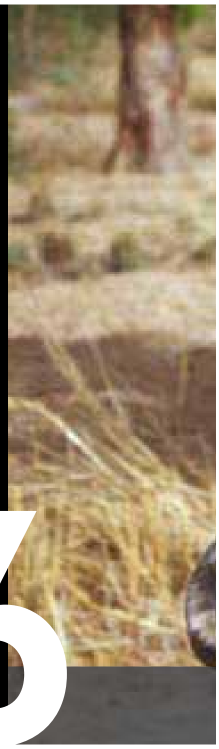


06

Policy challenges and options

This chapter deals with the policy challenges and implications arising from livestock's growing and changing impact on the environment. First, the peculiarities of livestock-environment issues and the surrounding policy context are discussed and specific challenges identified. General policy requirements are identified for the livestock sector to address the basic environmental dimensions considered by this assessment: land degradation, climate change, water and biodiversity. Finally, specific policy options and practical applications will be presented that promise to alleviate some of livestock's environmental burden, viewed through the prism of the livestock-environment hotspots identified in Chapter 2.

The preceding chapters have established the body of evidence of livestock's large and growing impact on the environment. It has become clear that, for a large part, technical solutions already exist that could drastically reduce that impact. Why are so many of those solutions not widely applied?

Obstacles to effective livestock-environment policy making

It appears that two things are missing. First, there is a lack of understanding about the nature and extent of livestock's impact on the environment, among producers, consumers and policy-makers alike. Livestock-environment interactions are not easily understood. They are broad and complex, and many of the impacts are indirect and not obvious, so it is easy to underestimate livestock's impact on land and land use, climate change, water and biodiversity. Second – and partially as a result of the lack of understanding – a policy framework conducive to more environmentally benign practices simply does not exist in many cases, or is rudimentary at best. Often existing frameworks address multiple objectives and lack coherence. Worse still, existing policies often exacerbate livestock's impact on the environment.

Neglect may be sometimes conscious and deliberate. In many poor and middle income countries, food supply and food security, in their narrow definitions, are given priority over environmental concerns. There is solid evidence that relates environmental concern and the willingness to act for environmental protection to levels of income. The inverted U-shaped relationship between income and environmental degradation - rising at first as incomes rise, then as incomes rise further, starting to decline – has come to be known as the "environmental Kuznets curve" (see, for example, Dinda, 2005; or Andreoni and Chapman, 2001).

Neglect of environmental impact may sometimes be motivated by belief in the low chance of success of possible remedies. The hundreds of millions of poor livestock producers who, in the view of many, cannot possibly be expected to change their way of operating in the absence of alternative livelihoods, are probably the most striking example. The remoteness of livestock production in many of the world's marginal areas, and the difficulties in physically and institutionally accessing these areas, create practical problems even to establish the rule of law and the reach of regulation. Obvious examples of "lawlessness" in remote areas are squatters in the Amazon basin, or pastoralists in the "tribal" areas of Pakistan.

Neglect may also stem from the strong lobbying influence that livestock producers wield in many countries, particularly developed ones (Leonard, 2006). This affects the political economy of public policy making in the livestock sector in the EU, the USA, Argentina and elsewhere. It is often argued that in the past, livestock lobbies have been able to exert an over-proportional influence on public policies, to protect their interests. An indication of this lobbying power is the persistence of agricultural subsidies, amounting to an average of 32 percent of total farm income in OECD countries, with livestock products (dairy and beef, in particular) regularly figuring among the most heavily subsidized products.

Whatever the motivation, for the most part, livestock's impact on the environment does not receive an appropriate policy response even though the technical means to do so exist. At the low end of the intensity spectrum, in grazing areas in dry or otherwise marginal areas, in developing and developed countries alike, pastoralists and farmers are considered by policy-makers to be unable to afford to make or to maintain investments that could benefit the environment. At the high end of the spectrum, well-connected large-scale commercial producers often escape environmental regulations.

This neglect is in stark contrast with the magnitude of livestock's impact on the environment and underlines the importance and urgency of developing appropriate institutional and policy frameworks. Such frameworks should consist of economy-wide policies, sector policies for agriculture or livestock, and environmental policies.

6.1 Towards a conducive policy framework

6.1.1 General principles

A series of guiding principles need to be taken into account in designing and implementing policies to address livestock's impact on the environment. First we need to be aware of the principle sources of mistaken or misguided policy actions, including market failures, information failures and failures due to differences in political influence.

Rationale for government intervention

Public policies need to protect and enhance public goods, including the environment. The rationale for public policy intervention is based on the concept of market failures. These arise because many local and global ecosystems are public goods or "commons," and the negative environmental impacts that livestock have on them are "externalities" that arise because individual economic decisions usually consider only private individual costs and benefits. There are also consumption externalities through the negative health impact of excessive consumption of certain livestock products, particularly animal fats and red meat – however, these are beyond the scope of this study. Information failures also exist, for instance the inadequate understanding of highly complex phenomena such as biodiversity or climate change. As a consequence of externalities and information failures, the market fails to deliver a socially desirable level of environmental impact. Not only are there market and information failures, there are also policy failures, such as, for example, subsidies that sometimes constitute perverse incentives, promoting inefficient resource use or activities that damage the environment.

Market failures

With regard to livestock and the environment, most market failures occur in the form of externalities. These are impacts borne by third parties as a consequence of decisions by individuals or organizations, and for which no compensation is paid or received. Both negative and positive externalities exist. The presence of nitrates in water drawn from farmland, and the damage they cause or the cost of removing them from drinking water borne by a utility company, would be an example of a negative externality. The presence of wild birds in silvopastoral systems, the carbon sequestered on improved pasture, or reduced runoff and downstream sedimentation resulting from improved grazing management are examples of positive externality, through which a benefit is provided to society at large but for which usually no compensation is received.

Externalities give rise to economic inefficiencies, in that the perpetrator has little incentive to minimize the negative externalities, or to maximize the positive, because the consequences are borne (or enjoyed) by the society, not the individual or company responsible. Therefore, it is necessary for these external costs (or benefits) to be "internalized", that is, to create a feed-back mechanism for external impact to be accounted for by the perpetrator (or providers). The attempt to correct for externalities is represented by the "polluter pays, provider gets" principle.

The problem with applying this principle is that many environmental goods and services are not traded and, while they are obviously valued by society, they do not have a market price. In the absence of a market, valuing the environment in an appropriate way presents formidable challenges, (compare Hanley *et al.*, 2001; Tietenberg, 2003); and a host of methods have been developed. They are often distinguished into cost-based methods which try to assess the damage, the abatement costs or the costs of substitution of an environmental good or service; and demand-based methods which attempt to estimate the willingness to pay or other expressions of preference for environmental goods or services. Problems with valuation also become problems of policy design and implementation.

Policy Failures

Apart from market failures, another kind of inefficiency arises from the failure of government intervention, referred to as policy failure. As opposed to market failure, a policy failure represents a distortionary effect of active government intervention. Governments intervene in markets to achieve certain objectives. Policy failures may have adverse consequences, either by directly harming the environment or by distorting price signals and causing a misallocation of resources (FAO, 1999). Government interventions may fail to correct market failures, or they may make existing distortions worse, or sometimes create new distortions of their own. Policy failures can arise from sectoral subsidies, inappropriate pricing, taxation policies, price controls, regulations and other policy measures.

Next we need to consider some positive principles.

The precautionary principle

A principle frequently used to link environmental concerns to decision-making is the "precautionary principle", which calls for action to reduce environmental impact even before conclusive evidence of the exact nature and extent of such damage exists. The precautionary principle stresses that corrective action should not be postponed if there is a serious risk of irreversible damage, even though full scientific evidence may still be lacking. However, there is considerable debate about the usefulness of this principle among policy-makers, a common understanding is still missing (Immordino, 2003).

Policy level: subsidiarity principle

Environmental policies have local, national and global dimensions. Global issues such as climate change and loss of biodiversity have an international reach and are the subject of intergovernmental treaties. In view of the local nature of many livestock-environment interactions, the literature on environmental policy stresses the subsidiarity principle, i.e. that decisions should be taken at the lowest relevant organizational level and be as decentralized as possible.

The broader policy framework is usually set at the national level. Even international treaties on, for example, trade tariffs and emission targets usually need to go through a ratification process at the national level before becoming law. Regulations for emission control, taxation, agricultural and environmental subsidies are usually part of national policies. Local resource access management, zoning and enforcement usually fall upon local government authorities.

International decision-making – FAO, Italy

Policy process: inclusivity and participation

For policies to be successful, they need to be inclusive. At the local and national level, they need to involve, and possibly be designed by, all involved stakeholders. Their involvement enhances the chances that policies will be effective. The active participation of communities and citizens is required for local policies and projects, such as watershed protection, or the organization of farmer groups for technical assistance. However, in practice, participatory approaches seldom go beyond local activities. Usually participation does not extend into the design of sector-wide policy packages and development strategies (Norton, 2003).

Policy objectives and trade-offs: assessing costs and benefits

Livestock sector policies need to address a host of economic, social, environmental and health objectives. In most cases, it will be impossible to design policies that will address all at once and at reasonable costs to government and the people affected. Though important trade-offs exist and compromises need to be made. For example, land access restrictions and grazing controls on communal land often entail lower returns for grazers in the short run. Similarly, higher waste emission standards for intensive producers raise production costs and may affect the competitiveness of one country compared to others with no or lower standards.

Therefore, it is essential to carefully assess the costs and benefits of livestock sector policy interventions, and to prioritize different objectives. These will depend crucially on factors such as level of income and economic development, level of smallholder involvement in the livestock sector, prospects for livestock exports, extent of livestock-induced environmental degradation, level of market development and so on.

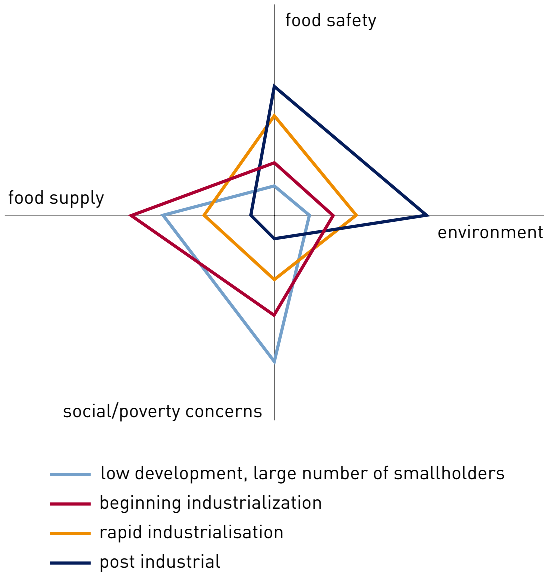
The four phases of development of policy priorities

Four different phases can be distinguished, depending on the level of economic development of a country.

Countries with low levels of income and economic development, and large involvement of smallholders in the livestock sector, often try to pursue social policies through the livestock sector, driven by concerns for the large masses of rural poor; other objectives are of second order. Most of sub-Saharan Africa and South Asia fall into this category. Typically, at this stage, policies include technology development and promotion, often in the area of animal production and health together with interventions in market development. The overriding objective is to maintain, and possibly further develop, the livestock sector as a source of income and employment for marginally productive rural people, as other sectors do not yet offer sufficient economic opportunities. Such strategies frequently fail to address, degradation and overexploitation of grazing resources, often under common property, in the form of overgrazing and other forms of unsustainable land management. Both governments and farmers lack the funds and ability to address widespread degradation. Regulatory frameworks may exist but are usually not enforced. Serious public and animal health issues relating to livestock are not vigorously addressed, either.

Moving up the ladder of economic development and income, into the early phases of industrialization, more attention tends to be given to environmental and public health objectives, but social objectives still maintain their predominance. Policy-makers are also concerned with the need to increase food supplies to growing cities. Allowing commercial meat, dairy and egg production in peri-urban areas provides a relatively quick fix. The smallholder livestock sector is still of overwhelming importance; although where livestock industrialization begins the smallholder sector tends to diminish in rela-

Figure 6.1 **Shift in livestock policy objectives in relation to economic development**



Source: Authors.

tive importance. The first attempts to address environmental objectives in the livestock sector are now being made. For example, by establishing institutions to deal with the degradation of common property resources, the establishment of protected areas, etc. Similarly, legal frameworks for food safety are being established and enforcement starts, usually with formal markets, and urban consumers begin to attract the attention of policy-makers. Currently Viet Nam may be a good example for this group and some wealthier African countries.

The picture changes more rapidly at the stage when developing countries fully industrialize. Governments no longer pursue social objectives in the livestock sector, as ample employment opportunities in secondary and tertiary sectors reduces the importance of the livestock sector as a social "reservoir", or "waiting room for development". On the contrary, a number of countries, such as Malaysia, actively encourage the demise of smallholder agriculture to mobilize additional labour for industrial development, and to rationalize the agro-food industry. Food safety standards are established to satisfy rapidly growing cities' increasingly sophisticated bulk demand for meat, milk and eggs. The ensuing consolidation of the food industry quickly reduces the number of producers and other market agents.

At this stage, the livestock industry becomes a profitable business and consolidates. The sector is increasingly expected to meet basic environmental standards, as the public begins to perceive the elevated environmental costs of rapid industrial development. However, agricultural and livestock lobbies sometimes maintain their influence and achieve protection, as a legacy of the sector's past importance, or because of the importance assigned to self-sufficiency in food products, or because of the cultural values embodied in livestock. Many East Asian countries such as China and Thailand, and Latin American countries such as Brazil and Mexico, are examples of this stage, even though these countries are highly diverse and heterogenous.

At full industrialization, environmental and public health objectives take predominance. The livestock sector is much reduced in its relative social and economic importance. However, in most OECD countries the agricultural and livestock sector is still more important in terms of employment than in it is in terms of contribution to GDP, and the agricultural sector regains some importance for services other than the provision of food and other primary products. The level of protection for livestock commodities indicates, for most developed countries, that related lobbies still wield widespread influence over policy-making.

Taking these observations into the future, it is not difficult to imagine the next step in fact, it is already taking shape. The demands for environmental services against the background of increased food supply, driven by heightened, and ever more sophisticated, consumer expectations will establish environmental and food safety requirements as the only motives in public policy-making. Protection will wane and implicit rights gradually disappear.

The stylized pattern of the four stages and their changing priorities is depicted in Figure 6.1. While no attempt is made to provide statistical evidence for these observations in the context of this study, such considerations are explicit in multi-criteria and hierarchical decision-support tools, such as in Gerber *et al*. (2005). The implicit trade-offs indicate that it may not be realistic to expect - as many in the livestock research and development community do - that the livestock sector can deliver on economic, social, health, and environmental objectives all at once and in a balanced form. Tools like hierarchical or multi-criteria decision-making can help addressing these trade-offs, but the conflicted and distorted policy framework, within which the livestock sector operates, is not easily disentangled.

The important subsidies that most developed countries have provided to the livestock sector underline the fact that the sector is assigned importance beyond its mere economic contribution. It can be stated, therefore, that the livestock sector continues to receive the attention of policy-makers for social, economic and food safety reasons, and the trade-offs that exist between these three and the environmental objectives often work to the detriment of the latter. The reasons for this vary, depending on the stage of development, but the overall tendency seems to be very widespread.

There may be a causal link between government subsidies and natural resource degradation. Chapters 3 to 5 give a description of what we might call "nature's subsidies" to the livestock sector - the provision of natural resources and waste sinks and their gradual degradation or exhaustion, without restoration or remediation. Eliminating a large part of these subsidies is a requirement for better resource use and limiting livestock's impact on the environment.

However, there will be a price to be paid:

- Consumer prices for livestock products are likely to go up as a result of correcting input prices for water and land, especially prices of beef and other types of red meat. Nature's subsidies are particularly high for ruminant products (in addition to high government subsidies in OECD countries).
- Livestock farming in many marginal areas, under common and private property alike, will often become unprofitable if current price distortions are removed and externalities are factored in. Many producers will need to find alternative livelihoods. If it is accepted that this is a desired long-term outcome, policies need to change direction now.
- The drive towards higher efficiencies, which will also generate savings in use of natural resources and reduce emissions, will make livestock production increasingly knowledge- and capital intensive. As a result, small family-based livestock producers will find it increasingly difficult to stay in the market, unless effective organizational arrangements, such as contract farming or cooperatives, can be designed and used (Delgado and Narrod, 2002). Again, the loss of competitiveness requires policy interventions, not necessarily to maintain smallholder involvement in agriculture, but to provide opportunities for finding livelihoods outside the agricultural sector and to enable an orderly transition.

Broad policy approaches: regulatory and economic instruments

Usually, policies do not consist of a single measure but of a series of measures. The key to successful policy design and implementation often lies in ensuring the right mix and sequencing of different policy measures.

Generally, the literature distinguishes between two broad approaches for implementing environmental policies: regulatory approaches and economic instruments. The choice between these approaches is not merely ideological, it also depends on the capacity of governments to enforce regulations; and wide differences exist between countries.

- Regulatory approaches (often termed "command and control") are often applied to emissions into the air, water and soil (mostly in

cases of point-source pollution) and generally, for access to and use of resources. Such approaches rely on sometimes onerous monitoring and enforcement, and depend on the related institutional capacity, which limits their use in many developing countries. Historically, environmental policies in most countries have started off with "command and control".
- Economic instruments rely on the role of monetary incentives to modify the behaviour of individuals or companies. They can be positive (in the form of subsidies or revenues from the sale of environmental services) or negative (in the form of levies or taxes). Many instruments rely on economic efficiency as the basic objective. Monitoring costs for economic instruments tend to be lower as there is greater scope for self-regulation, rewarded by financial incentives.

Commonly, both these approaches are used in combination. Other policy instruments include technology support and related capacity building, institutional development and infrastructure development.

Policies can drive changes in technology and management

Policies define rights and obligations. They also have the potential to determine input and output prices, and thus drive the delivery of public goods towards what society considers to be the optimal level. The concept of "induced innovation" widely published by Hayami and Ruttan has proved useful in the context of livestock–environment interactions (de Haan, Steinfeld and Blackburn, 1997). Ruttan (2001) links this concept to an earlier observation by Hicks (1932, pp. 123-25):

> *"A change in the relative prices of the factors of production is itself a spur to invention and to inventions of a particular kind – directed at economizing the use of a factor which has become relatively expensive."*

The induced innovation concept has since been further developed to include institutional change; for example Coase and Williamson (McCann, 2004) suggest that forms of economic organization, such as vertical integration, are the result of minimizing transaction costs. Without going into further detail of the economic models underlying these concepts, it is useful to view policies as potentially powerful drivers of technological change through their effect upon prices and their regulation of access to resources. By restricting access to grazing land, for example, land and related feed resources become relatively scarce, so technical change will move towards making more efficient use of these resources. Likewise, better pricing will encourage more efficient use of water, and drive water use towards optimal allocation among different competing uses (livestock, crops and other). The same applies to all other natural resources that feed into the livestock production process, such as water or nutrients. Likewise, new costs associated with the internalization of externalities from livestock production, such as emissions of ammonia or other forms of waste, will lead to increased efforts towards their avoidance. These effects are likely to be all the more important the higher current differences are between actual costs or prices and those reflecting an "optimal" level of environmental protection.

Today's decision-making on the livestock–environment–people nexus is characterized by the severe under-pricing of virtually all natural processes that go into the livestock production process, by the neglect of major down-stream externalities generated by the livestock sector without it being held accountable; and by a number of distortions, creating (broadly speaking) subsidized livestock sectors in developed countries and taxed ones in developing countries. Decision-making is further complicated by unrealistic expectations about pursuing social objectives through the livestock sector.

To summarise, the canvas upon which new policies will be designed is not blank, as it is already marked with broad brush strokes resulting from ignorance, neglect, conjectures and fallacies. This should not give rise to despair - rather it should inspire hope that relatively minor changes, in a sector that has often been considered environmentally unimportant, could have a major impact.

6.1.2 Specific policy instruments

Limiting livestock's land requirements

One important key to limiting livestock's environmental impact is to limit livestock's land requirements by pitching policies within the context of the geographic transition that the livestock sector is undergoing. As we have seen in Chapter 2, this transition has two facets.

First, there is the expansion of land used by or for, livestock. Until the mid-twentieth century, this was mainly in the form of grazing land. This expansion is still continuing in sub-Saharan Africa and especially in Latin America, where pasture is the main follower of deforestation. However, in most parts of the world, this expansion has either come to a halt (Asia, the Near East) or gone into reverse, with pasture reverting back to woodland or forest (industrialized countries).

At the same time, the use of concentrate feed has expanded significantly over the last 50 years greatly increasing livestock's demand for arable land. As of 2001, an estimated 33 percent of total arable land is devoted to producing feed, either as primary commodities (grains, oilcrops, tubers) or their by-products (brans, cakes). Again, this area expansion, although still ongoing in most developing countries, is poised to slow down and eventually reverse. This is happening already in industrialized countries where stagnant or modestly increasing demand for livestock products is accompanied by continuous gains in livestock productivity and crop productivity, resulting in lower overall land requirements for livestock.

If overall land requirements can be further reduced, which seems possible, this will benefit the environment by freeing land for environmental purposes. It would need to be accompanied by careful intensification of existing grazing and arable land, where the potential for yield increases exists.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An example of urban animal husbandry showing goats grazing on the citadel in the centre of Amman. Jordan - 1999

Second, there is the growing concentration of livestock activities in certain favoured locations. This applies to the industrialized parts of the livestock sector, notably intensive poultry and pig production and, to a certain extent, dairy and beef. As we have seen, this concentration is driven by the newly gained independence of industrial livestock from the specific natural endowments of given locations, which have previously determined the location of livestock production (as they still do for most of crop agriculture).

Geographic concentration, or what could be called the "urbanization of livestock," is in many ways a response to the rapid urbanization of human populations. Peri-urban livestock provides a quick fix for countries in rapid economic development with fast-growing urban centres. This geographic concentration is largely responsible for the problems related to disposing of livestock wastes by recycling on surrounding land.

However, developed countries have been relocating their livestock production away from cities, and have established infrastructures and regulations to do so. The same is happening in emerging economies, first as a response to the nuisance factors of livestock (odour and flies) and then to the issues of nutrient loading of waterways and public health. Policies are needed in emerging economies to facilitate rural-based livestock industries, and to avoid the "urbanization of livestock" where it has not yet occurred.

In the following sections, basic policy instruments, currently applied and possible responses to livestock's role in environmental degradation, are described along with their requirements and potential impact. The choice of policy instruments needs to be based on their efficiency; that is the level pollution control resources are extracted at which the difference between social benefits and social costs is maximized (Hahn, Olmstead and Stavins, 2003). Increasingly, however, the efficiency criterion alone is being complemented by effectiveness considerations. These begin with an environmental objective (such as the level of nitrates in drinking-water) and then the attempt to achieve the target at minimum aggregate cost, often including market-based instruments so as to bring about an allocation of at least the cost of pollution reduction. Another criterion to be used in the choice of policy instruments is that of equity, since the distribution of pollution control costs and environmental benefits is often unequal (Hahn, Olmstead and Stavins, 2003).

Correcting distorted prices

Many of the inefficient, degrading, wasteful or otherwise damaging aspects of livestock production result from distorted price signals that discourage efficient resource use and foster misallocation and uncontrolled degradation of resources. This relates in particular to underpriced natural resources and sinks, either as a result of an overt subsidy (as for example in the case of water) or because of a disregard for externalities.

Largely, market failures and policy distortions mean that current prices for inputs and outputs of livestock production do not reflect true scarcities. As we have seen in Chapter 3, the livestock sector is highly dependent on natural resources such as land, water, energy and nutrients. Yet these resources are almost universally underpriced because of policy distortions or because externalities are unaccounted.

Land is the most important factor of agricultural and livestock production. Land taxes are seen as an instrument to encourage more productive or intensive use of land. Particularly, land taxes may counteract speculation in situations where owners hold land, not for productive purposes, but as an asset to hedge against inflation, which is common in some Latin American countries (Brazil, Costa Rica) (Margulis, 2004). Further, land taxes may induce more efficient utilization of land and encourage its redistribution, since smallholdings tend to be more land-intensive and achieve higher yields (Rao, 1989).

Strengthening land titles

Without clearly defined rights of access to land, incentives are weakened for livestock and crop production to be carried out in a way that maintain the land's long-term productivity. Land and land-tenure policies are usually considered in light of goals concerning economic efficiency and the objectives of equity and poverty alleviation; although environmental issues are of increasing importance. Given the increasing scarcity of suitable agricultural land in most parts of the world, and the growing concerns about deforestation and land degradation, increases in land productivity will have to continue to provide the bulk of increased food supplies.

While most of the area cropped for feed is under private ownership, a large part of ruminant livestock production still takes place on communal lands (such as most of sub-Saharan Africa) or state lands (such as in India, Western Australia and Western United States). There seems to be a wide consensus that land titling and secure access to land, such as the long-term land leases practiced in China, are a prerequisite for agricultural intensification, gradual transition to full titling is occurring in response to population pressure. Norton (2003) states that "in regions of the world where customary rights already had been weakened or superseded, and where the State is not the sole owner of agricultural land, the case for accelerated implementation of titling systems is strong." Land titling is seen as a prerequisite to private investment in land, including those that protect and enhance its long-term productivity and those that benefit the wider environment.

Pricing water realistically

With regard to water Pearce (2002) estimates that between 1994 and 1998 annual water subsidies in developing countries amounted to US$45 billion per year. Water in agriculture is severely under-priced. Water has been identified as a major resource for livestock production, whether in the form of "blue water" (for irrigating fodder or feedcrops, for drinking, for waste management or for product processing), or in the form of "green water" - water on rainfed pastures that translates into vegetative growth for livestock grazing. The latter's importance is further enhanced by the essential function of many grassland areas in harvesting water and regulating its movement - both of which are crucial in providing reliable freshwater supplies for growing urban, industrial or agricultural needs.

The push towards efficiency, equity and sustainability in agricultural water management needs to be put into a broader context. As Norton (2003) puts it "achieving greater efficiency in irrigation in the broader sense may mean giving up water to other sectors where it has higher-value uses, even if sometimes that implies reducing the value of agricultural output." What holds true for irrigation is certainly true for all agricultural uses. Except for where irrigation water is used for forage crops, as in some OECD countries, livestock's use of freshwater does not often create a high level of agricultural output per unit of water, particularly when most of this water is used to keep animals alive rather than for producing output.

The fact that water is so widely and severely under-priced entails that water use is less efficient than would otherwise be the case. If prices were higher, water would be allocated differently as between agricultural uses and other uses. In stark contrast to current practices, Bromley (2000) calls for water pricing to be seen as part of a regime in which farmers are induced to contribute to a public good for several important goals to:

- stimulate conservation of water;
- encourage allocation to its highest value use (including non-agricultural uses);
- minimize the environmental problems arising from inefficient irrigation;
- generate enough revenues to cover operating and maintenance costs; and
- to recover the original investment.

Various methods are used for pricing water (Tsur and Dinar, 1997) including: volumetric, output, input and area (see Section 6.1.4). Formal markets for water rights currently exist in only a few places (such as the Australia, Brazil, Mexico and the western United States). In recent years, general interest has been excited because of their potential to foster efficient use of an increasingly scarce resource (Norton, 2003). Water markets work on the basis of legally recognized and registered water use rights. These rights are separate from land titles, and individuals and groups can trade water rights within the scheme. While there are a series of conceptual and location-specific practical issues, water markets have the potential to provide incentives for conserving water and to allocate it to higher-value uses. Through water pricing governments can monitor operations, more easily enforce regulations and prevent the abuse of monopoly power (Thobani, 1996).

There are similar price distortions where livestock are used for other than productive use. As described in Chapter 2, livestock are used to acquire land titles, leading to or contributing to deforestation. Likewise, livestock are used as an asset or as a store of wealth in many grazing areas under common property regimes, leading to or contributing to overgrazing. Both are cases where non-productive uses of livestock have taken predominance, and the ensuing resource degradation is a reflection of market imperfections and institutional failures. Removing price distortions and pricing natural resources at their actual cost will generally increase production costs and may thereby reduce overall consumption levels for animal products and livestock related services.

Removing subsidies can reduce environmental damage

In the livestock sector of most developed and some developing countries, subsidies strongly distort prices at the input and product level. In all OECD countries, in 2004, subsidies to agricultural producers amounted to more than US$225 billion a year, equivalent to 31 percent of farm income. There is increasing evidence that subsidies are not neutral in terms of environmental impact and, indeed, that certain forms of subsidies generate negative environmental effects (Mayrand *et al*., 2003).

For some countries, the removal of subsidies has been shown to have a strong potential to correct some of the environmental damage caused by livestock production. For example, New Zealand (see Box 6.1) made sweeping subsidy reforms in the 1980s, and now reports that the removal of subsidies resulted in significant reductions of environmental damage caused by agriculture in general, in the form of increasing forest land, less erosion, and less nutrient runoff. In the livestock sector in particular, it led to reduced grazing pressure in the hill country of the Northern Island (MAF-NZ, 2005).

Mayrand *et al*. (2003) and UNEP (2001) have used the OECD methodology (developed for assessing the environmental impacts of trade liberalization OECD, 2001) to asses the environmental impacts of agricultural subsidies. The authors found that subsidies had a significant impact on the environment, through their impact on scales of production, the structure of agriculture, input and output mixes, the technology of production and the regulatory framework.

Particular forms of impact include:

- Market price supports affect the scale of production. They translate into higher and more

Box 6.1 New Zealand – environmental impact of major agricultural policy reforms

In 1984, the New Zealand Government changed the agricultural policy almost overnight from one of heavy protection and subsidy (for example, in 1984, the assistance payment to farmers for lamb was 67 percent of the farm-gate price) to one of the most open, market-oriented agricultural sectors in the world. Export subsidies were eliminated and import tariffs phased out. Output price assistance for agricultural products and subsequently, fertilizer and other input subsidies were abolished. In addition, tax concessions to farmers were withdrawn. Free government services for farmers were eliminated.

While the first years were particularly stressful for the rural sector, very few farmers were forced by the reforms to leave the land. The rural collapse predicted by some never happened. New Zealand's rural population rose slightly between the 1981 census and the 1991 census despite the removal of subsidies. Since the removal of agricultural subsidies in the mid-1980s, there has been a gradual but steady change of land use from pastoral agriculture to forestry. Total area in various forms of pasture has declined from 14.1 million hectares in 1983 to 13.5 million hectares in 1995 and to 12.3 million in 2004. Meanwhile, the area of planted forest has increased from 1.0 million to over 1.5 million hectares, a 50 percent increase, over the same period, and to 2.1 million in 2004. Fertilizer use declined in the first decade after the reforms, and, there is some evidence of reduction in leaching of phosphates from hill country pasture catchments, where phosphate is the dominant nutrient applied. Soil erosion has also declined leading to improved water quality. However, the increased use of nitrogen fertilizer, following the move to dairy production, is a more worrisome trend.

Sources: MAF websites and Harris and Rae (2006).

intensive production levels. This affects the environment through input use (water withdrawal, fertilizer applications, etc.) and area expansion (for crop agriculture) or expansion of livestock numbers. The OECD (2004, p. 19) found that "in general, the more a policy measure provides an incentive to increase production of specific agricultural commodities, the greater is the incentive towards monoculture, intensification, or bringing marginal (environmentally sensitive) land into production, and the higher is the pressure on the environment".

- Support to agriculture can distort the allocation of resources because it is often unequal across commodities. In the livestock sector this can be exemplified by the high support to dairy as opposed to the small subsidies for poultry. As a result, farmers concentrate on the production of the most subsidized commodities, leading to reduced cropping flexibility and increased specialization. This in turn tends to decrease agricultural and environmental diversity and to increase the vulnerability of agro-ecosystems. An example is provided by the imposition of milk quotas in many OECD countries for price stabilization, which led to a geographic concentration of milk production (OECD, 2004, p. 20). Together with higher milk prices, farmers attempted to maintain profit levels by cutting production costs, reducing the number of cows while increasing their yield. This resulted in higher input use (feed concentrates) and reduced grazing, thereby increasing the intensity of dairy production and aggravating environmental pressures in specific locations.
- Subsides can prevent technological change by supporting specific inputs or technologies - thereby creating a technology "lock-in" effect (Pieters, 2002). For example, in the EU high price supports for cereals drove livestock feeding towards the use of cheaper cassava in the 1980s and 1990s thereby preventing advances in cereal feeding that would otherwise have occurred, and causing a massive transfer of nutrients (de Haan, Steinfeld and Blackburn, 1997). On the other hand, removal of such subsidies could induce technological change with more positive environmental outcomes. Also, shifting from subsidies for production towards payments to farmers for environmental services can lead to enhanced environmental benefits.
- It is generally accepted that agricultural subsidies affect the structure of agriculture, the number and size of production units and the organization of the value chain (e.g. vertical integration). However, both subsidies and trade liberalization are said to work towards large-scale industrial agriculture.
- Subsidies also have a distributive impact. A recent study by the OECD (2006) found that a large share of farm subsidies end up supporting land owners and input suppliers. When they are based on production totals, they tend to benefit larger farms and impoverish smaller ones and drive them out of business.
- Trade reforms may have a regulatory effect, i.e. they may have an impact on environmental regulations and standards. This may work both ways: on the positive side, agreements on trade liberalization may include measures to improve environmental standards. On the negative side, particular provisions of trade reforms may limit a country's ability to observe environmental protection standards (UNEP, 2001).

Mayrand *et al*. (2003) also found that market price support (which accounts for two-thirds of total subsidies in the OECD) is among the type of subsidy most likely to generate perverse environmental impacts. Market price support is included in the "amber box" of the Doha round of trade negotiations (the amber box includes support that should be reduced or removed, including all domestic support measures "considered to distort production and trade"). There is increasing evidence that the reduction of amber box subsidies can constitute both a trade liberalization and a benefit for the environment. Also, other types of subsidies (payments based on inputs, for example) tend to have a more neutral and sometimes positive impact on the environment. The OECD (2004) came to the same conclusion, in a review of policies and their impact on agriculture and the environment. Despite some reforms, agricultural support linked to production remains the predominant form of support in OECD countries. The OECD work shows that this provides incentives to adopt environmentally harmful practices and to expand production into environmentally sensitive land. The OECD also deplores the lack of policy coherence, with agro-environmental measures and commodity production-linked support policies pulling in opposite directions.

Trade liberalization and its environmental impacts

Rae and Strutt (2003) came to a similar conclusion when attempting to assess environmental pollution from livestock as affected by trade liberalization in OECD countries. They used the OECD nitrogen balance database in conjunction with a global computable general equilibrium model. Using three different scenarios of increased trade liberalization, their computations all resulted in improved environmental outcomes, with a reduction in the surplus nitrogen that can cause damage to soil, air and water. Rae and Strutt found that "total OECD nitrogen balances are expected to fall more, the more ambitious the reform modelled" (Rae and Strutt, 2003; p.12). In contrast, Porter (2003) argued in the case of the maize/beef sector that the production effect (the expansion of a commodity sector in response to positive price signals) as a result of trade liberalization is rather limited. He found that the environmental impact, stemming from expansion, is mediated or even nullified by technology advance. In addition, reactions to price signals are severely conditioned by the long "cattle cycle", i.e. the time lag between herd management decisions and bringing cattle to the market. However, this observation may be limited to the beef sector.

While trade liberalization seems to offer opportunities for reducing the environmental impact of livestock, there are various trade-offs, and complementary measures may be needed. First, trade liberalization will result in increased trade and hence movement of goods, which has its own environmental costs. These can sometimes offset any gains resulting from better resource use at the production level. Second, trade liberalization will likely be accompanied by locational shifts of livestock production to less densely populated areas, hence to accompany the shift, environmental polices are needed in areas where livestock production is growing. For example, Saunders *et al*. (2004) investigated environmental impacts of dairy trade liberalization through the application of a multi-commodity, partial equilibrium model for OECD countries. Their results "support the notion that production and environmental heterogeneity both between and within trading partners will lead to spatially differential changes in pattern of resource usage and environmental impacts (Saunders, Cagatay and Moxey, 2004, p.15).

More generally, trade-related policies and other macro-economic policies such as devaluation, commodity price stabilization, preferential trading arrangements all tend to have a significant impact on the environment (UNEP, 2001, p. 17). Environmental policies can be seen as second order policies, which are brought in after the gross macro-economic and trade policy distortions have been corrected.

What are the alternatives to commodity production-linked support? Various policy measures are being applied and studied, mostly in OECD countries:

- In some countries, land set-aside schemes are being applied that provide farmers with an incentive to set aside their poorest, economically marginal land. Here, the environmental impact crucially depends on quality of the natural resources associated with the land set aside. The more valuable the land in environmental terms, and the lower its value in productive terms, the more successful these schemes have been.

- Increasingly, production-linked support measures are linked to a requirement to meet certain environmental targets, known as cross-compliance. A recent OECD publication (2004) states that cross-compliance allows for a better harmonization of agricultural and environmental policies. It also may increase public acceptance of support to agriculture. However, any change in the level of support will change the effectiveness of cross-compliance, which carries the risk of losing environmental leverage when production-linked support is reduced. Adherence with cross-compliance requirements is also difficult to measure.
- Part of "getting the prices right" is the need to compensate livestock farmers for the environmental benefits they provide. The most frequent example is managing grazing pressure in water catchment areas to improve water infiltration and reduce siltation of waterways. A LEAD-initiated project in Central America experiments with payment for environmental services generated by improved pasture and silvo-pastoral systems, particularly improved biodiversity and carbon sequestration (see Box 6.2).
- In the case of environmental issues related to pesticide use, water quality, ammonia and greenhouse gas emissions, agro-environmental measures continue to focus on setting standards and targets.
- Pollution issues, such as manure storage and application, are subject to regulations governing related practices (mode and time of application, for example), and are supported by fines and charges for non-compliance.

Compared with other sectors, the agricultural sector is characterized by a relative absence of environmental taxes and charges and the dominance of incentive payments. This suggests that farmers have strong political clout and have succeeded in creating political acceptance of their implicit or "presumptive" rights in the use of natural resources. Therefore, there is still a wide scope for better cost internalization to correct for environmental damage and encourage pollution treatment.

Regulations

Regulations typically specify technologies or uniform emission limits. Regulations are the policy instrument of choice at the early stages of addressing environmental objectives. However, their implementation requires institutions for monitoring and enforcement. This is particularly difficult in remote and poor areas, and when dealing with non-point source pollution. In contrast, where pollution is highly localized and where livestock production is commercial, the prospect of enforcing regulations is improved.

In extensive livestock production, regulations are frequently established to limit grazing pressure or to protect environmentally sensitive areas. While grazing restrictions operate successfully in many cases in developed countries, success has been rather limited in developing countries unless there are strong local organizations.

Regulations concerning water are often used to set emission standards for the control of pollution from livestock activities. These are discussed in more detail in Section 6.1.3. Environmental regulations affect the spatial distribution of livestock; for example in the United States, Isik (2004) shows that areas with more stringent environmental regulations suffered declines in livestock numbers to counties and states with less stringent regulation (called "pollution havens").

A number of countries have started to address air-pollution related to the issues of nitrous oxide emissions and ammonia volatilization by means of regulations.

At the international level, the United Nations Economic Commission for Europe's Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (also known as the Gothenburg Protocol) was signed in 1999, under the 1979 Geneva Convention on Long-range Transboundary Air Pollution. It entered into force in May 2005. The main signatories are the European Community, the individual European countries, the USA, and the Russian Federation (which has not yet ratified the protocol). The protocol fixes national annual emissions targets to be reached by 2010 for different gases: SO_2, NO_X, NH_3 and volatile organic compounds. It also imposes different practical measures, for the control of ammonia emissions from agricultural sources, to be taken by parties (with some qualifications related to technical and economical feasibility). These include an advisory code of good agricultural practice; solid manure incorporation within 24 hours of spreading; low-emission slurry application techniques; low-emission housing and slurry storage systems for large pig and poultry farms;[1] and prohibition of ammonium carbonate fertilizers and limits on ammonia emissions from urea.

The European Union adopted its own regulation on atmospheric pollutants: the 2001 National Emission Ceilings (NEC) Directive (directive 2001/81/EC of the European Parliament and of the Council). The NEC directive fixes national emission ceilings for the same gases, at the same level (except for Portugal) as the Gothenburg Protocol. The NEC directive is currently in the process of implementation. Member states had to build national programmes by October 2002, to be updated and revised as necessary in 2006, for the progressive reduction of their annual emissions.

Supporting intensification and promoting research and extension of cutting edge technology

If the projected future demand for livestock products is to be met, it is hard to see an alternative to intensification of livestock production. Indeed, the process of intensification must be accelerated if the use of additional land, water and other resources is to be avoided.

The principle means of limiting livestock's impact on the environment must be to reduce land requirements for livestock production, including the implicit water, nutrients and other resources represented by land. This involves the intensification of the most productive arable and grassland used to produce feed or pasture; and the retirement of marginally used land where this is socially acceptable and where other uses of such land, such as for environmental purposes, are in demand. The goal becomes more important where land for livestock production is marginal and its natural resource value is higher.

Intensification will lead to gradual reductions of resource use and waste emissions across the board. For example, precision feeding and use of improved genetics can greatly reduce emissions of gases (carbon dioxide, methane, etc.) and of nutrients per unit of output. Intensification in the form of a relative expansion of concentrate-based production systems, in particular chicken and other poultry, at the expense of ruminant production, in particular feed lots can reduce the overall impact of the livestock sector on climate change.

Intensification also needs to occur in the production of feedcrops, thereby limiting the use of land assigned to livestock production, either directly as pasture or indirectly for feedcrops. This will alleviate the pressure on habitats and associated biodiversity. While conventional intensification may increase the environmental burden on the areas involved, use of conservation agriculture (minimum tillage, precision use of water, fertilizers and pesticides, etc.) may mitigate this risk. Pasture intensification and improved feed cropping can sequester carbon, or at least reduce emissions of greenhouse gases.

Intensification needs to be brought about by price signals, corrected for current distortions

[1] More than 2 000 fattening pigs or 750 sows or 40 000 poultry.

and neglect of externalities, and will lead to a better utilization of natural resources used in the livestock production process, notably water.

As well as correcting input and output prices, public policies can play a facilitative role in intensification, by stimulating technology research and development. However, public technology research and development has considerably slowed down in the past decade (Byerlee *et al*., 2003). While continued research into productivity increases for commercial and industrial livestock and related feed production and use can be largely left to the private sector, public research needs to play a stronger role in natural resource management and in poverty reduction where accessible technologies offer such potential.

Purcell and Anderson (1997) analyse the role of research and extension and the role public policies can play in promoting these. They stress the importance of a conducive environment, including macro-economic and sectoral policies, favourable market opportunities, access to resources, input and credit. It is still widely considered that the amount of private research will always be less than socially optimal, and public stimulation of research must step in to fill the gap. In particular, this may apply to livestock-environment issues as public research and development needs to anticipate future scarcities. However, supporting public sector involvement in technology development will remain ineffective if the gross price distortions are not corrected.

Institutional development

While the livestock sector undergoes rapid transformation, institutions have lagged in responding to the environmental challenges that have arisen, for reasons discussed at the beginning of Chapter 4. Many resource degradation issues related to livestock are characterized by an absence of policies and institutions to address them.

Institutions are required to monitor environmental externalities, both negative and positive, and to ensure that these are accounted for and fed back into private decision-making. Institutions are also required to negotiate and sometimes implement these measures. Institutions are needed to develop standards and regulations and to enforce their implementation.

Institutional change is required to correct the policy distortions that currently create perverse incentives and encourage inefficient resource use and misallocation of resources. Very often, inappropriate price signals stem from lack of institutional capacity, such as, for example, in situations where traditional authorities have lost their grip over common property resources. Environmental stewardship needs to be established at the appropriate level: at communal watershed level in the case of common property grazing resources and water-harvesting schemes; at the national level for the protection of natural areas, for environmental policies and their implementation; at international level for the protection of the atmosphere and global issues related to biodiversity.

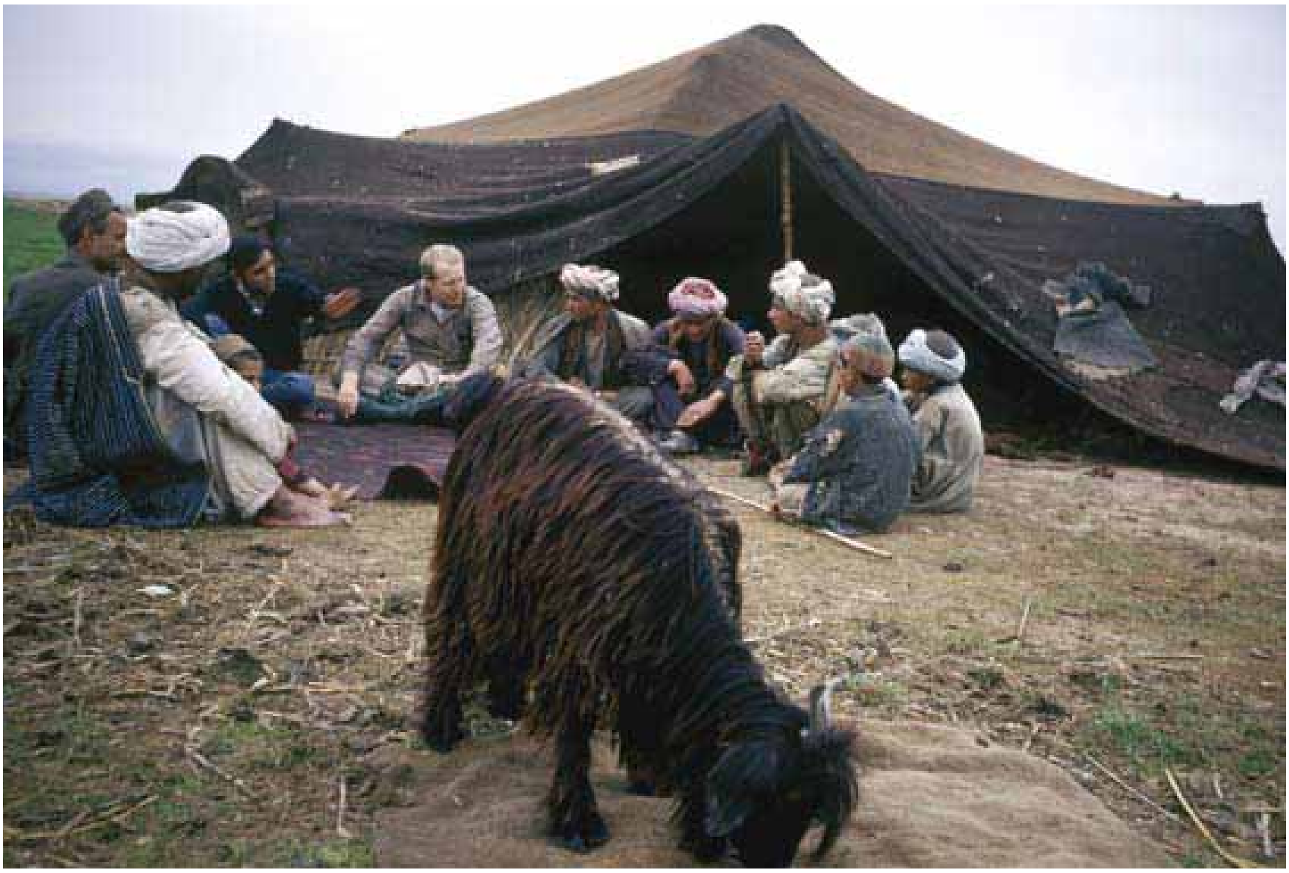
Awareness building, education and information

There is a pressing need to bring information about environmental concerns, and specifically awareness of the role of livestock in the degradation of natural resources, to the attention of the general public, of consumers, of pupils and students, of technical staff and extension workers, and of policy-makers and decision-takers in private business and public office. Communication among all stakeholders is important because most environmental issues related to livestock can only be successfully addressed in a concerted and negotiated way.

6.1.3 Policy issues in climate change

Having discussed general policy frameworks and approaches, we will look at their application in particular sectors beginning with climate change.

Agriculture (including livestock production) represents an important share of greenhouse gas emissions of many developing countries.



Project manager speaking with nomad shepherds in the north – Afghanistan 1969

However, it is apparent from the country emission reports submitted to the UNFCCC (National Reports, UNFCCC) that mitigation still tends to focus on other sectors. This is probably because of the technical difficulties related to assessing and certifying agricultural and land use, land-use change and forestry (LULUCF) sectors. However, progress is being made, and the potential contribution is huge.

Using the clean development mechanism

Currently the Kyoto Protocol's main mechanism for creating "certified emissions reductions" (CERs) that can subsequently be traded on the carbon market is the clean development mechanism (CDM). The CDM is a facility by which developed countries can reduce net carbon emissions by promoting renewable energy, energy efficiency or carbon sequestration projects in developing countries, receiving CERs in return. The purpose of the CDM is to help developed countries meet their obligations under the Kyoto Protocol while promoting sustainable development in developing countries.

The critical element for the success of the CDM is the participation of a broad cross-section of buyers (ultimately from developed countries) and sellers (from developing countries) of CERs. Three broad categories of projects qualify for the CDM:

- renewable energy projects that will be alternatives to fossil fuel projects;
- sequestration projects that offset greenhouse gas emissions (these are mostly in the LULUCF area); and
- energy efficient projects that will decrease the emissions of greenhouse gases.

For LULUCF projects, only afforestation or reforestation initiatives are recognized as being permissible during the Kyoto Protocol's first commitment period (2008-2012).

A critical factor concerning CDM transactions is an active international market for CERs which requires partnerships between several agents, namely project developers, investors, independent auditors, national authorities in host and recipient countries, and the international agencies that are responsible for implementation of the Kyoto Protocol (Mendis and Openshaw, 2004).

Since the protocol's ratification in February 2005, a considerable number of projects have been registered.[2] These projects are mostly based on predefined methodologies. Established methodologies in the livestock sector concern only emissions from the industrial production sector: the recovery of methane (as a renewable energy source); and greenhouse gas mitigation from improved animal waste management systems in confined animal feeding operations.[3] Scope exists for other types of projects aiming at mitigation of livestock emissions through intensification of production. For example, improving rumen fermentation efficiency through the use of better quality feed could substantially reduce emissions from the huge Indian dairy sector (Sirohi and Michaelowa, 2004). For this, credit (through e.g. micro-finance institutions), effective marketing, the use of incentives and promotional campaigns are required for broad acceptance of related technologies (Sirohi and Michaelowa, 2004).

Further problems relate to the fact that current CDM projects cannot be used to effectively alter a country's emission profile (Salter, 2004). A number of renewable energy projects would have major shortcomings, especially in terms of failure to demonstrate "additionality" and deliver added environmental and social benefits (Additionality refers to the situation where a project results in emission reductions over and above those that would have taken place - in the absence of the project). Defining what constitutes a baseline (the existing or projected greenhouse gas emissions in the absence of the project) is also problematic.

Seedlings being planted in an arid area for dune fixation. These activities form part of the rural forestry development project in the fight against desertification – Senegal 1999

Afforestation or reforestation (A/R) initiatives are the only land-use change projects that are currently eligible. However, they offer great potential for mitigating livestock's footprint on climate change by returning marginal, or degraded pastures, back to forest. Other potential methods that could significantly reduce emissions, but do not yet qualify for eligibility include: forms of pasture improvement, such as silvo-pastoral land use, reduced grazing pasture and technical improvements.

Promoting soil carbon sequestration

The effects of "leakage" may substantially raise the costs of carbon sequestration (Richards, 2004). "Leakage" occurs when the effects of a programme or project lead to a countervailing response beyond the boundary of the programme or project. This problem arises from two basic facts. First, land can be shifted back and forth between various forestry and agriculture uses. Second, the overall balance of activities on land will depend on the relative prices in the agriculture and forestry sectors. This is because individual projects and programmes do little to change prices or the resulting demand for land. For example, if forest land is preserved

[2] A list of registered projects and be found at http://cdm.unfccc.int/Projects/registered.html

[3] Methane recovery: http://cdm.unfccc.int/methodologies/DB/03E6PSPYME3LMKPM6QS6611K70A08F/view.html
Waste management: http://cdm.unfccc.int/methodologies/DB/3CQ19TPGO0FCG2XT08CP18P446L8SB/view.html

from harvest and conversion in one location, the unchanged demand for agricultural land and forest products could lead to increased forest clearing and conversion in another region. Thus, the effects of the preservation may be partially or entirely undone by the leakage. Similarly, if agricultural land is converted to forest stands, the underlying demand for agricultural land may simply cause other forested land to be converted back to agriculture.

Carbon sequestration programmes require different policy instruments than for carbon emissions control programmes (Richards, 2004). If carbon sequestration is either subsidized or used as an offset against carbon taxes or tradable allowances, then it will have quite a different effect on the system of public finance than an emissions control mechanism. In general, those instruments that require revenue-raising, such as subsidies and contracts, have a higher social cost than those that raise revenue, such as tradable allowances and emissions taxes.

Carbon sequestration activities require careful evaluation of the role to be played by government, to assess whether a pure market approach may be preferable to options under which the government retains more control over the type and manner of projects undertaken. One issue is the measurability and uncertainty of project outcomes. Another important point is the government's ability to credibly commit to maintaining incentives over long periods. Moreover, a carbon sequestration programme is likely to pursue multiple goals that may include erosion control, habitat provision, timber supply, and recreational enhancement. Thus, the goals of a sequestration programme are likely both to be difficult to measure and to shift over time. Similarly, Teixeira *et al*. (2006) suggest that a successful development of A/R projects in Brazil may require national policy involvement and regulatory action in addition to purely market oriented tools.

The potential for incremental accumulation of organic carbon in soils is huge and adapting extensive livestock systems is the key to unlocking this potential. Technical options to revert pasture degradation and sequester carbon, particularly in the soil by building up organic matter in the ground, exist and current pastures are probably the largest potential carbon sink available (see Chapter 3).

However, the same issues described above for A/R activities also apply here, e.g. "leakage", the pursuing of multiple goals, sustained government commitment, etc. The benefits accrue over a period of decades, in many cases peak carbon uptake rates occur only after 20-40 years. Landowners who make these investments will no doubt want to know whether the government will still be rewarding carbon sequestration long into the future when their activities come to fruition. Government needs to be able to make credible commitments to provide stable incentives over long periods.

While currently not eligible under the CDM, a most serious effort needs to be made to allow for certified emissions reductions from rehabilitation of degraded land and sustainable management of existing forest, be it under the CDM or in a different framework.

The potential benefits of improved soil carbon management are considerable and increase with scale. They include the:

- global level, climate change mitigation and enhanced biodiversity;
- national level, increased possibilities for tourism and enhanced agricultural sustainability and food supply; and
- local level, enhanced resource base for future generations and increased crop, timber and livestock yields (FAO, 2004b).

In the context of poorer developing countries, smallholders are a key group both in achieving the necessary scale, and in achieving developmental as well as environmental goals. In the absence of policy interventions and external financial support, smallholders use improved management practices at individually optimal levels but at socially suboptimal levels. On the basis of case studies, FAO (2004b) concludes that substantial funds from development organizations or carbon investors will be needed if soil carbon sequestration projects in dryland small-scale farming systems are to become a reality. The expected benefits are probably insufficient, without outside funding, to compensate farmers for costs occurring at the local level.

In addition to these purely economic calculations, there is an ethical concern. Expecting local smallholders to adopt management practices, at socially and globally optimal levels, implies that they subsidize the rest of society in their respective countries as well as global society. If sustainable agriculture, environmental restoration, and poverty alleviation are to be targeted simultaneously on a large-scale and over a longer period, then a more flexible and adaptive management and policy approach is needed. It should generate possibilities to strengthen farmers' own strategies for dealing with uncertainty while providing the necessary incentives.

Participatory approaches should be used. A long-term and large-scale carbon sequestration programme that might include several thousand individual smallholders is unlikely to succeed if all programme decisions are taken following an interventionist, top-down approach. This is likely to disillusion local farmers and increase the risk they will opt out of agreements. A first important step towards institutional integration is to identify already existing local and/or regional institutions that might be best suited to function as a vehicle for an anticipated carbon sequestration programme. In addition to being trusted by the majority of smallholders, such institutions should be able and willing to participate in the design of a local/regional programme; ensure the necessary participation of a large body of smallholders; guarantee a fair distribution of costs; coordinate monitoring and verification and channel eventual benefits in desirable and equitable ways (Tschakert and Tappan, 2004).

Soil carbon sequestration activities were not included as part of CDM in the first commitment period because of their complexity. However, they have great potential and they are among the goals of all major global environmental conventions - not only the Framework Convention on Climate Change, but also the Convention on Combating Desertification and the Convention on Biodiversity. There are a number of important alternative funding opportunities that could potentially be used to help implement carbon sequestration programmes: the BioCarbon Fund, the Global Environment Facility, the Adaptation Fund and the Prototype Carbon Fund (FAO, 2004b).

Substantial funds will be needed for soil carbon sequestration activities and the booming carbon or CER market may be a potential source. CER is one of the world's fastest-growing markets - some analysts project that it may be worth as much as US$40 billion dollars annually by the end of this decade . In 2004, the global volume of trade in CO_2 was only 94 million tonnes. In 2005, it rose to 800 million tonnes. In January 2006 alone, just among European players, the figure was more than 262 million tonnes for spot trading. When the Kyoto Protocol entered into force, a tonne of CO_2 sold for US$8-9 on the spot market. One year later, a tonne was changing hands at more than US$31.

6.1.4 Policy issues in water

Improving water efficiency is a critical objective as water resources become more scarce. From a technical viewpoint, improving the efficiency of water use refers to a reduction in losses. From an economic viewpoint it means increasing net returns to users while taking into account the externalities. Increasing water efficiency may mean some sectors give up water to other sectors where it has higher value uses. In some areas, this will lead to the preferential development of certain types of agricultural activities (Norton, 2003) and may reduce the output of the livestock sector.

Policies endeavoring to improve the efficiency of water use should focus on the adoption of appropriate water-efficient technologies, together with the management of water demand, in order to facilitate the use of water resources by the most water productive activities. This allocative efficiency can be achieved through the development of appropriate institutions governing water allocation, water rights, and water quality (Rosegrant, Cai and Cline, 2002). It is essential to include equity objectives in these policies, to distribute water equitably among the different actors so that no one will be deprived of access to this vital resource. Even if this objective is usually clearly mentioned in most policy frameworks, in reality it is often neglected (Norton, 2003).

Multiple policy instruments need to be included in water conservation policies. The appropriate mix of water policy instruments, water management reform and institutional arrangements have to be adapted to national and local conditions. Instruments will vary depending on the level of development, the agro-climatic conditions, the level of water scarcity, agricultural intensification and competition over access to water resources.

Voluntary participation should be the preferred strategy used; though coercion should be an available option (Napier, 2000). The implementation of adapted policy and technical options takes time, demands political commitment and finances (Rosegrant, Cai and Cline, 2002; Kallis and Butler, 2001).

Getting water pricing right

The fundamental role of prices is to help allocate resources among competing uses, users and time periods (Ward and Michelsen, 2002) and to encourage efficient use by users.

In practice, water for agriculture is, in many cases, provided free (representing a 100 percent subsidy) and even in countries where pricing systems have been instituted, water remains greatly under-priced (Norton, 2003). In many cases the introduction of water pricing, or attempts at reforming water prices, have stemmed from financial crisis, or pressure on government budgets, low recovery of costs, deteriorating infrastructure and increasing water demand (Bosworth *et al.*, 2002).

The general principles for water pricing have been set out by the Global Water Partnership (Rogers, Bhatia and Huber, 1998). In setting water prices, effluent charges, and incentives for pollution control, it is important to estimate the full cost of water used in a particular sector. This involves considering the following components (see Figure 6.2):

a) full supply cost (operation and maintenance and capital investment);
b) full economic cost (full supply costs plus the opportunity costs and economic externalities); and
c) full costs (full economic cost plus environmental externalities).

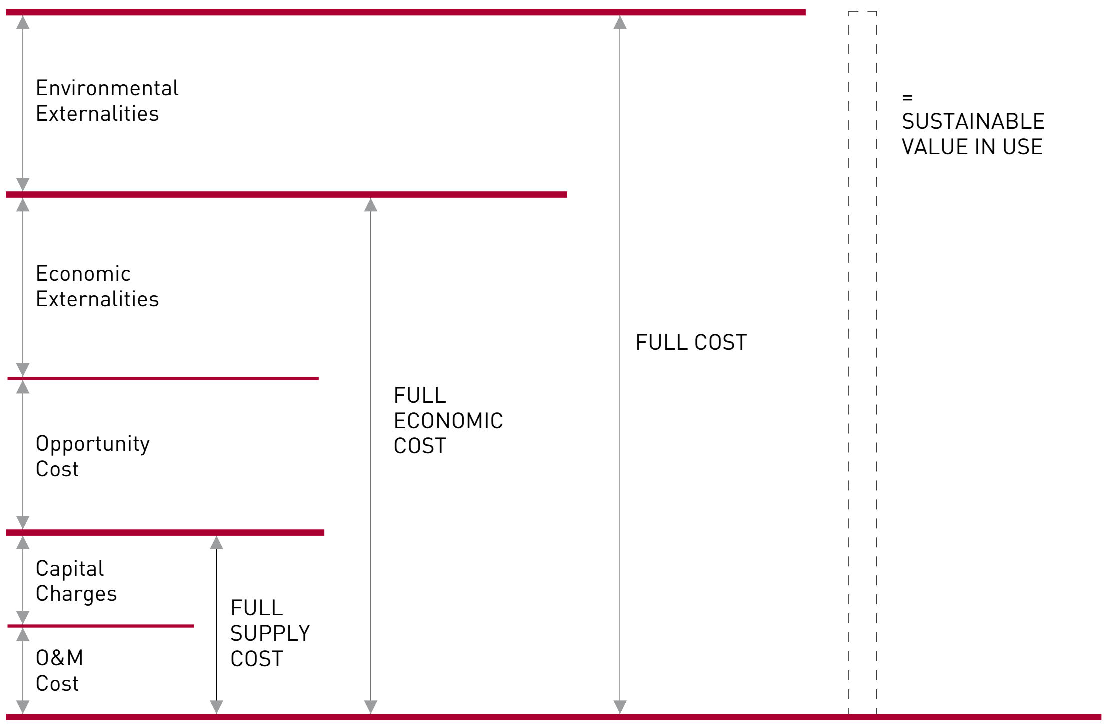
Prices should signal the true scarcity to users of water and the cost of providing the service; they should provide incentives for more efficient water use and provide service providers and investors with information on the real demand for any needed extension of water services. (Johansson, 2000; Bosworth *et al.*, 2002; Small and Carruthers, 1991).

Through measures, such as pollution charges and water pricing to encourage conservation and improved efficiency, pricing can serve as a means to ensure that actors internalize the environmental externalities that may arise from agricultural activities (Johansson, 2000; Bosworth *et al.*, 2002; Small and Carruthers, 1991). Adequate pricing can significantly reduce water withdrawals and consumption by agriculture, industry and households. Increasing water prices from the low levels prevailing in most countries can generate substantial water savings because of the high amount of water used in irrigation (Rosegrant, Cai and Cline, 2002).

Methods of water pricing

Water pricing methods include volumetric, non-volumetric, and market-based methods (Bosworth *et al.*, 2002; Johansson, 2000, Perry *et al.*, 1997; Small and Carruthers, 1991).

Figure 6.2 General principles for pricing water



Source: Rogers, Bhatia and Huber (1998).

Volumetric water pricing methods charge for water per unit of volume consumed. Volumetric water pricing is appropriate where the objective is to reduce water demand in the agricultural sector as well as reallocate water to other sectors. Volumetric methods depend on objective measurement of water abstraction and are often difficult to implement in practice. Several proxy methods or quasi-volumetric-pricing systems have been developed based on time of delivery, abstraction licences and block-rate/tiered volumetric methods.

Non-volumetric methods in agriculture can be based on agricultural outputs or area irrigated (Bosworth *et al*., 2002; Johansson, 2000). These methods are usually used where the objective is cost recovery. Area-based pricing, where farmers pay a fixed price per unit of irrigated area, is the most common method of irrigation water pricing (Bosworth *et al*., 2002).

In developing countries, the objective of water pricing is mainly to recover costs, more specifically operation and maintenance costs. In China for example, individuals are only charged for the pumping of irrigation water. However, the result is that only 28 percent of costs are recovered, providing little incentive to adopt water saving technologies (Jin and Young, 2003). In contrast, in developed countries the objectives are diverse and integrate demand management as well as the internalization of environmental externalities.

Water prices may consist of two components: a fixed charge and a variable charge. The fixed charge is intended to give the service provider a reliable stream of revenue, while the variable charge provides the user with the incentive to use water efficiently. The fixed component may be based on various denominators such as crop, unit area, duration of delivery, irrigation method or water velocity. The variable price component is based on the volume of water actually consumed (World Bank, 1997).

Not surprisingly, water prices tend to be higher in regions where water scarcity is an issue (Bosworth *et al.*, 2002). In countries such as Argentina, Bangladesh, India, Italy, Japan, Mexico, Pakistan, Spain, the Syrian Arab Republic, Sudan, Turkey, New Zealand agriculture is charged a flat rate based on the above denominators, whereas in Australia, France, Tunisia, the United Kingdom, the United States and Yemen users pay a varying tariff based on the amount of agricultural water consumed. At the other end of the spectrum, in Israel, farmers are given a water allocation for which they are charged on an increasing block tariff, according to the percentage of the allocation used. For the first 50 percent farmers are charged US$0.18/$m^3$, for the next 30 percent US$0.22/$m^3$ and for the last 20 percent US$0.29/$m^3$ (Bosworth *et al.*, 2002).

A flat rate per hectare, based on the area irrigated or crop type - irrespective of the volume of water used - is unlikely to create any incentives for change. In a study on the effectiveness of pricing-based water policies in major irrigation districts in northern China (where water is charged at a flat rate on the basis of land area), Yang *et al.*, (2003) found that despite an increase in water charges, farmers' water-use did not change. Likewise, farmers in India and Pakistan and many other countries that pay area-based fees for water find their marginal cost of acquiring additional water to be zero - and therefore they have no incentive to economize on its use (Ahmed, 2000). Even where progressive block rates are being used, for example in Jordan, the progression of the prices and their levels are often too low to induce any change (Chohin-Koper, Rieu and Montginoul, 2003).

Handling difficulties in water pricing

Although volumetric methods represent an ideal approach to pricing of water, practical difficulties make them difficult to implement, especially

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Water pump for irrigation – India 1997

in developing countries where farms are often small and scattered (Rosegrant, Cai and Cline, 2002). Problems include the objective measurement of water consumed plus transaction costs associated with monitoring and enforcement. As a consequence, proxies for volume of water are being used, such as length of delivery, the number of times a crop is irrigated and the share of a variable water supply to which a farmer is entitled.

The difficulty with volumetric pricing, at the level of the individual user, is sometimes overcome by a wholesale approach, whereby water is delivered and sold in bulk to organized groups of farmers at points where measurement of volume is feasible. Such water user associations consist either of farmers in smaller organization units that are common in Asia, or are specialized formal irrigation organizations such as those in Mexico and the United States (Hearne, 1999). Volumetric allocations are also common in Australia, Brazil, France, Madagascar and Spain (Bosworth *et al.*, 2002; World Bank, 1999; Ahmed, 2000; Asad *et al.*, 1999).

The fact that operation and maintenance costs are not, or not fully recovered, amounts to a subsidy for the crop and livestock sectors. Countries' experiences with cost recovery have been mixed. In a comparative study of 22 countries (World Bank, 1997), irrigation operation and maintenance cost recovery in developing countries has been found to range from a low of 20-30 percent in India and Pakistan (where the state remains heavily involved in the operation of irrigation systems) to a high of about 75 percent in Madagascar (where the role of the government is much reduced in favour of water users' associations who have been given responsibility for managing the irrigation systems). In OECD countries, the recovery of costs is much higher with the majority of countries obtaining full cost recovery for operation and maintenance cost. Countries like Australia, France, Japan, Spain, and the Netherlands also recover full supply costs from users (OECD, 1999). In the United States, state laws limit the charges that irrigation districts can impose on farmers to no more than their cost. Consequently, water prices are set to cover only costs of delivery and maintenance (Wahl, 1997).

The widespread under-pricing of water is a form of subsidy. These subsidies take several forms, including the public provision of water for agriculture at no or low prices, the subsidization of irrigation equipment or of energy for pumping groundwater. The removal of these subsidies is of prime importance in order to encourage efficient water use.

Agriculture generally enjoys subsidized water and is charged lower prices than industrial and domestic users. China, in pursuit of its objective of grain self-sufficiency, is stimulating grain production through the use of lower water charges for grain crops relative to other crops (Von Dörte Ehrensperger, 2004). In the United States, it was found that farmers pay as little as 1-5 cents per cubic metre while households pay 30-80 cents (Pimentel *et al.*, 2004). In Gujarat, India, electricity charges for groundwater pumping are subsidized - the charges paid by farmers for electricity are based on the capacity and not for the power used (Kumar and Singh, 2001). This amounts to a subsidy for water use and has contributed to water depletion and decline of the water table. Similarly, in France irrigation farming is on the increase, in part attributed to programmes that offer subsidies to farmers who invest in new irrigation equipment (OECD, 1999).

Subsidized development of boreholes in sub-Saharan Africa (mainly by development projects) has resulted in some places in the depletion of groundwater resources. In Namibia, for example, the provision of free water for livestock has resulted in water depletion, desertification and land degradation (Byers, 1997). Borehole development, the extensive use of groundwater coupled with the provision of water from canals and pipelines have been major contributing factors.

In many countries water pricing is a politically sensitive issue, especially where the economy is dependent on irrigation, as for example in China, Egypt or Sudan (Ahmed, 2000; Yang *et al.*, 2003; Von Dörte Ehrensperger, 2004). Moreover, an increase of water prices to a level that can influence behaviour may conflict with other policy objectives, including smallholder competitiveness, poverty reduction or food self-sufficiency. Furthermore holders of water rights may perceive the imposition or increase of water prices as an expropriation of those rights, thus reducing the value of their land (Rosegrant and Binswanger, 1994).

Creating the regulatory framework for water management

Regulations are often used to control pollution resulting from livestock activities or depletion of groundwater.

With water pollution, the establishment of water quality standards and control measures are central. While the use of uniform standards may simplify enforcement, smaller farms or enterprises may be unable to afford the costs of meeting the regulatory requirements or the waste treatment and relocation costs (FAO, 1999c). Hence standards can be defined locally or regionally, taking into account environmental and economic viewpoints as the marginal costs for technical adjustments may vary.

Regulatory mechanisms to control pollution can take a variety of forms:

- definition of minimum standards in order to reduce emissions and effluents to acceptable levels;
- specification of equipment to be used (effluent treatment) to meet the minimum standards;
- issuance of permits for the discharge of pollutants, which can also be traded. Tradable permits rely on payment-per-unit of pollution or the use of credits for reducing pollution. In that case market mechanisms are used to allocate pollution rights, once an acceptable overall level of pollution has been established; and
- specification of maximum industrial activity. For example, in livestock production systems limits may be placed on the number of livestock per hectare (FAO, 1999c).

These measures can be built into the codes that authorize access to water and regulate the water rights market (Norton, 2003). The establishment of penalties has to be done in a way that prevent their arbitrary removal by political edict. They should be of sufficient magnitude to act as effective disincentives to potential violators (Napier, 2000).

A set of criteria is used to monitor the impacts of livestock production systems on water quality and to set water quality standards for specific waterbodies. Parameters to be monitored to evaluate the impacts of livestock production systems include: sediment level; presence of nutrients (nitrogen, phosphorus and organic carbons); water temperature; dissolved oxygen level; pH level; pesticide levels; presence of heavy metals and drug residues; and levels of biological contaminants. The close monitoring of these parameters is a key element in evaluating compliance of production systems with defined standards and codes of practices. The European Commission proposes EU-wide emission controls and environmental quality standards for the substances and measures, its objective being the ultimate cessation, within 20 years, of emission of substances identified as hazardous (Kallis and Butler, 2001). Monitoring is costly and may represent a financial burden, especially in countries with limited monitoring capacities. Monitoring costs associated with the EU water framework directive was estimated at 350 million Euro for 1993 (Kallis and Butler, 2001).

Practices that pollute water resources are taxed in some places. For example in Belgium, wastewater from livestock production is either assimilated into domestic wastewater and taxed as such, or spread over agricultural land where it is subject to a special industrial tax (OECD, 1999). The EU water policy framework now includes a principle of "no direct discharge" to groundwater (Kallis and Butler, 2001).

Non-point source pollution is less easy to regulate. Codes of environmental practices and their enforcement are key elements in ensuring that agricultural activities that generate non-point source pollution would need prior authorization or registration based on binding rules (Kallis and Butler, 2001).

Extraction levels of groundwater resources are often regulated, especially in developed countries. Abstraction charges, especially within OECD countries, aim to control over-exploitation of groundwater resources. Countries where such charges are applied include Belgium, Bulgaria, Hungary, the Netherlands (Roth, 2001) and Jordan (Chohin-Koper *et al.*, 2003).

The extent to which groundwater protection policies have been effective is uncertain. Examples of policy failures are numerous, and users often have the opportunity to bypass environmental regulations. For example in the Netherlands, although farmers are subject to a groundwater extraction tax for water supplied for livestock production, they can extract the groundwater themselves without being taxed. In Belgium, while most livestock farmers pay wastewater tax, exemptions are given for about half of the water they consume (OECD, 1999).

Developing water rights and water markets

The lack of well-defined property rights in water often leads to unsustainable and inefficient resource use. In several countries, water rights are not defined and usually groundwater belongs to those who own the overlying piece of land. Hence, there is no restriction on the amount of water pumped by an individual land owner. In other countries, such as China, ownership of water is with the state, a fact that limits private incentives to conserve or use resources efficiently.

The proper functioning of water markets requires that water rights are formally and legally defined. In developing countries, such as Egypt, Pakistan and Sudan, water rights are insecure and poorly implemented with tail-end farmers often having insufficient water while farmers at the head take too much. Informal water markets, based on customary rights, are found for example in India, Mexico, and Pakistan. They usually consist of farmers selling surplus water to neighbouring farms or towns (Johansson, 2000). For example in Gujarat, India, rich landowners have invested in diesel pumps and pipe distribution networks to sell water to other farmers with no such equipment (Kumar and Singh, 2001). The development of a specific institution that manages the distribution and allocation of the rights may be required for conflict resolution mechanisms, for prevention of monopoly power and for the general enforcement of rules (Norton, 2003; Tsur and Dinar, 2002).

The organization of formal water markets is relatively new (Norton, 2003). The development of a water market will allow farmers to make decisions on whether to continue farming or to sell their water rights to the highest bidder and then improve water use efficiency. Australia, Chile, Mexico and the western United States are commonly cited examples of countries where formal markets and tradable water rights are being used to manage water allocation. Communal irrigation systems with tradable water rights are found for example in Nepal (Small and Carruthers, 1991).

Water markets show some pecularities compared to other markets. Usually transactions occur within the same watershed and even within the same irrigation system. Therefore, buyers and sellers are limited in number and the initial condition for a healthy market is generally not fulfilled. In northern Gujarat, India, informal groundwater markets are widely developed; although demand is lacking. Farmers are able to sell their excess of water to neighbouring farmers. However, efficient water allocation through these informal markets has not been achieved, because of the large number of sellers as opposed to buyers and the lack of opportunity to transfer water to other sectors.

Different types of water rights can be defined to fit with the market that will be established. Water rights should include a number of characteristics such as: the types of rights granted (total diversion rights, consumptive use rights or non-consumptive use), their duration, the system of sharing among users (ranked by level of priority among the users - appropriation system - or proportional rights among users) and the kind of users (rights can be delegated to individuals, private companies or communities) (Norton, 2003).

It is often hard to establish the initial water rights required by the system, because of the high costs related to water holding and capturing, and because the supply may be subject to unexpected changes (Ward and Michelsen, 2002). The allocation of free initial water rights, based on the existing use or right over access to water, can prevent conflicts associated with raising water prices and setting non-uniform charges. Furthermore, it can endow poor households with a valuable asset (Thobani, 1997 in Norton 2003, Rosegrant, *et al.*, 2002). Rosegrant *et al.* (2002) suggest that one solution to prevent conflict over the water price/water rights policy would be to apply a fixed base charge to an initial water rights baseline. For demand greater than the baseline an efficiency price equal to the value of water in alternative uses would be charged. On the other hand, for consumption below the base right, the water user would be paid back by the institution or the association (Rosegrant, Cai and Cline, 2002).

Paying for environmental services

Practices that lead to the provision of environmental services, such as improved water quantity and quality, can be encouraged through payments to the providers. Schemes of payment for environmental services (PES) rely on the development of a market for environmental services that have previously not been priced.

In a watershed context, upstream actors can be considered service providers if their actions result in improved water quality or quantity, for which they are compensated by downstream users. PES schemes require a market where the beneficiaries of these services (downstream water users) buy them from upstream providers. Obviously, this needs to be based on established cause-effect relations between the upstream land use and the downstream water resource conditions (FAO, 2004d).

PES schemes related to water services are usually of local importance at watershed level, with users and providers geographically close to each other. This facilitates the implementation of water-related PES schemes because of reduced transaction costs and easy information flow among the economic agents (FAO, 2004d), when compared to other types of environmental services with more remote or abstract linkages (carbon sequestration, biodiversity protection).

PES schemes are a promising mechanism for improving the condition of water resources in watersheds. They can sensitize the local population to the value of natural resources, and improve the efficiency of the use and allocation of these resources. PES schemes can also be used to resolve conflicts and can economically reward vulnerable sectors which offer environmental services (FAO, 2004d).

Nevertheless, the development of PES schemes is still at an early stage and implementation faces formidable difficulties. First, it is difficult to establish the relationship between land use and water-related services, as often the providers and users are not well identified. Usually, PES schemes rely on external financial resources; however, the long-term sustainability of the mechanisms is often uncertain. Furthermore, the level of payment is often politically imposed and does not correspond to effective demand for services (FAO, 2004d).

A few countries have specific legal frameworks for PES at the national or regional levels. Most of the existing PES schemes, however, operate without a specific legal framework. Some service providers take advantage of this legal gap to establish property rights for land and natural resources (FAO, 2004d).

The construction of large dams is usually associated with arrangements to reduce or eliminate grazing in water catchment areas that are susceptible to erosion and sedimentation. An example is the western China development strategy, attempting to reduce soil and water erosion and siltation into the Yellow and Yangtze rivers, which restricts or bans grazing in affected catchment areas, and in most cases provides compensation (Filson, 2001).

Coordinating institutional frameworks and participatory management

Implementation of better policies requires an adequate institutional framework. Typically, water resources are managed by several government ministries and departments (agriculture, energy, environment), which results in a fragmented decision-making process and lack of coordination among the different institutions (Norton, 2003). Water is a simple resource but its use is highly complex: different uses, by different users, controlled by different institutions in one part of the water cycle, may affect uses by other users in another part of the cycle. Both a strong coordination and an integrated approach involving all institutions are essential. Full cooperation between the different governmental bodies is a prerequisite to strategic planning and water policy implementation.

The development of specialized institutions is a key element in achieving the goals of a water agenda (Napier, 2000). The need to develop flexible and efficient institutions to maximize benefits from water use is obviously a pressing issue for economic development in dry places (Ward and Michelsen, 2002). The three main institutional approaches related to water policies are administrative allocation (public management), user-based allocation systems, and water markets.

Decentralization of the management of water resources and the involvement of user associations is another key aspect in the reform of existing institutional frameworks. The EU water framework directive is now following this approach. The implementation of its different policy measures will be coordinated at a "river-basin district" level. EU member states have designated river basin authorities within their own territories, and in coordination with other states for international waters (Kallis and Butler, 2001).

Institutional reliance on water user associations has proved to be effective. It improves local accountability, provides a mechanism for conflict resolution, and facilitates flexibility in water allocation. Furthermore, the costs related to information management for improved water resources allocation are significantly reduced (Rosegrant, Cai and Cline, 2002). In addition, recovery of operation and maintenance costs is improved. For example, in Mexico, a 30 to 80 percent increase in recovery rates. In Madagascar (where water users' associations manage irrigation systems) recovery rates are at the relatively high level of 75 percent (World Bank, 1997), because the responsibility of managing the irrigation systems has been transferred to the water users' associations. In contrast, where government continues to exert control over irrigation systems, as in China, India and Pakistan cost recovery is usually very low.

However, the transfer of responsibility for irrigation management to users will not necessarily ensure full cost recovery. Despite a definite increase in the levels of cost recovery, revenues are often still insufficient to cover full supply costs because water tariffs are generally set too low. The success of the transfer of irrigation management to water user associations is also dependent on the existence of a legal and institutional framework such as establishment of water rights.

Participatory watershed management is a key element in improving performance in water resources. Many watershed development projects have failed, or have performed poorly, because they did not sufficiently integrate and understand the local constraints and needs of local people (Johnson *et al.*, 2002). They suggested technology options that were ecologically and economically incompatible with local farming systems. Moreover, the new techniques imposed were exacerbating erosion as the new structures were not managed properly. Participatory watershed management programmes help local people define the issues, set priorities, select appropriate technologies and policy options adapted to their local context, and help sensitize them for monitoring and evaluation requirements (Johnson *et al.*, 20002).

6.1.5 Policy issues in biodiversity

While biodiversity loss is accelerating, the societal response to the problem has been slow and inadequate. This is caused by a general lack of awareness of the role of biodiversity, the failure of markets to reflect its value and its character as a public good (Loreau and Oteng-Yeboah, 2006). It has been suggested that an intergovernmental mechanism akin to the IPCC should be established, to link the scientific community to policy making, since the Convention on Biological Diversity is not in a position to mobilize scientific expertise to inform governments (Loreau and Oteng-Yeboah, 2006).

The area of biodiversity is intrinsically more complex than other environmental concerns and it is probably here that the gap between science and policy is largest. However, the scientific understanding of biodiversity and its functions has greatly improved in recent years, which is reflected in shifting attention from the side of policy makers. The scope of biodiversity conservation has been broadened to include protected areas and increased protection outside the designated areas based on the fact that whole ecosystems and their services often cannot be conserved by focusing on protected areas alone. New ways of financing biodiversity conservation are being explored to find alternative sources of funding. These include grants or payments from the private sector, conservation trust funds, resource extraction fees, user fees and debt-for-nature swaps at the governmental level.

A novel mechanism for conservation of biodiversity is the payment for environmental services approach, introduced in Section 6.1.4. Payments for environmental services are based on the principle that biodiversity provides a number of economically significant services. Payments need to be made to those who protect biodiversity to ensure the continued provision of these services. The environmental services that have received most attention are watershed protection and carbon sequestration. Other services, such as maintenance of biodiversity and landscape beauty, are also receiving increased attention (Le Quesne and McNally, 2004). Access charges and entrance fees to protected areas are also a form of payment for environmental services, in this case, conservation of biodiversity. They are not new, but recent schemes allow revenues to be used outside the protected areas and also be returned to local communities to provide incentives for biodiversity conservation (Le Quesne and McNally, 2004).

Recruiting land owners as protectors of biodiversity

A major challenge for new conservation approaches lies in the fact that in most countries endangered species are considered a public good, while their habitats are often on private land. As a private commodity, land can be transformed and traded. Biodiversity conservation can take place on private land but this relies on the owner's willingness and the land's opportunity cost. The opportunity cost of biodiversity conservation is difficult to estimate since the value of biodiversity depends on biological resources and ecosystem services.

The biological resources are not fully identified (the total number of species on earth is still unknown) and information on population numbers and risk status is still missing. However, some progress has been made in the valuation of ecosystem services. According to Boyd *et al.* (1999) the cost of conserving habitat should be valued at the difference between the value of land in its highest and best private use, and its value when employed in ways compatible with conservation.

To deal with the issue of ownership, new approaches have been tried, with relatively good success (Boyd, Caballero and Simpson, 1999). Most of these innovative approaches have been tried in forestry and at the community level, they can also be applied to livestock production.

- The purchase of full property interests involves the transfer of land from an owner who might develop the land to a conservator who will not. In order to purchase the property, the conservator must at least be able to pay the property owner the value of the land in private ownership. This value is the net present value of the land in whatever future use may be made of it, which is its opportunity cost. One of the distinguishing characteristics of full property interest acquisitions is that the conservator must compensate the landowner for the lost value of current financially productive land uses, as well as for the foregone opportunity of future conversion to more profitable use.
- Conservation easements are a contractual agreement between a landowner and a conservator. In exchange for payment (or as a donation that can be tax deductible) a land-

owner agrees to extinguish their rights to future land development. This agreement is monitored and enforced by the conservator, which may be a private conservation organization or governmental entity. Easements are often referred to as "partial interests" in land because they do not transfer the property itself to the conservator, merely the right to enforce prohibitions against future development.

- Another way to keep land out of development is for the government to give tax credits or other subsidies equal to the difference in value between developed and un-developed uses. For instance, if developed land earns US$100 more per acre than it does in low-intensity farming, a tax credit of US$100 per acre compensates the property owner for not developing the land. The subsidy is a cost borne by taxpayers.
- Tradable development rights imply a restriction on the amount of land that can be developed in a given area. Suppose, for instance, that the government seeks to restrict development by 50 percent in an area. It can do so by awarding each landowner the right to develop only 50 percent of their acreage. These development rights can then be traded. Tradable development rights impose costs on the landowners who have their development rights restricted. The aggregate opportunity cost is, as always, the value of development that is foregone in order to achieve the conservation goal. Though rights will be traded, the initial restriction of development opportunities imposes a cost on landowners. A tradable rights system has one particular advantage. Because property owners can, in effect, choose amongst themselves where development will ultimately be restricted, it leads to the least-cost development restrictions. In other words, development will be most restricted on those properties where the expected value of development is least.

Managing livestock and landscape for biodiversity conservation

Urban development causes major damage, stress and disturbance to ecosystems. McDonnell *et al.* (1997) studied ecosystem processes along an urban to rural gradient and found a cause and effect relationship, between the physical and chemical environment along the gradient and changes in forest community structure and ecosystem processes.

Livestock production is often structured along the urban to rural gradient, with industrial production systems in the peri-urban areas, feed-crops and mixed farming in rural areas, and extensive systems in the interface with wild habitats. This distribution, common in most countries, often places ruminant production in direct confrontation with wildlife and habitats.

In developed countries this interface is characterized mostly by wealthy or resource-rich farmers, operating under legislation for environmental protection, which is mostly enforced. In developing countries the interface is characterized by wide range stretching from resource-rich farmers to subsistence livestock holdings and herders. Even where legislation for environmental protection exists, it is often poorly enforced, or not at all. It is not surprising then that the major impact of livestock production is on habitat change. Land-use changes modify habitats extensively and are an important driver of biodiversity losses.

Prevention of perturbations is often the major goal of ecosystem management; however, disturbance is a natural component of ecosystems, and promotes biodiversity and renewal (Sheffer *et al.*, 2001). Ecosystems are subject to gradual and unpredictable natural events and respond by returning to their previous stable state or by shifting to an alternative stable state. Studies on ecosystem shifting (Sheffer *et al.*, 2001) suggest that strategies for sustainable management of ecosystems should focus on maintaining resilience enabling an ecosystem to absorb natural disturbances without crossing a threshold to a different structure or function.

The current state of thinking prefers landscape-focused conservation over site-focused conservation, particularly as an option to retain biodiversity in human dominated landscapes (Tabarelli and Gascon, 2005). Based on biodiversity conservation in corridors, the fundamental nature of landscape-focused conservation is to engage both conservation needs and economic development, by finding mutually beneficial interventions that might not necessarily occur within the buffer zones of protected areas. This may include new protected areas to protect watersheds, landscape management adding value to tourism, and the use of tradable development rights and easements to promote development compatible with the movement of species between protected areas (Sanderson *et al*., 2003).

Conservation efforts then should go beyond the protected areas and buffer zones to include a wide mosaic of land uses with a variety of production goals and socio-economic conditions of land users at the landscape level.

The integration of livestock production into landscape management poses many challenges for all policy and decision-makers and requires a truly holistic approach. The major challenges from the conservation point of view would be:

- to maintain the resilience of the ecosystem by predicting, monitoring and managing gradually changing variables affecting resilience such as land use, nutrient stocks, soil properties and biomass of long-term persistent species (including livestock); rather than merely to control fluctuations (Sheffer *et al*., 2001);
- to sustain the functionality of the ecosystem its capacity to sustain the processes required for maintaining itself, developing, and responding dynamically to constant occurring environmental changes (Ibisch, Jennings and Kreft, 2005). This includes the capacity of the ecosystem to provide environmental services; and
- to foster conservation efforts for taxa or species outside the protected areas, and to include forms of livestock development (land use and management practices) that are compatible with the requirements of such taxa or species.

To fully integrate livestock into landscape management it is necessary to recognize the multiple functions of livestock at landscape level. Apart from production objectives, livestock production can have environmental objectives (carbon sequestration, watershed protection), and social and cultural objectives (recreation, aesthetics and natural heritage) that should also be recognized, in order to achieve sustainable production. Livestock production has been proposed as a landscape management tool mostly for natural pasture habitats (Bernués *et al*., 2005; Gibon, 2005; Hadjigeorgiou *et al*., 2005) as it can constitute a cost-effective instrument to modulate the dynamics of vegetation to maintain landscapes in protected areas and to prevent forest fires (Bernués *et al*., 2005).

For an effective integration of livestock production into landscape management, radical changes should take place in management practices and land uses at the farm level. Recent research is focusing on new practices in managing grasslands, to address the relationships between grassland production and non-production functions. Among the research topics are:

- how management affects short- and long-term changes in grassland species composition and production - aiming to discover the impact of reduced fertilizer application on animal nutrition and N balance and/or the possibility of sustaining species-rich vegetation;
- the role of pasture vegetation, management practices and grazing behaviour on natural vegetation and faunal diversity, in both marginal and intensive livestock production areas, in relation to biodiversity conservation; and

- the spatial organization and dynamics of plant–animal grazing interactions at a variety of scales - with a view to optimizing the management of grazed landscapes so as to balance diversity, heterogeneity and agricultural performance; and
- The production and feeding value of species-rich grasslands - with a view to their integration in livestock production (Gibon, 2005).

However, the most important topic in relation to biodiversity conservation will be the issue of intensification because of its affect upon habitat change.

Agricultural intensification and land abandonment have considerable effects on biodiversity. In the EU, the decline of over 200 threatened plant species has been attributed to abandonment. Of the 195 bird species of European conservation concern, 40 are threatened by agricultural intensification and over 80 by agricultural abandonment (Hadjigeorgiou *et al.*, 2005). In grasslands it has been well documented that changes in vegetation patterns and structure that cause losses of biodiversity can result both from intensification of livestock production with increased use of organic and mineral fertilizers, and from intense grazing pressure without fertilization. Abandoned or low-grazed pastures, by contrast, result in encroachment of shrubby vegetation, causing losses of biodiversity and an increased risk of fires.

The issues of intensification and extensification will need to be managed at the landscape level according to socio-economic and environmental conditions. The optimal approach will probably be a mixture of intensification on land area, extensive grazing and setting aside land for conservation structured along the gradient: farm - communal area - buffer zone - protected area.

The driving factors that should be addressed at the landscape level are degradation and shrinkage of common land, high livestock densities, lack of common property management and inequity in the distribution of watershed benefits. Intensification of livestock production can contribute to biodiversity conservation at the watershed level. This would include pasture development, multipurpose trees for fodder, fuel or timber and improvement of the genetic capacity of local breeds. It would be accompanied by payments for environmental services (biodiversity protection, carbon sequestration and water quality) and a rationing system for common property resources (e.g. grazing fees).

From the point of view of biodiversity conservation, perhaps the major challenge in incorporating livestock into landscape management is to integrate livestock producers into conservation efforts at the landscape level. From the land users' perspective, biodiversity conservation is often considered as an externality, as are the improvement of water quality and availability and carbon sequestration benefits. As such, land users do not take them into consideration in making their land-use decisions, thus reducing the likelihood that they will adopt practices that generate such benefits.

Biodiversity conservation also implies the preservation of species that may hinder livestock production. In Latin America for example, poisonous snakes and vampire bats are considered agricultural pests for cattle rearing - they are considered as biodiversity instead of biodiversity. Under landscape management, farmers should incorporate conservation goals into livestock production. This will entail diversification of production; adoption of good management practices such as reduction of fire, pesticides and mineral fertilizers; and maintenance of the functional connectivity between livestock and the wildlife uses through different land uses at the farm and landscape level. There are many technical possibilities for maintaining functional connectivity on farms. They include live fences, biological corridors, land set aside for conservation, protected areas inside farms and fencing of riparian forests. At the landscape level functional connectivity can be enhanced by wildlife corridors to connect protected areas and isolated patches of forests.

Policies are needed to guide the current opportunistic development process of livestock development at the landscape level for preservation of biodiversity. One of the main issues for the formulation of policies is that at landscape level, property boundaries do not correspond with ecological boundaries. The number of land owners and the mixed set of ownership types (public and private) ensure that individual owners' decisions have an affect upon the decisions of neighbouring land owners (Perrings and Touza-Montero, 2004). Enforcement, auditing and monitoring mechanisms and decision support tools should be embedded into the policy framework.

Regional policy trends and options for management of livestock/biodiversity interactions

In the **European Union** the current trend in grasslands is towards more extensive use of pastures, particularly in valuable ecosystems. Driven, among other things, by the need to reduce agricultural surpluses, by pressures from social concerns about animal welfare and by consumer preferences for organic farming, the EU Agri-environmental Regulation, in place since 1992, sets limits on application of fertilizers to grasslands and offers incentives for extensive use of sensitive areas and the maintenance of biodiversity and landscapes (Gibon, 2005).

In **Latin America**, where the deforestation of biodiversity-rich habitats is linked to extensive livestock production, intensification of land use should be a priority, through the use of pasture-legume mixtures or silvopastoral systems, combined with incentives for setting aside land for conservation, delineation of sensitive areas, payments for environmental services such as carbon sequestration and biodiversity conservation.

Africa is a mosaic ranging from well-developed landscapes to relatively unchanged habitats, with a wide diversity of land uses and interactions with biodiversity. A major impact of the changing landscape has been increasing competition for the finite resources among growing human populations, many of them desperately poor. As a consequence, the wildlife/livestock interface has become more conflicted in certain areas of Africa, although in others it is no longer an issue (Kock, 2005). In arid and semi-arid lands where wildlife, livestock and people interactions are intense, arable agriculture has expanded into marginal lands and open communal grazing lands (Mizutani *et al.*, 2005).

There is growing evidence that both cattle ranching and pastoralism can have positive impacts on biodiversity. Ranching can do so by intensification and consequent reduction of herd size, along with sustainable exploitation of wildlife resources. Pastoralism can do so by adjusting grazing patterns so as to provide dispersal zones for wildlife outside the protected areas (Kock, 2005). The challenge, at the landscape level, is to match land use with ecological processes, so as to exploit the temporal and spatial variation of key resources to allow wildlife and livestock production (Cumming, 2005). African grasslands in humid and subhumid zones are subject to strong economic incentives to develop intensive ranching and agriculture, mostly at the expense of wildlife. The reason is the large difference in profits and revenues between traditional livestock management and using the land to its full agricultural potential. From the viewpoint of biodiversity, extensification will bring the best opportunities for conservation; however this needs the right mix of regulations and incentives to find acceptance. Tradable development rights and conservation easement schemes may be required to compensate landowners for not developing their land (Norton-Griffiths, 1995).

In the grasslands of the **Commonwealth of Independent States**, problems have arisen of intensification close to villages in pastoral areas and of land abandonment in remote pastures. These linked problems derive from widespread poverty along with several trends in the livestock sector:

- concentration of animals in peri-urban environments;
- disruption of transhumance herding by official sedentarization policies and other factors;

- lack of infrastructure and access to markets in remote pastures;
- lack of appropriate technology for pasture management; and
- fragmentation and change in composition of livestock holdings.

Land leasing is currently too cheap and this does not encourage the livestock farmers to take care of the land and to move to more distant pastures. On the other hand, livestock keepers in remote pastures do not have access to services, and are not compensated for the environmental services they provide.

A key strategy to encourage pastoralists to move away from pastures near villages, back to remote pastures, may be the creation of a pasture fund based on revenues from land leasing, with additional support from payments for environmental services, especially carbon sequestration. The pasture fund could have differential leasing prices - higher near villages and lower in remote pastures. It could also reward livestock farmers who make sustainable use of the land and introduce good management practices, by reducing the leasing prices, while fining farmers who do the opposite, by increasing their leasing prices. The pasture fund would also support transhumance by providing livestock services along the migration routes. A small increase in taxes on water would generate additional revenues to support the pasture fund, given that livestock farmers help to sustain water services especially in hilly and mountainous areas (Rosales and Livinets, 2005).

In the semi-arid and arid-lands of **India**, livestock production plays a crucial role in the management and utilization of fragile ecosystems. Under these conditions, animal husbandry is the traditional and major source of livelihoods, while arable farming plays more of a complementary role. However, growing human and livestock populations, and the adoption of non-sustainable practices, have lead to a rapid depletion of natural resources (especially of common property), which is affecting the functions of entire watershed ecosystems. Reduced availability of natural resources has already seriously affected the poor, marginalized and landless people, especially women, who depend on these resources for maintenance of their livestock and their own livelihood.

Integrating protected areas and livestock management

Since 1950, areas designated as protected by national legislations have been growing at a fast pace all over the world (see Chapter 5). Despite this, the number of species at risk of extinction and the destruction of habitats have also risen. At the same time, livestock numbers have increased at a steady rate along with the growth of human populations. There is an urgent need to change livestock production and conservation approaches to lessen the impacts on biodiversity.

Current conservation efforts have been criticized for focusing on single species rather than on ecosystem functionality (Ibisch, Jennings and Kreft, 2005). Protected areas can be effective for pure conservation purposes. Although, their effectiveness in providing and maintaining a full range of ecosystem services is often very limited, since many protected areas are too small and spatially isolated (Pagiola, von Ritter and Bishop, 2004). Protected areas also suffer from inadequate legislation and management, lack of resources and insufficient stakeholder involvement (MEA, 2005b).

Where the primary objective of protected areas is to maximize conservation, the primary objective of livestock production is to maximize productivity and earnings. Experience shows that these two objectives are often mutually exclusive. Most of the conflict could be alleviated if the goals of livestock production were broadened to include ecosystem conservation, services and management, rather than only to produce food. Conflict would also be alleviated if biodiversity conservation goals were broadened to include preservation outside the protected areas while maintaining the functionality of natural ecosystems in an integrated mosaic with food production at the landscape level.

Service oriented grazing

Livestock production is an important source of foreign currency, providing over half of the value of global agricultural output and one-third in developing countries. It is also a key element in the fight against poverty as approximately one-quarter of the global poor (of whom 2.8 billion live on less than US$2 per day) are livestock keepers.

PES offer a way of combating poverty and simultaneously addressing many other critical socio-economic and environmental goals by:

- integrating livestock production, particularly of ruminants, with conservation goals;
- using livestock as a tool for landscape management; and
- recognizing the benefits of biodiversity conservation and carbon sequestration.

PES have been discussed in the preceding sections. In the case of biodiversity such schemes are more difficult because of difficulties in measuring and valuing biodiversity. However, the MEA (2005) shows that protected areas function best when benefits from biodiversity preservation can be captured by local people.

6.2 Policy options for addressing environmental pressure points

6.2.1 Controlling expansion into natural ecosystems

The expansion of pasture areas into natural ecosystems has essentially come to an end in most parts of the world, except for Latin America (in particular the central part of South America) and central Africa. In Latin America, many currently forested areas are attractive for cattle ranching. Indeed, currently 70 percent of previously forested land in the Amazon is occupied by pastures. This has important consequences for humid tropical ecosystems. In contrast, the presence of trypanosomiasis in the humid and subhumid parts of Africa continues to constrain a similar expansion. Here, arable land (such as shifting cultivation or fallow cultivation) is the predominant land use following deforestation. Only when the habitat has become unsuitable for the vector of trypanosomiasis, the tse-tse fly (*Glossina spp.*), as a result of human population increase and expansion of cropping, can grazing animals move into the cleared areas.

The main policy issue, with regard to pasture expansion and related deforestation, lies with land titling and land markets, and with the weaknesses in establishing and enforcing regulations in remote areas such as the Amazon. Here, livestock are often used as a tool to occupy land for speculative purposes. At the initial, speculative phase of deforestation, forests are cut down or burned and occupied with cattle, on the expectation that land titling will be granted at a later point on the basis of such occupancy. In these situations the incentive for efficient land use and good land management is weaker, and livestock-induced degradation is more likely to occur. Land titling, and related institutional capacity, need to be quickly expanded and upgraded to stem the loss of valuable resources.

However, deforestation for cattle ranching has proven to be profitable in itself, from a micro-

Table 6.1

Comparison of key technical parameters in the beef industry in the Amazon area of Brazil (1985-2003)

	1985	2003
Carrying capacity (AU/ha)	0.2–1	0.91
Fertility rate %	50–60	88
Calf Mortality %	15–20	3
Daily weight gain kg	0.30	0.45

Note: AU=Animal Unit is a standard to aggregate different classes of livestock, with adult bulls at 1 AU, cows at 0.7 AU , yearlings at 0.5 AU and calves at 0.2 AU.

Source: Margulis, 2004. Data from the entire North West Brazil in World Bank 1991 Brazil: Key Policy Issues in the Livestock Sector-Towards a Framework for Efficient and Sustainable Growth" Agricultural Operations Division, Report no 8570-BR Washington DC economic perspective, in areas where titling is consolidated (Margulis, 2004). This, in large part, is the result of major improvements in the technology used in cattle ranching that have occurred in past years as shown by Table 6.1.

Land speculation also plays a role. The fact that land is still, in some parts of the world, unreasonably cheap, encourages horizontal expansion and extensive use of such land, in particular in the humid tropics of Latin America. Driving up the cost of holding land, by making squatting more difficult, and by taxing land ownership (perhaps with a tax-free minimum) will encourage productivity increases and enhance environmental sustainability. Land taxes have shown considerable potential to drive land use towards higher productivity, thereby limiting its use for speculative purposes. The introduction of deforestation taxes also appears to be a suitable instrument if they can be imposed (Margulis, 2004).

Zoning can be an effective instrument if there are functioning institutional frameworks to assign and police land uses. In the case of valuable natural resources associated with land, creation of protected areas may often be the preferred strategy. Zoning may also include limits on the number and size of livestock permitted, based on the vulnerability of the land to soil degradation and erosion (FAO, 2006). However, because of weak institutions in most areas concerned, usually remote areas in developing countries, there are problems with enforcement of zoning and encroachment on protected areas. To improve compliance, land policies and rules need to be developed in harmony with the interests and needs of pastoralists and other livestock owners. However, as Margulis (2004) indicates, in view of its enhanced commercial attractiveness it will be difficult to stop the expansion of ranching altogether, but it could be directed towards less valuable ecosystems, thereby saving those that are of most value.

Infrastructure policies also play a role. As the presence of infrastructure, and the expectation of future infrastructure development, has been identified as a powerful determinant for land use (including conversion of forests into pastures), infrastructure development planning needs to take this into account. Caution should be exercised so as to open areas only when there are functioning authorities to control access, land titling, area protection and law enforcement.

Public research and extension can help in driving land use towards more productive and sustainable forms, by developing technical packages focusing on intensification, including improved pasture, intensified dairy or beef production and the inclusion of forests and silvo-pastoral land use on farms. Research (Murgueitio, 2004; Olea, Lopez-Bellido and Poblaciones, 2004) has shown that such forms of land use are profitable, particularly for small farms with a relative abundance of labour, and can generate significant environmental benefits.

An associated issue is the degradation of pasture in previously forested areas. A large part of tropical pastures (estimates range up to 50 percent) are seriously degraded, caused by unsuitable terrain (slopes), and high rainfall. Deforestation and the spontaneous establishment of pastures without any protective measures or improvements, leaves the soil exposed and subject to erosion. The ensuing degradation can be addressed by forms of silvo-pastoral land use that mimic the original vegetation to a certain extent (see Box 6.2).

PES schemes have the potential to provide incentives for land-use change; the problem is to make such schemes sustainable so that change becomes permanent. The most immediate option lies in payment for water services, as benefits in improved water flows and quality would directly benefit local communities downstream. Silvo-pastoral systems, in combination with other measures of water protection, considerably reduce runoff and sedimentation of reservoirs. Payments for carbon sequestration are another option, which will depend on the development of effective carbon markets (see

Box 6.2 Payment for environmental services in Central America

The Global Environmental Facility (GEF) and the World Bank support a regional project in Central America, which uses payment for environmental services, as a tool to promote the conversion of degraded pastures towards more complex vegetations, which increase carbon sequestration and enhance bio-diversity. The adopted methodology was designed to reduce transaction costs[1].

- Different vegetation units were ranked by an expert panel, on their contribution to carbon sequestration and bio-diversity;
- Using satellite technology, an inventory of the main vegetation units was made of each farm. On the basis of this inventory a baseline was established;
- Each year, changes in the different vegetation types were measured, and used as a proxy for the payment. The level of payment was based on the equivalent of US$5 per tonne of carbon. In the absence of a functioning market for bio-diversity, about the same level was, rather arbitrarily, set for this aspect; and
- The project design features supported the simplicity: Payment was on the basis of performance (ex-post), the farmers had to obtain their own sources of funding, thus avoiding complex rural credit schemes, all funding was channeled through NGOs.

About 200 farmers in six watersheds in three countries (Colombia, Costa Rica and Nicaragua) participate in this scheme. The results, after three years of operation are promising:

- The relationship between vegetation types and carbon sequestration and biodiversity enhancement was strong, showing that vegetation types can be used as a proxy for the measurement of environmental services;
- Ranchers reacted very positively to the incentives provided. A total of about 2 000 hectares were established with improved, deeper-rooting pastures and more trees, more than 850 km of living fence were established, which significantly improved the connectivity of the different habitats, and about 100 hectares in slopes were left in fallow to regenerate to secondary forest. The average payment per farm was about US$38/ha in the second year of operation; the average monitoring costs about US$4/ha;
- Poorer farmers found the resources for the required investments. A survey found that the poorer farmers received higher payments per hectares than the larger ranches; and
- The reaction of the public institutions was quite favourable. In Costa Rica, the government decided to include agroforestry (and this scheme) in its forest environmental service payment scheme, which is funded through fuel taxes and water charges. In Colombia the National Livestock Federation is negotiating international and national funding sources to up-scale this pilot operation.

The biggest challenge will be to further simplify the methodology and find the international funding sources, linked to carbon trading, which will enable the application of such payment schemes for areas such as the Amazon, to tip the balance from continuing expansion to intensification of production.

[1] See also FAO (2006) (available at www.fao.org/AG/AGAINFO/resources/documents/pol-briefs/03/EN/AGA04_EN_05.pdf).

Source: Pagiola, von Ritter and Bishop (2004).

Section 6.1.3). In some cases, new opportunities for payment schemes are arising, such as for Costa Rica, where part of the fuel tax is used for such purposes. Payments for biodiversity protection are, at present, mainly in the form of tourism revenues.

6.2.2 Limiting rangeland degradation

The expansion of pastures into natural habitats over the last two centuries has been driven by the quest for additional food and other resources for growing populations. As described in Chapter 2, when introducing the concept of the livestock transition, pasture expansion has reached its peak in most parts of the world, occupying areas that are, at best, marginally productive, which are, in many ways, unsuitable for sustained production. Growing demands for environmental services are starting to compete with traditional forms of low-output livestock production, leading to progressive abandonment of marginal pastures.

Degradation of rangeland, on both communal and private lands, is a pressing issue in many countries, including developed countries. Degradation of rangeland has important negative consequences for water resources and biodiversity and is an important source of greenhouse gases. These problems are particularly pronounced in areas where the livelihoods of many poor people depend on livestock, and on the common pasture that sustains them, and where alternative livelihood options (such as urban employment) are absent. These conditions are widespread in arid and semi-arid zones of sub-Saharan Africa, and parts of the Near East, South Asia and Central Asia (see Map 26, Annex 1).

Under common property regimes, overgrazing of common property resources is often caused by mobility restrictions. These arise from the expansion of rainfed cropping in key dry-season grazing areas for mobile systems, land privatization, fencing and establishment of irrigation schemes. Pastoralists require improved access management to pasture resources, including

Spontaneous regeneration of mountain vegetation after a four year ban on grazing and cutting down trees – 1996

regulations controlling grazing and stocking rates. A key characteristic of the dry areas is the extreme variability of the rainfall, and hence bio-mass production. Fixing livestock numbers under such extreme variability is, therefore, counterproductive. What is needed are strong institutions and infrastructure, in particular for livestock marketing, which can adapt livestock numbers to the prevailing climatic conditions and standing biomass. Therefore, grazing management becomes risk management.

However, to counter the degradation of common property resources, in particular grazing land, overall grazing pressure needs to be lowered. However, this is difficult to implement under common property regimes in the absence of a strong local, traditional or modern, authority. Because of the increasing fragility of traditional institutions in developing countries frequently a mix of traditional and modern authorities is needed to achieve the type of collective action required.

In many cases, compensation schemes are needed, or payment-for-services schemes where herders receive payments for improved water management, which benefits water supply or reduces siltation of dams. Similar forms of payment schemes, including benefit sharing, have been developed to facilitate the harmoni-

Box 6.3 Wildlife management areas and land-use planning in the United Republic of Tanzania

Pastoralism is the dominant land use and livelihood strategy in northern Tanzania, one of the world's richest remaining refuges for wildlife. If properly managed, nomadic pastoral livestock production is potentially the most environmentally compatible agricultural activity in this ecosystem.

One of the main threats to biodiversity in pastoral ecosystems is the breakdown of traditional adaptive and flexible management strategies developed by pastoral communities to optimize the use of temporally and spatially variable natural resources. The spontaneous spread of agriculture throughout this semi-arid ecosystem, by both settled pastoralists and external agents, has resulted in habitat change and truncation of important ecosystems.

If returns from wildlife could be shared with pastoral households this could stem the expansion of crop cultivation. Currently, pastoralists bear most of the costs of wildlife in the form of predation and competition for grazing and water, but do not gain any of the potential substantial benefits. What is required is the integration of sound wildlife management with wildlife-compatible land use by pastoralists.

The Government of the United Republic of Tanzania has established a series of policies to improve the distribution of the benefits generated by wildlife to affected communities and to carefully plan the use of the common resources to protect the interest of the three main stakeholders i.e.: wildlife, croppers and herders. In this regard, the wildlife policy established in Tanzania in 1998 called for the creation of wildlife management areas (WMAs). WMAs give local communities some control over wildlife resources on their lands and enable them to benefit directly from these resources. When WMA are established, communities may lease trophy hunting or game viewing concessions to tourism operators or engage themselves in hunting. At the same time, the WMA policy, the National Land Policy and Land Act (1999) and Village Land Act (1999) promote village land-use plans to ensure the appropriate management of communal land.

The LEAD-GEF project entitled "Novel forms of livestock and wildlife integration adjacent to protected areas in Africa" is supporting the evolution of community-based natural resource management in Tanzania. This project implemented in six villages in the Simanjiro and Monduli districts includes the development and implementation of participatory land-use planning and WMAs; the design and the implementation of benefit sharing mechanisms to increase returns from integrated wildlife and livestock production systems including the development of conservation business ventures with private partners; and the development of decision support tools in order to strengthen sustainable resource access and management.

Source: FAO (2003c).

ous co-existence of wildlife and livestock in sub-Saharan Africa, some of which have been pioneered by the LEAD-Initiative (see Box 6.3).

Maintaining animals on communal land is economically attractive even if returns are low as long as costs are minimal; this results in overstocking. If priced appropriately, grazing fees and other forms of costs related to the number or units of animal grazed on communal grazing land will encourage herders to limit grazing pressure, by taking out unproductive animals and by de-stocking early. For example, such a grazing fee is common practice in Morocco. Such grazing fees could also be progressive, with higher fees paid for larger herds. Similarly, making grazing rights tradable could establish market mechanisms for resource use, which is particularly important when pastures are under temporary (drought) or permanent pressure. While these are potentially viable options, control and enforcement is a common problem.

Mobility is a key management requirement in many arid areas with highly variable rainfall, and limitations of mobility have been identified as a key determinant in resource degradation (Behnke, 1997), because they concentrate grazing pressure over-proportionally in certain areas. Where such limitations exist, institutional arrangements must be found for passage agreements to allow pastoralists to balance out grazing resources. This is becoming increasingly difficult as both rainfed and irrigated agriculture encroach into previous pastoralists' areas. Public institutions have a role to play in helping herders de-stock early in the case of drought, if necessary also in the form of market interventions. Early destocking can reduce environmental damage and vegetation recovers more quickly when the drought is over. Subsidies that would enable early destocking have been used in some places, such as in Morocco.

In high-income countries, and where there is widespread degradation of state-owned land leased out to individual farmers, such as in western Australia or in the western United States, there is a strong pressure to convert these marginal lands back to their original state. In the light of the small contribution that these areas make to overall livestock supply, and the growing demands for other uses such as recreation or environmental services for these areas, this is a real possibility in the long term.

While important to the livelihoods of millions of pastoralists and ranchers, extensive grazing areas occupy immense lands with sometimes devastating environmental consequences, but contribute little to overall food supply. With growing resource pressure and demand for environmental services, there will be increasing pressure to take these areas out of production. It will fall upon public policies to develop a way out for the people concerned, and to find alternative income and employment outside the extensive livestock sector. For those who remain, practices need to change in line with the growing and differentiating demand for these land resources hitherto considered of little value. The potential of dry lands to provide environmental services such as water protection, biodiversity conservation and carbon sequestration will easily offset the values currently generated through livestock production, if effective markets can operate.

Water is a critical resource in extensive livestock production, and is often supplied through public infrastructure and without charge, under policies that are driven mainly by social considerations. Yet often the infrastructure cannot be maintained. Cost recovery for water provision and forms of more appropriate water pricing will allow maintenance and improvement of infrastructure, and will also lead to more efficient water use, and better allocation of water among competing agricultural and non-agricultural uses. Full cost recovery needs to be applied, both for grazing under common property regimes and for private ownership.

Resource costs, price distortions and externalities vary among livestock products. Beef has been identified as carrying the largest costs in terms of land and water requirements for its production, as well as in terms of contribution to climate change. It can, therefore, be argued that relative to other forms of animal protein, beef carries the largest externalities and benefits most from price distortions. Since immediate changes in land and water prices for its production may be difficult to implement, governments may consider the option of taxing beef. Demand for beef would then decline relative to other meats, and the pressure on both extensive grazing resources and feedgrain areas would be reduced.

6.2.3 Reducing nutrient loading in livestock concentration areas

Another facet of the livestock transition is the ongoing concentration of livestock in specific favoured locations, such as those offering easy access to urban markets, or close to feed supplies. The separation of livestock production and the growing of feed crops is a defining characteristic of the industrialization of livestock production (Naylor *et al.*, 2005).

Nutrient loading is caused by high animal densities, particularly on the periphery of cities, and by inadequate animal waste treatment. Issues of nutrient loading are present in developed countries, but they are particularly pronounced in emerging economies with rapid industrialization of the livestock sector, such as Brazil, China, Mexico, the Philippines and Thailand. Map 4.1 (Chapter 4) gives a regional overview of areas facing such nutrient loading for Asia. Other affected areas mainly include coastal areas in Europe, Latin America and North America; also some inland areas such as parts of Brazil and the midwest of the United States.

Major forms of pollution, associated with manure management in intensive livestock production, were described in Chapter 4. They include (FAO, 2005e):

- eutrophication of surface water, killing fish and other aquatic life;
- leaching of nitrates and pathogens into groundwater, threatening drinking-water supplies;
- build up of excess nutrients and heavy metals in the soil, damaging soil fertility;
- contamination of soil and water resources with pathogens; and
- release of ammonia, methane and other gases into the air.

Policies to address the issue of nutrient loading include instruments to influence the spatial distribution of livestock, so as to avoid excess concentration, reduce waste per unit of output, by increasing production efficiency and regulation of waste management (FAO, 2005e).

The LEAD-Initiative has conducted a variety of studies and programmes (Tran Thi Dan, 2003) targeted at better geographic distribution, in what has been called area-wide integration of specialized crop and livestock activities. These efforts aim to re-connect nutrient flows from crop and livestock activities in a watershed context, for example by recycling manure on cropland, as these activities become increasingly disconnected with specialization and economies of scale. This takes into account that, where economic pressure makes family-based mixed farming unviable, one should still seek placing specialized livestock in a rural cropping context, to avoid nutrient loading (in livestock producing areas) and nutrient depletion (in crop producing areas) that would occur otherwise. Better geographic distribution can be achieved by a variety of policy tools that can, and often need to, be combined. In developing countries, there will often be a need for investment in rural infrastructure (roads, electricity, slaughterhouses) to make rural areas attractive to large-scale livestock producers.

Zoning regulations and taxes can be used, for example, to discourage large concentrations of intensive production close to cities and far from cropland where nutrients could be recycled. In Thailand, high taxes were levied on poultry and pig production within a 100 kilometre radius of Bangkok, while areas further away enjoyed tax free status. This led to many new production units being established away from the major consumption centre. Improving the spatial distribution creates opportunities for waste recycling on land, which can simultaneously increase farm profits and reduce pollution (Gerber and Steinfeld, 2006). In the Netherlands, tradable manure quotas have been practiced until recently, so as to keep a ceiling on overall livestock density while providing a market mechanism to encourage efficiency.

Decision-support tools exist to assist policymakers in designating zoning policies, taking into account environmental objectives and social and animal health considerations, while keeping in mind producers' requirements to operate profitably (Gerber *et al.*, 2006). This allows intensive production to be kept away from protected areas, human settlements, and surface water, and to be directed where there is arable land with a demand for nutrients, or where waste management is less of an environmental burden. Likewise, given that industrial livestock is a dynamic industry, which has become footloose with industrialization (Naylor *et al*, 2005) and moves where returns are most profitable. "Preferred zones" can, therefore, be designated so as to provide a growth stimulus to areas where this is lacking. Zoning is a particularly suitable instrument for the establishment of new operations, i.e. in areas with livestock sector growth; resettlement of already established farms has shown to be quite cumbersome. There is usually a need to combine zoning policies with licensing or certification schemes, so as to oblige operators to comply with environmental and other regulations before starting operations. Environmental licensing relies on nutrient management plans as an essential ingredient, which can be supported by appropriate models (for example LEAD, 2002).

Zoning is quite demanding in terms of institutional enforcement. It is usually combined with regulatory frameworks that include emissions standards for nutrients, biological oxygen demand, and pathogens; regulation of waste application (time, method, quantities); and regulations for feeding (use of antibiotics, copper, heavy metals, other feed quality). Regulations may vary by zone, and they may be more lenient where environmental problems are less pronounced. They may also be accompanied by training and extension programmes to acquaint farmers with the required knowledge and technologies.

A wide variety of management options exist to address pollution at various stages. Public policies need to encourage options that have been demonstrated to reduce nutrient loads and their environmental impact. These technical options were examined on Chapter 4 and include:

- manure separation and storage;
- lining of effluent ponds;
- provision of extra capacity to avoid overflows;
- optimizing land application of manure;
- close monitoring of nutrient flows;
- minimization of cleaning and cooling water;
- reduction of metal, antibiotic and hormone additives in feeds;
- optimal balancing of nutrients and improving feed conversion with enzymes and synthetic amino-acids; and
- biogas generation (which also reduces greenhouse gas emissions).

Such practices can be compiled into codes of conduct, as part of voluntary programmes, certification schemes or regulatory frameworks (see Box 6.4). Their application can also be facilitated through subsidy schemes, particularly for early adopters or when the adoption of these technologies requires investments, as is the case in many countries for biogas digesters. To capture the economies of scale in waste management, local authorities may encourage producers to form waste management groups and provide them with access to extension and training. Close monitoring of nutrient flows is crucial to nutrient management and enforcement of regulations.

The enforcement of environmental regulations to encourage or require adoption of advanced waste management technologies will affect production costs and competitiveness of farms to varying extents. Gerber (2006), modelling the costs of complying with environmental regulations for intensive livestock production in Thailand, found that profit reductions were limited (up to 5 percent) for farms with adequate access to land for waste application and advanced manure management technology. For those with no access to such land, profit reductions were higher, typically greater than 15 percent. This implies that differences in costs of compliance are likely to have an impact on where farms are located and, hence, on the geographical distribution of livestock.

6.2.4 Lessening the environmental impact of intensive feedcrop production

With 33 percent of all arable land dedicated to the production of feedcrops, livestock have an important environmental impact associated with

Box 6.4 Examples of successful management of livestock waste production from intensive agriculture

BELGIUM: LIVESTOCK WASTE MANAGEMENT STARTS AT THE FRONT AND NOT AT THE BACK OF THE ANIMAL

The government of the Flemish part of Belgium introduced a three-track strategy to reduce the excess of 36 million kg phosphate and 66 million kg nitrogen discharged in its soil and water. It consisted of (a) reducing livestock numbers and reducing nutrient intake by providing low-protein and phosphate feeds. The latter was introduced on the basis of a voluntary agreement between the government and the feed miller association, (b) manure processing and export, and (c) improving manure management. It was expected that the first two would reduce the phosphate surplus each by 25 percent, and that improved manure management by half. However, by 2003, when the P_2O_5 surplus was reduced to 6 million kg, measure (a) had contributed with 21 million kg (of which 13 million kg from improved feed technology, whereas (b) and (c) together had contributed only 7.5 million kg. The total reduction of 41 million kg, of nitrogen, 11 million was the result of low protein diets, demonstrating the potential optimal rationing of N and P in reducing nutrient loading.

Source: Mestbank (2004).

THE NETHERLANDS: LINKING ENVIRONMENT AND COMMERCE – INTRODUCING A MANURE QUOTA SYSTEM

A system of manure production quotas was established in the Netherlands in 1986. The quota was based on historical standard manure production amounts per animal. Farmers were allocated a manure production quota, expressed in kg P_2O_5. The manure production rights were made tradable in 1994, and supported by a mineral accounting system, and strict regulations on application techniques. Despite its significant administrative burden, and high cost to intensive livestock farms, the results are impressive, as the loading of the soil with N and P decreased substantially over time. Reduced application of mineral fertilizer also contributed to that. Between 1998 and 2002, the net loading of the soil decreased by 169 million kg per year for N and by 18 million kg per year for P. The net loading of the soil decreased by about 0.2 kg P and 0.8 kg N per euro spent (RIVM, 2004). The cost of removal of N and P from surface waters are much higher.

Source World Bank (2005).

intensive agriculture, and with the expansion of arable land into areas not previously cropped, in particular forests. The large-scale production of crops for feed is currently concentrated mostly in Europe, North America, parts of Latin America and Oceania. Expansion of cropland for feed is strongest in Brazil, in particular for soybeans, but it is also occurring in many developing countries, mostly in Asia and Latin America. The bulk of global feedcrops is produced under commercial and mechanized conditions. Smallholders play only a local role in supplying grains and other crops for feed.

The key to reducing the pollution and other environmental impacts associated with intensive agriculture for feed production lies in increasing efficiency that is, increasing production while reducing inputs that have environmental impacts, including fertilizer, pesticides and fossil fuel. Advanced technology has shown remarkable progress in some areas. For example, fertilizer and pesticide use has declined substantially in many developed countries at the same time as yields have continued to grow.

Research and regulatory frameworks have been instrumental in bringing down fertilizer application rates and in limiting pollution from fertilizer in most developing countries, by developing and disseminating slow release and other less polluting formulations, tightening emission and discharge standards for fertilizer factories, higher fines, placing physical limits on the use of manure and mineral fertilizers and by application of the nutrient budget approach (FAO, 2003). Since the early 1990s developed countries have also started to introduce economic measures in the form of pollution taxes on mineral fertilizers. A number of developing countries still subsidize mineral fertilizer production or sales, either directly or indirectly (as energy subsidies to nitrogen fertilizer producers). The use of low-efficiency fertilizers such as ammonium carbonate needs to be discouraged.

Pesticide use is rapidly increasing in many emerging economies, whereas it is declining from high levels in most developed countries. Policies to address excessive pesticide use include testing and licensing procedures for pesticides before they are allowed on the market (FAO, 2003). Environmental problems that arise from the accumulation of pesticide residues in soils and in water need to be monitored, preferably by independent institutions. The imposition of pollution taxes on pesticides creates economic incentives to reduce their use.

For areas that are experiencing expansion of arable land for feed production, into areas not previously cropped, there is a need to facilitate the land-use transition. The most suitable and productive areas need to be intensified and marginal areas retired into stable pastures or forest land. This process can be assisted by land titling and zoning policies, by targeted research and extension work, and by selected infrastructure development.

Targeted research and extension can also help in promoting more environmentally benign cultivation methods, including conservation agriculture or no-tillage systems and forms of organic farming. Precision agriculture, which uses advanced information and satellite technology to tailor the amount and timing of inputs to specific small areas, has been shown to have substantial potential for further productivity increases, while limiting and optimizing input use.

Since a large part of the feed-producing area is irrigated, particularly for dairy production where there is a need for fresh fodder, water is an important input that is greatly affected by livestock feed demand. Pricing, establishing water markets and building appropriate institutional frameworks, as discussed previously, are indispensable policy instruments for achieving higher water use efficiencies and for addressing depletion.

A different pathway to addressing the environmental impact of feedcrop production is to reduce demand. As has already been discussed in earlier chapters, this can be achieved by creating policy conditions to promote the use of advanced technologies to improve feed efficiency, such as phased feeding, the use of enzymes such as phytase and phosphatase, use of synthetic amino-acids and other feed ingredients. These inputs are sometimes subject to tariffs. A reduction, or elimination, of such trade barriers may facilitate the uptake of related technologies.