of research generally varies depending on the institution. For example, NARS have the ready access necessary to address the specifics of local farm systems. Whereas, International Agricultural Research Centres (IARCs) are generally better placed to address strategic and applied research needs at the international level.

NARS. National agricultural research systems are the foundation of a successful national research strategy. To be effective, NARS should include linkages to extension services, academia and private industry. In aggregate, NARS constitute the majority of human, physical and financial resources that can be brought to bear on research problems.

For example, in sub-Saharan Africa annual funding for NARS (expressed in 1980 dollars) was approximately US$372 million during the period 1981-85 (Pardey, Roseboom and Anderson, 1991). This was about four times the amount allocated to IARCs in sub-Saharan Africa. Unfortunately, the resources available to NARS are rarely utilized effectively. Too often, the majority of resources are devoted to the maintenance of staff and infrastructure. Thus, external donor funding is required for the marginal costs of experimentation.

The NARS addressing animal agriculture in sub-Saharan Africa are organized in several modes: as separate semi-autonomous research institutes, as departments within ministries and university-based institutes or as independent departments. There is often little connection between plant and animal-oriented research, even in countries where mixed crop/livestock systems are predominant. Stakeholders in the research process - farmers, extension agents, agribusiness, policy-makers - are not usually involved in setting national research priorities and developing programmes, but their involvement is essential for ensuring that research will be relevant to national needs.

Regional organizations. Regional collaboration among NARS concerned with similar problems offers an important opportunity to accomplish more with the scarce resources available for research. In Africa, there are several regional organizations addressing animal agriculture. The Centre International de Recherches et Développement sur l'Elevage du Zone Sub-humide (CIRDES), formerly Centre de Recherches sur les Trypanosomoses Animales (CRTA), located in Burkina Faso, has recently expanded its mandate for applied and adaptive technology transfer and training in livestock production and health.

Networking allows collaborating NARS partners to pool scientific efforts on a regional basis in order to address problems of mutual interest more effectively, thereby avoiding a duplication of efforts. Successful collaborative research networks typically have the following characteristics:

- a well-defined common theme and strategy;
- an existing or potential source of improved technology;
- a harmonizing (coordinating) institution serving as the hub of the network;
- regular meetings of participating scientists;
- an information exchange system;
- free exchange of results and methods among members;
- education and training opportunities;

- financial support for in-country research activities conducted by national scientists;
- explicit national commitments for research on the commodities covered by the network.

Multilocational regional projects, managed through networks, offer considerable opportunities for enhancing the efficiency of research. They allow the introduction of standardized methodologies and hence lead to more significant conclusions than can be obtained from isolated experiments.

IARCs, such as ILCA, can play a major role as collaborative research partners in networks, providing training opportunities for network participants, disseminating research methods and results and facilitating the exchange of information.

IARCs also assist with network support functions which include helping to attract donor funding, helping to organize networks (setting up network steering committees), sponsoring meetings of participating scientists and providing services in areas such as data analysis, documentation and publishing.

IARCs. Research activities at the international level include: assessing the changing research needs of global agriculture, fisheries and forestry; the collation, processing and dissemination of scientific information; the collection, preservation and exchange of germplasm and improvement of methodologies for its use; the enhancement of germplasm for crops, livestock, trees and fish dominant in the economic activity of many countries; the development of resource management and husbandry principles appropriate for agro-ecological conditions widely distributed around the globe; strategic research on production processes; and specialized training.

IARCs, supported by the Consultative Group on International Agricultural Research (CGIAR), are expected to conduct strategic and applied research of an international character that complements and supports the efforts of NARS, their principal clients. The ultimate objective of IARC is to benefit the poor in developing countries through technological change leading to increased food production and income generation. Among the 16 IARCs currently supported by CGIAR, two are primarily devoted to animal agriculture - ILCA and the International Laboratory for Research on Animal Diseases (ILRAD). The International Centre for Tropical Agriculture (CIAT) in Cali, Colombia, and the International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syrian Arab Republic are primarily oriented towards crop research but devote significant resources to livestock-related research: CIAT to tropical pastures ICARDA to small ruminants. The International Food Policy Research Institute (IFPRI), Washington, D.C., has identified animal agriculture as a promising basis for economic development as well as for policies which support animal agriculture. The International Service for National Agricultural Research (ISNAR), the Hague, the Netherlands, has encouraged the strengthening of NARS capacity to generate appropriate animal production and health technologies. In the past, ISNAR has emphasized capacity-building for crop-oriented research. However, more attention should be given to strengthening NARS to address crop-livestock and animal-based systems.

Technology Development

Technology is a major research output for the development of animal agriculture. It has been argued that an ample stock of appropriate technology is already on the shelf, but experience has generally shown this not to be true.

Technology transfer. Only rarely are technologies from developed regions directly transferable to developing regions. Climate, availability of services, trained personnel, dependability of power supply, marketing infrastructures are but a few of the factors affecting how well technologies work. These factors usually differ markedly between developed and developing regions. Thus, strategic, applied, adaptive and even basic research initiatives are required to adapt technologies to fit needs of animal agriculture in developing regions. Research to adapt and transfer technologies for small-scale farming systems will primarily involve publicly supported institutions, NARS and IARCs. Privately-funded initiatives are more likely to address the needs of the industrialized swine and poultry systems as well as the development of those technologies which are readily marketable.

Appropriate technology. The concept of "appropriate technology" is often interpreted to mean that technologies suitable for developing countries are less sophisticated and advanced than those used in developed countries. It follows, therefore, that a research strategy to develop appropriate technologies for developing countries will more than likely not involve advanced science. This generalization frequently holds and the highest priority should therefore be given to adapting relatively "low-tech" interventions. There are, however, important exceptions. For example, the battery-powered notebook computer - certainly in the forefront of available personal computing technology - is particularly useful where there is an erratic power supply, as is the case in many developing countries. Research strategies embodying development and application of advanced technologies should not be dismissed out of hand. Specific examples where state-of-science research is particularly appropriate to animal agriculture in developing countries include:

- molecular genetics research, including genome mapping and genetic engineering to combine productive and adaptive traits;
- development of thermostable, multivalent vaccines and animal-side diagnostics for field use;

- reproductive technologies, including in vitro fertilization, embryo transfer and other techniques to assist characterization of indigenous genetic resources;
- fermentation technologies to facilitate feed and food processing and preservation; for example, biocontrol of fungi and other microbes which cause silage spoilage and loss of nutrients;
- development of transgenic rumen bacteria to enhance cellulolytic activity and detoxification of antinutritional factors in foodstuffs.

LIVESTOCK FARMING AND ECONOMIC DEVELOPMENT IN TROPICS

The role of livestock in farming systems has changed dramatically in the last 50 years as they have become increasingly competitive rather than complementary with humans. Production systems have become specialized enterprises dependent on purchased feeds, often with no associated cropland area for feed production or to receive the manure. The ready availability of cheap oil has facilitated the use of agro-chemicals and husbandry practices, including crop rotations, forage crops for animals, and use of manure as fertilizer, have ceased to be a prerequisite for profitable farming.

Diminishing oil reserves and global warming will eventually mean higher prices for fossil fuels. Solar energy is the only sustainable alternative and livestock will play a vital role in enhancing the use of this resource but with primary emphasis being on their capacity as recycling agents rather than as primary converters of plant biomass into animal protein. The challenges are for the technologist to develop more efficient systems for deriving benefit from solar energy using an holistic approach; and for the economist to determine in monetary terms the presently intangible cost of pollution and the income to society of activities that enhance, rather than destroy, the environment.

These developments have been facilitated by the ready availability of cheap oil which led to cheap agro-chemicals. Good husbandry, which included crop rotations, forage crops for animals, and use of manure as fertilizer, was no longer a prerequisite for profitable farming. First coal, then oil, fueled the industrial revolution and urbanization, leading to profound changes in the ratio of food producers to food consumers. Import of food from agricultural to industrial countries was the first form of food security and, stimulated by two world wars, was followed by movements for self-sufficiency achieved in the industrial countries by massive subsidies made possible by access to cheap fossil fuel.

A return to integrated agriculture and ruralization will only be possible when the sun again becomes the dominant energy source. Diminishing oil reserves eventually means increasing costs of extraction therefore higher prices (there are signs that this is already happening). Recognition that the rate of global warming is increasing will ultimately lead to pressure to curb burning of fossil fuels:

Livestock and Fossil Fuel

The role of livestock in farming is directly related to the degree of utilization of fossil fuel energy. Cheap fossil fuel has changed the primary role of livestock from the recycling of plant nutrients to specialized production of meat and milk. As the world reverts to solar energy so the role of livestock will also change with efficient recycling being the priority instead of inefficient transformation of feed into animal products.

The task of the "new" professional must be to prepare for these opportunities. The "old" professionals wedded to disciplines, commodities and specialization may not yet be ready to change, viewing this shift of emphasis as turning back of the clock. The "new" professional will see the opportunities inherent in the application of new knowledge to solar-based agriculture and will respond to the challenge of feeding and providing energy and shelter to 10 billion people using only natural renewable resources.

A glance at the global energy flows shows us that this is possible. The energy from the sun that reaches the earth annually is one hundred time greater than the total proven reserves of fossil fuel; while newly formed biomass exceeds by a factor of ten the annual usage rate of fossil fuel. Use of solar energy to feed the world's population is more efficient when plant products are consumed directly rather than after "upgrading" by livestock. From the point of human health, especially in the industrial world, there will be benefits from reducing the proportion of the diet in the form of animal products. This does not mean that livestock will no longer be necessary. On the contrary, they will be even more important but in a changed and synergistic role. They will increasingly be seen as efficient "recycling" agents rather than inefficient "converters".

Strategy for efficient natural resource management for food, feed, fuel, and shelter Population pressure for food, fuel, shelter and environmental rehabilitation sets the stage for the following steps in the strategy for natural resource management:

- Maximization of solar energy capture into biomass easily fractionated into multiple end uses
- Promotion of cropping systems which simulate the local natural ecosystem. In the humid tropics this means multi-strata vegetation in which trees and shrubs predominate.
- Efficient use of the end products for food, fuel, shelter and environment enhancement

The first two elements in the strategy will change the nature of the products available for livestock production. The earlier discussion in this conference highlighted the opportunities of a new resource - the sugar palm - not previously considered as a source of animal feed. Water plants and leaves of trees are other new feed resources that are now receiving increased attention.

Identification and new uses of sugar cane in integrated farming systems for livestock and energy marked earlier attempts to direct attention to efficient solar energy capture as the starting point for better management of natural resources. This opened the way to consideration of other plant species as has been highlighted in the discussion about the merits and alternative uses of the sugar and coconut palms. There will be many more alternatives especially in the tropics when we begin to look "up" instead of "down" in our search for efficient and productive sources of plant biomass.

Transforming efficiently the new forms of biomass into desirable end products requires at the outset a multi-disciplinary and multi-commodity approach. Energy is as important as food in securing an acceptable standard of living and complementarity rather than competitivity must be the basis of the strategy.

Thus it makes no sense to derive power alcohol from potentially fermentable carbohydrate if this resource can be used as food. Equally the combustion of organic (high moisture) household waste to provide energy is unacceptable. Lignified plant residues are more appropriately converted to fuel (by gasification) than into livestock feed which requires expensive physical and/or chemical manipulation. All livestock and human excreta should pass first through biodigesters before being recycled as fertilizer.

Many of the technologies to promote more rational end use of the earth's natural resources already exist. What is lacking is political will and economic incentives.

Livestock in Integrated Farming Systems

The animal provides the most efficient pre-treatment of high-moisture biomass to convert it to a substrate suitable for biodigestion. Equally the "animalbiodigester" sub-system is a more efficient way of preparing organic matter for return to the soil than aerobic composting. In such systems the criteria for the 'efficient' animal should give greater weight to traits such as the capacity to select and consume voluminous and usually fibrous materials rather than digestibility. Milk and meat will be by-products rather than primary outputs in these scenarios.

Thus as emphasis has shifted from "adapting the resource to the system" (eg: the maize-soya bean feeding system for pigs) to "adapting the animal to the resource", the economic traits required of livestock will also change. This will be particularly true for the tropical regions. The advantages in the tropics of dual purpose (milk-beef) breeds and management systems over specialized milk and beef production as separate enterprises are increasingly being recognised at least in tropical Latin America. Incorporation of work, for land cultivation and transport as a third purpose, and of fuel (biogas) + fertilizer as a fourth purpose is perhaps too demanding on needs for nutrients. However, multi-purpose work plus fuel/fertilizer plus meat is a traditional way of using cattle and buffaloes in SE Asia and is a more efficient way of using fibrous crop residues than specialist (ranching) production of meat alone.

Our present methodologies for evaluating livestock-based activities are not suitable when the output is multi-faceted and has implications for the environment. Input-output coefficients have to be applied to the whole system and not just the animal. One approach is to make some measure of total solar energy capture in the system including that returned to the soil. Soil organic matter should be monitored as organic matter is a nutrient (source of energy) for soil organisms. Changes in soil fertility should be assessed and this can be related to effects on crop yields. The increases in annual yield of sugar cane of 10 tonnes/ha reported by Mui et al can be attributed mainly to increases in soil organic matter through return of dead sugar cane leaves to the soil.It would be desirable also to have some means of assessing changes in the flux of methane to the atmosphere which will be increased when ruminant animal components of the system are increased and will be reduced by processing livestock and human excreta through biodigesters and by improvements in soil fertility. It seems that soil organic matter may be an important source of energy for organisms that oxidize methane.

Gross income is tripled when the products of sugar cane are used in a diversified way rather than solely for production of sucrose. If the add-on value of the livestock products are also includedmilk, meat, manure for fuel (biogas) and fertilizer (biodigester effluent) - then the contribution to human needs and the environment is vastly increased as is the total income to the farmer. There are many new opportunities for livestock in integrated farming systems. The challenges are for the technologist to develop more efficient systems for deriving benefit from so'ar energy using an holistic approach; and for the economist to determine in monetary terms the presently intangible cost of pollution and the income to society of activities that enhance, rather than destroy, the environment.

LIVESTOCK, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

Although food availability has increased along with the growing human population over the last 30 years, there are still 800 million people suffering from malnutrition. This problem is not only the result of insufficient food production and inadequate distribution, but also of the financial inability of the poor to purchase food of reasonable quality in adequate quantities to satisfy their needs.

Livestock production constitutes a very important component of the agricultural economy of developing countries, a contribution that goes beyond direct food production to include multipurpose uses, such as skins, fibre, fertilizer and fuel, as well as capital accumulation. Furthermore, livestock are closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability.

Human and livestock populations have both grown considerably over the last three decades, although at different rates). The major differences are found between developed and developing countries. Since 1960 the total human population has increased by 75 percent, but developing-country populations have grown by 97 percent, compared with 28 percent in the industrialized world. All categories of livestock have increased in number as well, with a much greater increase for monogastric animals (pigs and poultry) than for ruminants. Ruminant populations have grown at about half the rate of the human population, while small ruminant populations (sheep and goats) have only increased in developing countries. The pig and poultry populations, however, have grown about one-and-a-half to two times that of the human population, and are three to four times greater in developing countries than they are in developed countries.

The world population is expected to increase from 5.4 billion to at least 7.2 billion within the next two decades, mainly in developing countries. This increase in human population, with the resulting increase in pressure on land and changes in composition of the livestock population, will have a major effect on both available natural resources and future demand for commodities, and this will consequently determine the type of livestock feeding and production systems to be adopted.

Official statistics tend to underestimate the overall contribution of animals since they generally underestimate or ignore the multipurpose role livestock play in food and agricultural production, as well as in the social life of small-scale farmers in developing countries.

To feed the growing human population, more land will need to be devoted to the cultivation of food and cash crops and, being a finite resource, this will reduce its availability for pasture and fodder, as has already occurred in Asia. On the other hand, increased food and cash crops will make available more crop residues and agro-industrial by-products, many of which represent valuable animal feed resources for which there is known technology to support increased levels of production. It is clear that, in order to maintain food production, the efficiency of resource utilization must be increased and alternatives - such as marine and freshwater fish culture - must be developed.

The importance of animals as an efficient and economic means of food production has been challenged, as have its effects on the environment. These concerns have been expressed on a number of issues, notably:

- Competition with alternative land uses and with the use of cereals (and some roots and tubers) as animal feed or for human consumption.
- Competition for carbohydrate and protein sources.
- Inability to meet national targets for animal proteins.

- Only a few large investments in livestock development projects have been marginally successful in increasing productivity and these have had a limited impact on agriculture.
- Inadequate demonstration of how livestock can play a key role in the development of sustainable agriculture in different agro-ecosystems, and the failure to transfer appropriate technologies. In particular, most of the increase in animal products has come from an increase in animal numbers rather than from an increase in individual-animal productivity.
- Resource degradation and environmental damage caused by deforestation, overgrazing and pollution.
- Contribution to global warming (methane from ruminants represents 2.5 percent of total greenhouse gases).
- Pollution from concentrations of intensive animal production enterprises.

Many of these problems are a result of the inability to identify appropriate technologies and define strategies for livestock development that are applicable to individual agro-ecosystems. Often, technology is transferred from developed countries unmodified, rather than generating appropriate technologies within the developing countries themselves. Imported technologies have almost always failed to overcome the constraints imposed on local farming systems or to meet the socio-economic requirements of the local farmers.

Careful analysis and assessment are required so that livestock development strategies can be reoriented towards better use of local resources, contribute more effectively to food security, improve the living standards of poor farmers and ensure sustainable animal agriculture development. The determining factors of this overall strategy include:

- political support for fair commodity prices and proposed strategies;
- better definition of the target recipients' needs;
- increased efficiency of use and management of natural resources;
- linking of production and post-production components to efficient infrastructure, services and marketing schemes;
- more appropriate policies for the use of common land and rangelands;
- improved capacity and commitment of national and international agricultural centres and non-governmental organizations (NGOs) to implement strategies that contribute to the development of livestock production within specific agro-ecosystems/ecoregions.

In livestock production, the overriding considerations are the availability and efficient use of local natural resources. A successful livestock development strategy requires the formulation of resource management plans that complement the wider economic, ecological and sociological objectives. Particular attention needs to be given to land-use systems and to the natural resources required for improved livestock production. The strategy will also need to consider the social, cultural, political and institutional elements that affect the management of natural resources. On the policy side, issues relating to land use, common property, legislation, price policies, subsidies, levies, national priorities for livestock development and research capacity have to be addressed. Finally, the implementation of action programmes requires both technical and institutional support and, equally important, government commitment.

Livestock as an Important Food Source

Livestock are important contributors to total food production. Moreover, their contribution increases at a higher rate than that of cereals. Recent increases in livestock products appear to be even more spectacular than those achieved for cereals from the green revolution. Most notably, egg production has increased by 331 percent over the last two decades, compared with 127 percent for meat production, 78 percent for cereals and 113 percent for fish (equivalent to 58 percent of that of meat production).

By the year 2010, animal products are expected to contribute proportionally much more to the food supply than they do at present, since income determines the protein intake of people, particularly in urban areas. Of the different animal species, meat production from monogastric animals (poultry and pigs) has increased at a much higher rate than that from either small ruminants (sheep and goats) or large ruminants (cattle and buffaloes). While in 1970 ruminant and monogastric meat production rates were approximately equal, it is expected that by 2010 monogastrics may produce 2.4 times more meat than ruminants, providing that feed is available and affordable.

Given the low per caput intake of animal products in developing countries compared with that in developed countries, there is considerable potential for increasing consumption and, hence, production of animal products (milk and meat) in these countries. An enormous number of poor people in developing countries cannot afford to include animal products in their diets - they are vegetarians by necessity rather than by choice.

Per caput nutrient supply in developing countries:

Calories. Animal products are primarily a source of proteins and essential amino acids, but when they are a major constituent of the human diet they also contribute a significant proportion of total calories. In developed countries they provide more than 30 percent of calories in the diet. In developing countries, however, this proportion is less than 10 percent, but they are a source of essential amino acids that balance the largely vegetable-based proteins.

Proteins. In developed countries, about 60 percent of the dietary protein supply is derived from animal products, which is higher than necessary for essential amino acids. This figure is only 22 percent in developing countries, which is less than desirable and takes no account of the skewed distribution in favour of the middle classes - the poor actually have a much lower protein intake. In these countries, where diets are composed of only a small number of staple foods, animal products are of great importance in preventing malnutrition as they are concentrated sources of the limited essential amino acids available in vegetable proteins of staple foods.

Fats. Excessive consumption of calories, particularly fat from animal products, is often the cause of human health problems, especially in wealthy societies. Excessive consumption of animal fat is not a problem for people in developing countries. In fact, animal fats complement an often-deficient calorie intake.

Livestock help to alleviate seasonal food variability. Even though milk production is seasonal and surpluses cannot be stored as easily as cereal grains, there are simple technologies that allow herders to keep milk products for weeks or months in the form of clarified butter, curds or various types of cheese. Animals, particularly small livestock, are slaughtered as the need arises. Meat preserved by drying, salting, curing and smoking can be used when other food sources are scarce.

Livestock as a Source of Income

Animal products not only represent a source of high-quality food, but, equally important, they are a source of income for many small farmers in developing countries, for purchasing food as well as agricultural inputs, such as seed, fertilizers and pesticides.

At the national level, livestock food products represent 27 percent of the total agricultural output. This subsector has achieved the greatest growth in production over the last three decades, and it is expected that it will continue to grow faster than all other agricultural subsectors in the next 20 years. The total value of milk and meat represents 3.5 times the value of wheat and rice and 2.8 times the value of fish. In addition, there are various other products and services provided by livestock that are not accounted for in these statistics, but which would increase the total value of livestock considerably.

At farm level, cash can be generated regularly from direct sales of livestock products, such as milk, eggs and manure, occasionally from the sale of live animals, wool, meat and hides and from fees for draught power or transport services.

An important feature of dairy income is its regularity. India's dairy development programme Operation Flood has created cooperatives that pay daily for the milk delivered, thereby providing regular income to thousands of poor farmers. An FAO/ United Nations Development Programme (UNDP) dairy project in Burkina Faso assisted 100 families in increasing their monthly income by about US$80, which is equivalent to an extra labour unit per family. In many countries, the provision of animal draught power services for cultivation, transportation and the pumping of irrigation water is an important source of income that is particularly beneficial to landless owners of cattle or buffalo. Livestock also provide increased economic stability to the farm or household, acting as a cash buffer (small livestock) and as capital reserve (large animals), as well as a deterrent against inflation. In mixed-farming systems, livestock reduce the risks associated with crop production. They also represent liquid assets that can be realized at any time, adding further stability to the production system.

The importance of livestock as a source of income for poor farmers is illustrated by the example of the Grameen Bank in Bangladesh, which assists only the poorest segment of the population and provides about 50 percent of its loans for the purchase of livestock, mainly large ruminants for milk production and draught power.

Livestock as a Generator of Employment

At farm level, dairying is a labour-intensive activity, involving women in both production and marketing. Labour typically accounts for over 40 percent of total costs in smallholder systems. It has been estimated that for each 6 to 10 kg of additional milk processed per day in India, one working day is added for feeding and care. Data from Kenya show that smallholder production there is in the order of 25 kg per working day; similar levels were experienced on parastatal dairy farms in Zimbabwe. Goat, sheep, poultry and rabbit husbandry, especially in backyard production systems, provides an important source of part-time job opportunities, particularly for landless women and children.

The livestock-product processing sector has also been identified as a contributor to employment generation and the reduction of rural depopulation. Small-scale milk processing/marketing is labour-intensive (50 to 100 kg per working day) and generates employment and income from the local manufacture of at least part of the equipment required. The meat sector also provides significant employment opportunities. Based on UN published data and experience from FAO projects, estimates have been made of labour requirements in small to medium-sized slaughter and meat processing operations.

Almost 50 percent of the grains produced in the world are fed to livestock, yet there remain about 800 million people suffering from hunger and malnutrition mostly in the developing countries. Because surplus grains are produced in developed countries, it has been assumed that increasing livestock production will be based on grains at the expense of poor people. Is this true?

Livestock as a Source of Energy

In mixed-farming systems, not only can farmers mitigate risks by producing a multitude of commodities, but they can also increase the productivity of both crops and animals in a more profitable and sustainable way. In this context, livestock can make a major contribution to the efficient use of available natural resources.

Draught animal power. Bovines, equines, camelids and elephants are all used as sources of draught power for a variety of purposes, such as pulling agricultural implements, pumping irrigation water and skidding in forests. The current number of animals used for draught purposes is estimated at 400 million. Fifty-two percent of the cultivated area in developing countries (excluding China) is farmed using only draught animals and 26 percent using only hand tools. During the past ten years, there has been a 23-percent increase in the number of cattle and buffaloes used for draught purposes as well as for meat and milk production. During the same period, the number of equines (horses, mules and asses) used primarily for draught and transport has not changed significantly.

Compared with the use of tractors, animal power is a renewable energy source in many developing countries and is produced on the farm, with almost all the implements required made locally. On the other hand, 90 percent of the world's tractors and their implements are produced in industrialized countries and most of those used in developing countries (approximately 19 percent) have to be imported. Animal traction, therefore, avoids the drain of foreign exchange involved in the importation of tractors, spare parts and fuel.

Draught animals remain the most cost-effective power source for small and medium-scale farmers. Draught animal power can be even more economic when one bullock is used instead of a pair or when a (cross-bred) cow is used instead of a male, since it reduces the cost of maintaining the larger herd necessary to satisfy both replacement and milk production requirements. It is expected that draught animal power will decline slightly by the year 2000 as will dependency on human power, but the contribution of draught animals will remain much more important than that of mechanical traction. Given their importance as major contributors to food crop production, as a risk-avoidance mechanism and as a source of income, greater efforts need to be devoted to promoting the wider and more efficient use of draught animals.

Dung for fuel. In many countries, cow dung is highly valued as fuel for cooking and heating, reducing expenditures for fuelwood or fossil fuels. It represents the major fuel supply for household use by millions of farmers in Asia, Africa and in parts of the Near

East and Latin America. In India alone, 300 million tonnes of dung are used for fuel every year. The collection and drying of dung for cooking generates income for women. It is also used directly as plaster and other building materials, while its ash can be used as fertilizer.

Biogas production. Biogas production from manure is an excellent substitute for fossil fuel or fuelwood for farmers in tropical countries. The best manure for these purposes comes from (in descending order) pigs, cattle, horses, camels and poultry. Twenty-five kilograms of fresh cow dung produces about 1 m3 of biogas. Simple low-cost plastic biodigesters have recently been developed in Cambodia, the United Republic of Tanzania and Viet Nam through a number of FAO/Technical Cooperation Programme (TCP) projects. On-farm biogas production reduces the workload of women by eliminating wood collection or fuel purchasing. It is person-friendly because of its convenience and increased hygiene, and it also provides a number of services, such as lighting, warm water and heating. Biogas can also be used to drive machinery such as water pumps. Effluent from biodigesters can be recycled as fertilizer - with even better results than the original manure - or as a fish feed, or it may be used to grow azolla and duckweed. Biogas technology has been successfully adopted by millions of farmers in developing countries; about 25 million people use it in China alone. New simple technology should be promoted to extend biogas development.

Livestock as a Source of Fertilizer and Soil Conditioner

Nutrient recycling is an essential component of any sustainable farming system. The integration of livestock and crops allows for efficient nutrient recycling. Animals use the crop residues, such as cereal straws, as well as maize and sorghum stovers and groundnut haulms as feed. The manure produced can be recycled directly as fertilizer. One tonne of cow dung contains about 8 kg N. 4 kg P_2O_5 and 16 kg K_2O. The chemical composition of manure varies, however, according to the animal species (poultry manure appears to be a more efficient fertilizer than cow manure) and also to the nature of their diet. For example, farmers in Cambodia and the Niger have observed that they obtain more rice grain when they use manure from animals fed on urea-treated straw (because of its higher nitrogen content) than when they use that derived from animals fed on untreated straw. It has been estimated that, in the semiarid tropics, less than 6 percent of the cropped area receives an average application of 10 tonnes of manure per hectare every year. In the humid tropics, up to 12 percent of the cropped area may be manured at this level. In addition to the direct contribution of plant nutrients, manure provides important organic matter to the soil, maintaining its structure, water retention and drainage capacity. The value of manure is so well-recognized that some farmers keep livestock primarily for this purpose.

The cultivation of legume fodders and trees, for example, in alley farming systems, also contributes to the enrichment of soils through nitrogen fixation. Soybeans in the humid tropics can supply 40 kg of nitrogen per hectare, although this contribution varies considerably with the species. In systems using sugar cane as livestock feed, for example, in Colombia and Viet Nam, it has been demonstrated that the recycling of dead leaves into the soil (instead of burning them) favours the fixation of nitrogen by bacteria and reduces weed growth and water evaporation, thus increasing the yield of the subsequent harvest.

Livestock and Weed Control

Livestock, particularly sheep, are efficient in controlling weeds. They are used in many countries in the Mediterranean basin to reduce forest undergrowth so that the risk of fire during summer is diminished. In rubber and oil-palm plantations in Malaysia, the integration of livestock to utilize the vegetative ground cover under the tree canopy has been shown to increase overall production and save up to 40 percent of the cost of weed control. Similarly, sheep have recently been used to control weeds in sugar-cane fields in Colombia, suppressing the cost of herbicides, reducing by half the total cost of weed control and providing an additional income from meat production. Such systems also safeguard the environment and avoid chemical pollution while supplying additional organic material to the soil.

Livestock-recycled Secondary Products

Not only can manure be recycled for biogas and fertilizer, but it can also be a valuable source of feed for other animal species. For example, poultry manure is commonly used for ruminant feeding and poultry and pig manures can be used to generate algae as a feed for fish.

By-products such as slaughterhouse wastes, when adequately processed, make a good source of protein (offal and viscera) and mineral (bones) supplements in animal feeds. In developing countries, household wastes are commonly fed to pigs and small animals in backyard farming systems. In urban and pert-urban areas, restaurant and catering wastes can be readily processed for pigs, as is done in Cuba.

Industrial fish waste creates pollution around canning plants. The common practice is to dry it, at a very high cost, in order to produce fish-meal, which is then usually exported to developed countries. Preservation of fish waste in molasses has proved to be an option that is technically and economically feasible for poor farmers. Such recycling makes animal agriculture systems more sustainable and environmentally sound.

Utilization of Marginal Lands and Crop Residues by Livestock

In the vast semi-arid or arid areas where crop production is extremely risky, livestock can use vegetation that would otherwise be wasted and convert it to valuable, high-quality products. However, these are environmentally fragile areas. Over the centuries, pastoralists established complex management systems that were sustainable until the relatively recent dramatic increases in population and subsequent livestock density. Overgrazing is the main threat to these areas, and a holistic approach to resource management is necessary to avoid their permanent and irreversible degradation.

Crop residues, such as straw, are more efficiently utilized through ruminant feeding, including the production and use of manure and possibly biogas, rather than by burning them, creating pollution and contributing to global warming, or ploughing them back into the soil to improve its structure and water retention. Several hundred million head of cattle and buffaloes are fed throughout the year on rice and cereal straws.

At present, developing countries are major importers of animal feeds (mainly coarse grains) as well as meat and dairy products. The cost of importing animal feeds into developing countries is estimated at between US$10 billion and $15 billion per year. Although exports of animal feeds are not negligible, a large proportion of them are oilseed cakes. Being an important source of bypass protein, the cakes could be put to better use locally to improve production from the national herd, which, in turn, would reduce imports of animal products.

The situation regarding the importation of dairy products into developing countries is critical. Imports have dramatically increased during the last three decades, while exports have remained negligible. The prospects for local dairy production have recently become more favourable, however, following the reduction of milk production subsidies in western developed countries and the introduction of more realistic exchange rates under structural adjustment programmes. These recent changes have provided many developing countries with the opportunity to develop their own milk industries, primarily through small-scale production, which will have a major impact on different levels of cash income.

Livestock are often accused of contributing to soil erosion in different ways. One classic example is the deforestation in the Amazon to produce grazing land, which has attracted much attention from ecologists and the mass media. Yet clearly it is not the animals that cut down the trees! The responsibility lies with the business people who - aided and abetted by government subsidies - cause irreversible damage by destroying the forests to plant pastures for short-term financial gain. Another example is that of the long-term overgrazing of semi-arid rangelands, which has lead increasingly to desertification. It is well known, however, that sound resource management could avoid this deterioration of the environment while maintaining a productive system. If livestock are managed in an appropriate way, they can even contribute to the reduction of soil erosion. The use of perennial fodder trees and high biomass fodders (sugar cane) and the establishment of fodder hedgerows on the contour provide excellent protection against erosion and should be established practices.

Agro-sylvo-pastoral systems in semi-arid areas are a viable proposition for the protection of the fragile soils of these regions. Multipurpose trees contribute to the protection of the soil, as well as to animal and energy production, and store carbon that would otherwise contribute to atmospheric carbon dioxide.

It is also a criticism of ruminant production that the animals contribute to the greenhouse effect, since they produce methane as an end-product of rumen digestion. It should be recognized, however, that ruminant populations have increased only moderately compared with those of other species, and that their contribution is estimated at just 2.5 percent of the total greenhouse gases. Gas emissions from cars and industry are far greater and have increased at a much higher rate. There are two ways to reduce methane emission from livestock: by introducing an appropriate diet supplementation that could reduce ruminant methane production per unit of milk or meat by a factor of 4 to 6, and by favouring the production of meat from monogastric animals.

The third complaint about livestock is pollution resulting from accumulated excrete and nitrite-contaminated groundwater. This is primarily a problem with intensive, industrialized production systems. It can be reduced by implementing manure processing technologies as well as nutrition and feeding strategies that reduce the amount of nitrogen and phosphorus in the diet of animals. It could also be controlled by limiting the size of such enterprises to that which allows excrete to be easily accommodated on neighbouring lands or used for fertilizer products. Smallholders usually cause less pollution than large intensive units.

Livestock for Investment and Savings

In the rural areas of many developing countries financial services such as credit, banking and insurance are virtually non-existent. In these areas, livestock play an important role as a means of saving and capital investment, and they often provide a substantially higher return than alternative investments. A combination of small and large livestock that can be sold to meet petty-cash requirements to cover seasonal consumption deficits or to finance larger expenditures represents a valuable asset for the farmer.

World production of hides and skins increased significantly between the 1960s and the 1980s, with bovine hides reaching 1.8 million tonnes (55-percent increase) and sheep and goat skins up to 220 000 tonnes (5-percent increase). Over the same period, however, production in developing countries fell; bovine hides dropped by 50 percent (down to 47 000 tonnes) and sheep and goat skins were reduced by 25 percent (down to 68 000 tonnes). Since the number of cattle and small ruminants slaughtered has not declined in developing countries, it must be concluded that hides and skins are not being fully utilized. FAO has already initiated efforts to improve flaying techniques to increase hide and skin quality. The world market price for cattle has varied between US$1.50 and $2 per kilogram over the last ten years, which ought to give adequate incentive for the production of better quality raw hides and skins.

The following conclusions are drawn from the above discussion of the role of animals in food production and agricultural development:

- The contribution of animals to both agricultural and overall economic development has not been adequately evaluated. Official statistics grossly underestimate the contribution of livestock since many important non-food outputs - most of which are difficult to quantify in monetary terms - are excluded.
- Improved efficiency of animal agriculture, with its various commodities and service products, is crucial to achieving sustainable agricultural development and food security, particularly in low-income, food-deficit countries.
- The role of animals in food and agricultural development programmes is underrated almost everywhere throughout the world despite the increasing demand, especially in developing countries, for all the different animal products and services.
- A prerequisite for the sustainable development of animal agriculture is the identification, testing under local conditions and promotion of appropriate technologies that utilize local and affordable resources.
- Policies, infrastructure and support services enabling such technologies to succeed and reach small-scale farmers must be established.
- The integration of livestock and agriculture increases both the short-term benefits and longer-term sustainability.

The livestock sector is both multifaceted and flexible enough to be able to react to changes in the national economy. Species of monogastrics and ruminants are available that are adapted to different local conditions and are able to utilize local resources to produce valuable products and services.

Greater emphasis should be given to monogastric animals, as they are the main suppliers of meat and have been largely neglected in development programmes. Care must be taken to use alternative feeds that do not compete with human food. The importance of ruminants must not be forgotten, however, and particular attention is required to develop their role as a source of draught power.

Greater attention should be given to the provision of facilities and credit that benefit the small-scale producer, rather than major investments in institutions and facilities, such as big slaughterhouses, dairy plants and feedmills, which are usually oversized, overstaffed and overequipped.

Livestock projects have a bad reputation among development banks and institutions, which have become reluctant to fund new projects. It has been stated that: livestock eat cereals that would be better used for feeding people; livestock cause environmental deterioration; livestock products are not indispensable in the diet; livestock projects are not viable in economic terms.

However, provided that the right technologies are identified and applied, taking into account the local constraints, and that the appropriate support in expertise, the logistics for the supply of inputs and the marketing of animal products are ensured, livestock projects have proved to be very profitable, in both economic and social terms, on many occasions. The following are some spectacular examples of successful projects.

- *Operation Flood in India,* which promotes dairy development among small or landless farmers, has established a modern and efficient dairy industry in that country. Similarly, in Uganda, a dairy project has successfully developed milk production around Kampala under difficult conditions, while small cheese-making units in the Niger have provided several hundred women with jobs and income.
- *The beef-fattening project in the Hebei and Henan provinces of China.* By using local resources, such as cereal straw treated with urea, adequately supplemented with cottonseed cake, the farmers of these provinces have become the most important beef producers of China. Strategies for on-farm testing and field support activities were similar (but applied on a much larger scale!) to those implemented in another successful beef-fattening project in northern Tunisia in the 1970s.
- *The New World Screw worm (NWS) project in North Africa* which, using environmentally safe biotechnology, successfully eradicated this threatening pest from the region in less than four years, has been a remarkable example of efficient organization and cooperation between donors and United Nations executing agencies. It is now more widely recognized that livestock projects are as successful as any other agricultural projects, if not more so.

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