



07



Summary and conclusions

As we have seen, the livestock sector is a major stressor on many ecosystems and on the planet as whole. Globally it is one of the largest sources of greenhouse gases and one of the leading causal factors in the loss of biodiversity, while in developed and emerging countries it is perhaps the leading source of water pollution.

The livestock sector is also a primary player in the agricultural economy, a major provider of livelihoods for the poor and a major determinant of human diet and health. Hence its environmental role needs to be seen in the context of its many different functions, in many diverse natural and economic environments, subject to diverse policy objectives.

Previous chapters have described the state of knowledge about livestock–environment interactions at local, regional and global scales. This chapter puts forward possible future scenarios for the sector. What are societies' expectations of the livestock sector? What are the differences between countries and how are these expectations changing over time?

The necessary steps towards shrinking livestock's long shadow are outlined. Mastering the political will to implement these steps obviously hinges on the question: what relative value should we assign to the environment, compared to other objectives such as the provision of livelihoods or the cheap supply of animal products?

And, if we do rate environmental considerations as important, how can public attention be moved beyond the more obvious, but less serious “nuisance” of flies and odour, to the more important pressures of land degradation, water pollution, biodiversity erosion and global climate change?

7.1 Livestock and environment in context

Chapter 6 presented the conflicting policy objectives schematically. Policy decisions will be based largely on the economic, social, health and food security considerations as summarized below.

Economic importance

Heading for over half of agricultural GDP

As an economic activity, the livestock sector generates about 1.4 percent of the world's GDP (2005). The sector's growth rate of 2.2 percent for the last ten years (1995 to 2005) is roughly in line with overall economic growth (FAO, 2006b). It is growing faster than the GDP of agriculture, which is declining in terms relative to overall GDP. Currently, the livestock sector's GDP accounts for a global average of 40 percent of agricultural GDP, and shows a strong tendency to increase towards the 50 to 60 percent range that is typical for most industrialized countries. The livestock sector provides primary inputs (raw milk, live animals, etc.) to the agricultural and food industry, where value-adding activities multiply the value of these raw materials.

Social importance

Livelihoods for one billion poor

In terms of livelihood support, income and employment, the livestock sector is much more important than its modest contribution to the overall economy would suggest. Livestock provide livelihood support to an estimated 987 million poor people in rural areas (Livestock In Development, 1999), equivalent to 36 percent of the total number of poor, currently estimated at 2 735 million (i.e. people living on less than

US\$2 per day) (World Bank, 2006). As livestock rearing does not require formal education or large amounts of capital, and often no land ownership, it is often the only economic activity accessible to poor people in developing countries. In many marginal areas of developing countries, livestock production is an expression of the poverty of people who have no other options, and do not have the means to counteract environmental degradation either. The huge number of people involved in livestock for lack of an alternative, particularly in Africa and Asia, is a major consideration for policy-makers, and any attempts to address livestock-associated environmental degradation must take these livelihood concerns into account. In contrast, in the developed countries decades of continuous structural change have reduced the number of people engaged in livestock production, which is more in line with the sector's modest economic contribution.

Decision-making in the livestock sector is often complicated by the important socio-cultural roles that livestock continue to play in many societies. These take different forms and include livestock as an expression of wealth and prestige, as a method of payment (bride price and dispute settlement) and risk diversion for mixed crop-livestock farmers, etc. Food preferences and taboos relate in a particular way to products of animal origin.



Milk offers a good way of providing a protein-rich diet for the mass of Indian people, a great number of whom are vegetarians – India 1977

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A headman looks over his cattle – Swaziland 1971

Nutrition and health

A major determinant

In terms of nutrition, livestock food products globally contributed an average of 17 percent of energy and 33 percent of protein to dietary intakes in 2003 (FAO, 2006b). There are stark differences between countries and country groups, with meat consumption ranging in 2003 from only 5 kg per person and year in India to 123 kg in the United States (FAO, 2006b). Because developing countries still have low intakes of animal food the share of livestock products in the “global average diet” is expected to continue to rise to reach the OECD country averages of about 30 percent of dietary energy and 50 percent of protein intake. In terms of health and nutrition, therefore, livestock products are a welcome addition to the diets of many poor and under- or malnourished people who frequently suffer from protein and vitamin deficiencies as well as from lack of important trace minerals. Children in particular have shown to benefit greatly in terms of physical and

mental health when modest amounts of milk, meat or eggs are added to their diets, as shown by long-term research carried out in Kenya (Neumann, 2003). In contrast, a large number of non-communicable diseases among the more wealthy segments of the world’s population are associated with high intakes of animal source foods, in particular animal fats and red meat: cardio-vascular disease, diabetes and certain types of cancer. While not being addressed by this assessment, it may well be argued that environmental damage by livestock may be significantly reduced by lowering excessive consumption of livestock products among wealthy people. International and national public institutions (e.g. WHO and Tufts University, 1998) have consistently recommended lower intakes of animal fat and red meat in most developed countries.

In terms of health and food safety, livestock products as a category are more susceptible to pathogens than other food products. They have the capacity to transmit diseases from animals

to humans (zoonoses). The World Organization for Animal Health (OIE) estimates that no less than 60 percent of human pathogens and 75 percent of recent emerging diseases are zoonotic. A series of human diseases have their known origins in animals (such as common influenza, small pox). Tuberculosis, brucellosis and many internal parasitic diseases, such as those caused by tapeworm, threadworm and so on, are transmitted through the consumption of animal products. Recent emerging diseases, such as avian flu, Nipah virus or the variant Creutzfeldt-Jakob disease demonstrate the potential of the human-livestock interface to develop and transmit novel diseases. Therefore, sanitary concerns are of paramount importance in the livestock industry, particularly when the requirements of long and sophisticated food chains govern the retail sector as is the case in OECD countries and increasingly in developing countries. Human and animal health concerns are a major driving force for structural change in the livestock sector. In the case of animal health, control of major disease is greatly facilitated by, and sometimes impossible without, confinement of animals and animal movement control.

Food security

Livestock compete for crops but provide a buffer against grain shortages. In simple numeric terms, livestock actually detract more from total food supply than they provide. Livestock now consume more human edible protein than they produce. In fact, livestock consume 77 million tonnes of protein contained in feedstuff that could potentially be used for human nutrition, whereas only 58 million tonnes of protein are contained in food products that livestock supply. In terms of dietary energy, the relative loss is much higher. This is a result of the recent trend towards more concentrate-based diets for pigs and poultry, with nutritional requirements more similar to humans than ruminants.

This simple comparison obscures the fact that proteins contained in animal products have

higher nutritive values than those in the feed provided to animals. Moreover, it does not capture the fact that livestock and their feed also make a contribution to food security objectives by providing a buffer in national and international food supplies that can be drawn upon in case of food shortages. However, as the livestock sector moves away from using feed and other resources that have no or little alternative value, towards using crops and other high value inputs, it enters into competition with food and other uses of commodities and land. While it is probably true that livestock do not detract food from those who currently go hungry, it raises overall demand and prices for crops and agricultural inputs.

These various aspects of livestock's importance feed into national decision-making for the sector. The different policy objectives of food supply, poverty reduction, food safety and environmental sustainability take on different levels of importance depending on factors such as stage of development, per capita income and general policy orientation of a country. In least developed countries with large smallholder sectors, concerns of small producers weigh heavily, along with those of providing cheap supplies to urban consumers. In higher income countries, consumer concerns for food and environmental safety usually override producer interests, even though governments continue to support and protect domestic production for a variety of reasons (see Chapter 6).

There is a stark contrast between the rather modest economic contribution of the livestock sector and its important social, environmental and health dimensions. It is against this background that livestock-environment interactions need be seen. These are the facts that emerge:

Land and land-use change

Humanity's largest land use

Livestock's land use includes grazing land and cropland dedicated to the production of feed-crops and fodder. In fact livestock represent the largest of all anthropogenic land uses. The total

Table 7.1

Global facts about livestock

Dimension	Parameter	Value	Remarks
Economic importance^a	Contribution to total GDP (2005)	1.4 percent	
	Contribution to agricultural GDP (2005)	40 percent	
	Growth rate (1995 to 2005)	2.2 percent p.a.	
	Contribution to agricultural export earnings (2004)	17 percent	
Social importance^b	Number of poor engaged in livestock activities	987 million	Full time or partially
	Total number of people engaged in livestock production	1 300 million or 20 percent of world population of 6.5 billion	Full time or partially
Food security^c	Human edible protein supplied to livestock ¹	77 million tonnes	
	Human edible protein supplied by livestock ¹	58 million tonnes	
Health^c	Contribution to total dietary intake of energy ^d	477 kcal per person/day or 17 percent of average daily intake	
	Contribution to total dietary intake of protein ^d	25 g per person/day or 33 percent of average daily intake	
	People suffering from under or malnourishment ²	864 million	Livestock products are a possible remedy
	Number of overweight persons ³	1 000 million	Livestock products are one of the major causes
	People suffering from obesity ³	300 million	Livestock products are one of the major causes
Environment: land^e	Total land for grazing	3 433 million ha or 26 percent of terrestrial surface	
	Grazing land considered degraded	20 to 70 percent	
	Total land for feed crop cultivation ⁴	471 million ha or 33 percent of arable land	
Environment: air and climate⁵	Livestock's contribution to climate change in CO ₂ equivalent	18 percent	Incl. pasture degradation and land use change
	Livestock's share in carbon dioxide emissions	9 percent	Not considering respiration
	Livestock's share in methane emissions	37 percent	
	Livestock's share in nitrous oxide emissions	65 percent	Including feed crops
Water⁶	Share of livestock in total use of freshwater	8 percent	Drinking, servicing, processing and irrigation of feed crops
	Share of livestock in water evapotranspired in agriculture	15 percent	Evapotranspiration for feedcrops production only; other factors significant but not quantifiable

¹ Protein content derived by applying the appropriate protein nutritive factors to respective input and output commodities.

² Three-year average 2002-04.

³ Data refers to adult population.

⁴ See Chapter 2 and Annex 3.1.

⁵ See Chapter 3.

⁶ See Chapter 4.

Sources: ^a World Bank (2006) and FAO (2006b); ^b Livestock In Development (1999); ^c FAO (2006b); ^d Data on livestock contribution to protein and energy dietary intake: FAO (2006b); data on malnourishment: Food Security – FAO (2006b); data on obesity and overweight: World Health Organization, 2006. ^e FAO (2006b).

areas involved are vast, amounting to 70 percent of all agricultural land and 30 percent of the ice-free terrestrial surface of the planet.

The total land area occupied by livestock grazing is 3 433 million hectares equivalent to 26 percent of the ice-free terrestrial surface of the planet. A large part of these areas are too dry or too cold for crop use, and only sparsely inhabited. While the total grazing area is not increasing, in tropical Latin America there is rapid expansion of pastures into some of the most vulnerable and valuable ecosystems, with 0.3 to 0.4 percent of forest lost to pastures annually. In the Amazon, cattle ranching is now the primary reason for deforestation. In contrast, in developed countries, forest areas are growing as marginal pastures are afforested, but the biodiversity and climate change value of these forest areas gained in developed countries are much inferior to those lost in tropical areas.

About 20 percent of the world's pastures and rangeland have been degraded to some extent, but 73 percent of rangeland in the dry areas (UNEP, 2004b). The Millennium Ecosystem Assessment has estimated that 10 to 20 percent of all grassland is degraded. Some of the dryland grazing ecosystems have proved to be quite resilient and degradation has shown to be reversible in parts.

The total area dedicated to feedcrop production amounts to 471 million hectares, equivalent to 33 percent of the total arable land. Most of this total is located in OECD countries, but some developing countries are rapidly expanding their feedcrop production, notably maize and soybean in South America, in particular in Brazil. A considerable part of this expansion is taking place at the expense of tropical forests. It is expected that future growth rates of livestock output will be based on similar growth rates for feed concentrate use (FAO, 2006a). Intensive feed production is often associated with various forms of land degradation, including soil erosion and water pollution.

Gaseous emissions and climate change

More impact than road transport

Here too livestock's contribution is enormous. It currently amounts to about 18 percent of the global warming effect – an even larger contribution than the transportation sector worldwide. Livestock contribute about 9 percent of total carbon dioxide emissions, but 37 percent of methane and 65 percent of nitrous oxide.

Greenhouse gases are emitted from rumen fermentation and livestock waste. Carbon dioxide is released when previously forested areas are converted into grazing land or arable land for feed. Therefore, expansion of pasture and cropland at the expense of forests releases significant amounts of carbon dioxide into the atmosphere. As does the process of pasture and arable land degradation, which results in a net loss of organic matter. Carbon dioxide releases resulting from fossil fuel consumption used for the production of feed grains (tractors, fertilizer production, drying, milling and transporting) and feed oil crops must also be attributed to livestock. The same applies with the processing and transport of animal products. Yet another category is constituted by nitrous oxide emissions from leguminous feedcrops and from chemical fertilizer applied to other feedcrops.

In terms of polluting gaseous emissions not linked to climate change, livestock waste emits a total of 30 million tonnes of ammonia. This is focused in areas of high animal concentrations, where ammonia is a factor in the occurrence of acid rain, which affects biodiversity. Livestock contribute 68 percent to total ammonia emissions.

Water

A major driver of use and pollution

The livestock sector is a key player in increasing water use and water depletion. The water used by the livestock sector is over 8 percent of global human water use. The major part of this water is in fact used for irrigation of feed crops, representing 7 percent of the global water use. The

water used for product processing and drinking and servicing is insignificant at global level (less than 1 percent of the global water), but it may be of local importance in dry areas (livestock drinking requirements represent 23 percent of total water use in Botswana).

Apart from livestock's use of water for drinking, water is used for irrigating pastures and cropland for feed production. Considerable amounts of water are used in processing of meat and milk in particular. Through the compacting effect of grazing and hoof action on the soil, livestock also have a determining, and often negative, impact on water infiltration and the speed of water movement across the landscape. Livestock play an important role in water quality through the release of nutrients, pathogens and other substances into waterways, mainly from intensive livestock operations.

The contribution of the livestock sector to water depletion is not easily quantified with our current knowledge but there is strong evidence that the sector is a major driver. The volume of water evapotranspired by feedcrops represents a significant share (at 15 percent) of the water depleted every year.

Water pollution figures from the United States, the world's largest economy and fourth largest land area, may give some indication of the livestock sector's importance. In the United States, livestock are responsible for an estimated 55 percent of erosion, 37 percent of the pesticides applied, 50 percent of the volume of antibiotics consumed and for 32 percent of the nitrogen load and 33 percent of the phosphorus load into freshwater resources. Although the effective load into freshwater resources is not assessed for sediments, pesticides, antibiotics, heavy metals or biological contaminants, livestock are likely to have a major role in these pollution processes.

Livestock land use and management (especially of animal wastes) appear to be the main mechanism through which livestock contribute to the water depletion process.

Biodiversity

Livestock are a key factor in loss of species

Livestock affect biodiversity in many direct and indirect ways, most of which are difficult to quantify. Livestock and wildlife interact in grazing areas, often negatively, sometimes positively. Livestock help to maintain some of the open grassland ecosystems in their traditional state, but health concerns pose new threats to wildlife.

Pasture expansion, often at the expense of forest, has vast negative consequences on some of the most valuable ecosystems in Latin America, while rangeland degradation affects biodiversity on all continents. Crop area expansion and intensification for livestock feed undoubtedly affect biodiversity negatively, sometimes with dramatic consequences (soybean expansion into tropical forests). Water pollution and ammonia emissions, mainly from industrial livestock production, compromise biodiversity, often drastically in the case of aquatic life. Livestock's important contribution to climate change will clearly have repercussions on biodiversity, while the historic role of livestock as a driver and facilitator of invasions by alien species continues.

Livestock now account for about 20 percent of the total terrestrial animal biomass, and occupies a vast area that was once habitat for wildlife. Further, livestock determine, to a significant extent, the nitrogen and phosphorus flows. The fact that the livestock sector is industrializing, in a number of concentrated locations, separates the sector from its land base and interrupts the nutrient flows between land and livestock, creating problems of depletion at the sources (land vegetation and soil) and problems of pollution at the sinks (animal wastes, increasingly disposed of into waterways instead of back on the land). Pollution, as well as overfishing for feed, leads to an increasingly strong impact of livestock on the biodiversity of marine ecosystems.

Differences between species, products and production systems

There are huge differences in environmental impact between the different forms of livestock production, and even the species.

Cattle provide a multitude of products and services, including beef, milk, and traction. In mixed farming systems, cattle are usually well integrated in nutrient flows and can have a positive environmental impact. In developing countries, cattle and buffaloes still provide animal draught for field operations, and in some areas, animal traction is on the increase (parts of sub-Saharan Africa) so that animals substitute for potential fossil fuel use. Livestock also use crop-residues some of which would otherwise be burned, thus making net contributions to environmental objectives. However, cattle in extensive livestock production in developing countries are often only of marginal productivity. As a result, the vast majority of feed is spent on the animal's maintenance, leading to resource inefficiencies and high levels of environmental damage per unit of output.

The dairy sector is much better connected to land than is the case for other forms of market-oriented production. Most milk operations tend to be close to areas of feed supply because of their daily demand for fibrous feed, and so they are predominantly well integrated with nutrient flows, although excessive use of nitrogen fertilizer on dairy farms is one of the main causes of high nitrate levels in surface water in OECD countries. There is a risk of soil and water contamination by large-scale dairy operations, as witnessed by "dairy colonies" in South Asia, and by industrial-type operations in North America and increasingly also in China. Dairy production is also labour-intensive and less subject to economies of scale. Therefore, dairy is the livestock commodity where small-scale or family-based operations can resist market pressures for longer than is the case for poultry or pork.

Beef is produced in a wide range of intensities and scales. At both ends of the intensity

spectrum there is considerable environmental damage. On the extensive side, cattle are instrumental in degradation of vast grassland areas and are a contributing factor to deforestation (pasture conversion), and the resulting carbon emissions, biodiversity losses and negative impacts on water flows and quality. On the intensive side, feedlots are often vastly beyond the capacity of surrounding land to absorb nutrients. While in the feedlot stage the conversion of concentrate feed into beef is far less efficient than into poultry or pork, and therefore beef has significantly higher resource requirements per unit than pork or poultry. However, taking the total life cycle into account, including the grazing phase, concentrate feed per kilogram of growth is lower for beef than for non-ruminant systems (CAST, 1999).

The production of sheep and goats is usually extensive. Except for small pockets with feed lots in Near East and North America, intensive production based on feed concentrate barely exists. The capacity of small ruminants, in particular goats – to grow and reproduce under conditions otherwise unsuitable for any form of agricultural production – makes them useful and very often essential to poor farmers pushed into these environments for lack of alternative livelihoods. Because of their adaptive grazing, sheep and goats have extended their reach further into arid, steep and otherwise marginal territory than cattle. The browsing of goats affects land cover and the potential for forest re-growth. Under overstocked conditions, they are particularly damaging to the environment, through degradation of vegetative cover and soil. However, the low economic value of sheep and goat production means that it does not usually lead directly to mechanized large scale deforestation, as is the case for cattle ranching in Brazil.

Extensive pig production, based on use of household waste and agro-industrial by-products, performs a number of useful environmental functions by turning biomass of no commercial value – and that otherwise would be waste – into

high-value animal protein. However, extensive systems are incapable of meeting the surging urban demand in many developing countries, not only in terms of volume but also in sanitary and other quality standards. The ensuing shift towards larger-scale grain-based industrial systems has been associated with geographic concentration, to such extents that land/livestock balances have become very unfavourable, leading to nutrient overload of soils and water pollution. China is a prime example of these trends. Furthermore, most industrial pig production in the tropics and sub-tropics uses waste-flushing systems involving large amounts of water. This becomes the main polluting agent, exacerbating negative environmental impact.

Poultry production has been the species most subject to structural change. In OECD countries, production is almost entirely industrial, while in developing countries it is already predominantly industrial. Although industrial poultry production is entirely based on feed grains and other high value feed material, it is the most efficient form of production of food of animal origin (with the exception of some forms of aquaculture), and has the lowest land requirements per unit of output. Poultry manure is of high nutrient content, relatively easy to manage and widely used as fertilizer and sometimes as feed. Other than for feedcrop production, the environmental damage, though perhaps locally important, is of a much lower scale than for the other species.

In conclusion, livestock-environment interactions are often diffuse and indirect; and damage occurs at both the high and low end of the intensity spectrum, but is probably highest for beef and lowest for poultry.

7.2 What needs to be done?

The future of the livestock-environment interface will be shaped by how we resolve the balance of two competing demands: for animal food products on the one hand and for environmental services on the other. Both demands are driven by the same factors: increasing populations

and increasing incomes and urbanization. The natural resource base within which they must be accommodated is finite. Therefore, the considerable expansion of the livestock sector required by expanding demand must be accomplished while substantially reducing livestock's environmental impact. In this section we put forward perspectives as to how this can be achieved, compared to a backdrop of "business as usual."

The growth in demand for animal products over the coming decades will be significant. Although the annual growth rate will be somewhat slower than in recent decades, the growth in absolute volume will be vast. Global production of meat is projected to more than double from 229 million tonnes in 1999/2001 to 465 million tonnes in 2050, and that of milk to increase from 580 to 1 043 million tonnes (FAO, 2006a). The bulk of the growth in meat and in milk production will occur in developing countries (FAO, 2006a). Among the meat products, poultry will be the commodity of choice for reasons of acceptance across cultures and technical efficiency in relation to feed concentrates.

Business as usual leads to mounting problems

In the absence of major corrective measures, the environmental impact of livestock production will worsen dramatically. Viewed very simply, if production doubles, without any reduction in environmental measures per unit of production, then environmental damage will double.

Taking into account likely changes in the structure of the industry, while there has been no attempt to quantify the environmental impacts of livestock, it is probably safe to state that under a "business as usual" scenario:

- The spatial and commercial concentration of livestock production will continue to grow, leading to large areas with high nitrogen and phosphorus surpluses, concentrated discharge of toxic materials, polluting and contaminating land and ground and surface water, and destroying terrestrial and aquatic biodiversity. Continued geographic concentra-

tion, with large-scale commercial production growing but with less intensive, widely scattered smallholder production still existing alongside, will exacerbate the risk of emerging and traditional zoonotic diseases.

- Demand for feedcrops will grow, causing a further conversion of natural habitats into cropland in some places, notably Latin America. The factors that slowed use of feedgrain in the period 1985 to 2005, including EU agricultural policy reform, drastic structural changes in the previous socialist countries of Eastern Europe and CIS, and the global shift to poultry as efficient converters of feed crops, are likely to wane (FAO, 2006a); therefore feedgrain use is projected to expand more in line with output growth in livestock products. The pressure on crop agriculture to expand and intensify will remain high; and so the associated environmental impacts, in terms of water depletion, climate change and biodiversity loss, will grow.
- Livestock's contribution to anthropogenic greenhouse gas emissions will increase, in particular of the more aggressive nitrous oxide, raising the sector's already significant contribution to global climate change; and
- Livestock-induced degradation of the world's arid and semi-arid lands will continue, in particular in Africa and South and Central Asia, again contributing significantly to climate change, water depletion and biodiversity losses, and sometimes leading to irreversible loss of productivity. The poor who derive a living from livestock will continue to extract the little they can from dwindling common property resources while facing growing marginalization.

Consumers may drive change towards a sustainable livestock sector

These "business as usual" trends lead to disaster and need to be diverted into more beneficial paths. Growing economies and populations combined with increasing scarcity of environmental

resources and rising environmental problems are already translating into a growing demand for environmental services. Increasingly, this demand will broaden from immediate factors of concern, such as reducing the nuisance factors of flies and odours, to the intermediate demands of clean air and water, to the broader, longer-term environmental concerns, including climate change, biodiversity, etc. At the local level, markets will undoubtedly develop for the provision of such services; this is already the case for water in many places. At the global level, this is more uncertain although promising models already exist, for example carbon trading or debt-for-nature swaps.

There are reasons for optimism that the conflicting demands for animal products and environmental services can be reconciled. Both demands are exerted by the same group of people, the relatively affluent, middle to high level income class, which is no longer confined to industrialized countries. It has already firmly established itself in a number of developing countries, and is poised to grow substantially in most developing countries over the coming decades. This group of consumers is probably ready to use its growing voice to exert pressure for change and may be willing to absorb the inevitable price increases. The development of markets for organic products and other forms of eco-labelling are precursors of this trend, as are the tendency towards vegetarianism within developed countries and the trend towards healthier diets.

Encouraging efficiency through adequate market prices

Resource-use efficiency is the key to shrinking livestock's long shadow. A host of tested and successful technical options are available to mitigate environmental impacts, which can be used in resource management, in crop and livestock production, and in post harvest reduction of losses. They have been summarized in the various chapters of this assessment. However,

for them to be widely adopted and applied will require adequate price signals, more closely reflecting the true scarcities of production factors, and correcting the distortions that currently provide insufficient incentives for efficient resource use.

Prices of land, water and feed resources used for livestock production do not reflect true scarcities. This leads to an overuse of these resources by the livestock sector and to major inefficiencies in the production process. Any future policy to protect the environment will, therefore, have to introduce adequate market pricing for the main inputs.

In particular, water is grossly under-priced in most countries. The development of water markets and different types of cost recovery have been identified as suitable mechanisms to correct the situation. In the case of land, suggested instruments include the introduction and adjustment of grazing fees and lease rates, and improved institutional arrangements for controlled and equitable access. Further, the removal of price support at product level (i.e. the production subsidies for livestock products in the majority of industrialized countries) is likely to improve technical efficiency. This is shown, for example, in New Zealand where in the early eighties radically cut agricultural subsidies, resulting in what has become one of the most efficient and environmentally benign ruminant livestock industries.

Correcting for environmental externalities

Although the removal of price distortions at input and product level will go a long way to enhancing the technical efficiency of natural resource use in the livestock production process, this may often not be sufficient. Environmental externalities, both negative and positive, need to be explicitly factored into the policy framework, through the application of the “provider gets - polluter pays” principle.

Correcting for externalities, both positive and negative, will lead livestock producers into

management choices that are less costly to the environment. Livestock holders who provide environmental services need to be compensated, either by the immediate beneficiary (such as with improved water quantity and quality for downstream users) or by the general public. Examples of actions that could be rewarded include land management and use forms and vegetative covers that maintain or restore biodiversity; or the sequestration of carbon in stable organic matter in the soil through pasture management. Managing grasslands in order to reduce runoff and increase infiltration can greatly reduce sedimentation of water reservoirs: compensation schemes need to be developed between water and electricity providers and grazers.

Likewise, livestock holders who emit waste into waterways or release ammonia into the environment must be held accountable and pay for the damage, to encourage them to move to less polluting practices. Applying the polluter pays principle should not present insurmountable problems in situations like these, given that burgeoning demand for livestock products provides the potential for adequate profits, and that there is an increasing demand for milk and meat produced in a sustainable way. It will be difficult to apply this principle to methane emissions from single cows owned on an Indian mixed farm of half a hectare. However, for most waste emissions in intensive production units, a combination of disincentives and regulation seems to be the most appropriate approach.

It is expected that the taxation of environmental damage and incentives for environmental benefits will be much more rigorously applied in future, tackling local externalities first but increasingly also trans-boundary impacts, through the application of international treaties, underlying regulatory frameworks and market mechanisms. Government policies may be required to provide incentives for institutional innovation in this regard.

Accelerating technological change

In industrial, and mixed production systems, the gap between current levels of productivity and levels that are technically attainable indicates that important efficiency gains can be realized by adopting intensifying technologies. With extensive grazing, this is more difficult, sometimes even impossible – particularly under marginal conditions with severe resource constraints (such as in the Sahel), where current low productivity may be the maximum that can be achieved (Breman and de Wit, 1983). Intensification would be possible only on a limited area, estimated at about 10 percent of the total pasture area (Pretty *et al.*, 2000).

Correcting for distortions and externalities will bring us a step closer to prices for both inputs and outputs that reflect the true scarcities of production factors and natural resources used. These changed prices will induce technological change that will make better use of resources, and limit pollution and waste. Producers have shown their ability to respond quickly and decisively when such price signals are sent consistently.

For now there does not appear to be a problem of lack of improved production technologies. Given the large market, and policy failures, under which the livestock sector operates, there is still a huge amount of progress that can be achieved from wide adoption of existing tried and tested technologies. However, there is a continuing need for research and development of new technologies suited to more conducive policy frameworks.

Technological change needs to be driven towards making optimal use of land and water as the most important production factors for livestock, including feed production. Research and development for feed crop production need to further increase yields and factor efficiency. However, this is beyond the scope of this study.

In the livestock sector, the quest for increasing efficiencies mainly falls on feeding, breeding and

animal health. The application of modern feeding techniques, in production systems that are already industrial but technologically not very advanced, can help reduce feed grain consumption significantly – perhaps by as much as 120 million tonnes, or 20 percent of total feed grain use (assuming that half of the yield gap between top feed performers and world averages can be closed). Such improvements would include the use of optimized rations, enzymes and artificial amino acids. Further savings in the grain bill could come from the use of advanced animal genotypes. While research into technological advances for commercial and industrial livestock production have been largely left to the private sector, the public sector needs to assume a proactive role in research and technology development with regard to natural resource management, and in reducing market barriers for small producers.

Reducing the environmental and social impacts of intensive production

As described in Chapter 1, an estimated 80 percent of total livestock sector growth comes from industrial production systems. The environmental problems created by industrial systems do not derive from their large scale or their production intensity, but from their geographical location and concentration. In extreme cases, size may be a problem: sometimes units are so large (a few hundred thousand pigs, for example) that waste disposal will always be a problem, no matter where these units are put.

Industrial systems are often located in a way that prevents sustainable waste management. Crop production and livestock activities are being increasingly separated, so that sufficient land to safely dispose of waste is not available nearby. So far, environmental concerns have not often been a factor shaping the regional distribution of livestock production. Easy access to input and product markets, and relative costs of land and labour have so far been the major deter-

mining factors. For developing countries, the concentration of industrial units in peri-urban environments is typical because of infrastructure constraints. In developed countries, there is certainly a move towards rural environments but this often seems to be motivated by an attempt to hide these places away, rather than addressing the fundamental environmental concerns. However, limitations on livestock densities (as introduced by the EU) have been a strong factor in arriving at a better balance between livestock and the surrounding ecosystem.

What is required therefore is to bring waste generated into line with capacity of accessible land to absorb that waste. Industrial livestock must be located as much as possible where cropland within economic reach can be used to dispose of the waste, without creating problems of nutrient loading – rather than geographically concentrating production units in areas favoured by market access, or feed availability. Suitable policy options include zoning and licensing, mandatory nutrient management plans, and facilitation of contractual agreements between livestock producers and crop farmers.

Only a spatially decentralized livestock sector will create sufficient opportunities and incentives for recycling livestock waste on land. For the medium-term future, the preferred option is the reintegration of crop and livestock activities. Policies need to drive the decentralization of industrial and intensive livestock away from consumption centres and ports, towards rural areas with nutrient demand. Such policies must comprise regulatory and incentive frameworks. Regulations are needed to deal with heavy metal and drug residue issues at the feed and waste levels, and with other public health aspects such as food-borne pathogens.

Spatially decentralized livestock activities can also offer substantial social benefits for rural development, particularly in areas with limited alternative employment and growth opportunities. Incentives need to accompany these regula-

tions, such as lower taxes for establishment of commercial production units in nutrient deficit areas, eventually subsidies for relocation of large scale enterprises.

Where decentralization cannot be achieved, industrial systems need to have systems of zero-emission in place, such as in industrial parks with full waste treatment, including biogas digestion and processing of manure for use as fertilizer. With current technology these systems will be costly and energy-intensive, but bio-gas, where technology is improving fast, might be an attractive option.

In parallel, there is a need to address the environmental impacts associated with production of grain, oil and protein feed. Feed is usually produced in intensive agriculture, and the principles and instruments that have been developed to control environmental issues there need to be widely applied. They include integrated pest management, and soil management and fertilization plans. In parallel, to reduce pressure on marine capture fisheries, the sector needs to develop alternatives to the use of fishmeal as feed, for example by using synthetic amino acids.

The shift to intensive production systems is accompanied by increasing size of operation, driven by economies of scale. Despite an overall growth of the sector, this is only achieved at the cost of pushing numerous small- and middle-scale producers and other agents out of business. The trend is observed in all countries following the path of intensification: in the EU and North America from as early as the 1960s, and in emerging economies since the 1980s and 1990s. This trend raises social issues of rural emigration and wealth concentration. Diversification within and outside the agricultural sector and social safety nets are some of the policies developed to address these issues.

Reorienting extensive grazing towards provision of environmental services

Grazing systems need to intensify, in those areas where the agro-ecological potential so permits, in particular for dairy production, and where nutrient balances are still negative.

In many OECD countries, excess nutrient loading is a major issue in grass-based dairy farming. Reductions in the number of livestock have been imposed, sometimes with quite positive results.

However, the vast majority of extensive grazing lands are of low productivity. Grazing occupies 26 percent of the terrestrial surface but the contribution that extensive grazing systems make to total meat production is very small with less than 9 percent of total meat supply. In areas with little potential for intensification, extensive grazing systems currently provide little in terms of productive output and have high costs in terms of environmental damage (water flows, soil losses, carbon, biodiversity).

In a world with more than 9 billion people by 2050, most of whom will be more affluent and therefore will demand environmental services, it is doubtful that these little productive extensive systems will survive, unless they include the provision of environmental services as an important, and perhaps predominant, purpose. These systems need to be re-oriented towards adding environmental service provision, rather than mere production or subsistence. This can be facilitated by payments for environmental services or other incentives to enable livestock producers to make the transition.

The central argument here is that the value of marginal land is changing and that this change will accelerate. In the past, livestock occupied vast territories because there was no possible alternative use, i.e. the land had no opportunity costs; this made marginally productive activities, such as extensive grazing, profitable.

Water-related services will likely be the first to grow significantly in importance in future, with

local service provision schemes the first to be widely applied. With suitable incentives, grazers will agree to reduce and more carefully manage grazing pressure, and in certain sensitive areas to abandon grazing activities altogether.

Biodiversity-related services (e.g. species and landscape conservation) are more complex to manage, because of major methodological issues in the valuation of biodiversity, but they could find a ready uptake where they can be financed through tourism revenues. This will not be confined to rich countries. Recent examples of sharing of benefits from wildlife in Africa and elsewhere demonstrate that tourism revenues can be used to help grazers to co-habit with wildlife. Care needs to be taken that such payments for biodiversity extend beyond the "attractive" species -mammals and other species interesting to tourists - and include biodiversity at large.

Carbon sequestration services, through adjustments in grazing management or abandonment of pastures, will also be difficult, but given the potential of the world's vast grazing lands to sequester large amounts of carbon and to reduce emissions, mechanisms must be developed and deployed to use this potentially cost-effective avenue to address climate change. International agreements will require adaptation so they include carbon sequestration through Land Use, Land Use Change and Forestry (LULUCF) and the expansion of market mechanisms, which are emerging on an experimental and pilot basis.

As the scarcity of environmental resources increases, so does their value. When functioning market mechanisms can be devised, the demand for environmental services could out-compete livestock production in many diverse locations, in particular in more marginal areas where the stocking rate (and hence the gross revenues) would be only one-third of the global average. This is easier where land is under private property. It is more difficult where it under common property, particularly where large numbers of

impoverished herders or smallholders depend on such land. This is not to say that responsible stewardship for natural resources does not exist in extensive grazing; rather, these systems have come under a series of endogenous (population growth) and exogenous (e.g. arable encroachment) pressures, resulting in growing environmental deterioration.

Grazing access will have to be restricted and managed, often in a way that makes livestock production a secondary output, and environmental services primary one. This is already happening in the Alps and other areas in Europe or North America, which are both environmentally vulnerable and precious in environmental terms. Payment for environmental services will have to occur at local, national and international level, depending on the nature of the service - water and soil conservation are local goods whereas biodiversity and carbon are global goods.

The large areas that have become degraded as a result of poor management and grazing pressure can be restored if countries realize the immense damage resulting from “laissez faire” and the equally important potential gains from a process guided more consciously by environmental considerations. The opportunities for this transition depend on the relative value of the productive potential of a given area, compared with its potential for environmental service provision (Lipper, Pingali and Zurek, 2006). The lower the agricultural productivity (e.g. poor soil, steep slope) and the higher the potential for environmental service provision (e.g. watershed protection), the easier the change. Degraded grazing areas fit the bill, particularly in the more humid and hilly or mountainous areas of developing countries, but making the change will still require appropriate institutional arrangement for sellers and buyers of environmental services, at the local, national and global scale. Hence, developing such schemes needs to be given priority.

Suggesting a shift from current “extractive”

grazing practices to environmental service-oriented grazing raises questions of paramount importance: how to share benefits from environmental services and how to deal with the poor who currently derive their livelihoods from extensive livestock? Their numbers are considerable. Livestock provides an important source of livelihood in poor countries. In Mauritania (where it provides 15 percent of GDP), the Central African Republic (21 percent) and Mongolia (25 percent). However, this does not automatically imply that the livestock sector provides an avenue for poverty reduction.

Obviously there is no silver bullet. Alternative employment generation and out-migration and social safety nets are some of the more obvious policy needs. Arguably, the establishment of social safety nets for these populations, can be seen as an international obligation, especially in countries where the economic potential for other sectors is also limited, and where global assets such as biodiversity or climate are concerned. Such measures, combined with payments for environmental services, could facilitate the transition from mining of marginal grazing lands to a more sustainable use of these vast areas.

7.3 The challenge ahead

Livestock is a sector of striking contrasts. Though of modest economic importance, it still has overwhelming social importance in many developing countries, and still commands significant political clout in many developed countries. It causes considerable environmental damage in terms of climate change and air pollution, water supply and quality, and biodiversity. This is in stark contrast to the positive effects in waste recycling and conservation of non-renewable resources that characterized most mixed farming following the Agricultural Revolution. At the same time, livestock-dependent livelihoods of people living in, or at the margins of, poverty, are threatened.

A major outcome of this assessment is that, compared to its economic performance, the

environmental impacts of the livestock sector are not being adequately addressed, despite the fact that major reductions in impact could be achieved at reasonable cost. The problem therefore lies mainly with institutional and political obstacles, and the lack of mechanisms to provide environmental feed-back, ensure that externalities are accounted for and embed the stewardship of common property resources into the sector.

Why is this so? First, civil society seems to have an inadequate understanding of the scope of the problem. Perhaps even among the majority of environmentalists and environmental policy-makers, the truly enormous impact of the livestock sector on climate, biodiversity and water is not fully appreciated. Hopefully, this assessment will help to remedy that situation.

Second, environmentally motivated action by civil society usually focuses on the functions and protection of specific ecosystems. As we have seen, the mobility of the livestock industry allows its relocation without major problems becoming apparent. However, the pressure on the environment is usually shifted elsewhere, and manifests itself in different forms. For example, intensification may reduce pressure on grazing lands but increase pressure on waterways.

Third, and related to this, is the complexity of livestock-environment interactions, and their many manifestations, make concerted actions more difficult. That is also true of many environmental issues and is a major reason why environmental policy-making lags behind other areas.

Finally, the livestock sector is driven by other policy objectives. Decision-makers find it difficult to address economic, social, health and environmental objectives simultaneously. The fact that so many people depend on livestock for their livelihoods limits the available options to policy-makers, and involves difficult and political sensitive decisions on trade-offs.

Despite these difficulties, the impact of live-

stock on the local and global environment is so significant that it needs to be addressed with urgency. Information, communication and education will play critical roles towards the promotion of an enhanced willingness to act.

Consumers, because of their strong and growing influence in determining the characteristics of products, will likely be the main source of commercial and political pressure to push the livestock sector into more sustainable forms. Major progress has been made in the fisheries and forestry sectors in eco-labelling of sustainably harvested fish and forest products. Eco-labels such as those of the Marine and Forest Stewardship Councils have already gained consumers' interest. This has not yet emerged in the meat and milk sector. Institutions are urgently required for the appropriate certification and labelling to guide consumers in discerning between products produced in an environment-friendly way and others. The development and application of environmental standards critically relies on functioning institutions that need to include specific environmental challenges of the livestock sector.

Many of the negative environmental impacts occur in an institutional void, without adequate institutions either to monitor the scale of the problem or to deal with it. Traditional institutions, that used to regulate access to common property resources, have become ineffective or disappeared altogether. These now need to be revived and adapted. Meanwhile, modern institutions, which would regulate the problems, are not emerging fast enough. The surge in industrial production in Asia and Latin America has not been accompanied by a concomitant upgrading of environmental regulations and related enforcement. This has led to much of the unparalleled environmental damage that is currently occurring.

Environmental damage is "traded" in the form of feed and livestock products, without the real costs appearing in the trade balance (Gal-

way *et al.*, 2006). Appropriate institutions are required to establish more appropriate pricing mechanisms that truly signal natural resource shortages and externalities.

Policy-makers are faced with the quandary of achieving the multiple objectives of affordable supply of high value food, food safety, livelihoods and environmental soundness in a sector that, while industrializing, is still dominated by large numbers of small-scale producers in many parts of the world. In fact, concern for family-based farming is prominent in the livestock policies of many countries.

Expecting the livestock sector to deliver on all fronts is ambitious. It will require difficult choices; the policy framework for the livestock sector, as for other areas, is characterized by a large number of trade-offs. For example, a large commercial expansion of the sector, benefiting from economies of scale and with upgraded food safety standards, creates barriers to smallholder producers. Many simply will not have the financial and technical means to compete and will be forced out of business. Likewise, distortions and externalities can be corrected but the costs of higher input prices and environmental controls will have to be passed on to the consumer, in the form of higher prices for meat, milk and eggs. As we have seen, the world's rapidly growing middle class might be willing to pay the higher costs.

Current trends of structural change imply the likely and probably accelerating exit of smallholder livestock producers in developing countries as well as developed. This trend is likely to persist even where suitable institutional mechanisms, such as cooperatives and contract farming, can be used to connect smallholders to the growing and modernizing agri-business. Such mechanisms are important for buffering the social impact of structural change. However, many poor people engage in livestock activities for lack of alternative rather than out of choice, the demise of smallholders may not always be bad. This is already happening in OECD coun-

tries, it is generally not regarded as a problem, and adequate employment possibilities exist outside the sector.

However, it becomes a major social problem if such employment opportunities do not exist in other sectors and social safety nets will then be required. Policies that attempt to stem the trend of structural change, in favour of small-scale or family farming, will be costly. As demonstrated by the EU's agricultural policy, they may only prolong the process and perhaps still fail. The important issue will be to find alternative options for displaced people to gain a living outside the livestock or agricultural sector.

Given the planet's finite natural resources, and the additional demands on the environment from a growing and wealthier world population, it is imperative for the livestock sector to move rapidly towards far-reaching change. The present analysis suggests four lines of action.

First, there is a need for continued efficiency gains in resource use for livestock production, on the basis of much-required price corrections for inputs, and replacing current suboptimal production with advanced production methods - at every step from feed production, through livestock production and processing, to distribution and marketing.

Second, there is a need to accept that the intensification and perhaps industrialization of livestock production is the inevitable long-term outcome of the structural change process that is ongoing for most of the sector. The key to making this process environmentally acceptable is facilitating the right location to enable waste recycling on cropland, and applying the right technology, especially in feeding and waste management. Locating industrial livestock units in suitable rural environments and not in congested peri-urban or otherwise favoured settings allows for the recycling of nutrients.

Third, extensive land-based production will continue to exist. However, grassland-based production will need to turn to the provision of

environmental services as a major purpose, and probably as the most important one in vulnerable areas. It must adjust itself to deliver landscape maintenance, biodiversity protection, clean water and eventually carbon sequestration, rather than only production of conventional livestock commodities.

Last, but certainly not least, for the suggested changes to occur, there is an urgent need to develop and implement effective policy frameworks at the local, national and international

level. This will need to be established with a strong political commitment, based on a civil society that needs to be more aware of the environmental risks of continuing “business as usual.”

The livestock sector is responsible for a significant share of environmental damage. With these changes, undertaken with an appropriate sense of urgency, the sector can make a very significant contribution to reducing and reversing environmental damage.