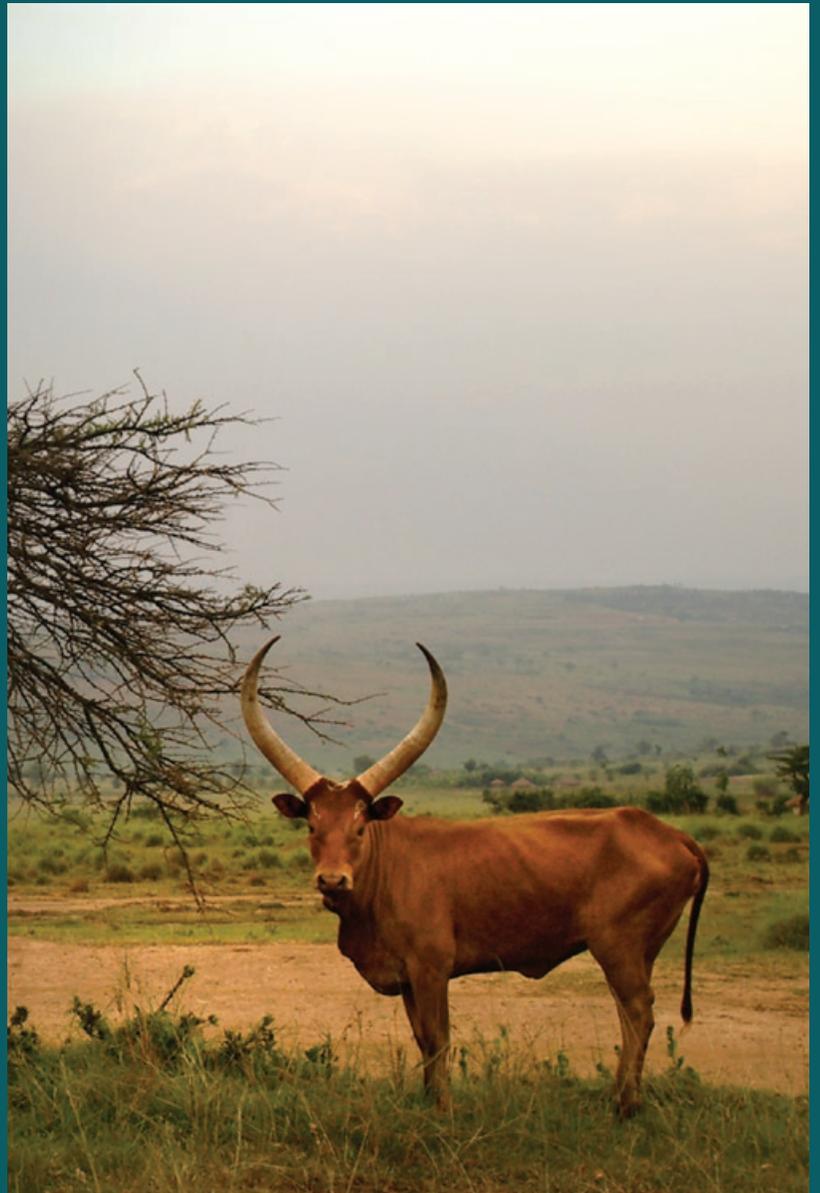




THE WORLD BANK

Minding the Stock

*Bringing Public Policy to Bear
on Livestock Sector Development*



Minding the Stock: Bringing Public Policy to Bear on Livestock Sector Development

Report No. 44010-GLB



THE WORLD BANK
AGRICULTURE AND RURAL DEVELOPMENT DEPARTMENT

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Foreword

After the considerable attention given to agricultural development during the 1970s and early 1980s by both international donors and developing countries, support precipitously declined during the 1990s. During the late 1970s, for example, the share of overseas development assistance (ODA) devoted to agriculture was between 12 and 15 percent, a proportion that fell to about 2.5 percent in 2000. Despite a small increase since then, this proportion was still only approximately 4 percent of ODA by 2004. It is hoped that the response by donors and developing countries to the 2008 World Development Report *Agriculture for Development*, coupled with the current global food crisis, will encourage them to make the necessary investments in agriculture.

The livestock sector in developing countries accounts for more than a third of the agricultural gross domestic product and is growing faster than most other agricultural subsectors. In many developing countries, the sector had suffered benign neglect until the threat of highly pathogenic avian influenza (HPAI) propelled it onto the public development agenda. Driven by private investments, the sector has been experiencing what is termed the “Livestock Revolution.” Population growth, urbanization, and most importantly, increasing income have resulted in a rapid increase in demand for livestock products, which is likely to continue well into the future. This growth of the livestock sector presents both enormous opportunities and challenges.

There is however a need to balance the strong private sector-driven growth with substantially greater public support to put livestock firmly on the path of sustainable growth. This report, therefore, comes at an opportune time for policy makers and practitioners in developing countries and in the international community. Livestock is a major contributor to food and nutrition security for both rural and urban people and it serves as an important source of livelihood for nearly a billion poor people in developing countries. Its importance to attaining the Millennium Development Goals should not be underestimated. Livestock policies and programs should aim to safeguard the enormous public goods that the sector provides, while addressing its adverse impacts on land, water, and the environment and the risks it poses to animal and human health.

We hope this report will help generate renewed interest in the livestock sector and serve to promote the increased investment that is urgently needed.

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Acronyms and Abbreviations

AI	Artificial insemination
AIDS	Acquired immunodeficiency syndrome
AMA	American Medical Association
AVMA	American Veterinary Medical Association
ARD	Agriculture and Rural Development Department of the World Bank
AU	Animal Unit
BOD	Biochemical oxygen demand
BSE	Bovine spongiform encephalopathy
CAHWs	Community animal health workers
CAPRI	Collective Action and Property Rights (of the CGIAR)
CDM	Clean Development Mechanism
CERs	Certified emission certificates
CGIAR	Consultative Group on International Agricultural Research
CH ₄	Methane
CNA	Brazilian National Agricultural Confederation
CO ₂	Carbon dioxide
EU	European Union
EU ETS	European Emissions Trading Scheme
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot-and-mouth disease
FNEC	National Federation of Central African Livestock Owners
FVE	Federation of Veterinarians of Europe
GDP	Gross domestic product
GDS	<i>Groupements de Défense Sanitaire</i>
GEF	Global Environment Facility
GERFAE	Global Emergency Response Fund for Animal Epizootics
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global positioning system
Ha	Hectare
HIV/AIDS	Human immunodeficiency virus/acquired immunodeficiency syndrome
HPAI	Highly pathogenic avian influenza
I&R	Identification and registration
IFA	International Fertilizer Industry Association

IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
kg	Kilogram
km ²	Square kilometers
L	Liter
LEAD	Livestock Environment and Development Initiative
LUAs	Livestock users associations
MDGs	Millennium Development Goals
N ₂	Diatomic nitrogen
NDDB	National Dairy Development Board
NGO	Nongovernmental organization
NH ₃	Ammonia
NIs	Nitrification inhibitors
NOAA	National Oceanic and Atmospheric Administration
N ₂ O	Nitrous oxide
N ₂ O-N	Nitrogen content of nitrous oxide
ODA	Official development assistance
OECD	Organization for Economic Cooperation and Development
OIE	World Organization for Animal Health
PES	Payment for environmental services
PRSPs	Poverty Reduction Strategy Papers
PVS	Performance of Veterinary Services
P ₂ O ₅	Phosphorus pentoxide
RFID	Radiofrequency identification
SARS	Severe acute respiratory syndrome
TKV	Development Foundation of Turkey
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VS	Veterinary services
WHO	World Health Organization

Executive Summary

Driven by population growth, urbanization, and increased income, the demand for animal-source food products in developing countries is rapidly increasing. Livestock, which already constitutes 30 percent of the agricultural GDP in the developing world, and about 40 percent of the global agricultural GDP, is one of the fastest-growing subsectors in agriculture. Growing demand presents real opportunities for economic growth and poverty reduction in rural areas. It could directly benefit the 1 billion poor people who depend on livestock as a source of income and subsistence. Livestock also provides traction for about 50 percent of the world's farmers and is a source of organic fertilizer for most of the world's croplands, converting waste products into inputs in the production of high-value food. For these reasons, the sector has a critical role to play in making agriculture sustainable, in reducing poverty, and in contributing to economic growth.

Growth in the livestock sector is driven almost entirely by private investment. In terms of public sector investment and policy it has been the object of "benign neglect," the results of which are often anything but benign. Unregulated, livestock generates significant negative externalities. It contributes to land degradation and water pollution and to the erosion of biodiversity, and it is a major source of greenhouse gas emissions. It poses serious risks to public health, including diseases such as highly pathogenic avian influenza (HPAI) and bovine spongiform encephalopathy (BSE). The neglect of livestock in public policy has also led to the exclusion of smallholders from the benefits of growth in this sector. These adverse impacts and missed opportunities are likely to continue unless public policy and investment in the sector changes.

Left entirely to the market, incentives often lead producers to make decisions contrary to larger social interests such as public health. Market failures can force competing small producers out of the market and make market entry difficult, if not impossible, for many prospective producers. These market failures need to be rectified if the potential benefits of livestock-sector development are to be realized among smallholders and the communities to which they belong. Appropriate policies and effectively enforced regulations are needed to mitigate the risks and negative impacts of the sector on public health and on the

environment. Active public sector engagement is generally required to bring about some level of convergence between the incentives of individual producers and the interests of society.

A variety of factors led to public sector disengagement from the livestock sector and account for the low levels of public funding for livestock development, both by national governments and international development agencies. Recognition of the fact that growth in the sector is led by private investment, and the departure of global donor funding for parastatal entities during the early 1990s, contributed to a general neglect of the public goods quality of livestock production and consumption—including some that are global public goods. Livestock is also notable for being an unpopular sector throughout much of the community of nongovernmental and civil society organizations, which gained considerable voice during the latter 1990s when a number of international development agencies pursued broader engagement with them. Anti-livestock advocacy by these groups and others was also effective in reaching policy makers, who became more reluctant to devote public resources to oversight of the sector.

The results of this disengagement by governments and the international community have been perverse. Owing to the lack of effective policies and regulatory frameworks, livestock remains both a major contributor to pollution and greenhouse gas emissions and a major source of risk to public health.

This report presents an analysis of the issues related to market failures in the livestock sector, and an examination of policy and investment options that can be used to overcome them. Its principal intended audience includes policy makers and development practitioners. Much of the analysis will focus on identifying the needs of the public sector as it sets out to redress the imbalance between public and private investment and to begin establishing an enabling environment in which private sector livestock development can take place in a way that is consistent with public health, poverty reduction, and environmental sustainability. While the report focuses on developing countries, much of its treatment pertains to industrialized countries as well, particularly with respect to issues of cross-cutting global significance, such as greenhouse gas emissions and emerging highly infectious diseases.

A number of prominent issues discussed in this report warrant a preliminary summary.

Public and private sector roles. There is a lack of clear understanding among policy makers about the distribution of public- and private sector roles in providing livestock services and in the division of global, national, and local responsibilities in public policy relating to livestock. A clearer definition and division of responsibilities would enable the public sector to “do less but to do it better” once it re-engages in the sector, in part by strengthening public–private partnerships that are involved in the public-goods facets of livestock production. Moreover, assigning a “global public good” character to many livestock-related externalities is counterproductive, and greater selectivity is recommended based on economic principles. Among the issues that do warrant priority on the global public-good agenda, the control of zoonotic diseases and greenhouse gas emissions feature prominently.

Natural resource management. Grasslands cover more than one-fourth of the world’s terrestrial surface, and the livestock sector is the largest user of agricultural land. The effects of livestock grazing on land are manifold, and depend mainly on the prevailing ecosystem. In the *arid rangelands*, the extent of land degradation is subject to considerable debate. Estimates vary, identifying between 20 and 70 percent of arid rangelands as being degraded. What is clear is that arid ecosystems are being used at full capacity and that they are highly resilient. Most arid rangelands are common property, and public policy and development programs can play a major role in their management. Developing alternative employment to stimulate outmigration is a priority. Programs that facilitate herd mobility would effectively increase the resilience of pastoral systems. Insurance services and destocking and restocking facilities would help producers manage risk. Payment for environmental services (PES) would create alternative income sources and reorient pastoral production systems from their narrow emphasis on animal products to land management. In the *humid tropics*, livestock-induced deforestation is driven by technological advances and the fast-growing demand for feed grains. The earlier driving force of subsidization of cattle ranching has greatly diminished. The recommended policies and investments require a combination of

regulation (zoning), incentives (PES), and research for alternative feeding systems. While the share of *water* withdrawal (7 percent) and depletion (15 percent) by the livestock sector is still relatively small, the current and projected worldwide water shortages also warrant more attention to reducing the sector's water requirements. Policy and investment should prioritize increasing the efficiency of irrigation and reducing pollution from livestock waste. About three-quarters of the meat and milk produced in the developing world come from *mixed farming systems*, and a large part of the remainder comes from fast-growing high-input-high-output industrial systems. Recycling of nutrient and livestock waste is the chief environmental issue related to these production systems. In principle, they use the livestock sector's best system of recycling, with livestock by-products (manure, traction) essential for crop farmers and crop residues critical for livestock farmers as livestock feed. However, regional imbalances are common, with excessive concentration in some areas. The availability of infrastructure defines the geographic location of production. In earlier stages of development, processing tends to concentrate around urban centers. As infrastructure improves, processing shifts to feed-producing areas. A number of policy options are available to promote a more even geographic distribution of livestock. These policies generally pursue a strategy of intensification without concentration, encouraging more intensive forms of production, but preventing the intensive production units from concentrating in one area. The negative environmental impact of the sector would be mitigated by improvements in infrastructure, and a level playing field for waste recycling such as organic fertilizer and biogas-generated power—including the use of carbon trading schemes.

Global climate change. In light of the current debate on global climate change, greenhouse gas emissions from the livestock sector are a critical priority. And the figures are staggering. Considering emissions along the entire commodity chain, the livestock sector currently contributes 18 percent of total human-induced greenhouse gas emission equivalents, including about 9 percent of total carbon dioxide (CO₂), 37 percent of methane (CH₄), and 65 percent of nitrous oxide (N₂O) emissions. This exceeds the emissions of the global-transport sector. As a global public good, urgent action by the

global community is required. This should start with creating awareness at the highest political levels because livestock emissions have not yet been addressed by global decision-making institutions. Raising high-level awareness should lead to an active participation of livestock sector stakeholders in the post-Kyoto negotiations. Technical options include: (a) carbon sequestration on grazing land; (b) reduction of methane emissions from low-input ruminant production, in particular, dairy, through improved feeding; and (c) reduction of methane and nitrous oxide emissions from animal waste, through energy recovery and improved waste management.

Public health. While livestock products are critical in the diet of vulnerable groups in the developing world, the livestock sector also poses major health risks. Over the past 15 years, 75 percent of the human diseases that have emerged have been of animal origin. Livestock-induced foodborne diseases affect millions. Meat has also become an important factor in the obesity crisis, which has begun to affect the developing world. In addition, the so-called diseases of trade, such as foot-and-mouth disease and classical swine fever, cause billions of dollars in economic losses. The recent emergence of highly pathogenic avian influenza has focused the world's attention on the need for efficient early-warning response and control systems. The integration of human and animal health systems in an ecosystems context, as pursued with the *One World, One Health* strategy, would be an important overarching organizing framework, but one that needs to be made operational. At the global level, improved coordination and risk-management tools (compensation, communication) need to be developed and implemented. Increased international support to technology development for the control of the "diseases of the poor" is also needed. At the national level, emphasis needs to be placed on strengthening the public-good services of surveillance and early warning and early response to disease outbreaks.

Poverty. There is a significant risk that livestock-sector development will exclude smallholders. Access to the fast-growing and more sophisticated market for meat and milk products is dependent on higher quality and stricter safety standards, greater uniformity of the product, stricter reliability of supply, and verifiability of origin. Owing to the

economies of scale enjoyed by large producers, practically all these standards carry higher costs per unit product for smallholders. Small producers and processors risk being crowded out of more remunerative markets. Quality and safety standards also provide opportunities and can add value and generate employment along the supply chain. Capitalizing on these opportunities will require support for collective action through cooperatives, associations, or contract farming and vertical integration. For contract farming to function well in this capacity, a sound legal framework is required to ensure the proper enforcement of contracts. For cooperatives to develop properly, government interference should be avoided. Public-safety standards should be set with careful attention to the government's capacity to enforce them, to the relevance of the public health risk they seek to address, and to the overall competitiveness of the market. Producers generally have little leverage in the setting of private sector standards. Finally, smallholders should be assured of equal treatment in the incentives frameworks—for instance, in subsidies.

Investment needs. For these policies and programs to work, the prevailing imbalance between

public and private investments in the livestock sector needs to be redressed; this will require major investments by the public sector. While more precise estimates will be needed, a preliminary assessment of the costs of increasing the preparedness to contain emerging zoonotic diseases amounts to about US\$300 million per year over the next three years, and a moderate reduction of greenhouse gas emission, based on carbon-emission trading, would require US\$1.2 billion. These amounts are significantly lower than the several billions of dollars of economic losses incurred by emerging animal diseases and are only 10 percent of the current trading volume in emission rights. Yet they are still considerably higher than current investments. Investments at the national level would have to increase considerably as well. To arrive at those levels, it would be necessary to create a much greater awareness of the potential and challenges of the livestock sector and a broader consensus that business as usual is not enough. Concerted action in establishing sound incentive frameworks and in providing supporting investments is needed if livestock is to make a significant contribution to economic development.

A Changing Livestock Sector in a Changing World

THE OPPORTUNITIES

Setting the scene. Livestock is the principal user of global land and a significant source of livelihood for about 1 billion people, of whom 800 million are poor. It affects, positively or negatively, the natural-resource base, public health, social equity, and economic growth. As experience has shown in both industrialized and developing parts of the world, if the sector is left to the market, major negative effects occur. Public policy is therefore necessary. The purpose of this document is to inform policy makers in developing countries and practitioners working in development agencies about issues related to livestock development and to recommend policies and investments that can enhance the sector's contribution to equitable economic development and mitigate its negative impacts on public health, social equity, and the environment.

The trends. Livestock is one of the fastest-growing agricultural subsectors in developing countries. Its share of agricultural GDP is already 33 percent and is quickly increasing. This growth is driven by the rapidly increasing demand for livestock products. Population growth, urbanization, and increasing income are driving demand for animal-source foods in developing countries, a phenomenon described by Delgado et al. (1999) as the "Livestock Revolution." Between 1975 and 2001, for example, annual per-capita consumption of poultry, pork, beef, and milk grew by 5.9, 4.0, 3.2, and 1.7 percent, respectively. The share of world consumption of meat by developing countries increased from 36 percent in 1983 to 57 percent in 2003 and of milk from 24 percent to 45 percent (Speedy 2003). However, despite this rapidly increasing share of global consumption in developing countries, per-capita consumption is still comparatively low. Current meat consumption in the United States, for example, is approximately 124 kilograms (kg) per capita per year, while the global average is 38 kg. Per-capita consumption of milk in the United States is approximately 118 kg per year, as compared with 47.5 kg in India—the developing country with the highest consumption rate. Table 1.1 contrasts the consumption of livestock products in developed and developing countries.

As a result of the increased demand, total meat production in the developing world tripled, from 45 million tons to 134 million tons, between 1980 and 2002. Developments have been most dynamic in countries that experienced rapid economic growth, notably in

Table 1.1: Past and Projected Trends of Consumption and Production of Livestock Products

	Developing Countries					Developed Countries				
	1980	1990	2002	2015	2030	1980	1990	2002	2015	2030
Consumption										
Annual per-capita meat consumption (kg)	14	18	28	33	38	73	80	78	83	88
Annual per-capita milk consumption (kg)	34	38	46	57	67	195	200	202	204	211
Total meat consumption (million tons)	47	73	137	191	257	86	100	102	113	122
Total milk consumption (million tons)	114	152	222	330	449	228	251	265	278	292
Production										
Annual per-capita meat production (kg)	14	18	28	33	38	75	82	80	85	91
Annual per-capita milk production (kg)	35	40	50	62	73	300	301	266	270	280
Total meat production (million tons)	45	43	134	190	255	88	103	105	116	126
Total milk production (million tons)	112	159	244	359	491	352	378	349	369	387

Source: FAO 2006b, 2006c.

East Asia and led by China. China alone accounted for 57 percent of the increase in total meat production in developing countries. Production was very largely concentrated in monogastrics (animals with a single-chambered stomach)—notably, poultry and pigs, which together accounted for 77 percent of the increase in production. This was a fourfold increase as compared with the 111 percent increase in ruminant production (cattle, sheep, and goats) during the same period.

In developed parts of the world, commercialization took place a long time ago, and the transition from extensive to intensive production often entailed major negative environmental consequences. Livestock production and merchandizing in industrialized countries are big business, accounting for 53 percent of the agricultural GDP. However, production and consumption of livestock products in the developed world are now growing only slowly or stagnating. Health concerns, low or zero population growth, and saturated markets have resulted in a scant 0.5 percent annual increase in per-capita meat and milk consumption. Between 1980 and 2002, total meat production increased by just 22 percent. Poultry and pig production increased by only 1 percent

annually, while ruminant meat production actually declined by 7 percent over the 22-year period.

The combination of strong growth in demand in the developing world and limited to negative growth in demand in industrialized countries represents a major opportunity for livestock keepers in developing countries, where most demand is met by local production, and will continue to be well into the foreseeable future. The opportunity carries great significance for the Millennium Development Goals, particularly for those of reducing poverty and improving food security and nutrition.

THE CHALLENGES

Livestock-sector development generates substantial risks and negative externalities as well as opportunities, all of which must be addressed by public policy. These externalities spill over from individual producers into society and become manifest in environmental impacts, in public health risks, and in the frequent inability of smallholder producers to meet more exacting consumer and industry standards.

- *The production of greenhouse gases, land degradation, water pollution, and the destruction of*

plant biodiversity. It is estimated that the livestock sector produces 18 percent of anthropogenic carbon dioxide (CO₂), and that, depending on the estimate about 20 to 70 percent of the world's grasslands are degraded by overgrazing. For example, in the United States, the sector is responsible for about one-third of the nitrogen and phosphate loading of freshwater resources (Steinfeld et al. 2006). The sector is also a major force behind the loss of biodiversity from some of the world's most diverse ecosystems.

- *The global public health risks from emerging and reemerging animal diseases, in particular those transmissible to humans (zoonoses) with pandemic potential.* Other diseases, though not threatening to human health, are of extreme importance to livestock health and represent enormous barriers to trade. Total economic losses resulting from recent disease scares run in the tens of billions of dollars.¹
- *The social exclusion of smallholder producers.* Consumers are demanding better quality and safer livestock products, and the expanding supermarket sector is imposing increasingly stricter international standards. With significant economies of scale required to meet those standards, smallholder producers run the risk of not being able to compete, and are being crowded out of the sector.

Answering these challenges will involve selective priority-setting by responsible public institutions. Mitigating the negative impacts of the livestock sector in such a way that the positive contributions of the sector are allowed to materialize will entail substantive public policy and investment. While capitalizing on positive externalities relies principally on private investment, the effectiveness of that investment in producing positive impacts depends in large measure on the creation of a broader enabling environment. This enabling environment is very much the province of public policy, and would address such matters as tenure security, the provision of public infrastructure, and other factors that influence the investment climate.

¹ For example, foot-and-mouth disease (about US\$30 billion in the United Kingdom); bovine spongiform encephalopathy (BSE, about US\$6.5 billion); and, more recently, highly pathogenic avian influenza (HPAI, more than US\$1 billion).

While much of this policy is outside the scope of the livestock sector itself, and is therefore beyond the scope of this paper, chapter 7 devotes much of its treatment to promoting access to markets among smallholders and the potential this represents in terms of poverty reduction.

Public sector responsibilities for livestock management are the focus of this paper. While policy makers working in public institutions are the paper's principal intended audience, the interface between policy and the private operators that policy is directed toward is a central facet of the analysis presented here. This introduction warrants another important qualification. While livestock issues in developing countries are the paper's principal subject matter, the issues it addresses are fundamental to livestock in industrialized countries as well. Issues such as carbon emissions trading, payment for environmental services, the expansion of cropland in the developing world to meet demand in industrialized societies, and a variety of mitigation efforts clearly apply to both developing and industrialized countries, and in an interrelated world, should be of interest to policy makers in both.

Chapter 2 presents the theoretical underpinnings of the scope for public policy in the livestock sector by differentiating public goods and private goods. It also defines global, national, and local public goods. These distinctions are at the heart of the question of appropriate public political involvement and funding.

The following chapters review the areas that livestock development affect, the scope of its impacts, and the institutions and policies that are needed to mitigate or enhance those impacts. Chapter 3 focuses on land and water pollution in ecosystems used for grazing. Chapter 4 addresses nutrient cycling and waste management in ecosystems used for crop and livestock production, and those based mainly on feed-crop-based nutrient systems. Chapter 5 treats livestock's role in the global nitrogen (N) and carbon (C) cycles underlying climate change. Chapter 6 discusses the interface between livestock health and public health. Chapter 7 then provides a description of one of the most important strategies to ensure that the livestock sector contributes to poverty reduction—helping smallholders to get access to markets. Chapter 8 concludes with an inventory of development implications.

Public Goods and the Scope for Intervention in the Livestock Sector

The rationales for active public sector involvement in the livestock sector are straightforward given the externalities generated by livestock. Inadequate disease protection of a herd on an individual farm can put the health of animals on other farms at risk. That risk can extend to national or even global levels. Land degradation from overgrazing upstream in a watershed can affect water quality downstream. Indiscriminate crossbreeding with exotic breeds can cause future generations to forever lose invaluable genetic diversity. Greenhouse gas emissions from individual livestock herds contribute to global climate change and affect the well-being of societies globally. All of these are issues in which short-term individual incentives often diverge from long-term societal interests. Cost saving on vaccinations, using cheaper feeds that emit more greenhouse gases, and a variety of individual measures to achieve short-term gains in animal production can contribute to outcomes that conflict with long-term societal interests such as those relating to good health, clean water, stable climates, and genetic diversity.

The lack of alignment of individual incentives with the broader interests of society is problematic. Among its most instructive illustrations is that of vaccination. Vaccinating livestock reduces the overall burden of disease, and is an important element of livestock health. For the individual livestock producer however, vaccination is a cost—one that many producers will seek to avoid. When a large enough number of producers vaccinate their herds, disease pressure is reduced, and for the producer who avoids the cost, his or her decision not to vaccinate affords a “free ride” that is effectively paid for by others.

Incentives in well-functioning markets can often lead individuals to seek a free ride in accessing free goods and services that are perceived as being useful. The value of public goods such as clean water and vaccinated animals on the other hand is often not represented or manifest in full market values. Market forces do not bring about the convergence of short-term objectives of income maximization of the individual farmer with the greater, longer-term interests of the environment, public health, or social equity.

The effects of market failures spill over as externalities onto third parties who are not directly involved in the livestock industry. Public policy, such as regulations and taxes can be used to address these externalities and to secure public goods that are more in accordance with the larger interests of society. In situations in which government

institutions lack the capacity to support the provision of public goods, certain forms of collective action may be used to fill the gap, and are examined near the end of this chapter. With increasing globalization and the growing complexity of the global economy, issues relating to the types of collective action required to produce appropriate levels of public goods are gaining attention at different policy levels.

The public goods that relate to the livestock sector are the subject of this chapter. Two issues in particular pertain to public policy that addresses the externalities and public goods that are generated by livestock. These concern the division of roles and responsibilities between the public and private sectors and between international, national, and local agents.

PUBLIC GOODS AND SCOPE FOR INTERVENTION IN THE LIVESTOCK SECTOR

Pure public goods share two qualities—*nonexcludability* and *nonrivalry*.

- *Nonexcludability* (or indivisibility of the benefits) means that when provided to one party, the public good is available to all.
- *Nonrivalry* means that the consumption of the public good by one party does not reduce the amount available to others.

There are a number of exceptions in which these principles are not clear-cut, and in which private goods and public goods overlap.

- *Merit goods* are goods that the government feels that people, if left to their own decision, will under-consume. They ought, therefore, to be subsidized or provided free at the point of use. Livestock extension and vaccinations against contagious diseases may fall into this category.
- *Moral hazards* occur when a party insulated from a risk behaves differently from the way that party would act if it were fully exposed to the risk. The typical example of a moral hazard occurs in the insurance sector, when an insured person might be less vigilant against risk than an uninsured one.
- *Asymmetry of information* arises, for example, in the purchase of feed and drugs, when

smaller producers lack access to pertinent information about the quality of the input or lack knowledge to assess the reliability of the information presented to them.

- *Economies of scale* occur when the costs of supplying certain goods decrease when they are produced and supplied in large quantities. It is often used by international organizations to justify, for example, their involvement in disease-control campaigns.

PUBLIC AND PRIVATE GOODS

A number of public goods, such as national security, border protection, and quarantines to prevent animal epizootics,² benefit the entire society. These are nonrival and nonexcludable public goods. All livestock keepers benefit from the freedom of disease that is provided by these public goods, and the benefit to any one livestock keeper does not diminish the benefit to other livestock keepers. These, therefore, qualify as “pure” public goods, justifying full oversight and budgetary support from the public sector. Freedom from disease also benefits society at large in that it reduces the price of animal products and protects against the disruption of local and national economies that are associated with disease outbreaks.

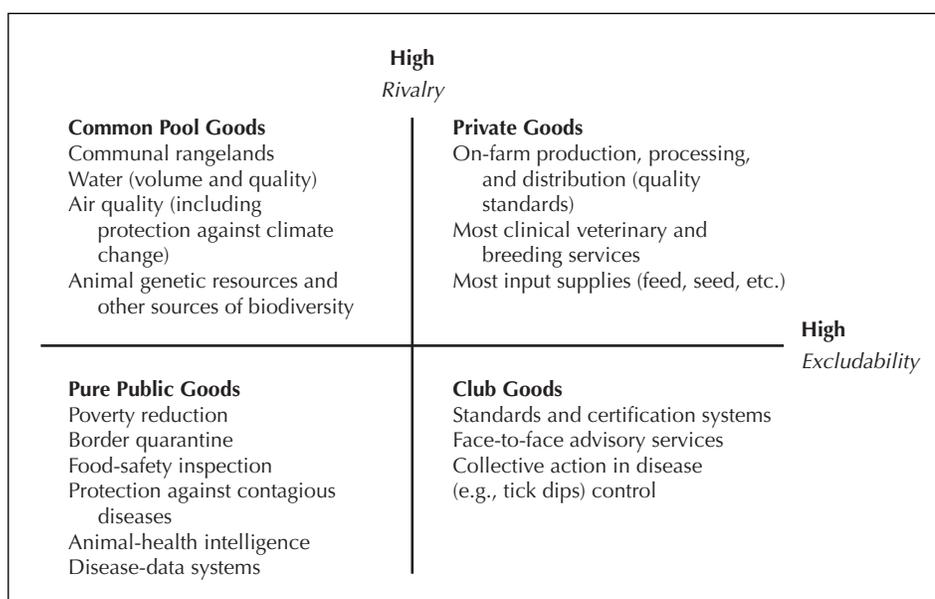
However, in reality, most claimed public goods are “impure” in that they only partially meet the criteria of nonexcludability and nonrivalry. If they have a low rivalry but high excludability, the term “club goods” is often used. If they have a low excludability, the term “common pool goods” is used. Figure 2.1 illustrates this terminology with examples from the livestock sector.

The characteristic of the good determines to a significant degree how it should be funded and implemented. For goods with both public and private good features, joint oversight and cost sharing between the public and private sectors is needed. Taking into account these characteristics, Table 2.1 provides recommendations on how services related to the livestock sector can best be overseen, funded, and implemented.

It warrants qualifying that Figure 2.1 and Table 2.1 are only indicative. Other factors in

² An outbreak of disease affecting many animals of one kind at the same time (*Webster’s Dictionary*).

Figure 2.1: Overview and Selected Illustrative Examples of the Main Categories of Public and Private Goods in Livestock



addition to government preferences will determine how the supply of a public good is funded and managed. These include a variety of social and institutional factors, including the stage of the country's economic development, and the human resources that are available. In the poorest developing countries for instance, and among the poorest segments of the population, environmental factors such as air and water quality tend to be assigned less value than in industrialized countries or among wealthier segments of the population. Mitigating the negative effects of livestock on the environment therefore receives lower priority in these conditions.

Genetic improvement is another case in point. Artificial insemination is normally considered a purely private good in that the farmer captures all of its benefits. However, insofar as it can be regarded as a merit good, some level of government support may be warranted. Through membership in livestock breed societies, artificial insemination also assumes the potential to be something of a club good. While government intervention to promote the introduction of artificial insemination for a finite initial period to familiarize farmers with the technology is sometimes justified using an "infant industry" argument, in practice phasing out such temporary subsidies has proven difficult.

In farmer advisory services, cost sharing, or even full cost recovery, is increasingly common in Organization for Economic Cooperation and Development (OECD) countries, but is not yet possible in most of the developing world, and collective action can be justified as a "merit good."

With respect to animal health, the public sector in meat-exporting countries will assign much higher priority to the control of animal diseases than will meat-importing countries.

With regard to food security, the supply of adequate and affordable food is perceived by many governments of developing countries as a public good, although this has led to inefficient policies pursuing self-sufficiency.

Adaptation of such considerations about the nature of goods and services to local conditions is clearly of critical importance.

GLOBAL, NATIONAL, AND LOCAL PUBLIC GOODS

The issue of the distribution of responsibilities between local, national, regional, and international levels raises similar concerns. In general, responsibility for oversight can best be allocated according to the principle of subsidiarity. This means that the

Table 2.1: Distribution of Responsibilities for Implementation, Funding, and Oversight of Selected Key Services in the Livestock Sector

	Funding	Responsibility for Implementation	Oversight
Pure Public Goods			
<i>Veterinary health</i>			
Border quarantine	Public sector	Public sector	Mainly national Veterinary services (VS)
Surveillance of main contagious diseases	Public sector	Preferably in subcontract with private operators	Mainly district service, with clear lines to national VS, with international support in developing countries and international coordination among all countries
Early alert and response for main contagious diseases	Public sector	Preferably in subcontract with private operators	Mainly national VS with international support
<i>Vaccination</i>	Public/private partnership	Mostly private sector	Mainly national VS with international support
<i>Vaccine development</i>	Public/private partnership	Mostly private sector	National or regional public institutions
<i>Disease data systems</i>	Public/private partnership	Mainly public sector	Mainly national VS with international support
<i>Food safety and human public health</i>	Public/private partnership	Preferably in subcontract with private operators	Mainly local, within overall guidelines of national and, eventually, international buyers
<i>Research and education</i>	Public/private partnership	Preferably private with subcontracts	Public/private at corresponding levels
Common Pool Goods			
<i>Range resources</i>			
Legislative framework	Public national sector	Public/associative at community level	National legislation, with district-level oversight
Grazing and water management	Individual (fees) and associative sector	Associative at community level	Mostly at community level, with district-level oversight
<i>Biodiversity</i>			
Animal genetic resources	National and international public sector	National associative and/or public sector	National level
Club Goods			
Parasitic disease control (dips, etc.)	Mainly private; initial subsidy possible	Community	Community and local VS
Standards and certification systems	Mainly public	Private	Public
Advisory Services			
	Private/Public	Mainly Public	Private/Public
Private Goods			
Feed-supply services	Private	Private	Public/private for quality control
Milk and meat processing	Mostly private	Mainly private; could be funded through a local tax on milk	Private, with public oversight on food safety
Milk and meat marketing	Mainly private	Public/private	Private
Clinical veterinary services	Private	Private	Veterinary associations/orders
Breeding services	Private	Private	Public/private partnerships

supply and funding of the public goods should be managed and overseen at the lowest possible level of government. The recommendations presented in Table 2.1 suggest both the appropriate distribution of responsibilities between the public and private sectors and the optimal levels at which different facets of oversight should be carried out. Again, however, the determination needs to be adapted to the specific social and economic context within which a country's livestock sector operates, and to the capacity of and resources available to the institutions concerned.

The question of how to appropriately apply the concept of global public goods has assumed particular importance in recent international development community debates about public sector interventions to control HPAI. The concept is also used in addressing the livestock sector's environmental impacts, particularly its contributions to greenhouse gas emissions, climate change, and biodiversity loss (Steinfeld et al. 2006). International institutions such as the World Organization for Animal Health (OIE) and the international agricultural research institutions of the Consultative Group on International Agricultural Research (CGIAR) use the global public goods concept as a rationale for engagement in a variety of areas.

There is, however, a danger that the term "global public good" is becoming overused, which may be an almost inevitable result of the variety of definitions it is attributed in the literature.

- "... a good, which it is rational, from the perspective of a group of nations collectively, to

produce for universal consumption, and for which it is irrational to exclude an individual country from consuming, irrespective of whether that nation contributes to its financing" (Smith and MacKellar 2007).

- "... a good . . . with benefits or costs, that extend across nations and regions, across rich and poor population groups and even across generations" (Kaul et al. 2003).
- A good focused primarily on the geographic origins and characteristics of the beneficiaries (International Task Force on Global Public Goods 2006) (see Box 2.1).

Smith and MacKellar (2007) warn that the term's frequent use has led it to lose "some of its value as a general tool for resource mobilization, and is at risk of being attached to almost anything promoting development" in the field of human health. "This" they continue "overstretches and devalues the validity and usefulness of the concept." It is, therefore, important to clearly circumscribe what a global public good constitutes. With regard to livestock, the concept's application to poverty reduction, enhancing public health, and protecting the environment is fairly straightforward. Somewhat less clearly, it is applied to livestock trade and its role in providing economic stability and fostering economic growth. The differentiation between global and public goods at lower, more detailed levels, is often less clear.

Inappropriate use of the concept of global public good also entails a moral hazard. National institutions should properly maintain responsibility

Box 2.1: Definitions of Public Goods

A local public good benefits all the members of a local community, possibly to include the citizens of more than one country.

A national public good benefits all the citizens of a state.

A domestic public good benefits all members of a community situated within a single state. National public goods are domestic public goods, but domestic public goods need not be national public goods.

A regional public good benefits countries belonging to a geographic territory.

A global public good benefits all countries and, therefore, all people.

An international public good benefits more than one country. Global and regional public goods are both international public goods.

Source: International Task force on Global Public Goods 2006.

governing the management of resources such as livestock using funds from their national budgets. Some national institutions may however designate that resource a “global public good” in order to rationalize transferring that responsibility and the financial requirements it entails to international institutions. For example, overstressing the global benefits of the conservation of particular animal breeds, or the dangers of spillover of animal diseases, might lead national animal production or veterinary services to neglect their own funding and respective conservation and disease-control responsibility. This could endanger the long-term national sustainability of that capacity. National institutions are often better equipped than international agencies to handle country-specific challenges, and their budgetary support can be less fickle than that of international institutions.

Moreover, international interventions in the animal health area aimed at supporting global public goods are often “vertical” in orientation—focusing on one disease or a specific environmental issue. In this way, they also manage to attract the majority of the local funding and relevant human resources. Such specificity can be at the cost of the more structural broad-based needs related to general veterinary health issues. This is also evident in the human health sector, with global initiatives such as those to combat human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), tuberculosis, and malaria, and, to a somewhat lesser extent, in the current and past global veterinary health initiatives to control HPAI, foot-and-mouth disease (FMD), and rinderpest or “cattle plague.” For example, while rinderpest in Africa has been successfully eradicated with funding from the European Union, the capacity to eradicate a cattle disease has apparently not engendered an increase in the capacity for surveillance for HPAI. Following the recent outbreak in Sub-Saharan Africa, it emerged that the surveillance and early warning capacity for HPAI was practically nil. Extensive new inputs were required to enable the services to detect HPAI outbreaks at an early stage. Overreliance on international support for global public goods can therefore backfire on long-term stability through service provision at national and more local levels.

On the basis of these definitions and considerations, table 2.2 presents a simple classification of various major global threats concerning livestock.

This classification is based on the share of the population affected, the degree of public good (based on the definitions of nonexcludability and nonrivalry), and on the degree of “globalness,” which is the term used here to describe the feature of global public goods that are national and “cannot be provided adequately through domestic policy action alone but require international cooperation to be available locally” (Kaul et al. 2003).

WILLINGNESS TO FUND GLOBAL PUBLIC GOODS

Perceptions naturally play a major role in international decision making regarding support for global public goods. The World Bank’s 2007 Global Economic Prospects report *Managing the Next Wave of Globalization* (World Bank 2007b) compared international efforts in mitigating global climate change, overfishing, and human health risks (particularly HPAI) and concluded that the speed of response of international support depends on: (a) the time scale of the threat, (b) the degree of scientific consensus on the severity and approach to mitigate the threat, (c) the benefit to own country or region, (d) the number of countries involved, and (e) the effectiveness of the institutions involved. Applying those conditions to the three global threats reviewed in this report, HPAI clearly received the highest priority, as also evidenced by the establishment of the Global HPAI Funds.

The World Bank Global Public Goods report (2007c) also presents criteria for Bank involvement in addressing global public goods. They are:

- There should be an emerging consensus in the international community that global action is required.
- There should be an institutional gap that the Bank could help fill to encourage global action.
- The Bank should have the requisite capabilities and resources to be effective.
- The Bank’s engagement should be consistent with its development mandate and relative strengths.
- Global action by the Bank should support or catalyze other resources.

If these criteria are applied to those factors with high global goods character from Table 2.3, the

Table 2.2: Indicators to Prioritize Measures Related to Global Livestock-related Threats

Global Public Good	Service to Produce Good	Share of Global Population Affected	Degree of Nonrivalry	Degree of Non-excludability	Degree of "Globalness" ^a	Rationale and Comment
<i>Protection against highly contagious zoonotic diseases</i>	All aspects combined	High	High	High	High	Has potential rapid transboundary spillover and, therefore, a high level of global public good.
	Vaccine development	Mostly limited, potentially high	Moderate	High if developed through private sector	Moderate to high	Has increasingly become a private good, but remains in the public domain for "orphan" diseases. Because it is linked to poverty reduction, there is some level of justification of global public good.
	Early-warning systems	High	High	High	High	Surveillance and early-warning systems have high returns.
	Early response	Moderate	Moderate	Moderate	Moderate	Has much stronger national benefits/characteristics.
<i>Livestock-related environmental sustainability</i>	Food safety	High	High	High	Low	
	All aspects combined	High	High	High	Moderate	Provides important national and local public and private benefits.
	Greenhouse gas (GHG) mitigation	High	Absolute	Absolute	High	GHG emission by livestock affects global climate.
	Conservation of wild biodiversity	Moderate	Moderate	Moderate	Moderate	Some of the benefits can be captured by local and national authorities.
	Conservation of domestic animal genetic biodiversity	Low	High	Moderate	Moderate	
	Water-pollution control	Low	Low	Low	Low	Mostly local benefits.
<i>Poverty reduction through livestock development</i>	All aspects combined	1 billion (16 percent of global population)	Moderate	Moderate	High	Has been declared global public good by global community (Millennium Development Goals [MDGs]).
	Access natural resources	Moderate	Low	Low	Moderate	Mostly national, as many trade-offs are involved.
	Access to technology and knowledge	High	High	High	Moderate to high	Depends on geographic applicability of technology and knowledge.
	Access to policy and appropriate institutions	High	Moderate	High	Moderate	Mostly national, as many trade-offs are involved.
<i>Economic stability and growth</i>	All aspects combined	High	Moderate to low	Moderate to low	High	In livestock, mostly trade-related issues.
	Adherence to international standards	High	Moderate	Low	Moderate	Benefits mostly captured by national actors.

a. A subjective indication of the extent to which international cooperation is required to deliver the particular global public good (following Kaul et al. 2003).

Table 2.3: Key Factors Affecting Priority of Global Threats

Threat	Service to Control Threat	Time Scale of Threat Mitigation or Measure	Degree of Scientific Consensus	Benefit to Country's Own Mitigation	Number of Countries Involved in Solution	Effectiveness of Solution
Control of zoonotic diseases	All aspects combined	Short	High	Moderate	High	Moderate
	Vaccine development	Medium	High	Moderate	High	High
	Early warning	Short	High	High	High	High
	Early responses	Short	Moderate	High	High	Moderate
	Food safety	Long	High	High	High	Moderate
Livestock-related environmental sustainability	All aspects combined	Long	Moderate	High	High	Moderate
	GHG emission reduction	Long	High	Low	High	Low
	Conservation of domestic animal genetic biodiversity	High	High	Moderate	High	High
Livestock-induced poverty reduction	All aspects combined	Long	Medium	High	High	Moderate
	Access to technology and knowledge	Long	High	High	High	High
Economic stability and growth, including trade	All aspects combined	Long	High	High	Medium	High

emerging picture points to early warning for highly emerging infectious diseases (pandemics) and greenhouse gas emissions, as high priority areas for investment.

There are, however, clearly synergies between the different levels, and it is, therefore, neither advisable nor feasible to clearly distinguish between global, national, and local public goods. For example, one of the most important inputs in the control of highly infectious emerging zoonotic diseases is the availability of an efficient surveillance system. This increasingly is recognized as a global public good. Such an efficient system would also benefit the detection of nonzoonotic and less-infectious diseases. The key differentiation here, however, would be that the follow-up to the early detection (culling, compensation, vaccination) for the infectious emerging zoonotic diseases would be a global responsibility, while these tasks for other diseases would be more a national responsibility.

COLLECTIVE ACTION

Laws and regulations issued and enforced by the public sector are the most common tools used to correct externalities, because funds to provide positive incentives are often not available. But in most developing countries enforcement agencies are underfunded and underskilled and lack a strong institutional base. More or stricter regulations could thus lead to noncompliance, fraud, and corruption among the agencies responsible for enforcing them. In those situations, alternative approaches, either market-led or based on collective action—or a combination of the two—can be a useful component in a package of measures to address market failures and externalities in the livestock sector. Collective action seeks to promote the self-regulatory capacity and negotiating power of private agents to manage externalities. In this chapter some of the main principles of collective action

Box 2.2: Institutions for Collective Action

Associations are defined as any group with a common objective that can pool part of its resources to achieve that objective. This is the most flexible form of collective action in terms of the legal responsibilities of its members.

Cooperatives are defined as user-owned, user-controlled businesses that distribute benefits on the basis of use; they are generally legally and financially more tightly organized than associations.

Commercial vertical-integration models are defined as contractual arrangements led mostly by a processor covering more than one component of the production and processing/distribution chain, owning or having contracts with its upstream suppliers and its downstream buyers. This is probably legally and financially the most binding type of collective action.

are reviewed. Specific examples regarding protection of the environment and ensuring public health and poverty reduction are provided in the chapters that follow.

Forms of Collective Action

Collective action can be organized in different institutional models. The three most common forms are associations, cooperatives, and commer-

cial vertical integration models. Their definitions are provided in Box 2.2, although in the literature these sometimes overlap, and particularly in literature on poverty reduction, all three forms are often used.

Collective action, particularly by cooperatives, has been most successful in promoting market access for smallholders. With minor exceptions however, cooperatives have not performed well in the area of environmental management.

Livestock Externalities in Land and Water Use

Livestock depends on land for grazing and for the production of feed grains and oilseeds for supplementary feeding. Grasslands, used by livestock, occupy about 34.8 million square kilometers, or 26 percent of the world's land surface. Land for feed-crops occupies about 211 million hectares, or about one-third of the total global area cropped. As such, the livestock sector is the world's largest land user (Steinfeld et al. 2006).

Extensive grazing systems of the arid lands, generally known as rangelands, constitute the largest category area-wise (60 percent of all pastures). They are characterized by their low biomass production, and are located mostly in dry and/or cold climates. This category is particularly dominant in developed countries, where it represents almost 80 percent of grasslands. In developing countries, arid rangelands account for just below 50 percent of total pasture area. The remaining grazing systems consist mostly of grasslands in higher-potential areas. In the humid and subtropical savannahs these grasslands produce relatively more biomass while grasslands in temperate climatic zones are characterized by lower biomass but higher quality grasses.

Livestock impacts land and water in many ways. On the negative side, overgrazing by ruminant livestock leads to nutrient depletion, soil compaction, and ultimately to soil denudation and erosion. In addition, livestock's feed-grain and oilseed requirements lead to the expansion of the arable agricultural frontier, in particular in subhumid and humid tropical forest areas, resulting in soil erosion and biodiversity loss. On the positive side, livestock can enhance soil fertility, and, through animal traction, improve the soil's physical qualities. Investment options for the arid and humid tropical grazing systems are summarized below, together with a description of the forces that drive livestock development in these zones, and the impacts this development has.

This chapter reviews the livestock sector externalities related to land and water use. Owing to the different nature of the issues that prevail in arid and humid areas, they are treated separately. In arid zones, the prevailing pastoral systems are already producing at maximum capacity, but their growing population is affected by a reduction in grazing areas, leading to a downward cycle of land degradation and poverty. There are too many people for the available animals. On the other hand, the annual vegetation of these ecosystems

has proven to be remarkably resilient. A paradigm shift is needed in pastoral development by:

- Enhancing the resilience of pastoral systems, through more emphasis on alternative employment generation outside the sector, enabling herd mobility (rather than current prevailing policies of “settling the pastoralists”), promoting collective action (pastoral associations) and introducing risk management systems (destocking and restocking, insurance); and
- Developing systems for payment for environmental services (PES), to enable pastoralists to shift from being producers of meat and milk to being stewards of the landscape, conserving land and biodiversity.

In humid zones, diminishing availability of fishmeal and recent sanitary restrictions on the use of other sources of animal protein have increased the demand for high quality protein feed from plant sources. Together with improved livestock technologies, this has made ranching and soybean production financially viable without subsidies. It has also made livestock in humid zones a major force in deforestation. Development inputs need to focus on the conservation of the most sensitive areas as a global public good. This means:

- Introduction and stricter enforcement of regulatory instruments for zoning; and

- Intensification of production and payment for environmental services to reduce the pressure on highly biodiverse areas such as forests.

For water, the emphasis would have to be on increasing the efficiency of water use, in particular in the production of feed-crops, and on the reduction of pollution. Water use efficiency can be increased through investment in irrigation infrastructure and increased cost recovery for water. Water pollution can be reduced through technology development in feeding (better balancing and reduction of phosphorous content) and manure management and storage. These matters are described in greater detail in chapter 4.

THE ARID TROPICS

The Footprint

Livestock contributes to soil degradation in the arid areas through overgrazing and soil compacting. However, there is still a strong debate on the degree and reversibility of such livestock-induced land degradation (Box 3.1). Current scientific evidence points to the strong resilience of the annual vegetation of these areas and the high level of efficiency with which the tropical arid rangelands are used. For example, sub-Saharan arid rangelands annually produce from 0.6 to 3.2 kg of animal protein per hectare (Breman and de Wit 1983). This is

Box 3.1: Views and Perspectives on Degradation of Arid Rangelands

There are a number of views on the degradation of arid lands. The more significant ones include the following:

- The pessimistic views of, for example, the United Nations Environment Programme (UNEP) (Dregne and Chou 1994) and others, with 35 million km², or 70 percent, of the arid lands degraded, the figure still often quoted in the international press;
- The “dynamic perspective” introduced by Tucker and his colleagues from the National Oceanic and Atmospheric Administration (NOAA) (Tucker et al. 1985), who point to an “expanding and contracting Sahel”;
- The “nonequilibrium” school of range ecologists, Roy Behnke and Ian Scoones (1993), which follows up on the earlier findings of Tucker and stresses rangeland dynamics and the strong resilience of apparently degraded areas; and
- The “soil fertility” school, exemplified by Breman and de Wit (1983), which stresses the current productivity of these rangelands and the importance of the soil nutrient balances.

substantially higher than the average 0.4 kg of animal protein per hectare per year obtained in ranches in the United States or Australia under similar rainfall conditions. While part of this higher production might arguably be due to overgrazing, long-term trends show rather stable production in areas such as the Sahelian rangelands (de Haan et al. 2001). This points to high productivity and resilience.

Moreover, livestock is only one of the many causes of land degradation. Cropping in marginal areas and firewood cutting are also important causes (de Haan et al. 2001). Livestock-induced land degradation occurs mostly around settlement areas, water points, and along livestock trek routes. In addition, livestock-related land degradation is mostly induced in times of drought, when the perennial vegetation of trees and shrubs is cut for fodder.

Environmental Impacts

Carbon emissions. Range degradation can cause the release of large amounts of the greenhouse gas carbon dioxide (CO₂) into the atmosphere, aggravating global climate change. Steinfeld et al. (2006) estimated an annual emission from grassland degradation of 0.1 billion tons CO₂ equivalent, most of it coming from the arid rangelands. However, if properly managed, arid rangelands can also be an important carbon sink. For example, the Australian Center for Research on Climate Change estimates the total capacity for carbon storage of the Australian rangelands at 48 billion tons CO₂ equivalent,³ if the rangelands were restored in their original, pre-livestock grazing, state.

Impacts on biodiversity. The world's arid rangelands are among the richest depositories of biodiversity, in particular of large mammals. For example, the species wealth in Sub-Saharan Africa approaches the biodiversity of the tropical forests (Blench and Sommer 1999). Overgrazing by livestock reduces plant biodiversity and puts other animal species that rely on this biodiversity, under pressure. So does the increased encroachment of sites of high potential by arable farming. While exact data on an ecosystem-wide basis are not available, in Kenya, for example, a reduction in

large mammals in arid rangelands of 33 percent was reported between the 1970s and the 1990s (Blench and Sommer 1999).

Social Impacts

The estimated pastoralist population⁴ occupying the arid rangelands is about 200 million.⁵ They are among the poorest and most destitute agricultural peoples in the world. Environmental degradation and longer and more frequent droughts are forcing them into a downward cycle of increased hunger and food-aid dependency. For example, the food aid expended during the 2006 drought in Kenya had an estimated cost of about US\$150 million for approximately 3.5 million people; the government of Kenya paid US\$13.7 million, or about 50 percent of the total costs, from its own budget over the first two months of the year.⁶ Moreover, because the natural resources are used at maximum efficiency (Breman and de Wit 1983), the scarcity of land and water are making conflicts over these resources increasingly common. Even more serious, these conflicts are aggravated by the recent introduction of automatic weapons in these areas.

The Driving Forces

A good overview of the driving forces of arid land degradation and the pastoral downward cycle of poverty and loss of livelihoods is provided in the ALive Policy Notes on Drought and Mobility.⁷ These forces are summarized here.

- *Population pressure.* Population growth, leading to competition between livestock keepers and farmers for resources that are already being used at maximum capacity, is one of the root causes of the downward trends. This competition is particularly strong for the sites of high potential (valley bottoms, oases) and water. Encroachment of these areas by farmers can destabilize a well-functioning pastoral livestock system.
- *Deteriorating internal social discipline.* Arid rangelands are predominantly communally

⁴ Peoples deriving their livelihood at least mostly from grazing domestic livestock.

⁵ Based on the figure for 1993 of 180 million reported by Sere and Steinfeld (1996).

⁶ <http://www.wfp.org/english/?ModuleID=137&Key=2031>.

⁷ www.alive-online.org.

³ http://www.greenhouse.crc.org.au/counting_carbon/rangelands.cfm.

owned, but grazed by individually owned animals. They are, therefore, typically common pool goods. Under conditions of communal grazing, the incremental feed required for an additional animal is free to the individual herder, and the incremental labor required to herd that additional animal is practically zero. Keeping an animal until it reaches its maximum weight and therefore maximum price is therefore fully rational from the financial perspective of the individual herder. This maximization of individual objectives conflicts with society's objective of maintaining high-yielding rangelands. Traditionally, this conflict between individual and societal objectives was managed through resource-access discipline based on strong social cohesion. With such cohesion, social (community) goals could be enforced to prevail over individual objectives. However, the disintegration of the social structures in pastoral societies causes this access to shift into "free for all," and the "tragedy of the commons" starts to apply. As a consequence, rangelands rules regarding the use of fire, access to water, and dry-season grazing areas are being grossly disregarded.

- *Climate change* has multiple effects. In arid regions these include greater weather variability, with more droughts and floods, reduction in overall biomass availability, and direct impacts on animal health, growth, and reproduction. This might lead, on the herd side, to changes in species composition, with a shift to sheep and goats, and its resulting effect on the vegetation. This in turn may lead to greater vulnerability of local people, and increasing levels of conflict on resource access.
- *Inappropriate government policies*. Several policies contribute to the current downward trends. Restrictions on herd mobility are an important case in point. Herd mobility is critical for the sustainable use of arid rangelands because it enables herds to most efficiently graze the fragmented vegetation patches resulting from the erratic rainfall in these areas. Government policies to encourage or force settlement—and encroachment by farmers of dry-season grazing and watering resources—has greatly reduced herd mobility. This has accelerated degradation and increased poverty. Inappropriate policies limiting herd mobility are not the only policies that interfere

with sustainable range management. Other such policies serve to provide inappropriate incentives. Providing free inputs for private goods, such as free water, grazing, and emergency feed supplies and free services, such as veterinary services are examples. Increased cost recovery would cause pastoralists to need more cash, and hence provide an incentive for them to sell more animals than if they operated in a purely nonmonetary environment. Finally, permitting the import of subsidized meat from the OECD (mainly European) countries, which, while providing urbanites with low-cost animal products, was threatening the livelihood of the pastoralists. The increase in meat prices worldwide has, for now, eliminated this practice.

Collective Actions

Collective actions to manage land and water resources focus on upstream-downstream interactions within the context of a watershed, and often involve the management of common resources. User and producer associations and other types of collective organizations have been able to exert pressure on upstream users to correct environmentally inappropriate behavior such as excessive water extraction and practices that lead to pollution and erosion that reduce the availability and quality of water for downstream users. In South Asia in particular, wide experience has been accumulated by employing watershed-based approaches to natural resources management (World Bank 2001). A review (Kerr, Pangare, and Pangare 2002) of these experiences reveals the main lessons to be the following:

- Participation of all users is essential; the most successful operations consist of a combination of good social organization and sound technical improvement.
- Short-term benefits are needed to gain participation of the beneficiaries for the long-term objectives and benefits.
- Downstream users, while generally poorer, often carry a larger share of the costs than the wealthier upstream users, who often have access to more irrigated land.
- Improvements in common lands (mostly used for livestock grazing) were least sustainable.

Relatively less evidence is available from watershed groups in sub-Saharan Africa. The Consultative

Group on International Agricultural Research (CGIAR) System-wide Program on Collective Action and Property Rights (CAPRI) has developed research and pilot activities in the East African Highlands that similarly underscore the need to combine participation and technical innovation. In Latin America, watershed development is increasingly linked to the payment for environmental services, especially for water quality in water-scarce environments such as those in Mexico.

Because communal land access is a prominent feature of arid pastoral systems, pastoral associations that manage these common resources played important roles in a number of World Bank-funded arid land projects in the 1990s. However, experiences with this form of collective action have been mixed at best, particularly in situations of high population pressure, where social cohesion and internal discipline had often eroded (Pratt, de Haan, and le Gall 1997). A review of the performance of the World Bank-funded Livestock Project in Mauritania for example, found a discrepancy between the focus of the World Bank on sustainable range management, and the focus of pastoralists, who were more interested in the upgrading of water and animal health services (World Bank 1999). Similarly, in Mongolia, the initial reemergence of traditional communal management systems of family groups (*khot-ail*), after the transition, now seems to have been replaced by intensive competition for grazing resources by individual families, with increasing gaps between poor and rich pastoral families (Franklin and Mearns 2003).

Policies and Investments

Production systems in the areas described above are complex and the scope for maneuvering is limited. However, key policy, institutional, investment, and scientific interventions could include the following⁸:

- *Facilitating outmigration.* Most regions, particularly those with land degradation in Sub-Saharan Africa, have reached the limits of their human-carrying capacity, and population pressure needs to be reduced. Providing pastoral peoples with education and micro-credit services to enable them to find alternative sources of livelihood is therefore an

important priority for policy and investment. Some populations will also require concerted and purposefully targeted food aid administered with policies that avoid cultivating dependency on food aid.

- *Managing climatic variability.* Drought is probably the main event that sets off irreversible land degradation. Ameliorating this problem requires developing early-warning and response systems at national and local levels, strengthening livestock market infrastructure to enable swift offtake of animals in times of imminent drought, and swift restocking as rains return. This can include creating transport-subsidy schemes to facilitate early destocking; livestock-loss insurance schemes, such as those introduced in Mongolia (although there they were for losses that occurred as a result of ice storms, which are a more discreet event than drought, see Box 3.2); and establishment of fodder reserves. Because global climate change is a global public “bad,” this warrants global funding.
- *Investing in infrastructure.* When markets and infrastructure improve, as they did in the Machakos region of Kenya, the downward cycle of land degradation can be reversed (Tiffen and Bunch 2002). Improved market infrastructure encourages early offtake and marketing of livestock and increases access to services, which will increase the participation of the pastoralists in the cash economy.
- *Changes in the incentive system* with two major components.
 - *Developing systems of payment for environmental services (PES)* in arid ecosystems. The arid areas currently provide only a limited contribution to total animal production, and there is even less potential for productivity to increase. However, there is potential for significant contributions to carbon-sequestration and biodiversity in arid rangelands. A paradigm shift in the way the global community views and remunerates these rangelands is, therefore, needed. This implies a shift from “pastoralists as producers of meat and milk” to “pastoralists as managers of landscapes.” It will imply the development of payment systems that reward pastoralists for the provision of services in carbon-sequestration, biodiversity conservation, and water-quality improvement. Incentives have to be

⁸ See also Pratt, de Haan, and le Gall 1997; and ALive 2006.

Box 3.2: Managing Risk and Vulnerability in Pastoral Areas

Several World Bank–funded projects in pastoral areas apply the principles outlined in the text. The Kenya Arid Lands Natural Resource Management Projects have developed an efficient participatory early-warning system, based on simple anthropometric (skin and body) measures and livestock and grain price ratios. These objective indicators link into district and national contingency plans with again clearly defined stages of alert. This has helped to get the decisions on the allocation of food aid away from the politicians, where allocation was often based on party allegiance, rather than needs, into the hands of the community of direct stakeholders.

Two World Bank projects in Mongolia seek to protect nomadic herders from major climatic risks, mainly ice storms, which in 1999–2000 caused the death of at least 10 percent of the national herd. The

Mongolia Sustainable Livelihoods project seeks to improve marketing through improvement in feed reserves, and, to improve the resilience of the nomads to drought and ice storms through agricultural diversification.

The Mongolia Livestock Insurance project is establishing an index-based insurance scheme to compensate herders whenever the adult mortality rate exceeds a specific threshold for the district. The first layer of losses would thus be for the herder, the second for private industry, and the third (disaster level) would be covered by the project. The focus on a district and index-based system would reduce adjustment costs and the ex ante moral hazard of reduced care and the ex post moral hazard of falsely declaring the death of animals.

Source: World Bank 2005. Index-based Livestock Insurance Project.

performance-based and possess the correct balance between individual and collective remuneration for the services provided. There is not much experience with these systems, but earlier PES systems included some revenue sharing for wildlife conservation. Because of the global public good nature of the cause and the effects, this would be suitable for global funding.

- *Increasing the level of cost recovery* in veterinary services, water, and even grazing to reduce the marginal cost-benefit ratio of incremental growth of almost mature and hence slow-growing animals. This encourages earlier offtake. As this concerns mainly private goods, cost recovery is justified. By making the fee progressive (a higher fee per animal for larger herds), such an incentive system would support an equitable use of the rangelands, although the politics of such a system are sensitive. It would also require the establishment of a sharply targeted feed-aid policy. Feed aid ordinarily discourages destocking and therefore threatens the long-term sustainability of the rangelands.

- *Enabling institution building*, adapted to the special requirements of mobility and risk management. This will include education, health, and animal health services that are adapted to the mobile nature of the pastoral systems. There is good experience with mobile schools for nomadic children in Iran and other West Asian countries. Because government influence in those areas is normally quite limited, the development of pastoral associations is also critical, although experience with those groups is mixed.

THE HUMID TROPICS

The Footprint

Livestock ranching has for a long time been associated with the deforestation of tropical rainforests. However, this connection has gained increased significance in recent years, as the rate of deforestation increased and the role of livestock in the process became more pronounced. In the Amazon area, deforestation has accelerated from about 18,000 km² per year over the 1990–2000 decade, to

about 25,000 km² per year in recent years, and grew at 0.6 percent during 2000–2005 (Margulis 2004).⁹ It is estimated that in 2010, livestock in South America will be grazing on 24 million hectares, which were still forests in 2000; 60 to 70 percent of the conversion in the Amazon area is for cattle ranching or feed-grain production; the rest is mostly for small-scale subsistence farming. The Central American picture is more varied. Costa Rica has an expanding forest area and Panama and Colombia have a very slow deforestation rate of 0.1 percent per year, but countries such as El Salvador and Guatemala have rates of more than 1 percent per year. Dairy and crop farming seem to be the driving forces. In Asia and Central Africa, legal and illegal timber extraction is the main driving force and livestock development plays only a minor role in the deforestation of the tropical rainforest. This chapter will, therefore, focus almost exclusively on the humid tropics of the Americas.

Environmental Impacts

Carbon emission. The conversion of tropical forest into cropland causes the release of large quantities of CO₂. Amazonian evergreen forests account for about 10 percent of the world's terrestrial primary productivity and 10 percent of the carbon stored. It is estimated that the conversion of tropical rainforest to grassland for livestock ranching annually produced about 1.7 billion tons of CO₂ equivalent and 0.7 billion tons for the conversion of tropical forest into cropland for livestock feed (corn and soybean) (Steinfeld et al. 2006).

Biodiversity. The South American rainforest area is the largest rainforest biome in the world, with about 2.5 million insect species, tens of thousands of plants, and some 2,000 birds and mammals. The rate of loss of the biodiversity because of livestock-induced deforestation is a matter of discussion. The official view is that about 400 species are at risk of extinction, although some estimates are dramatically higher.¹⁰ The impact of the livestock sector on biodiversity has different forms (Steinfeld et al. 2006). Most of the biodiversity losses result from habitat destruction, as the natural forest vegetation

is replaced by ranching or soybean farming. However, habitat fragmentation and invasion of alien species, when patches of native vegetation become isolated in the landscape and lose their connectivity because of erratic ranching settlement patterns, is also an important cause.

Water quality. The Amazon region is one of the world's main freshwater reservoirs, holding about one-fifth of world's volume of fresh water, and the conversion of tropical forest to grassland or cropland, with its resulting increased erosion, is a major danger to the quality of this resource. Already, the world's biggest silt accumulation is found at the mouth of the Amazon River.

Social Impacts

There are an estimated half-million indigenous peoples (down from 7 million to 10 million in the 15th century), and they have a culture with unique features. They are in danger of losing this culture and its unique knowledge of medicinal plants as a result of deforestation. The preservation of this knowledge can be of enormous benefit for the development of future medicines against a variety of diseases. The expansion of ranching and feed-crop production can cause this unique pool of knowledge to be lost. Most soils are exhausted after 10 to 15 years, leaving many evolving farming systems unsustainable and forcing local populations into highly mobile livelihoods that lead to substantial displacement and social upheaval.

The Driving Forces

There are major forces pushing the increased rate of deforestation in the humid areas of the Amazon region:

A strong increase in demand for soybean products for livestock and aquaculture feed. Demand for pork and poultry products has grown about 10 percent per year in East Asia, causing a worldwide increase in demand for animal feed of about the same order. Fishmeal, once the predominant high-quality protein source for pigs and poultry, is now facing increased competition from the aquaculture subsector (Box 3.3), making soybean meal the main protein source in pig and poultry feed. Soybean production in the Brazilian Amazon increased by about 60 percent between 1998 and 2002. Brazil is now the world's second-largest soybean exporter.

⁹ There was a decline to 13,000 km² from August 2005 to August 2006 (<http://news.mongabay.com/2006/1026-brazil.html>).

¹⁰ www.rain-tree.com/facts.htm.

Box 3.3: Livestock, Aquaculture, Soybean Meal, and Deforestation in the Amazon

Shifting consumer demand, changing food safety standards, and increasing inter-sectoral linkages made livestock the driving force behind the expansion of soybean cultivation in the Amazon area. The prohibition against using animal by-products in livestock feed because of bovine spongiform encephalopathy (BSE) led to increased demand for plant protein, and especially for high-quality soybean meal. At the same time, the fast-expanding, high-value aquaculture subsector (shrimp and so forth), which is more dependent on fishmeal (and fish oil) than terrestrial animals, used an increasing share of the rather inflexible supply of fishmeal. For example, the share of fishmeal used by aquaculture grew from 8 percent in 1988 to about

35 percent in 2000 (Delgado et al. 2003) to 45 percent in 2005 (World Bank 2006a). So, both BSE and aquaculture forced the livestock subsector to look for alternative sources of plant protein, and drove the strong expansion of soybean as one of the highest-yielding and best-quality sources of plant protein. This demand was particularly strong from East Asia. This, combined with the development of new soybean varieties adapted to the humid tropical environment, led to a rather spectacular growth of the areas under cultivation. While this is mostly degraded cattle-ranching land, soybean production pushes cattle ranching into deforesting new areas.

Source: Steinfeld et al. 2006.

Increased competition for land for the production of biofuel. In addition to the competition from the aquaculture subsector, the growing use of land for the production of biofuel has increased pressure on tropical savannahs and forest areas. Ethanol produced from sugarcane already accounts for 40 percent of the fuel sold in Brazil, and occupies about 3 million hectares (ha) of land,¹¹ or about 5 percent of the total cultivated area. Land used for soybean cultivation (partly for biodiesel) has expanded at the rate 16.8 percent annually since 2000, and now covers more than 8 million ha.¹²

Brazil's veterinary health status. Brazil is free of BSE and most of the Amazon area has been declared "Free with Vaccination" for foot-and-mouth disease. This has opened access to markets in Russia and West Asia in particular. For example, during 2000–2004, the value of beef exports from Brazil to Russia increased from zero to US\$239 million, to Egypt from US\$3 million to US\$160 million, and to Iran from US\$2 million to US\$102 million. Between 1996 and 2004, the total export value of beef increased tenfold from US\$190 million to US\$1.9 billion, making Brazil the world's largest beef exporter.

Greatly improved technical efficiency of Brazilian beef production. In the 1980s and early 1990s cattle ranching could be sustained only through subsidized interest rates and strongly rising land prices, and even then only as part of a land-use sequence. This also included cereal (corn) and subsistence production (de Haan et al. 1997). Since then, a technological revolution, based on improved pasture management, mineral feeding, and better reproductive management (estrus synchronization and artificial insemination) has made livestock ranching highly profitable on its own, with a return on capital exceeding 10 percent, although land speculation is still a major driving force in the frontier areas. Table 3.1 compares some of the key productivity parameters reported in the literature in the 1980s and the more recent work of Margulis (2004).

The policy framework. Although much has changed from the strong government promotion of livestock development in tropical forest areas in the 1980s with subsidized credit, export subsidies, and perverse land tenure incentives (titles were given only to deforested land) (Faminov 1998), the overall policy framework is still important regarding the following:

- The devaluation of the Brazilian real, for example, from 1.2 to 3.6 to the dollar during 1998–2002, doubled the value of the beef in

¹¹ www.mstbrazil.org/?q=carlsenonagrofueltrap.

¹² http://news.mongabay.com/2007/0516-ethanol_amazon.html.

Table 3.1: Technological Progress: Comparison of Key Technical Parameters in the Beef Industry in the Amazon Area of Brazil, 1985–2003

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

a. AU stands for animal unit and is a standard measure 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.

Sources: 1985 data for North West Brazil in World Bank 1991; 2003 data for the Rondonia Region in Margulis 2004.

- the domestic market, while at the same time the fall in US dollar value in the international market increased the competitiveness of Brazilian beef in the international market; and
- Funding of infrastructure (roads and power), and the resulting reduction of beef transport costs has been one of the key drivers of cattle ranch expansion in the Amazon.

These factors together cause the deforestation process to have become basically endogenous (that is, occurring without outside incentives, except road development), and, therefore, more difficult to mitigate through public policy.

Public Policy and Investment Options

With many of the economic distortions of the 1970s and 1980s already phased out, and the deforestation process basically having evolved into an endogenous, private sector–driven process, the key strategy should be to acknowledge that cattle ranching in the tropical rainforest is for the individual rancher a profitable activity (Margulis 2004). Sustainable forest management does not provide a financially attractive alternative to cattle ranching, with cattle ranching investments having a present net value of about US\$500 per hectare, against the US\$203 for sustainable extractable wood. With the caveat of methodological gaps in the valuation of forest, the social value of forest was estimated to be about US\$100 per hectare per year, compared to a current income of US\$75 per hectare per year for cattle ranching (Margulis 2004). Environmental services and their benefits would need to be included to make it attractive. If the financial attractiveness of cattle ranching is the main driving force, the

approach should be to work with the ranchers and not against them, and focus on sustainable development, rather than on unenforceable conservation. Some of the main instruments that can be applied are zoning agreements, tradable development rights, and incentive frameworks.

Negotiating zoning agreements among ranchers, other stakeholders, and the government would lead to cattle ranching occupying areas that are less sensitive from a social and environmental point of view, and the protection of areas with high social or environmental values. Because enforcement in such areas is traditionally weak, zoning approaches could be supported with the allocation of credit depending on ecological criteria.

Introducing tradable development rights would be a further and more sophisticated refinement of the zoning instrument. If combined with a classification and valuation of the ecological importance of the designed zones, the tradability would allow a higher degree of deforestation in the potentially more productive areas, while facilitating the conservation of the ecologically richer areas.

Providing an incentive framework that encourages conservation of the socially and environmentally valuable areas at the same time promotes the intensification of areas that are of lesser concern in these respects. These incentives could include:

- Taxation for deforestation integrating into the environmental externalities into the cost of ranching, although the work of Margulis (2004) suggests that high taxes would be needed to significantly reduce ranching-induced deforestation. Model calculations show that a tax of US\$15 to US\$20 per hectare would not be enough to stop deforestation.

Box 3.4: Payment for Environmental Services

The Global Environmental Facility (GEF) and the World Bank supported until early 2008 a regional project in Central America that used PES as a tool to promote the conversion of degraded pastures to more complex vegetations, which increases carbon sequestration and enhances biodiversity. The adopted method was designed to reduce transaction costs as follows.

- Different vegetation units were ranked by an expert panel on their contribution to carbon sequestration and biodiversity.
- Using satellite and global positioning system (GPS) 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, using GPS technology, 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 ton of carbon. In the absence of a functioning market for biodiversity, about the same level was, rather arbitrarily, set for this service.
- 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 complicated rural credit schemes; and all funding was channeled through nongovernmental organizations (NGOs).

About 270 farmers in six watersheds in three countries (Colombia, Costa Rica, and Nicaragua) participate in this scheme. The results, after four years of operation are promising:

- The relationship among 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. About 5,000 ha were established with improved, deeper-rooting pastures and more trees; more than 1,200 kilometers of living fence was established, which significantly improved the connectivity of the different habitats; and about 40 ha in slopes were left fallow to regenerate to secondary forest. The average payment per farm was about US\$38 per hectare in the second year of operation, and the average monitoring costs were about US\$4 per hectare.
- Also, the poorer farmers found the resources for the required investments. A survey found that the poorer farmers received higher payments per ha than the larger ranches.
- The reaction of the public institutions was quite favorable. In Costa Rica, the government decided to include agroforestry (and this scheme) in its forest PES scheme, which is funded through gasoline taxes and water charges. In Colombia the National Livestock Federation is negotiating international and national funding sources to scale-up this pilot operation.

The biggest challenges will be: (a) to simplify the method even more; and (b) to find the international funding sources, linked to carbon trading, that will enable the application of such payment schemes for the areas such as the Amazon, to tip the balance from continuing expansion to intensification of production.

a. See also: www.fao.org/AG/AGAINFO/resources/documents/pol-briefs/03/EN/AGA04_EN_05.pdf.

- Payment to ranchers for the environmental services provided by conservation of tropical rainforest, or for the shift from the common monoculture pastures to more complex vegetation. The latter, at the same time, would promote the possibility of increasing the stocking rate, thus, reducing pressure on primary forest. There have recently been a number of interesting pilot operations in Payment

for Environmental Services, notably in Central America (Box 3.4). The challenge now is to amass the financial resources to scale up such pilots to the large rainforest areas currently under threat of deforestation.

- Strengthening the governance of the institutions responsible for enforcement, and the allocation of property rights, which are still fraught with fraud and corruption.

WATER

The livestock sector withdraws (uses) an estimated 7 percent of the total water withdrawals of agriculture, and depletes (consumes) through evapotranspiration, integration into other products, and pollution about 17 percent of total agricultural water depletion (Steinfeld et al. 2006). The share that is used for direct drinking and servicing is less than 1 percent. Most water is used for the production of feed-crops, with 15 percent depletion/consumption. Pollution with nitrogen and phosphorus is also an important cause of freshwater depletion. In the United States, for example an estimated 33 percent of nitrogen pollution and 32 percent from phosphorus pollution comes from livestock. These figures are much higher in East Asia, with, for example, figures for Vietnam of 38 and 92 percent for nitrogen and phosphorus, respectively. Other causes of water depletion are contamination with antibiotics, pesticides, and erosion.

There are various estimates on water use efficiency for meat and milk production. Very high figures are estimated by Pimentel et al. (1997), who reported an estimate of 100,000 liters (L) of water per kilogram of beef, a figure still often found in the NGO literature. However, the extrapolation of such figures to a worldwide scale would mean that

the sector would use more than all the world's water resources. This estimate is apparently based on the assumption that all feed used for beef production comes from irrigated land, which is clearly not the case. Beckett and Oltjen (1993) estimated the total use of developed water for U.S. beef production, including water for irrigation, drinking water, and water used for animal processing at marketing. They calculated that the total water requirement was 3,682 L/kg of beef (CAST 1999).

While the share of withdrawal and depletion from the livestock sector is still relatively small, the current and projected worldwide water shortages also warrant more attention in the sector to reducing water needs. With the large majority of water now being used for the irrigation of feed-crops, increasing irrigation efficiency is the first priority. Promoting collective action through the establishment of water-user associations and introducing cost recovery for water used has a proven record in World Bank projects. On the investment side, improvement in the irrigation infrastructure (canal lining, land leveling and so forth) is also essential.

Stronger regulation of pesticides and antibiotics in the sector can reduce contamination. Manure management to reduce nitrogen and phosphorus is described in the next chapter.

Livestock Externalities, Crop–Livestock Interaction, and Nutrient Cycling

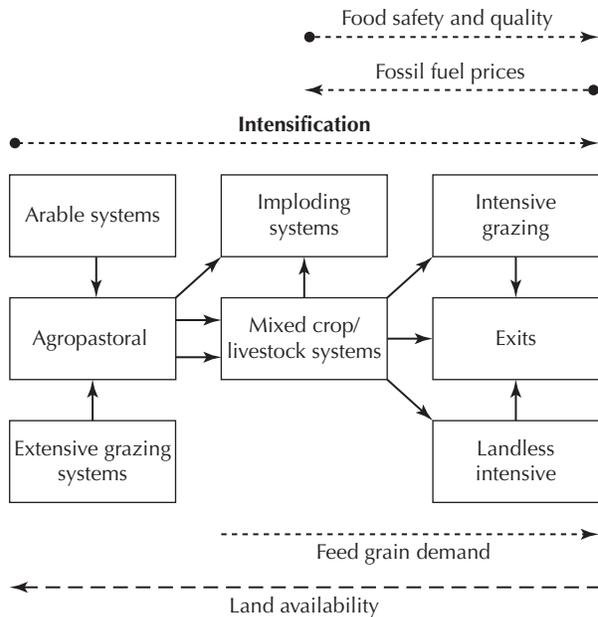
Mixed farming systems, in which livestock by-products such as manure and traction, and crop residues are used as reciprocal inputs, are the most important production systems in the developing world. They produce about 80 percent of milk, 50 percent of pork, and 35 percent of poultry in developing countries. Most are rain-fed, although in the tropics, milk and pork production comes largely from irrigated mixed farming systems (Steinfeld et al. 2006).

This chapter focuses on mixed and so-called landless systems. Mixed farming systems are the best recycling systems in the livestock sector. Landless systems use the most external inputs, principally feed, from outside the farm. The flows and balances of nitrogen and phosphorus nutrients from manure vary substantially by region, and are heavily influenced by the extent of economic development. At earlier stages of development, livestock producers tend to settle in proximity to consumers. Later, as transport infrastructure improves, they often move their operations to feed-producing areas. Policies can improve the geographic distribution of livestock production when infrastructure development enables a strategy of intensification-without-concentration. Such strategy makes for a more level playing field for biogas-generated power and organic fertilizer. Recycling nutrients becomes increasingly important for the expanding organic market, whereas improved technology and carbon trading schemes open new opportunities for biogas, which deserves international support.

Mixed farming is a production system that is particularly benign to the environment. The crop residues such as straw and milling by-products, which would otherwise be burned or allowed to decompose and convert into greenhouse gases, are instead recycled through animals. The use of manure reduces the need for inorganic fertilizers and causes less water pollution. Manure, or organic fertilizer, also increases the effectiveness of inorganic fertilizer and the water retention of soils. The use of animal traction reduces the need for fossil fuels. Because mixed farming systems are diversified, they reduce climate and price risk for smallholders, making them also attractive from a social perspective.

However, not all mixed farming systems have balanced nutrient and energy cycles. As, livestock systems evolve, this balance changes significantly. Three principal factors define the systems' evolution: market access, land pressure, and transport infrastructure. These

Figure 4.1: Schematic Presentation of Development Pathways of Main Livestock Production Systems and Selected Main Drivers



factors determine livestock density and production intensity. Livestock density is defined as livestock biomass per unit of surface area. Production intensity is mainly a function of the system's level of dependence on outside inputs. Density and intensity determine the spatial distribution of nutrients from livestock waste. As pressure on land increases and market access improves, mixed grazing and cropping systems become more intensive to capitalize on the fertility and energy inputs of the livestock subsystem and the feed inputs from the crop subsystem. The dynamic is depicted in Figure 4.1.

As incomes grow further however, food safety and general quality standards become more important. With concomitant economies of scale, the specialization of livestock into so-called landless systems or other high-value crops will emerge. For these landless operations, inputs come from outside. These inputs of nutrients affect the nutrient balance. While future trends will vary by region, it can be expected that mixed farming will remain globally important for decades to come, and particularly in Sub-Saharan Africa, a growing mixed farming sector is likely to develop. In East Asia the main growth will probably be in specialized pork, poultry, and beef production systems.

Transport costs for feed and livestock food products also play an overriding role in the location of production. Where transport infrastructure is poor and transport costs are high, livestock production tends to concentrate in proximity to urban consumer markets and to ports where feed imports are available. This is particularly true of pig and poultry production, which is strongly concentrated on China's heavily populated eastern seaboard, and around Bangkok and Ho Chi Minh City. In Europe, production is concentrated in places near seaports such as the Netherlands, the Brittany region of France, and around Barcelona (Gerber et al. 2005). In some instances, the industry locates itself near feed-producing areas, such as in the Corn Belt in the United States and, now increasingly in Brazil, where, with improved road transport infrastructure, the large meat producers and processors increasingly establish themselves in the Amazon area of Mato Grosso. The number of processors in the area has nearly tripled over the past decade (De Zen et al. 2005).

Finally, the stringency and level of enforcement of environmental (and increasingly animal welfare) regulations also play a significant role in the location of livestock production. This is one of the main reasons for the stagnating production in Western Europe. The differences in the stringency of environmental regulations and their enforcement is reportedly also one of the reasons for the shift of intensive pig operations to the Southern United States and Mexico, although other factors such as prices and the investment climate have also played a significant role (Speir et al. 2003). In the Philippines, Delgado et al. (2006) noted that large production units near Manila have moved to Mindanao, while more difficult to regulate smaller units have proliferated around Manila.

NUTRIENT FLOWS

Trends and Impacts

Nutrient flows range from extensive nutrient-deficient systems, where losses are higher than the inputs and soil fertility is depleted, to systems where inputs by far exceed those of the exports, and soil-nutrient loading, with groundwater contamination, surface-water eutrophication, and soil pollution occur. Nutrient loading in these conditions will lead to loss of biodiversity, and constitute

a major public health risk. Balancing nutrient inputs and outputs is therefore of crucial importance.

Nutrient Cycling in Extensive Livestock and Cropping Systems

Extensive grazing and arable farming systems are generally exporters of nutrients. The rate of loss of nitrogen and phosphorus through the export of grain and meat products, combined with volatilization and runoff, exceed the replenishment of those nutrients from imported chemical fertilizers and nitrogen fixation by leguminous crops.

In cultivated croplands in Niger, 10 to 15 kg of nitrogen per hectare were reported lost annually (Powell and Williams 1990). In Mali, 15 kg of nitrogen were lost per hectare annually (de Haan et al. 1997). In many extensive systems these losses are much higher. In Ethiopia, for instance, they average 100 kg (Breman and Debrah 2003).

Within those extensive systems, there is a significant transfer from the grazing to the cropping systems. Manure is hauled to the crop fields or animals are corralled on the fields at night. The latter gives a higher return of nutrients because both urine and manure are deposited in the fields. Migratory pastoralists often contribute nutrient material as well, in a variety of exchange relationships.

The ratio of grazing to cropping area will then define the overall sustainability of the system, because a much larger area for grazing is needed to supply a reasonable level of nutrients to maintain soil fertility on the croplands. In West Africa for example, it was estimated that the ratio was about 10 to 40 ha of dry-season grazing and 3 to 10 ha of wet-season grazing to provide adequate nutrients for 1 ha of millet cropland (Williams et al. 1995). However, this ratio is declining fast, as shown in one Malian community, where between 1952 and 1998, the ratio between crop and rangeland dwindled from 13:1 to 3:1—tremendously reducing the transfer of fertility from rangelands to cropping areas. If most crop residues are used, but manure is deposited elsewhere or subject to heavy losses, as often occurs in the Sahel, negative nutrient balances occur. This leads to a downward spiral, with the depletion of soil fertility, loss of soil biodiversity, increased erosion, and growing vulnerability among local populations.

Chemical fertilizers are therefore needed to stabilize these systems. They would also have a

synergistic effect when used in coordination with livestock manure. Fertilizer use in the Sahel for instance remains very low, at about 5 kg per hectare each year. Subsidizing chemical fertilizers has led to disappointing results although the 2008 World Development Report, *Agriculture for Development* (WDR, 2008), acknowledges that in certain conditions, subsidies might be recommended to kick start use, correct market distortions, or provide some necessary environmental benefit. In other conditions, alternatives to fertilizer subsidies are important to develop. A report published by the World Bank's Agriculture and Rural Development department examined a variety of these alternatives and recommended a broader focus on improving the investment climate, providing financial services, investing to improve infrastructure and reduce transport costs as elements of a more enabling environment to encourage fertilizer use in Africa (World Bank 2006d).

Nutrient Loading from Intensive Systems

As livestock population density increases, negative aspects also start to emerge. Livestock manure (especially from pigs) contains a high percentage (95 percent) of water. Per kilogram of nitrogen or phosphorus, therefore, it is costly to transport and apply on land in areas with low livestock density. Data from the French province of Brittany indicate that transporting nitrogen and phosphorus from pig manure cannot compete with inorganic fertilizer if the manure has to be transported more than 5 km (de Haan et al. 1997). Inorganic fertilizer is also often preferred because of the readily available nutrients in exactly the required combination and its ease of transport.

Significant quantities of inorganic fertilizer are often applied on top of already adequate amounts of nutrients from livestock manure. For example, Gerber et al. (2005) estimate excess phosphate applications on 23.6 percent of East Asia's agricultural land, mainly located in eastern China, the Ganges basin, and around urban centers such as Bangkok, Ho Chi Minh City, and Manila. Livestock manure in these areas is on average estimated to account for 39.4 percent of the phosphate (phosphorus pentoxide, or P_2O_5) supply (the remaining share being supplied by chemical fertilizers). Livestock are the dominant agricultural source of P_2O_5 around urban centers and in livestock-specialized areas (southern

Box 4.1: Key Data on Nutrient Loading

- About 46 percent of the cropped area in East Asia is estimated to have an annual phosphate surplus of more than 10 kg/ha, and 4 percent has an estimated surplus of more than 40 kg/ha (Gerber et al. 2005) resulting from high livestock concentration.
- Of the 3,141 counties in the United States, 8 percent have an excess in nitrogen and 15 percent in phosphate from manure (USEPA 2005).
- In the Netherlands, 270,000 ha of the sandy soils of the Eastern and Southern parts are saturated with phosphate (Hooda and Edwards 2002).
- Excessive algae and other plant growth resulting from direct discharge into open water or leakage

- of nutrients into surface water is a major threat to aquatic biodiversity. For example, pig production accounts for an estimated 46 percent of nitrogen, and 90 percent of the phosphate flows into the South China Sea, through the Pearl River (Impact of Animal Production on Water Availability and Quality, FAO Policy Brief, FAO 2005).
- Leakage of nitrates from saturated soils into groundwater constitutes a major cost in the production of drinking water, although the health consequences of higher nitrate levels are now well documented.

Source: World Bank 2005.

and northeastern China), while chemical fertilizers are dominant in crop (rice)-intensive areas. Selected global livestock-related soil and water pollution data are provided in Box 4.1.

Considerable progress has been made in recent years in manure production, storage, and application techniques (World Bank 2005). Improvements have included reducing manure output through better feed composition, balancing manure application with crop-nutrient demand, and better timing and method of application (nutrient injection) and the introduction of buffer zones and scavenger crops to reduce leakage.

This is particularly important under smallholder conditions near urban areas, where the fragmented nature of smallholder farms makes the pollution non-point-source, and more difficult to control, than the point-source discharge from large farms. Delgado et al. (2006) found in Brazil, the Philippines and Thailand that draining manure into open water and depositing it on the open soil surface, with the risk of runoff, was much more common among smallholders than among larger units. The larger units in these countries also used better methods of disposal of dead animals, from an environmental and public health perspective. Where large numbers of animals are kept in the same area, smallholders are likely to pollute more than large enterprises.

COLLECTIVE ACTION

Voluntary collective action in managing nutrient loading is limited, although in Europe recently, so-called *environmental cooperatives* are starting to play a role in promoting collaboration in environmental management. Environmental cooperatives consist of local farmers groups that promote activities related to sustainable agriculture and rural development. They are an institutional innovation of particular importance in the Netherlands, where, since the foundation of the first cooperative in 1992, the numbers have rapidly grown to about 125, with an estimated 10,000 members, involving about 10 percent of all farmers and 40 percent of all agricultural land. Farmers are paid (from national and European Community funds) on an output basis (diversity of the botanical composition of the grassland, and bird population). Collective action increases the overall impact, because the cooperation facilitates the reduction of landscape fragmentation and therefore favors the expansion of bird populations, and hence payment. There is, thus, a direct benefit to the individual farmer. Although cost-benefit analyses have not been conducted (Franks and McGlion 2007), there seems to be sufficient evidence to suggest that these innovations have benefited all actors involved—farmers, the government, the environment, and the rural economy.

Collective use of a biogas facility is another activity under this category. There are strong economies of scale in the investment costs of biogas installations, but transport costs of manure are high compared to its value. Successful village associations for the operation of biogas plants are reportedly operating in Nepal (World Bank), and particularly its collective action in benefiting from the Clean Development Mechanism, and for their maintenance in China (IFAD).¹³

PUBLIC POLICIES AND INVESTMENTS

The case for major public policy involvement in more or less balanced mixed farming systems is probably less pronounced than in other production systems. Most synergies of mixed farming are confined within the farm and directly benefit the producer, and therefore do not require express policy interventions. However, in contrast to the other systems, assuming that the positive spillovers on the environment and social equity through risk reduction are more important than the negative externalities of nonpoint pollution, there is a case for policy intervention to enhance those positive spillovers. The sheer importance of the mixed farming system would justify such interventions.

Public policy and investments are needed both in conditions of fertility decline and land degradation and in conditions of nutrient loading.

Reversing fertility decline and land degradation through policies and investments that encourage mixed farming will involve focusing on land and market access. Establishing an appropriate investment climate will entail ensuring farmers' secure access to land so that farmers who invest in crop rotation and manure recycling will capture the benefits of the resulting long-term improvements in soil quality. Building a more enabling investment climate will also entail adequate savings and credit banking systems.

The importance of infrastructure and market development is also well established by experience in the Machakos region in Kenya. There, a fivefold increase in the local population could have led to environmental degradation and declining income. However the proximity of the attractive Nairobi market led to a major intensification of the farming

system, with a shift from cattle to small ruminants and high-value plant products. It also resulted in an improved resource base (Tiffen and Bunch 2002).

Research and development are necessary to address a number of technical issues that are unlikely to attract substantial investment in private research. The integration of fodder crops into the cropping cycle has seen limited success owing mainly to labor constraints during the planting season. Developing an effective technical or methodical solution to this limitation could yield very substantial productive and social benefits, but would not attract private research. With certain exceptions such as the use of urea to treat straw, the improvement of feeding value and fodder cereal production was largely neglected during the Green Revolution and in breed improvement more generally. Strategic supplementation of lactating and growing animals is one such area that warrants investment in public research and development. For this type of technical research to have noticeable impacts, however, the basics of markets and land scarcity will have to be recognized during the conduct of the research.

Reduction in nutrient loading will require a combination of regulatory, financial, and communication measures. New technologies offer significant possibilities to reduce the quantity and facilitate the management of the waste produced.¹⁴ Creating public awareness of the long-term and global effects of livestock waste on water and soil pollution can generate political demand, and can build on general awareness of the more immediate, observable nuisance effects of odor and noise. This public and political pressure can be important forces behind the passage and enforcement of regulations to improve the handling and application of manure and to achieve a better spatial distribution between livestock waste production and the absorptive capacity of the surrounding areas. Such regulations may limit the number and density of farms and animals, and stipulate the technologies that are required.

Acceptable livestock and farm density will depend largely on the cost of transport, the nutrient content of the waste, soil and arable farming characteristics, and the price of alternative sources of fertilizer. Generally, pig waste, with high water

13 www.ifad.org/newsletter/pi/15.htm#5.

14 See also World Bank 2005.

content, has the smallest area in which it can be spread on an economically and ecologically sound basis. The instruments to be used include zoning regulations, which can be based on combining land characteristics (soil, water, and slope), biodiversity values, and market and human population density characteristics. Geographic information systems (GIS) can be usefully applied in identifying areas with potential for expansion or reduction of livestock production.

The amount, timing, and technology of the application are also important in reducing leakage into groundwater and surface water. This covers maximum amounts to be applied, restrictions regarding application during particular (high rainfall and/or cold) periods, and obligatory use of soil-injection technology to reduce runoff and emissions. It can also include the use of GPS and satellite technology to identify areas with lower nutrient levels, and thus provide a much more precise application, according to the soil's fertility needs.

Financial instruments are generally required to support and supplement regulatory instruments. Financial instruments include taxes and subsidies and can eventually be supported by tradable rights and quotas and tradable emission reduction credits.

- *Subsidies* are often provided to offset the investment costs of equipment for manure management and processing. For example, in many countries, including developing countries such as China, equipment for manure storage and biodigestion is being subsidized, together with projects funded by the Global Environmental Facility and World Bank. Subsidies are also often provided to encourage farmers to reduce livestock density or to exit the sector entirely, particularly in fragile areas. This has been successful in the Netherlands, where it has reduced phosphate and methane emission by about 7 percentage points (RIVM 2004). Subsidies in the form of tax breaks can also be provided to encourage settlement in areas with low livestock density, an approach used with success in Thailand (Gerber et al. 2005). At the farm level, the number of animals per farm can also be restricted, as is being done in Germany for dairy cattle and in Norway for pigs. On the other hand, incentive systems in some countries still favor large units, for example, through favorable import tariffs for feed grain and other tax breaks.

- *Taxes* are often levied *on inputs* that are a potential source of nutrient loading, such as high-phosphate-content feed, or to discourage the use of inorganic fertilizer. They can also be used to support zoning policies by discouraging production in areas with an already high livestock density, such as around urban centers, and could also include tax rebates for shifting production to more distant areas that are less densely populated with livestock.

These financial instruments can be made more effective by making zoning permits tradable and transferable, whereby regulatory agencies assign a maximum discharge quota on livestock density to a farmer. This system was introduced in the Netherlands in the mid-1990s, and in order to reduce nutrient loading, the government reduced the quota by 25 percent in each trade. While the system did reduce nutrient emission, its implementation was found to be very complex, and in 2003 the Netherlands was forced to follow a more prescriptive imposition of limits on livestock numbers in a European Union (EU) directive.

An interesting additional option to improve the financial attractiveness of biogas, and thus reduce the effluent and methane emission of manure, is provided by the recent introduction of certified emission reductions (CERs) in Europe, and other opportunities for carbon trading under the Bio-Carbon Fund, managed by the World Bank. Successful examples of these are currently in place in Brazil and Nepal. Incentive systems can be used to make the use of organic fertilizer and animal traction more attractive. This is an important area for policy to establish a more level playing field with inorganic fertilizer and fuel.

Recycling through the use of livestock waste in animal feed, through conversion into energy or through organic fertilizer are also effective ways to manage livestock waste, and can lead to win–win situations. Specific technologies in these areas are:

- Poultry waste is one of the driest animal wastes, and has the highest protein content of any animal waste. Properly treated, it can be used in up to 20 percent of cattle and fish feed. This is now practiced in many tropical countries and the United States and Canada, although, in Oceania and the EU it has been

banned as livestock feed because of the danger of BSE when recycling animal materials to other animals (Agriculture and Agri-Food Canada Poultry Section 1990).

- The use of animal waste as an energy source through the biogas process is now common in many countries. The technology has made remarkable progress. New opportunities will arise by further promoting biogas through carbon-financing mechanisms, because the use through biogas, even if flared, reduces greenhouse gas emission. Biogas will reduce the biochemical oxygen demand (BOD) load on surface water, but will not reduce the amount of nitrogen or phosphorus to be further processed. The World Bank has supported biogas installations in several East and South Asian countries.

- Use as fertilizer, and in particular for organic production, although nutrient availability is not as fast, and the possibility for exact dosage is less precise than with organic fertilizer.

Finally, public sector investment in promoting the recycling of livestock waste needs to devote particular attention to capacity-building and public awareness. Awareness of the need to make livestock production more sustainable is particularly important to cultivate among policy makers. Purposefully communicating practical information that can effectively inform policy formulation and livestock zoning operations warrants clear priority. Capacity building of environmental cooperatives in managing common resources will be a highly appropriate area for public investment in many developing countries.

Livestock-Sector Externalities Relating to Greenhouse Gases and Global Climate Change

Greenhouse gas emissions from livestock are closely connected to the sector's impact on land use and land-use change. Livestock currently contributes a staggering 18 percent of total human-induced GHG emission equivalents. The livestock commodity chain contributes about 9 percent of total carbon dioxide (CO₂) emissions, but 37 percent of methane (CH₄), and 65 percent of nitrous oxide (N₂O). N₂O emissions will substantially increase over the coming decades, because pastureland is currently at maximum expanse in most regions. Future expansion will therefore increasingly be fertilizer- and crop-based. A variety of options to reduce livestock emissions are available, can be applied at reasonable costs, and would be suitable for international support. These options include: (a) carbon sequestration on extensively used grazing land; (b) reduction of methane emissions from low-input ruminant production, in particular, dairy; and (c) reduction of methane and nitrous oxide emissions from animal waste through energy recovery and improved waste management.

At senior political levels, awareness of the magnitude of livestock's contributions to GHG emissions and of the options available to reduce them is low. It is necessary to raise awareness in order to more closely integrate the issue into the coming post-Kyoto discussions.

This chapter examines the role of livestock in GHG emissions from a global perspective and at the various stages of the commodity chain. It then reviews options for emission reductions and suggests lines of action for international engagement, as the pure public good nature of GHG becomes more clearly established. It first assesses GHG emitted from the carbon cycle, and then the contribution of the nitrogen cycle to total GHG emissions. The chapter is based in large measure on Steinfeld and Wassenaar (2007).

LIVESTOCK IN THE CARBON CYCLE: TRENDS AND IMPACTS

The role of livestock in global carbon cycles is determined mainly by the sector's land use and the degradation of pasture lands and their expansion at the expense of forests. Intensive systems contribute by expansion of area cropped for feed, their degradation, and fossil-fuel

use. Furthermore, livestock releases important amounts of CH₄ from enteric digestion, mainly in ruminants and from manure.¹⁵

Desertification of grazing land. Desertification reduces productivity and vegetation cover, and changes carbon and nutrient cycles and stocks, causing a net loss of carbon into the atmosphere. Although changes in aboveground biomass and carbon stocks are often small, total soil carbon usually declines. Asner et al. (2003) found in Argentina that desertification resulted in little change in woody cover, but that soil organic carbon declined by 25 to 80 percent in areas subject to long-term grazing. Soil erosion accounts for part of this loss, but the majority stems from the nonrenewal of decaying organic matter stocks. Assuming a loss of 8 to 12 tons of soil carbon per hectare (Swift et al. 1994) on a desertified land area of 1 billion hectares (UNEP 1991), the total historic loss would amount to 8 billion to 12 billion tons of soil carbon. Similarly, degradation of aboveground vegetation has led to a carbon loss of an estimated 10 to 16 tons per hectare—a historic total of 10 billion to 16 billion tons. Thus, the total carbon loss as a consequence of desertification may be 18 to 28 billion tons (FAO 2004).

Livestock occupies about two-thirds of the global dryland area, and the rate of desertification has been estimated to be higher for grazing land than for other land uses—3.2 million hectares per year, as compared with 2.5 million hectares for cropland (UNEP 1991). Considering only soil carbon loss (that is, about 10 tons of carbon per hectare), CO₂ emissions from the desertification of pastures amounts to 100 million tons per year.

Pasture expansion into forest. The expansion of pasture and arable land for feed-crops has been the most extensive in Latin America. Most of this expansion has been into previously forested areas, and most of the forests cleared in the region end up as pasture (Wassenaar et al. 2007). The conversion of forest into pasture releases considerable amounts of carbon into the atmosphere, particularly when the area is not logged but simply burned. During the period from 2000 to 2010, pasture area in Latin America is projected to expand into forest by an annual average of 2.4 million

hectares. This accounts for some 65 percent of the deforestation expected.

Forest clearing produces a complex pattern of net carbon fluxes that change direction over time. The Intergovernmental Panel on Climate Change (IPCC 2001) estimated the average annual flux owing to tropical deforestation for the decade 1980 to 1989 at a mean (\pm SD) of 1.6 \pm 1.0 billion tons of carbon as CO₂. Only about 50 to 60 percent of the carbon released from forest conversion in any one year was a result of the conversion and subsequent biomass burning in that year. The remainder was delayed emissions resulting from oxidation of biomass harvested in previous years (Houghton 1991).

Assuming that forests are completely converted into climatically equivalent grasslands and croplands (IPCC 2001), and combining changes in carbon density of both vegetation and soil in the year of change, emissions from the conversion of forests into pastures can be estimated at approximately 1.7 billion tons of CO₂ per year.

Cropland expansion into forest. The rise in the demand for feed is not only met by intensification, but also by expansion of the corresponding cropland. Large losses of carbon to the atmosphere occur where this expansion occurs at the expense of forest. Wassenaar et al. (2007) showed that, although less than pasture, large areas of cropland too will replace forest in the Neotropics. Much of this land will produce soybean primarily destined for feed use (Morton et al. 2006; Nepstad et al. 2006). Assuming that half of the projected cropland expansion into tropical forests in Bolivia and Brazil can be attributed to providing feed for livestock, then there is an additional annual deforestation for feed of over 0.5 million hectares per year. This results in an estimated corresponding emission of 0.7 billion tons of CO₂ per year.

Carbon loss from soils cultivated to produce feed. Soils are the largest reservoir of the terrestrial carbon cycle and continue to release significant amounts of carbon for a very long time after conversion. Under appropriate management practices (such as zero tillage), agricultural soils can conserve a large part of their original carbon content. Losses beyond this level can be considered a result of management practices. Sauvé et al. (2000) found annual loss rates of about 100 kg of CO₂ per hectare on permanently cultivated temperate brown soils under conventional cultivation practices. The large area in temperate regions that produces coarse

¹⁵ Enteric fermentation is the process of digestion of feed in the digestive system, in cattle, in particular, in the rumen.

grains and oil crops for feed is under large-scale intensive management, which is still dominated by conventional tillage practices. It can therefore be estimated that the approximately 1.8 million km² of arable land cultivated with maize, wheat, and soybean for feed adds an annual CO₂ flux of about 18 million tons.

In addition, practices such as soil liming¹⁶ contribute to net emissions. Soil liming is a common practice in more intensively cultivated tropical areas because of soil acidity. Brazil, for example, estimated its CO₂ emissions owing to soil liming at 8.99 million tons in 1994 (MST 2004), and these emissions have most probably increased since then. To the extent that these emissions concern cropland for feed production, they can be attributed to the livestock sector, adding another 10 million tons of CO₂.

Use of fossil fuel to manufacture fertilizer. About 670 million tons of cereals and large amounts of agroindustrial by-products, such as brans and oil cakes are fed to animals (FAO 2006a). Mineral nitrogen fertilizer is applied to much of the corresponding cropland, and about 97 percent of nitrogen fertilizers are derived from synthetically produced ammonia via the energy-intensive Haber–Bosch process.

The production of feed-crops accounts for a very substantial share of fertilizer consumption based on the use of fertilizer by different feed-crops and on the fraction of these crops used for feed in major nitrogen fertilizer-consuming countries (FAO 2002, 2003). This is largely attributable to maize production, which not only covers large areas but also requires high doses of nitrogen fertilizer. More than half of total maize production is used as feed. Other feed-crops, such as barley and sorghum, are also important consumers of chemical nitrogen fertilizer. Energy requirements result in an estimated annual emission of CO₂ of more than 40 million tons at this initial stage of the animal food chain.

On-farm fossil-fuel use. In intensive production systems, the bulk of the energy is used to produce feed. Like the energy used for fertilizer, important amounts of energy are spent on seeds, herbicides and pesticides, diesel for machinery, and electricity. Data suggest that CO₂ emissions induced by on-farm fossil-fuel use for feed production amount

to some 60 million tons of CO₂ globally (Ryan and Tiffany 1998; UNFCCC 2005). An estimated 30 million tons of additional CO₂ emissions are generated by livestock rearing itself.

Fossil fuel for processing and transport. Several studies assess the energy expenditure for processing animals for meat and other products (Sainz 2003). Among livestock products, large amounts of energy are used to pasteurize milk and transform it into cheese and dried milk. The largest emissions result from soybean processing, caused by energy-intensive physical and chemical oil extraction. Considering the value fractions (Chapagain and Hoekstra 2004) of these two commodities, two-thirds of these soy-processing emissions can be attributed to the livestock sector. This would amount to several tens of million tons of CO₂.

Although rough indications, these figures show that emissions from energy use by processing are much higher than that from transport in the animal food chain. Transport occurs mainly at two key stages: that of feed to animal production sites and that of animal products to consumer markets. Large amounts of bulky raw ingredients for concentrated feed are shipped around the world. The total annual CO₂ emissions induced by meat transport are estimated at between 800,000 and 850,000 tons (Cederberg and Flysjö 2004; IPCC 1997).

Methane emissions from enteric fermentation. The specific characteristics of ruminant physiology lead to net gaseous emissions of carbon as CH₄. Livestock is globally the largest source of anthropogenic CH₄ emissions. CH₄ emissions from enteric fermentation varies greatly among countries. In Brazil, CH₄ emissions from enteric fermentation totaled 9.4 million tons during 1994–93 percent of agricultural emissions and 72 percent of the country's total emissions of CH₄. Over 80 percent of this originated from beef cattle (MST 2002), and the Brazilian cattle population has increased by about 25 percent since that time (FAO 2007). In the United States, CH₄ from enteric fermentation totaled 5.5 million tons in 2002, again overwhelmingly originating from beef and dairy cattle. This was 71 percent of all agricultural emissions and 19 percent of the country's total emissions (USEPA 2004).

Levels of CH₄ emissions are affected by energy intake and several other animal and diet factors, including quantity and quality of feed, animal body weight, age, and amount of exercise. Because many countries do not possess such detailed information,

¹⁶ Adding calcium carbonate-containing fertilizers, such as ground limestone.

Table 5.1: Global Methane Emissions from Enteric Fermentation in 2004

Region/Country	Emissions (million tons of CH ₄ per year, by source)					Total
	Dairy Cattle	Other Cattle	Buffalo	Sheep and Goats	Pigs	
Sub-Saharan Africa	2.30	7.47	0.00	1.82	0.02	11.61
Asia ^a	0.84	3.83	2.40	0.88	0.07	8.02
India	1.70	3.94	5.25	0.91	0.01	11.82
China	0.49	5.12	1.25	1.51	0.48	8.85
Central and South America	3.36	17.09	0.06	0.58	0.08	21.17
West Asia and North Africa	0.98	1.16	0.24	1.20	0.00	3.58
North America	1.02	3.85	0.00	0.06	0.11	5.05
Western Europe	2.19	2.31	0.01	0.98	0.20	5.70
Oceania and Japan	0.71	1.80	0.00	0.73	0.02	3.26
Eastern Europe and the Commonwealth of Independent States	1.99	2.96	0.02	0.59	0.10	5.66
Other developed countries	0.11	0.62	0.00	0.18	0.00	0.91
<i>Total</i>	15.69	50.16	9.23	9.44	1.11	85.63
Livestock Production System						
Grazing	4.73	21.89	0.00	2.95	0.00	29.58
Mixed	10.96	27.53	9.23	6.50	0.80	55.02
Industrial	0.00	0.73	0.00	0.00	0.30	1.04

a. Excludes China and India.

an approach that is based on standard emission factors is generally used in emission reporting.

CH₄ emissions from enteric fermentation change as production systems intensify and move toward higher feed use and increased productivity. A global estimate of total CH₄ emissions from enteric fermentation in the livestock sector using regional and production system-specific emission factors has been provided by Steinfeld et al. (2006). Total global emissions of CH₄ from enteric fermentation are estimated at 86 million tons annually. The distribution across regions, species, and production systems of such CH₄ emission is given in Table 5.1.

Methane released from animal manure. Substantial amounts of CH₄ are released from the anaerobic decomposition of organic material in livestock manure. This occurs mostly when manure is managed in liquid form, such as in lagoons or holding tanks. Lagoon systems are typical for the majority of large-scale pig operations in most of the world except Europe. These systems are also used in large dairy operations in North America and in some developing countries, such as Brazil. CH₄ emissions from livestock manure are influenced by a number

of factors that affect the growth of the bacteria responsible for CH₄ formation, including ambient temperature, moisture, storage time, and the energy content of manure.

The default emission factors currently used in country reporting to the United Nations Framework Convention on Climate Change (UNFCCC) do not reflect the strong changes in the global livestock sector. Steinfeld et al. (2006) reassessed and applied emission factors to the animal population figures specific to each production system. The total annual global emission of CH₄ from manure decomposition is estimated at 17.5 million tons, which is substantially higher than previous estimates.

LIVESTOCK IN THE NITROGEN CYCLE

Livestock's role in the nitrogen cycle is strongly determined by its efficiency in assimilating nitrogen from feed, the emissions caused by feed-related fertilizer production and use, and the emissions

from manure, either directly, from storage, or as applied on land.

Assimilation from feed. Diatomic nitrogen (N_2) in the atmosphere is a large and stable pool of nitrogen. In contrast, natural ecosystems have only a modest capability to drive the nitrogen cycle, which, prior to the advent of artificial nitrogen fertilizer, constituted a major hurdle in satisfying the food needs of growing populations (Galloway et al. 2004). Livestock has traditionally contributed to alleviating this problem by making reactive nitrogen fixed in grass and other fodder available to humans through animal products. But in doing so, they often impoverish natural ecosystems because livestock uses the scarce resource inefficiently.

The efficiency of nitrogen assimilation varies considerably among different animal species and products. van der Hoek (1998) estimates average nitrogen assimilation efficiency to be around 20 percent for pigs and 34 percent for poultry. Smil (2002) calculated the protein conversion efficiency of intensively produced dairy products in the United States to be 40 percent, but only 5 percent for beef cattle. The low nitrogen assimilation efficiency of extensively held ruminants, in particular cattle, is partly inherent to large animals with long gestation periods and a high basal metabolic rate.

Nitrogen emissions from feed-related fertilizer. It has been estimated that humans have already doubled the natural rate of nitrogen entering the land-based nitrogen cycle, and this rate is continuing to grow (Smil 2001). Synthetic fertilizers now provide about 40 percent of all the nitrogen taken up by crops. Although more efficient than animal production, crop production also uses the additional resource at a rather low efficiency—about 50 percent. Chemical processes involving nitrous oxides are particularly complex (Mosier et al. 2004), and soil N_2O emissions are determined, among other things, by temperature, soil moisture, and the chemical balance of the soil.

N_2O emissions for major world regions can be estimated using the Food and Agriculture Organization/International Fertilizer Industry Association (FAO/IFA) (2001) model. N_2O emissions amount to a mean (\pm SD) of 1.25 ± 1 percent of the nitrogen applied. This estimate is the average for all fertilizer types, as proposed by Bouwman (1995) and adopted by the IPCC (1997). Livestock production can therefore be considered responsible for a global N_2O emission from mineral fertilizer of

0.2 million tons of nitrogen content of nitrous oxide (N_2O -N) per year.

Leguminous feed-crops also produce N_2O emissions. Based on the total area devoted to soybean and pulse production, and on the share of production used for feed, about 75 million hectares in 2002 released 0.2 million tons of N_2O -N (FAO 2007). Including alfalfa and clover probably doubles this figure. It is therefore plausible that intensive forms of livestock production are linked to more than 0.5 million tons per year of total N_2O -N emissions from soils under leguminous crop cultivation.

Mineral fertilizer nitrogen loss to aquatic sources and subsequent emissions. The nitrogen uptake rate in global crop production is estimated at about 50 percent on average (van der Hoek 1998; Smil 1999). Smil (1999) estimates that globally, in the mid-1990s, about 27 million tons were exported from cropland through nitrate leaching (17 million tons) and soil erosion (20 million tons). This nitrogen is gradually denitrified in subsequent reservoirs of the nitrogen cascade (Galloway et al. 2003). The resulting enrichment of aquatic ecosystems with reactive nitrogen causes emissions not only of N_2 , but also of N_2O . Galloway et al. (2004) estimate the total anthropogenic N_2O emission from aquatic reservoirs to be about 1.5 million tons of nitrogen, originating from a total of some 59 million tons transported to inland waters and coastal areas. Feed and forage production induces a loss of nitrogen to aquatic sources of some 8 to 10 million tons per year, assuming that such losses are in line with nitrogen fertilization shares of feed and forage production (some 20 to 25 percent of the world total; see “Livestock in the Carbon Cycle,” above). Applying the overall rate of anthropogenic aquatic N_2O emissions, induced mineral fertilizer nitrogen loss to aquatic reservoirs results in livestock-induced emissions from aquatic sources of around 0.2 million tons of nitrogen from N_2O .

Nitrogen lost to the atmosphere following direct deposit of manure. A significant amount of nitrogen is returned to the environment through animal excretions. When directly deposited on pasture or crop-fields, some of the reactive nitrogen reenters the plant production cycle. However, a large share leaves the system through gaseous emission and volatilization, and to a lesser extent through leaching and erosion. While N_2O and ammonia (NH_3) are the two dominant reactive forms in which nitrogen is lost, this analysis focuses on N_2O because

ammonia does not contribute to global warming—its negative impacts on the environment lay elsewhere. Wide variations in the quality of forages consumed by ruminants and in environmental conditions make nitrogen emissions from manure directly deposited on land difficult to quantify. The FAO/IFA study (2001) estimates the nitrogen loss via NH_3 and volatilization from animal manure after application, to be 23 percent worldwide. Smil (1999) estimates this loss to be at least 15 to 20 percent.

Manure-induced soil emissions are clearly the largest livestock source of N_2O worldwide. Emission fluxes from animal grazing (unmanaged waste, direct emission) and from the use of animal waste as crop fertilizer are of a comparable magnitude. The grazing-derived N_2O emissions are in the range of 0.002 to 0.098 kg $\text{N}_2\text{O-N/kg}$ of nitrogen excreted, whereas the default emission factor used for fertilizer use is set at 0.0125 kg $\text{N}_2\text{O-N/kg}$ of nitrogen.

Emissions from applied manure need to be calculated separately. The FAO/IFA study (2001) estimates the N_2O loss rate from applied manure at 0.6 percent—that is, lower than most mineral nitrogen fertilizers, resulting in an animal manure soil N_2O loss of 0.2 million tons of nitrogen during the mid-1990s. Following the IPCC method would increase this to 0.3 million tons.

In the mid-1990s, animal excreta directly deposited on pastures loaded approximately 30 million tons of nitrogen on land in extensive systems. Applying the IPCC emission factor (0.02 kg $\text{N}_2\text{O-N/kg}$ of nitrogen excreted) to this total results in an animal manure soil N_2O loss of 0.6 million tons of nitrogen. This gives a total N_2O emission of about 0.9 million tons in the mid-1990s. Applying the IPCC method to the current estimates of the livestock production system and animal numbers (Steinfeld et al. 2006) results in an overall loss of 1.7 million tons per year in the form of direct animal manure soil N_2O .

Nitrogen lost to the atmosphere from stored manure. Because of the low nitrogen assimilation efficiency of livestock, large amounts of nitrogen are lost in intensive production units. The nitrogen harvested in feed over a wide area is used and largely lost in a spatially highly concentrated manner by highly intensive or industrial production units with very large animal numbers. This concentration is often aggravated by excessively nitrogen-rich diets.

Nitrogen is lost from stored manure, applied in excess to nearby land or in a more balanced manner over a wider area, sold as fertilizer, or simply discharged into surface waters.

Manure is stored in all industrial production units, although the duration and mode of storage varies. For the most part, excreted nitrogen compounds mineralize rapidly during this first phase of manure management. In urine, typically over 70 percent of nitrogen is present as urea (IPCC 1997). Uric acid is the dominant nitrogen compound in poultry excretions. When expressed in $\text{N}_2\text{O-N/kg}$ of nitrogen in the waste (that is, the share of nitrogen in waste emitted to the atmosphere as N_2O), losses from animal waste during storage range from less than 0.0001 kg $\text{N}_2\text{O-N/kg}$ of nitrogen for slurries to more than 0.15 kg $\text{N}_2\text{O-N/kg}$ of nitrogen in the pig waste of deep-litter stables. Steinfeld et al. (2006) suggest N_2O emissions from stored manure equivalent to 0.7 million tons per year.

Aquatic N_2O emissions after manure nitrogen loss. In intensive systems, a very large amount of nitrogen leaves the local system through surface-water flows, either resulting from leaching of excess amounts applied to land or from direct discharge. In the mid-1990s, about 25 million tons of nitrogen from animal manure remained available per year for plant uptake in the world's croplands and in intensively used grasslands after losses to the atmosphere during storage and following application and direct deposition. Applying the crop nitrogen-use efficiency of 40 percent to the remainder of animal manure nitrogen applied to cropland, in the mid-1990s about 9 million or 10 million tons of nitrogen entered the nitrogen cascade mostly through water. Applying the N_2O loss rate for subsequent N_2O emission (see "Nitrogen lost to the atmosphere from stored manure," above), an additional 0.2 million tons of N_2O are emitted through this channel. N_2O emissions of similar magnitude can be expected to have resulted from the redeposited fraction of the volatilized NH_3 from manure that reached the aquatic reservoirs in the mid-1990s. Total N_2O emissions following nitrogen losses would, therefore, have been about 0.4 million tons of N_2O per year during that period.

SUMMARY: EMISSIONS

Tables 5.2 and 5.3 summarize the range of aforementioned livestock sector impacts on the carbon

Table 5.2: Summary of Current Impacts on the Carbon Cycle

Process	Impact on Carbon Cycle	Contribution from Extensive Systems ^a	Contribution from Intensive Systems ^a
Nitrogen fertilizer production	Addition of atmospheric CO ₂	—	0.04
On-farm fuel use	Addition of atmospheric CO ₂	—	~0.09
Savannah burning	Changing carbon distribution in vegetation Contribution to climate change	Majority of burned area worldwide	—
Pasture desertification	Soil carbon loss		
	Addition of atmospheric CO ₂	~0.1	—
	Soil and vegetation carbon loss		
Deforestation	Addition of atmospheric CO ₂	~1.7	~0.7
	Changing local carbon cycle		
Soil tillage	Soil carbon loss	—	~0.02
	Addition of atmospheric CO ₂		
Soil liming	Addition of atmospheric CO ₂	—	~0.01
Enteric fermentation	Addition of atmospheric CH ₄	1.6	0.20
Methane from manure	Addition of atmospheric CH ₄	0.17	0.20
Processing	Addition of atmospheric CO ₂	—	0.01–0.05
Transport	Addition of atmospheric CO ₂	—	~0.001

a. Quantified contributions concern additions to and removals from the atmospheric pool and all are expressed in billion tons CO₂ equivalent.

Table 5.3: Summary of Current Impacts on the Nitrogen Cycle

Process	Impact on Nitrogen Cycle	Estimated Contribution from Extensive Systems ^a	Estimated Contribution from Intensive Systems ^a
Mineral fertilizer application	Eutrophication of aquatic systems	—	8–10
	Addition of atmospheric N ₂ O	—	0.4 (0.2)
	Volatilization/deposition of NH ₃	—	3.1
Leguminous feed-cropping	Addition of atmospheric N ₂ O	—	0.5 (0.2)
	Nitrogen loss from local terrestrial pools	18	—
Extensive grazing	Addition of atmospheric N ₂ O	1.8 (0.8)	—
	Volatilization/deposition of NH ₃	6	—
	Addition of atmospheric N ₂ O	1.3 (0.6)	0.5 (0.2)
Manure management	Volatilization/deposition of NH ₃	11	7
	Eutrophication of aquatic systems		More than 10 ^b

a. Quantified contributions are expressed in million tons N per year, except for additions of atmospheric N₂O, also expressed in billion tons CO₂ equivalent (in parentheses).

b. Overall estimate based on mid-1990s figures but lacks information on the importance of direct discharge of manure to water.

and nitrogen cycles. Not all impacts are quantifiable. Figures corresponding to processes leading to N₂O emissions comprise direct and indirect emissions. The figures should be considered as indicative values.

Livestock-related emissions of CO₂ are a huge component of the global carbon budget when deforestation for pasture and feed cropland and pasture degradation are taken into account. Although small by comparison, the livestock food chain is becoming more fossil-fuel-intensive, because the shift from traditional local feed-based ruminant production to intensive monogastrics fundamentally entails a concomitant shift away from solar energy to fossil fuel.

The leading role of livestock in CH₄ emissions has long been well-established. With the decline of ruminant livestock in relative terms, and the overall trends toward higher productivities also in ruminant production, the importance of enteric fermentation will likely not grow much more. While much lower in absolute terms, CH₄ emissions from animal manure are growing rapidly. Together they represent some 80 percent of agricultural emissions and about 35 to 40 percent of total anthropogenic CH₄ emissions.

Livestock activities contribute in a major way to the emission of nitrous oxides, the most aggressive greenhouse gas. Their contribution to the global budget is as high as 65 percent, and as high as 75 to 80 percent of agricultural emissions. Current trends suggest that these levels will substantially increase over the coming decades.

MITIGATION

Just as the livestock sector has large and multiple impacts on both carbon and nitrogen cycles, there are multiple and effective options for mitigation. Much can be done, but strong involvement of public policy is required. Most of the options are not cost-neutral, and simply enhancing awareness will not lead to widespread adoption.

Compared to the amounts of carbon released from changes in land use and land degradation, emissions from the food chain are small. For carbon, the environmental focus needs to be on addressing issues of land-use change and land degradation. Here, the livestock sector offers significant potential for carbon sequestration, particularly in the form of improved pasture. This

potential has been demonstrated by a number of European authors (Soussana 2008).

The challenge in addressing land-use change is to slow and eventually halt and reverse deforestation. Vlek et al. (2004) demonstrate that the only available option to free up the land necessary for carbon sequestration is to intensify agricultural production on some of the better lands, for example, by increasing fertilizer inputs. The carbon that is sequestered and the emissions of organic carbon that are avoided as a result of foregoing deforestation will far outweigh the increased CO₂ emissions that result from extra fertilizer production. Apart from improved fertilizer use, other options for intensification include the use of higher-yielding, better-adapted varieties and improved land and water management.

Cultivated soils have enormous potential for net carbon sequestration as well. The carbon sink capacity of the world's agricultural and degraded soils is 50 to 66 percent of the historic loss from soils of 42 to 78 gigatons of carbon (Lal 2004). There are proven new practices that can improve soil quality and raise soil organic carbon levels for example through conservation tillage and organic farming. These practices achieve yields comparable to conventional intensive systems.

Improved grassland management is another major area in which soil carbon losses can be reversed, leading to net sequestration, through the use of trees, improved pasture species, fertilization, and a variety of other measures. Because pasture is the largest anthropogenic land use, improved pasture management could potentially sequester more carbon than any other terrestrial sink (IPCC 2000) (see Table 5.2).

In the humid tropics silvopastoral systems are used to sequester carbon sequestration and improve pastures. There were employed in the Central American Silvopastoral Project (Pagiola et al. 2004), sponsored by the Global Environmental Facility (GEF) and the Livestock Environment and Development Initiative (LEAD). In dryland pastures, dryland soils have characteristics that help in carbon sequestration. Dry soils are less likely to lose carbon than wet soils because the lack of water limits soil mineralization and therefore the flux of carbon into the atmosphere. As a result, carbon sometimes resides in dryland soils even longer than it does in forest soils. Although the rate at which carbon can be sequestered in these regions is

low, it can be cost-effective, particularly taking into account all the side benefits for soil improvement and restoration (FAO 2004).

The most efficient approach for reducing CH₄ emissions from livestock is by improving the productivity and efficiency of livestock production through better nutrition, genetics, animal health, and general husbandry practices. Greater efficiency means that a larger portion of the energy in the animals' feed is directed toward the creation of useful products so that CH₄ emissions per unit product are reduced. The trends toward high-performing animals and toward monogastrics and poultry are particularly valuable in this context because they reduce CH₄ per unit of product.

A number of technologies exist to reduce CH₄ release from enteric fermentation. The basic principle is to increase the digestibility of feedstuff, either by modifying feed or by manipulating the digestive process. Examples of improvements in fibrous diets are the use of feed additives or supplements and the increased level of starch or rapidly fermentable carbohydrates in the diet. These reduce excess hydrogen and, as a result, CH₄ formation.

More advanced technologies that are being studied involve reducing hydrogen production by stimulating acetogenic bacteria, and through defaunation (eliminating certain protozoa from the rumen), and vaccination (to reduce methanogens).

CH₄ emissions from anaerobic manure management can be readily reduced with existing technologies. Such emissions originate from intensive mixed and industrial systems that usually have sufficient resources and capacity to invest in these technologies. A first obvious option to consider is balanced feeding (increased carbon-to-nitrogen ratios). Additional measures include anaerobic digestion (producing biogas as an extra benefit), flaring or burning (chemical oxidation, burning), special biofilters (biological oxidation) (Monteny et al. 2006; Melse and van der Werf 2005), composting, and aerobic treatment. Biogas may achieve a 50 percent reduction in emissions in cool climates, and higher in warmer climates, for manures that otherwise would be stored as liquid slurry.

An important mitigation pathway for nitrogen loss lies in raising low animal nitrogen assimilation efficiency through more balanced feeding by optimizing proteins or amino acids. Improved feeding practices also include phased feeding and improving

the feed conversion ratio through tailoring feed to physiological requirements. Even with these measures however, manure still contains large quantities of nitrogen. The use of an enclosed tank can nearly eliminate nitrogen loss during storage and offers an important synergy with respect to mitigating CH₄ emissions and production of biogas. N₂O emissions from the subsequent spread of digested slurry can also be reduced.

The key to reducing nitrogen loss resulting from the application of manure is to fine-tune waste application to accommodate specific environmental conditions, including timing and amounts and form of application in response to crop physiology and climate. Another technological option is the use of nitrification inhibitors (NIs) that can be added to urea or ammonium compounds (Monteny et al. 2006). Some of these substances can potentially be used on pastures, where they act on urinary nitrogen, an approach being adopted in New Zealand (Di and Cameron 2003).

In conclusion, livestock plays an important role in both the global carbon and nitrogen cycles. The contribution to the carbon cycle mainly stems from livestock's land use and role in land-use change, in particular deforestation and pasture degradation. Livestock's role in the nitrogen cycle is mainly determined by their demand for concentrate feed and by livestock waste storage and disposal. Because the scope for pasture expansion and intensification is limited, extensive livestock is stagnating, but industrial livestock is growing rapidly. Consequently, there is an ongoing shift toward a growing role of livestock in the nitrogen cycle and a stagnating or declining role in the carbon cycle, albeit from a very high level.

POLICY AND INVESTMENT OPTIONS

While important strides have been made in the recent past, the impact of livestock production on climate change is still not well understood. More detailed analysis is required to shape policies that can effectively mitigate environmental impacts at every relevant step of the various commodity chains. Mitigation of and adaptation to climate change are both priorities. The international community should facilitate the generation of substantial additional knowledge and the enhancement of

professional and institutional capacity, increase awareness, and develop, test, and replicate innovative approaches.

The publication of *Livestock's Long Shadow* (Steinfeld et al. 2006) helped to focus attention on the role of livestock in GHG emissions. Most of the attention the publication raised, however, was among animal welfare activists and vegetarians. It went less far in reaching policy makers, among whom emissions reductions in the global transport sector remain the focus of public discourse. More work on the economics of GHG reductions, and on the relative contributions of the livestock and transport sectors to emissions is needed to more effectively reach this important, and arguably decisive, audience. Raising political awareness of the vital importance of the livestock sector to climate change is an urgent priority for international dialogue in the Post-Kyoto era.

Equity issues and environmental concerns in the livestock sector form a nexus that is both a daunting intellectual challenge and a large yet unexploited development opportunity. Important environmental gains can be made by obliging large-scale commercial livestock producers to comply with heightened regulatory standards that serve to reduce GHG emissions. The energy and nutrients contained in animal waste can be recovered. The total nutrients contained in animal manure exceed those contained in commercial inorganic fertilizer. Yet most of these nutrients are wasted, and the waste poses a massive and growing threat to the environment. Wasting these nutrients represents a likewise massive opportunity cost to development.

Recycling rather than wasting the energy and nutrient content of animal waste carries win-win opportunities for both the environment and for development. Capitalizing on these opportunities entails challenges that are familiar to development practitioners and environmentalists. For instance, livestock production among poor herders and farmers in extensive systems throughout most of the developing world probably faces higher resource costs and imposes greater environmental impacts on a per-unit basis than anywhere else. Yet it is in these areas and among these producers that introducing better practices is most difficult and expensive.

Given the vast area that livestock occupies and the growth and structural changes the sector is

experiencing, animal agriculture offers great potential for high-return investments that can simultaneously achieve substantial environmental and social benefits. In intensive systems, the recovery of energy and nutrients from industrial livestock production yields environmental and social gains at the same time that it increases financial returns to producers—once economic distortions and information bottlenecks are removed. Extensive grazing systems on the other hand afford opportunities to provide environmental services over vast areas (e.g., carbon sequestration, water, biodiversity conservation) while diversifying the income sources of poor holders through payment schemes. Through relatively simple measures, methane emissions per liter of milk can be cut by half in traditional dairy systems.

World Bank policy dialogue and investment may be catalytic in a number of areas including the following.

- *Addressing pastoral systems in drylands*, including adaptation to climate change, and income diversification through the provision of environmental services, in particular carbon sequestration in arid rangelands, with specific attention to drought management.
- *Addressing grazing systems in the humid tropics*, with a focus on mitigation and especially on the reduction of livestock's contribution to the deforestation process. This would need to include the assessment and certification of the carbon sequestration capacity of grazing land under different forms of management; the reduction of methane emissions from enteric fermentation through different approaches, such as improved diets; feed additives; and increased intensification of production.
- *Addressing mixed systems in sub-Saharan Africa and South Asia*, with a focus on reducing methane emissions from dairy cows in low-productivity production. This would include an assessment of methane emissions from enteric fermentation in different dairy production systems, and the use of suitable technical packages for intensification and productivity growth while significantly reducing methane emissions per liter of milk produced. An important component would be the development of suitable institutional arrangements, in particular carbon trading schemes and the

Clean Development Mechanism (CDM), to provide a changed incentive framework.

- *Addressing intensive monogastric production (worldwide)*, with a direct focus on recovery and recycling of energy and nutrients. Requiring large-scale commercial producers to comply with stringent environmental regulations has created a more level playing field, in which different types of producers compete. Pushing industrial producers into rural areas has the advantage of creating economic stimuli, and leads to income and employment in forward and backward linkages. In addition, it will improve the peri-urban

environment, where currently many poor people live.

- *Promoting knowledge exchange in raising awareness and transferring technology*, particularly in the areas of rehabilitation of degraded grazing land for poverty reduction and the provision of global and local environmental services (carbon sequestration, biodiversity protection, water); reduction of methane emissions from extensive ruminant production and supporting CDM-like mechanisms; and recovery and recycling of energy and nutrients from industrial livestock production in developing countries.

Livestock and Public Health Externalities

While livestock products are critical in the diet of vulnerable groups in the developing world, the livestock sector also poses major health risks. Over the past decade, 75 percent of the human diseases that have emerged as epidemics have been of animal origin. Livestock-induced foodborne diarrheal diseases affect millions. Meat is also an important factor in the obesity crisis that populations in developing countries are increasingly sharing with those in industrialized countries. Infectious diseases, such as foot-and-mouth disease and classical swine fever, cause billions of dollars of economic losses. The recent emergence of highly pathogenic avian influenza has focused the world's attention on the need for efficient early-warning response and control systems. At the global level, the integration of human and animal health systems in an ecosystems context, as pursued with the *One World, One Health* strategy, will provide an important overarching organizing framework. Making that framework operational will be a pressing challenge.

At the global level, improved coordination and risk-management tools such as compensation mechanisms and communications initiatives need to be developed and implemented by the international community. Emerging infectious diseases at the human-animal-ecosystems interface will be an enduring priority, and increased international support to technology development for the control of the "diseases of the poor" is clearly justified. Strengthening developing countries' national capacity to implement and administer efficient surveillance and early warning systems is a natural priority for the international community, for such systems are necessarily local. This support must also extend to the formulation of national contingency plans to direct the control of outbreaks of contagious diseases through combinations of culling, movement controls, and ring vaccinations supported by market-price-based compensation schemes. The national level is also where the divisions and distributions of public and private sector roles have to be defined, and where in most instances, strategies that entails the public sector "doing less, but better" need to be played out.

The contribution of livestock and livestock products to poverty reduction, dietary impacts, and the enhancement of livelihoods of the poor are well-recognized benefits. The analysis of sustainable livelihood strategies, for example, indicates that more positive livestock impacts are woven into the complex fabric of household production and consumption decisions. Livestock provide essential

food, income, organic fertilizer, draft power, financial assets, and social status. There is, however, an increasing concern for the public health externalities associated with the livestock sector related to infectious diseases that originate with animals, including zoonoses. These pose an immediate and obvious risk to human populations such as rabies, avian influenza, brucellosis, and many other diseases. There are also a number of less obvious facets of the human–animal interface that significantly impact the lives of people who tend livestock, live near animals, and who consume livestock products (Randolph et al. 2007).

LIVESTOCK–PUBLIC HEALTH INTERACTIONS

Livestock and its products provide a substantial livelihood and essential nutrients for the physical well-being and development of innumerable vulnerable groups, particularly in developing countries. Undernutrition and micronutrient malnutrition have deleterious effects on cognitive development, school performance, and individual achievement, and these effects are further exacerbated by the generational impacts of the increased likelihood of low-birth-weight infants (Randolph et al. 2007). Livestock products are high in digestible energy for dietary requirements, and are often preferred in communities with critically low levels of readily digestible energy in their diets, such as those based on tubers. Meat, eggs, and dairy products also contain many of the essential amino acids in a form that can readily be assimilated by the human body, and their consumption enhances the absorption of iron and zinc from plant food. Red meat is high in very-long-chain omega-3 fatty acids, although not as high as in fish. It is therefore not surprising that in areas with protein deficiency and energy malnutrition, the consumption of small amounts of livestock products has a very positive effect on nutritional well-being and health. In Kenyan schools, for example, children provided with small amounts of meat did significantly better in overall development and academic testing (Whaely et al. 2003).

The livestock sector and its products, however, pose significant risks by harboring human pathogens and providing a reservoir for zoonotic diseases. Many of these diseases can be found in the livestock-keeping communities of the

developing world, and the impact in terms of human mortality, morbidity, and livestock losses usually falls most heavily on poorer societies. Historically, goats have transmitted tuberculosis to humans; cattle have been the origin of major measles epidemics; and rabies, bovine tuberculosis, and human infections of brucellosis from livestock remain major problems in the developing world. Accelerated globalization, the increased density of both human and animal populations, and the facilitation of contacts at the human–animal interface have precipitated an upsurge in animal diseases that spill over into humans. Over the previous 15 years, 75 percent of the human diseases that have emerged as epidemics have been of animal origin and, overall, 60 percent of human pathogens are considered to be zoonotic (WHO/FAO/OIE 2006; Brown and King 2004) (Table 6.1). A growing number of these pathogens are developing antibiotic resistance, and many of these animal pathogens have potential as bioterrorist weapons and pose the risk of intentional introduction into human populations. New zoonotic disease appears every second year or so, and previously apparently dormant but endemic zoonoses have begun to reemerge.

The range and distribution of these microbes have been accelerated with the expansion of global trade, population growth of both people and animals, and changes in human behavior and lifestyles. The situation is further compromised by excessive concentration of livestock production units, changing weather patterns, and changes in the human condition including aging, urbanization, social disruption, poverty, and immunocompromised individuals as a result of acquired immunodeficiency syndrome (AIDS) as well as other health risk factors. The public health significance of the zoonotic diseases becomes most important in those, mainly developing, countries with a relatively high incidence of AIDS. There, patients tend to be more susceptible in general to zoonotic diseases, including tuberculosis, other related mycobacterial infections, and a variety of other pathogens of animal origin (i.e., toxoplasmosis, cryptosporidial enteritis, foodborne salmonella infections, other enteric organisms, *Campylobacter*, *Listeria*, and *Yersinia*). It is also possible that other zoonotic diseases that are dormant or occur infrequently (e.g., leptospirosis, plague, glanders, melioidosis, and pseudoglanders) may emerge in

Table 6.1: Examples of Outbreaks of Recent Highly Infectious Zoonotic Diseases of International Significance

Disease	Date	Animal	Human Fatalities/Cases	Animal/Economic Impact
Nipah virus	1994	Swine, dogs, fruit bats	112/257	1.2 million pigs
Bovine spongiform encephalopathy (BSE)	1986	Cattle	149 cases of Creutzfeldt–Jakob disease	200,000 cattle US\$20 billion
Severe acute respiratory syndrome (SARS)	2003	Civet cats	774/8101	Not applicable
Highly pathogenic avian influenza (HPAI)	2003–present	Poultry, wild fowl, and mammals	240/381	Over 200 million poultry with costs of more than US\$10 billion

individuals with AIDS or other immunocompromising conditions (Brown and King 2004).

A significant number of foodborne diseases originate from animal products, and contamination of surface water and groundwater caused by livestock waste has proven to be problematic in many countries. Pathogens such as *Escherichia coli*, *Campylobacter*, *Salmonella*, *Leptospirosis*, and hepatitis A virus, which are subclinical or asymptomatic in livestock, are estimated to cause at least 6,000 human deaths per day worldwide. The poor in developing countries bear a disproportionate burden of these diseases. While a number of factors contribute to increased risk among the poor, their relatively close proximity to the animals that are reservoirs for these diseases is probably the most important. Bovine tuberculosis, anthrax, and brucellosis are examples of primarily occupational diseases of livestock keepers, although poor rural consumers of unprocessed meat or unpasteurized dairy products are equally at risk. In addition, they are less likely to seek or be able to afford medical care once infected, and whatever care they manage to obtain is very often inadequate. The most devastating impact felt by vulnerable households is the loss through illness or death of the principal breadwinner. The loss of valuable livestock assets from disease or compulsory removal or culling is in many cases disastrous as well (WHO 2006).

Consumers in developing countries are increasing the consumption of high-energy livestock products as their disposable incomes increase. This is leading to serious health problems similar to those already experienced in industrialized countries, including obesity, cardiovascular disease, and diabetes. The resulting diseases become a serious cost

burden to the public health system, the national economy, and society at large. Worldwide, the number of obese people (1 billion) has now surpassed the number of malnourished people (800 million). A significant part of the growth in obesity statistics has occurred in the developing world, and the World Health Organization estimates that this includes 300 million obese adults and 115 million people who suffer from obesity-related diseases. In China, for example, the number of overweight people has increased from less than 10 percent to 15 percent in just three years. In Brazil and Columbia, the figure hovers around 40 percent, a level comparable to that in many European countries.¹⁷ While a variety of factors such as urbanization and lack of physical activity contribute to the trend, increased consumption of animal products plays the most significant role.

Experience in a number of World Bank projects in Europe and Central Asia and elsewhere has identified some of the less obvious social aspects of animal ownership and the important role that free-range backyard livestock and poultry fill in the social fabric of the community. Drastic culling and the loss of familiar animals and their presence and sounds are extremely disturbing and discomforting for some villagers, especially the elderly. While this subjective psychological effect is of course not captured by the calculus used by public health officials responding to serious zoonotic outbreaks, it needs to be recognized and accounted for in the design of effective disease control and culling programs. Sensitivity to these emotional reactions

¹⁷ <http://www.fao.org/FOCUS/E/obesity/obes1.htm>.

is important in addressing and minimizing the trauma and mistrust that are likely to result from interventions that require lethal means.

LIVESTOCK, PUBLIC HEALTH, AND PUBLIC GOODS

The many externalities of livestock production at the global, national, and local levels present a variety of rationales for public sector engagement in the sector. Whether this engagement is direct or indirect varies by issue. In the case of zoonoses and food safety, more direct engagement is warranted. The most fundamental practical concern regarding public intervention in the livestock sector is determining which agency or institution bears responsibility for the particular issue, and at what geographic order of magnitude. The parallel question often applies at the national level, where the division of roles and responsibilities between the private and public sector also has to be defined in order to avoid the perils of leaving vacuums of responsibility between the two.

At the global level, the human risks and economic losses related to animal diseases are clearly demonstrated by recent outbreaks of severe acute respiratory syndrome (SARS) and highly pathogenic avian influenza (HPAI). In these instances, the effects of poor sanitary conditions and weak surveillance and monitoring in a number of developing countries led to disease outbreaks and economic losses that quickly spread to other countries, including more industrialized parts of the world. The transboundary nature of diseases such as HPAI and foot-and-mouth disease (FMD) can often justify direct intervention at the international level. It is clearly in the interest of the developed countries to reduce the risk of emerging diseases from less-developed countries and to protect their own livestock and populations. For example, the 2001 FMD outbreak in the United Kingdom, which originated in South Asia, caused more than US\$5 billion in direct losses to agriculture. Losses in other sectors of the British economy, including tourism, were similar as the result of spillover and ripple effects (Thompson et al. 2001). Comparable impacts and economic losses have been experienced in countries recently reporting outbreaks of HPAI and incidents of bovine spongiform encephalopathy (BSE).

While controlling these outbreaks at their points of origin in developing countries is clearly in the

interests of industrialized countries, increased support to surveillance, early-warning, and early-response systems has not materialized. For the HPAI epidemics, for example, significant international support and funding were not really mobilized until two years after the first risks of a global pandemic were identified. This trend may be changing as the global community recognizes that the risks associated with animal diseases, zoonoses, and potential panzootics and pandemics extend beyond HPAI, and should be considered in the context of a more meaningful and integrated *One World, One Health* approach that encompasses both animal and human health issues at the animal–human–ecosystems interface.

Although the emerging veterinary public health risks related to zoonoses are important, the externalities associated with the food safety risks of livestock products and the regulatory frameworks that seek to minimize those risks also fall within the category of public goods. This is especially so in the context of trade access for emerging economies. The livestock supply chain issues, per se, mainly involve commercial or private sector activities, but the facilitation and regulation (incentives, standards, certification, and so forth) and related food-safety risks do have public good implications. In addition to the more obvious disease prevention and control responsibilities, the monitoring of animal feeds and additives, meat inspection, and licensing of the use of animal remedies are some examples of veterinary public good functions that are essential to ensure a safe and reliable value chain for animal and livestock products and to protect public health. Chapter 8 provides more details on the equity constraints and opportunities of smallholder integration into the livestock value chain.

DEFINING THE INSTITUTIONAL ARCHITECTURE

The emergence and reemergence of zoonotic diseases, food safety issues, and other related livestock externalities present challenges not only to veterinarians, but also to all medical doctors and paraprofessionals concerned with public health. The increased emphasis on food safety and the need to reassure consumers and trade partners have significantly increased the profile of veterinary public health and the delivery of related services as a public good. Although the veterinary

profession has traditionally been at the forefront of control and eradication of animal diseases, early cooperation of veterinarians and public health physicians led to a more holistic partnership for the eradication of bovine tuberculosis first in the Nordic countries and then in the United States and Canada.

This and subsequent experiences has clearly indicated the need for close cooperation between veterinarians and medical professionals in the provision of public good services to prevent, control, and eradicate zoonotic diseases. This partnership, in line with the *One World, One Health* concept has, however, proven to be problematic in many countries where it is needed the most. There, social practices, tradition, competition for limited resources, economic constraints, and a fundamental resistance to interdisciplinary cooperation limit the adoption of this approach. More recently, some progress has been made in HPAI-related activities, such as the preparation of Integrated National Action Plans, and at the international level in the preparation of joint OIE/FAO/WHO strategies for the control of HPAI. The question of how to make the *One World, One Health* concept operational in terms of incentives and mandates, and how to integrate environmental health risks into the concept, remains largely unresolved and continues to require considerable effort from all concerned.

Successful delivery of veterinary services has evolved in many countries to include five essential components: (a) livestock producers and their organizations, (b) a national public veterinary service, (c) a private veterinary sector, (d) a legislative framework and statutory regulatory body, and (e) a veterinary professional association. Each component has different responsibilities and may represent different stakeholders. Ideally, the five components interact with checks and balances so that all clients are fairly represented. The logic and rationale for the creation of each component, and for assigning specific tasks and responsibilities, are based on economic, biological, and social principles. Unfortunately, many of these basic elements for an effective veterinary service are lacking in the developing countries, which are at the greatest risk.

The international donor community, including the World Bank, has played an important role in the development of a better division of responsibilities between the public and private sectors in the provision of veterinary services, particularly in sub-Saharan Africa (see Box 6.1).

The improved division of function between public and private responsibilities has increased the quality of on-farm clinical services in many cases. However, it has had a nominal impact on public or regulatory veterinary services, as was clearly illustrated with the spread of HPAI. There have been a number of fundamental shortcomings in the public veterinary service, including but not limited to:

- Increases in staffing have not been accompanied by funding allocations for adequate salaries and operational costs.
- Resource capacity has been overwhelmed by the increased number of tasks; especially as food safety and transboundary diseases become more important.
- Public veterinary services have continued to perform private good services (i.e., clinical treatments, drug sales, and so forth), thereby competing with fledgling private veterinary services and compromising the delivery of their regulatory public good tasks, such as disease surveillance.
- Decentralization and wholesale or drastic privatization of veterinary services, such as the recent reforms in Georgia, has compromised the surveillance, early-warning systems, and effective disease control.
- Critical public/private partnerships have not been established and have been compromised by a lack of mutual trust.
- Legislative frameworks for food safety, animal health, and designation of responsibilities between public and private service providers have been weak and poorly enforced.
- Plans and programs for initial capacity-building, professional development, and long-term improvement in veterinary education have been inadequate.
- Development initiatives, in particular in sub-Saharan Africa, have tended to incorporate veterinary services with extension and animal husbandry programs, thereby diluting their effectiveness and priorities.
- In previously planned economies, the decollectivization of state farms has resulted in large numbers of fragmented holdings that have proven difficult to control and monitor.

The results of the use of the Performance of Veterinary Services (PVS) toolkit recently

Box 6.1: Improving the Distribution of Private and Public Responsibilities in Sub-Saharan Africa: Selected Results

In recent decades, public policy intervention in animal health in sub-Saharan Africa has focused on reaching a better distribution of responsibilities between (a) the public and the private sector and (b) professional and paraprofessional staff. These developments have been accelerated, at least in part, by structural adjustment programs that presumably reduced funding for

A number of surveys conducted over the past couple of years also show that the quality of the clinical services has also improved. For example, comparing areas without and with paraveterinarians in Kenya and Tanzania, Peeling and Holden (2004) found that mortality was halved; the benefits accrued were, respectively, US\$87 to \$100 per year, with a

	1986–1989	1997–2001	2004
Public veterinarians (service)		2,410	2,429
Public veterinarians (laboratories and universities)		355	654
Total public sector veterinarians	2,271	2,765	3,083
Total private sector veterinarians	69	1,343	1,780

veterinary departments. They have led to the emergence of private professional and paraprofessional veterinary service providers, although as shown by the numbers from 15 important sub-Saharan livestock countries^a presented in the table below, the number of public veterinarians has also increased.

high level of accuracy in disease diagnosis, and the paraprofessionals exceeded government staff in applying the correct doses of antibiotics and other compounds, which could pose a danger for public health.

a. Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Ethiopia, Ghana, Kenya, Madagascar, Mali, Níger, Senegal, Tanzania, and Zimbabwe.

Sources: 1986–1989 data: Anteneh 1984; 1997–2004 data: OIE Handistat.

developed by the World Organization for Animal Health (OIE),¹⁸ although not yet consolidated for different countries in a summary form, seem to confirm these shortcomings.

COLLECTIVE ACTION IN MANAGING ANIMAL AND PUBLIC HEALTH

Disease control traditionally has been managed through the public sector, which sought more or less successfully to impose strict sanitary rules, including centrally directed, public-sector-funded, obligatory vaccination campaigns, directives on the handling of pharmaceutical products, and government-enforced control of movement in the case of a disease outbreak. The enforcement of compliance with food-safety standards has similarly been attempted through public agents. However, with declining

budgets and expanding mandates, there has been a trend to share public sector responsibilities with the private sector through the establishment of public–private partnerships, subcontracting of services to the private sector, and collective action in the supply of veterinary services. A number of examples provide useful illustration of collective action in the supply of animal health services.

In disease control, the Brazilian National Agricultural Confederation (CNA) with the Foot-and-Mouth Disease Fund, provides an innovative approach to bridging the difference in the incentives for disease control between the rich and the poor. The CNA supports education and awareness creation at the national level for FMD control, and subsidizes FMD vaccination in marginal areas, particularly in areas with many smallholders, such as Indian reserves, North Brazil, and the border areas with Bolivia. To maintain export market access from FMD freedom, the large ranchers thus subsidize the protection from FMD for the small producers, for which FMD freedom is much less

¹⁸ http://www.oie.int/download/Vet_serv/PVS_IICA_en.pdf.

important, because the quality of their cattle would not allow them access to export markets anyway (Dubois and Moura, 2004).

The payment of compensation to eradicate epizootic disease outbreaks exists, for example, in the Netherlands (World Bank 2006a), through a national public–private partnership. This is a cost-sharing scheme, whereby the three commodity boards (livestock and meat, poultry and eggs, and dairy products), which represent the entire food chain for these respective commodities, and the government, agree on the relative shares of compensation for emerging actions in the case of a contagious disease outbreak (culling, vaccination, disinfection, and so forth). The commodity boards fund these operations through product levies.

Animal health and production services, including those considered a public good in France, are supplied through a network of Sanitary Defense Groups (*Groupements de Défense Sanitaire*, GDS), which covers about 90 percent of the national cattle herd, with somewhat lower coverage in the other species. A GDS consists of a partnership between producers and the public veterinary services, to support the latter in regulatory prophylaxes, such as vaccination, animal identification, and supplemental compensation, and even in breeding and environmental services. A GDS on average consists of about 236,000 cattle distributed over about 4,000 farms, and is funded partly by its own members and partly from local and national public sources (le Brun 2004).

Several efforts have also been mounted in sub-Saharan Africa to link community animal health workers (CAHWs) to livestock users associations (LUAs) (Cadley et al. 2004). Such LUAs often had multiple objectives in providing services in animal health, resource access, and livestock marketing; it was thought that the pooling of resources would enable economies of scale in the purchase of inputs, and allow better supervision of the CAHWs. However, in practice the LUAs have had a mixed performance and poor sustainability. In animal health the National Federation of Central African Livestock Owners (FNEC) demonstrates these points. While quite successful in the initial phase (1985–1995) of its operation, distributing about 60 percent of all veterinary pharmaceuticals in that country, government interference and governance issues within the association caused a virtual collapse of the organization in the late 1990s (de Haan et al. 2001).

PUBLIC SECTOR INTERVENTIONS

A recent study commissioned by the World Organization for Animal Health (OIE) indicated that when a comparison is made of prevention compared to outbreak costs for HPAI, the majority of the reviewed studies and country cases found that the benefits that accrue from improved prevention and control measures significantly outweigh the costs of the investment. The control tools to respond to the most challenging of the transboundary animal diseases and zoonoses should be funded as a public good, particularly in developing countries, including good governance of veterinary services, animal health legislation, disease surveillance and information systems, compliance with international standards, research and development, and veterinary education.

At the national level there is a strong case for public intervention and investment (Le Gall 2006). The assessment of the current status of the veterinary services for a given country should be undertaken using the OIE's Performance of Veterinary Services (PVS) toolkit.¹⁹ This process evaluates the key components of an effective veterinary service in accordance with international standards and practices and identifies the gaps and focus for interventions and priorities for investments. The key elements for the evaluation include: (a) human, physical, and financial resources; (b) technical authority and capability; (c) interaction with stakeholders; and (d) access to markets.

Potential public sector functions of the veterinary services might include:

- Disease exclusion, quarantine, and early warning, because these systems benefit the entire society, and transfer of such responsibilities to private individuals would be prone to free-riding and nondisclosure of information.²⁰
- Food safety, in particular regarding control of foodborne disease pathogens, residues, or contaminants (antibiotics, heavy metals, and so forth), because the consumer is unable to monitor these risks and the State should be responsible for protecting the population.
- Disease prevention for the main transboundary and highly contagious diseases such as

¹⁹ Performance, Vision and Strategy for National Veterinary Services. www.oie.int/download/Vet_serv/PVS_IICA_en.pdf.

²⁰ See also Umali et al. (1992).

FMD, classical swine fever, HPAI, rabies, and others.²¹ Vaccination, culling, and movement control for such diseases has a significant public-good element. Vaccination and other control strategies allocated to private operators may be subject to cost-cutting decisions, reduced preventive measures, and increased risks of exposure to introduction of disease to individual herds or countries. In some cases, where a vaccination program protects both the public risk and the assets of the individual whose animals are being vaccinated, the intervention could be considered a mixed public/private good, and costs shared accordingly.

- Communication and public awareness, because the HPAI prevention and control programs have shown their fundamental importance to the control of zoonoses, food safety, and other public health risks associated with the externalities of the livestock sector.

THE ROLE OF THE PRIVATE SECTOR

The benefits of other animal disease control interventions, such as clinical treatment of individual livestock for production-related health problems accrue to the individual producer, and therefore may be considered a private good. The production of vaccines and other pharmaceuticals to treat conditions such as mastitis, endoparasites, ectoparasites, and lameness belong within this category. On the other hand, quality control, monitoring, and licensing to ensure safe production, sale, and application of these vaccines and animal remedies is more properly the province of the public sector owing to moral hazards and to unequal access to information, which generally adds to the disadvantage of groups with fewer resources.

The benefits of most production-related livestock services such as breeding and feeding accrue to the private investor in the service and are therefore generally not considered to be a public good, with the possible exception of some club goods such as extension and training, and some services

that seek to benefit the poor, such as subsidies and safety nets.²²

POLICY AND INVESTMENT OPTIONS

The designation of a public good related to livestock is seldom absolute. There is usually a continuum between private and public investments and the direct and indirect costs associated with the investment. The relative stage of development of a particular country will also play an important role in assigning the services to the private or public sector. In countries with a poorly developed private sector, there may be a stronger case for public sector involvement and vice versa. Yet using a country's stage of development to determine which roles should be public and which private can also be problematic. In the case of public animal health services, for example, it has been demonstrated that if the government veterinary service includes official or informal remuneration for a primarily private good (i.e., clinical treatments), there will be reluctance on the part of the government veterinarians to eventually give up this work, and the revenue it generates, to the private sector.

Legal, administrative, and operational frameworks and guidelines are required for government funding and implementation of clearly defined public goods that can be delivered by the private sector operators on a fee-for-service basis. This partnership also requires that the appropriate regulations, procedures, and penalties be put in place and enforced to ensure the quality of service and the compliance of veterinarians (public and private) and producers alike. Subcontracting of public sector tasks such as blood testing, vaccination, and meat inspection, can be a powerful tool to promote the emergence of a vibrant private veterinary service. Such private–public partnerships are the cornerstone of the more effective animal health systems found in many countries.

Some specific policy investments might include the following:

At the global level:

- Development of a program to improve coordination, compensation, and insurance for the livestock sector, which acknowledges the

²¹ See a complete list of notifiable diseases at: www.oie.int/eng/maladies/en_classification.htm.

²² See also IFAD (2002).

global-public-good character of emerging and reemerging animal diseases, in particular concerning the risks for disease outbreak in the developed world that might originate in developing countries. Because of their global nature and the fundability, priority should be given to those diseases at the animal–human interface. However, it is acknowledged that some activities, in particular in the development of efficient surveillance systems, should be addressed across diseases, and here the global support should not be restricted to highly infectious diseases at the human–animal interface. Global support, for the *control* of other infectious diseases is considered a national or private responsibility. Several international agencies are currently developing a proposal to create such a mechanism.

- Support for the research on “pro-poor” animal disease control and focusing on infectious diseases and zoonoses that are of particular importance to the poor even though they may be of limited economic importance and, therefore, of limited market potential. Since some individual benefits would accrue for these diseases, a mixed private/public good approach would be justified. Examples of such diseases might include the Peste de Petit Ruminants and African swine fever. A more extensive list is provided by the International Livestock Research Institute (ILRI), which is taking the lead in this regard in collaboration with other donors.²³
 - Promotion and support of the global community and more developed countries for long-term commitment to veterinary education, professional development, and training in developing countries at greatest risk and the establishment of effective local training institutions. The approach should include short-term interventions to address immediate needs and more long-term development of trainers focusing on a few key disciplines such as veterinary public health, pathology, diagnostic skills, applied epidemiology, surveillance, and information systems.
 - Development and implementation of the *One World, One Health* concept, and its eventual
- implications for the future institutional architecture of the organizations concerned with zoonotic diseases.
- Enhancement of the understanding of the respective responsibilities at the global, national, and local levels and among the public, private, and associative sectors.

At the national level:

- Development of national animal disease surveillance systems for the prevention, control, and ultimate eradication of disease, but with appropriate resources (staff, transportation, hardware, software), and that includes the participation of all key stakeholders, including farmers, processors, and consumers. The system should be appropriate for the current country’s needs and capacity linked to food safety and public health information systems, and to evolve as the needs and capacity of the country grow. Such a modular system could initially focus on transboundary diseases (border inspection, animal-movement controls, and so forth) and diseases of domestic concern (i.e., zoonoses), and evolve with time and improvements in capacity to a greater level of complexity and sophistication to address issues such as food safety and traceability, individual animal identification, and geographic information systems (GIS).
- Development of national contingency plans to direct the control of outbreaks of main contagious diseases through combinations of culling, movement controls, and ring vaccinations supported by market-price-based compensation schemes to avoid spread from infected areas. Typical weak elements in such schemes are inadequate compensation for culled animals leading to underreporting of disease incidents, clandestine sales of diseased animals, and inadequate resources and incentives for field-based monitors. The nature of the disease defines the level of public sector support, with the highest priority being given to the OIE-listed diseases, those of major importance for trade. For other non-contagious diseases that carry less risk of infecting other animals but for which the benefits from control are directly captured by the owner, the owner must bear the responsibility and costs for prevention, control, and treatment of these diseases or conditions (Umali et al. 1992).

²³ www.ilri.cgiar.org/InfoServ/Webpub/Fulldocs/InvestAnim/Book1/media/26_34.htm.

- Development of a food-safety regulatory system that acknowledges the special food preparation and consumption habits of specific cultures and ensures safe food for the consumer. Such a system would be designed to consider the implications of the tradeoff between increased costs of safer food and reduced disease risk. A classic example of this tradeoff involves the need for pasteurization of milk in some areas. This is justified in areas where milk is consumed without further processing but is redundant in cultures that routinely boil milk directly, for example, in combination with tea for home consumption.
- Inclusion of communication and public awareness campaigns as essential tools in the veterinary public health arsenal and programs to integrate both veterinary and medical health professional services in the prevention, control, and eradication of those public health risks of livestock sector externalities.

The Exclusion of Smallholders

Livestock comprises or contributes to the livelihoods of about 70 percent of the rural poor worldwide, or, according to *Livestock in Development* (1999), 987 million people. Superimposing poverty and livestock distribution data, the International Livestock Research Institute (ILRI)²⁴ estimates that about 35 percent of poor livestock keepers live in South Asia, about 30 percent in Sub-Saharan Africa, about 15 percent in East and South East Asia, and the remainder are distributed over Latin America, West Asia and North Africa, and Europe and Central Asia. While livestock will not be the pathway out of poverty for all of them, and outmigration will be an imperative for many, the sector's growth clearly represents significant opportunities for poverty reduction and economic growth.

Smallholders are often excluded from livestock sector development. Access to the fast-growing and more sophisticated markets for meat and milk products is dependent on a number of factors:

- Quality and safety standards, which often requires investments in on-farm hygiene (cooling, tiling, etc);
- Uniformity of the product, requiring investments in breeding, feeding, and veterinary health;
- Reliability of supply, which requires product specialization and/or higher level of production; and
- Verifiability of origin, which requires traceability systems.

Owing to the economies of scale enjoyed by larger producers, satisfying these standards imposes higher costs per unit product for smallholders. They therefore pose a threat to small producers and processors, who risk being crowded out of these more remunerative markets. However, compliance with higher standards serves to add value to livestock products and can generate employment throughout the supply chain. To capitalize on these opportunities, the following actions are required:

- Political and investment support for collective action, either in the form of cooperatives and associations, or under contract farming and vertical-integration models. The development of cooperatives relies on the absence of government interference, while contract farming benefits from an effective legal framework that ensures that the terms of contract are enforceable.

²⁴ www.ilri.org/InfoServ/Webpub/Fulldocs/Mappoverty/media/index.htm.

- Setting appropriate levels of public safety standards, with due regard for the state of the market, overall competitiveness, and enforceability. Producers generally have little leverage in the setting of private sector standards; and
- Ensuring equal treatment of smallholders in the incentive (subsidies, etc.) framework.

EQUITY

As markets move from local to rural to national, and further to regional and international markets, standards become more exacting, and the costs of meeting them become higher. Currently, the informal, traditional markets for livestock products are still dominant in most developing countries. For example, figures from recent World Bank food-safety action plans show that 85 percent of Vietnam's pork supply and 90 percent of Ghana's beef supply are channeled through the informal markets. Smallholders can compete in these informal markets in which quality standards and reliability of supply are still relatively unimportant. These standards and reliability become key determinants of access to more sophisticated formal markets, including those in which a modern retail sector is emerging.

Modern retail sectors are in fact emerging rapidly throughout most of the developing world, and the costs of meeting its quality and supply demands represent a major challenge to smallholders. In 2000, supermarkets had 50 to 60 percent of the market in Latin America, 10 to 30 percent in

South East Asia (about 15 percent in Asia), and were emerging in sub-Saharan Africa. In Kenya, for instance, supermarkets have a 20 percent share of the processed food market (Reardon et al. 2004). For these more sophisticated retail markets, the margins are higher, as shown in an example of the Kenya livestock and meat trade in Table 7.1, but the cost of compliance with the safety, quality, and supply reliability becomes much more important. Increasingly, in those modern supermarket sectors, "the farm-to-table" concept, supported by the risk-analysis approach, is becoming the dominant quality-related driving force.

The main requirements for entry into the *modern national markets* and, in even stricter form, the international markets, and their consequences for smallholders are the following:

Uniformity of product requires consistency in: (a) breeding, and therefore the use of improved breeds, which have much less genetic heterogeneity than the traditional breeds. Because these improved breeds also need better care, for the smallholder, this means the need for a higher skill level, and higher veterinary and feeding costs; (b) feeding, which requires purchase of feeds from the larger feed mills, because they have adequate stocks of basic ingredients and proper quality control, to avoid fluctuations in feed composition. There are strong economies of scale in feed delivery, leading to a lower feed price for larger operations. In addition, the feed-quality requirements imply that the smallholder can use less on-farm-produced feed; and (c) veterinary health systems, to avoid differences in growth rates because

Table 7.1: Net Margins (%) of Different Livestock Value Chains from North-Eastern Kenya^a to Nairobi

		Traditional Market		Improved Markets
Initial transport	7–22	Small market to Garissa	15–34	Small markets to fattening ranches in Likipia
Market to slaughterhouse	7–9	Garissa to Nairobi slaughterhouses	23–47	Fattened steers from Voi to Nairobi
Slaughterhouse to the butcher	9	Middlemen to butcheries	31	Slaughterhouse own purchase to larger retailers
Butcher to consumers	53	Low-class butcheries	100–249	High-class butcheries for boneless beef

a. Adapted from AU-IBAR 2006.

of differences in health status. In veterinary health delivery, there are also significant economies of scale.

Reliability of timing of the supply requires reproductive management of the breeding stock or planning for the purchase of young stock, to ensure that adequate numbers are available at the contracted time. Only by collective action can smallholders guarantee such a regular supply of adequate numbers.

Reliability of the origin of the supplies requires traceability systems to trace back the products to farms (in the case of pigs and poultry) or animals (in the case of cattle). It also establishes liability for eventual deficiencies in quality or safety. This will include investments in animal identification technology (electronic or conventional, such as ear tags) means of identification, and the supporting computer and physical control systems. Such traceability systems (or identification and registration [I&R] systems) are expensive, and have higher transaction costs for the smallholder. For example, Blasi et al. (2003) calculated the costs of radiofrequency identification (RFID) at US\$4 per head for herds over 1,000 heads and over US\$20 per head for herds of less than 100 cattle.

Meeting sanitary standards depends for the international market on the disease status of the country (or region) where the farm is located, and, when those are met for any given market, on the sanitary status of the value chain. In general, standards become more stringent as markets get more sophisticated, and the decision on the level of standards to pursue is an important policy issue. Government officials often argue for full adoption of the international Codex²⁵ and World Organization for Animal Health (OIE) standards. However, care should be taken that these standards are in the interest of the producer and consumer. For example, in situations in which the large majority of milk is boiled for consumption, but where home refrigeration is poor, as is the case in many developing countries, mandatory pasteurization is counter-productive, because it increases the price to the consumer, whereas with some training, raw milk

might present a lower health risk than pasteurized milk, as shown by ILRI research in Nairobi.²⁶ Requiring smallholders to meet those standards can cause their exclusion. For example, the requirement for full pasteurization of milk, with obligatory on-farm cooling of milk, caused the number of milk suppliers in the milk-collection areas of metropolitan Brazil to decrease in three years from 175,000 to 115,000 (Farina 2002), because only those with more than 200 L per day could economically install cooling equipment.

These requirements can therefore be a threat, because they drive up the costs of compliance, squeeze margins, make market access more difficult, and ultimately crowd smallholders out of production altogether. While in rapidly growing economies there are often adequate employment opportunities in other sectors, in stagnating economic conditions, they can cause social deprivation. For example, while the fate of the exiting dairy farmers from the Rio milk shed is not known, quite likely some will have wound up in urban slums. However, it could also be an opportunity if they are seen as part of broader process of development because it adds value and generates employment in the processing and retailing sector.

INSTITUTIONS, POLICIES, AND INVESTMENTS

Policies

Collective action, the establishment of appropriate standards, and a level playing field for the pricing of inputs are three main policy instruments to facilitate equitable livestock sector development.

Encouraging collective action. Collective action is especially important in gaining market access in the livestock sector, because: (a) the sector's products (milk and meat) are highly perishable, and individual producers, particularly if they are small, have little leverage; and (b) there are major economies of scale in meeting food safety and other animal health standards. Collective action dealing with market access in the livestock sector involves: (a) procurement and processing cooperatives and associations, particularly in dairy and live animals; (b) contract farming and vertical integration; and

²⁵ The *Codex Alimentarius*, commonly referred to as the Codex, is the product of the Codex Alimentarius Commission, which, together with the Food and Agriculture Organization and World Health Organization, sets scientifically based standards and guidelines for all aspects of world food production. They are considered the gold standard for all aspects of food production.

²⁶ www.ilri.org/Link/Publications/Publications/SDP%20Brief%204%20FINAL.pdf.

(c) representation at the national level of producer interest.

There are good experiences with livestock cooperatives in the processing sector. For example, in India, the well-known cooperative movement (“Operation Flood”) under the National Dairy Development Board (NDDB), supported over 15 years by the international community including the World Bank, serves about 13 million families by buying and processing about 90 million kg of milk per year, with major poverty-reducing impacts. Another successful example of World Bank–supported collective action in the livestock sector is the Development Foundation of Turkey (TKV), which developed a fully integrated poultry chain from breeding to marketing, which in the 1990s integrated about 2,500 farmers, with about 4,000 broilers per cycle, and captured about 30 percent of the broiler market in Turkey.

The main lessons that emerge from the Indian and Turkish experience concern the importance of (World Bank 1998):

- Combining different levels of technology in the value chain. The Indian cooperative model combines low levels of technology at the farm level with sophisticated technology at the processing and distribution levels.
- Freedom from government interference, particularly in setting producer and consumer prices. Differences in the level of government interference in the different Operation Flood states showed how the financial viability and overall sustainability of the cooperatives was affected by the government.
- Development of a stepwise approach, with initial collection and processing at the local level, and further processing and marketing at the regional or state level, benefiting from economies of scale.
- Charismatic leadership; both the NDDB and the TKV benefited from strong and committed leaders with strong political ties.

Staal et al. (2006), however, compared dairy subsector growth in Pakistan and India and argued that there is no empirical evidence that dairy cooperatives are more effective than other market channels in linking poor farmers to output markets.

Vertical-integration models can also link smallholder farmers to formal markets. In the livestock sector, vertical integration is quite common in meat production, especially in the pig and poultry

subsector. Combining the procurement of inputs and the marketing of outputs does yield a reduction in transaction costs and increases the revenue within the chain. Moreover, because the integrator can supply uniform breeding material, feed, and technical assistance, this model enables the production of a uniform product at the smallholder level, which the processing and distribution subsector increasingly demands. In many developed countries, vertical integration, whether through pure commercial or cooperative enterprises, has been the engine of technological change of the family farm.

The effect on farmers’ income of joining a vertical integrator is not considered universally positive. The detailed studies by Delgado et al. (2006) covering smallholders in Brazil, India, the Philippines, and Thailand show that both smallholder and large contract farmers are more profit-efficient than independent farmers. The study shows that smallholders, in particular, benefit from the reduction in transaction cost. However, some reports are less positive. For example, in China’s beef industry, many households do not feed to the specification of the integrators and readily renege on contracts by, for example, selling cattle through other channels before they reach the required finished weight. On the other hand, households often complain about integrators discounting purchase prices when cattle are bought on the basis of subjective assessment of live weight, carcass weight, fat score, hide size, and condition, especially when input–output price alignments are not favorable to the integrator (Waldron 2007).

Finally, collective action in *representing the interest of the producers* exists in both the developing and the developed world. In industrialized countries, farmers associations such as the National Cattlemen’s Beef Association, the Pork Council, and the National Milk Producers Associations in the United States, and the Dairy Board in various European Union (EU) countries, are quite powerful. The associations have succeeded in making beef and dairy products some of the most protected agricultural commodities. In the developing world, associations have less influence because they lack a strong organizational structure, and many governments seek to control their activities. Some have been able to bring the needs of their members into the public eye, as for instance, federations of pastoralists in East and West Africa (these were described in chapter 3). Strong organization, the

ability to champion the interests of their members, and freedom from government dominance appear to have been critical elements of their effectiveness.

Setting appropriate standards. The need for a certain caution in applying Codex standards in developing countries, with due regard to food preparation habits and the type of markets targeted, makes the question of how standards are set highly significant. Three principal factors affect this determination:

- *The state of the markets.* In many developing countries the urban markets are in transition, and, as distances between farm and table get longer, health risks increase, and traditional food preparation might no longer be adequate.
- *Overall competitiveness.* For example, seeking to meet EU standards that are in place to prevent most contagious diseases is not recommended if the product would not be competitive quality-wise.
- *Enforceability.* Excessive stringency in regulation leads to clandestine, often riskier, practices and opens opportunities for rent-seeking by the enforcers. Enforceability has been particularly relevant in the case of food-safety standards in small, locally producing slaughterhouses, where any stricter enforcement leads to uncontrolled backyard slaughtering.

Ensuring a level playing field. Financial advantages such as subsidies, and differential import and export incentives, are often enjoyed by many large operators. For example, Delgado et al. (2006) showed that the large feed mills enjoy preferential import tariffs for feed grains, which puts them into a comparative advantage vis-à-vis the

smallholder, who does not have that opportunity. Such differential treatments would need to be eliminated.

Investments

A variety of support and investments are needed to bring about enhanced access of smallholders to markets, and in particular to arrive at successful collective action in the livestock value chain.

- Investment in rural infrastructure is particularly important for smallholder dairy producers, and can consist of communal refrigerated milk-collection centers, livestock markets, and roads.
- Support for institution-building, producer organizations, dispute-resolution mechanisms, and eventually, milk and meat commodity exchanges.
- Support, on a matching-grant basis, for investments in innovation or public health and environmental improvement in the value chains, for example, for the development of new products, the incremental improvement of municipal slaughterhouses, waste management, and so forth.
- Support for training of the different stakeholders in the value chain on good husbandry, manufacturing practices, and food safety, with particular attention to raising consumer awareness.
- Support to research and advisory services with a focus on those aspects important to the smallholder and the poor; that is, use of local breeds, local by-products, more attention to the diseases of the poor, standards setting, and so forth.

Livestock has attracted little public investment over the past decade, either by developing countries or by the international development community. World Bank support for instance fell from total project costs of about US\$2 billion annually in the late 1970s and early 1980s, to about \$200 million in the late 1990s (in constant 1998 US dollars) (figure 8.1). Funding from other donors followed a similar trend (Blackburn and de Haan 1993). This chapter provides an account of trends within public policy and investment in livestock, and of the financial implications of engagement focusing on a number of entry points that address the sector's most critical externalities.

The focus of investments in the late 1990s and early 2000s was still rather traditional, as exemplified by the analysis of the 2001 portfolio, which focused mainly on cattle (46 percent of the total project costs) and East Asia (40 percent of project costs) and which covered the entire food chain. The portfolio's focus on cattle indicates a relative neglect of poor smallholders, who raise mostly smaller stock. It also reflects relative inattention to the environmental and public health effects of the fast-growing industrial pig and poultry systems.

A more recent livestock portfolio review (Agwe and Smith 2008), showed that World Bank support for livestock development fell further in 2002 and 2003, but increased to about US\$200 million in 2006. Funding continued to focus disproportionately on East Asia (44 percent); cattle (35 percent); and research, extension, and financial services (40 percent). Support to range management and environmental management, unfortunately, remained low.

The 2008 portfolio review did not include the increase in funding for HPAI, for which World Bank commitments amounted to US\$317 million in credit and grants by March 31, 2008. 40 percent of these credits and grants were used for human public health. The remaining 60 percent of HPAI funding went to agriculture, and this was principally directed to strengthening veterinary services and to developing surveillance and early-response capacities. Bank funding for HPAI thus remained consistent with that of its broader livestock portfolio, targeting specific areas with relatively little attention to larger issues of sustainability and equity.

A variety of reasons explain the low levels of public funding for livestock development, both by national governments and international development agencies.

- Agriculture as a whole was severely underfunded. Investments in agriculture declined from over 12 percent of donor

Figure 8.1: Average Annual Lending for Livestock Projects and Components Funded by the World Bank, 1974–2000



Note: Amounts are based on Total Project Costs.

Source: de Haan et al. 2001.

investments in the 1980s to about 4 percent in the 2000s, even though 75 percent of the poor live in rural areas and depend on agriculture for at least part of their livelihood (WDR 2008). (Just one-eighth of the 4 percent of official development assistance that was invested in the agriculture sector went to the livestock subsector.)

- Livestock projects continue to have a poor image, largely owing to the sector's poor performance during the 1980s, when the World Bank's Operation Evaluation Department attributed them a 43 percent success rate—this compared to the 70 percent success rate attributed to agriculture sector projects overall (Blackburn and de Haan 1993). Since then, the performance of livestock projects is at least on a par with the rest of the sector, at 65 to 70 percent, with a positive end-of-project rating.
- This negative image was exacerbated by the negative externalities that livestock production involved and that led major international NGOs to argue against international support for the sector. Those organizations acquired significant political influence during the late 1990s and early 2000s, making many policy makers more reluctant still to commit public resources to the sector. (The professional animal science community and commercial interests on the other hand have resisted

acknowledging the negative externalities of the sector.)

- Recognizing that livestock sector development and production growth is chiefly a function of private sector investment, the World Bank and other donors moved away from funding production by parastatals during the early 1990s. Productivity increase remained the primary objective. With this narrow objective, the wider social need for public goods was neglected.

The acknowledgement that the rapid growth and transformation of livestock—"the Livestock Revolution"—is mainly driven by the private sector, led to an imbalance between public and private goods within the livestock sector. Anti-livestock advocacy by international and national civil society and the reluctance of policy makers to devote public resources to the governance of the sector has led to a perverse outcome, in which livestock remains both a major contributor to pollution and a major risk to global public health. This stagnation of public funding needs to be reversed at the individual, national, and international levels if:

- major environmental and public health risks are to be averted;
- livestock development is to be made more sustainable and equitable; and
- the livestock sector is to produce safe and healthy products.

Advocacy for lowering meat and milk consumption as an alternative to reducing the environmental and public health risks posed by the sector cannot realistically be expected to lead to a significant reduction in consumption. This is not only extraordinarily unlikely, but from the perspective of consumers in developing countries whose consumption of livestock products is still limited, the irony of calls to reduce that consumption coming from industrialized countries where consumption levels are so much higher, may seem almost offensive. Nor would informing those consumers that the appeals are coming from largely vegetarian quarters of industrialized societies likely make the appeals any more acceptable. Answering those who advocate reduced consumption by pointing to the inevitability of increased consumption in developing countries is not tantamount to advocating for the livestock sector, but is, rather, an appeal for realism. Indeed,

falling into the pattern of rivalry that has characterized controversy about the sector would be serious a tactical mistake on the part of those who seek to raise awareness about the sector. This awareness-raising is the first matter to address in considering the road ahead.

THE ROAD AHEAD

Awareness-raising

A concerted effort combining major investments in awareness-raising at the international, national, and local levels, with policy changes and investment, are clearly required. Awareness-raising needs to cover both the positive and negative effects of the livestock sector. If it overemphasizes the sector's negative effects, it will likely discourage the public investments that are necessary. If it overemphasizes the sector's positive effects, it is likely to be ineffective and perceived as advocacy by parties with interests within the sector. Both dangers are clear based on past experience. Responsible awareness-raising must also point to

the reality of increasing demand in the developing world without expressing contempt toward the often laudable and rational pleas of those advocating reduced consumption.

A number of directions warrant high priority:

- Increase, through the international and national press, general awareness for the need for action. The publication of *Livestock's Long Shadow* (Steinfeld et al. 2006) and the emergence of HPAI have led to an increase in interest at the international level. Box 8.1 contains an excellent example of the type of message in the international press that needs to be encouraged.
- Integrate, through active lobbying, environmental and public health issues (and in particular the global public goods of emerging infectious zoonotic diseases and GHG emission) into the international dialogue on environment and health issues and upcoming negotiations. This would include active participation in the discussion the post-Kyoto agreements, which are now still dominated by

Box 8.1: *New York Times* Opinion

Meat and the Planet

When you think about the growth of human population over the last century or so, it is all too easy to imagine it merely as an increase in the number of humans. But as we multiply, so do all the things associated with us, including our livestock. At present, there are about 1.5 billion cattle and domestic buffalo and about 1.7 billion sheep and goats. With pigs and poultry, they form a critical part of our enormous biological footprint upon this planet. Just how enormous was not really apparent until the publication of *Livestock's Long Shadow* by the Food and Agriculture Organization of the United Nations.

Consider these numbers. Global livestock grazing and feed production use "30 percent of the land surface of the planet." Livestock—which consume more food than they yield—also compete directly with

humans for water. And the drive to expand grazing land destroys more biologically sensitive terrain, rain forests especially, than anything else.

But what is even more striking, and alarming, is that livestock are responsible for about 18 percent of the global warming effect, more than transportation's contribution. The culprits are methane—the natural result of bovine digestion—and the nitrogen emitted by manure. Deforestation of grazing land adds to the effect.

There are no easy trade-offs when it comes to global warming—such as cutting back on cattle to make room for cars. The human passion for meat is certainly not about to end anytime soon. As "Livestock's Long Shadow" makes clear, our health and the health of the planet depend on pushing livestock production in more sustainable directions.

Source: *The New York Times*, "Meat and the Planet," Opinion Editorial, December 27, 2006.

the transport sector, and active participation in the *One World, One Health* discussion now being launched from various sides.²⁷

- Seek to integrate the livestock sector, and in particular the fate of poor livestock keepers, into developing country policy documents, such as the Poverty Reduction Strategy Papers (PRSPs). Creating tools to enable the sector stakeholders to make the case more effectively to policymakers, such as prepared by the African Livestock Platform (ALive)²⁸ for pro-poor livestock development, and by the World Organization for Animal Health (OIE) for Performance of Veterinary Services (PVS), can be a major help.

FUNDING NEEDS AND MECHANISMS

Correcting the imbalance between public and private goods in the livestock sector will require additional funding. Combinations of the following sources should be envisioned.

- *Producers and consumers.* Generally, there should be a stricter application of the “Polluter Pays” principle, internalizing the costs of the environmental externalities into the price of the products. A greater cost sharing of environmental mitigation of the livestock sector might be feasible, because the growing middle-income class in developing countries is becoming increasingly environmentally conscious (Steinfeld et al. 2006). The size of the incremental costs differs according to the situation, but the calculations done in Malaysia and Australia yield a modest 6 to 10 percent cost increase.²⁹ On the other hand, those producers that provide services through carbon sequestration in their pastures, energy conversion of livestock waste,

and the enhancement of biodiversity should be compensated.

- *The Global Community,* in particular, for the high-priority goods of public health and global climate change.

For *emerging diseases*, considerable work has been done by OIE and the World Bank to prepare the establishment of a global fund, the Global Emergency Response Fund for Animal Epizootics (GERFAE),³⁰ although questions regarding the proper source of funding, country, type of disease, and eligibility remain. For example, depending on the choice of countries, the annual budget of GERFAE in the case of outbreaks of HPAI varies from US\$73 million a year under a scenario of four least developed countries affected, to nearly US\$600 million if the funding covering culling and control costs of all 50 least developed countries were to be covered. FAO has estimated the total needs for the control of HPAI (but would also be for the enhanced preparedness for the containment of other diseases) at US\$882 million for 2006–2008, excluding eventual compensation. Choices are, therefore, needed, and more work is required on the actual costs of setting up efficient surveillance and on early-reporting and early-response systems.

For *global climate change*, existing carbon-trading mechanisms will have to be used. Under rough estimates of the lower-level global emission due to the livestock sector of 4.6 billion tons CO₂ equivalent (Steinfeld et al. 2006), a reduction of 1.2 percent (as per the Kyoto agreement) and a price of US\$30 per ton CO₂³¹ would already imply an annual cost of about US\$1.5 billion, or about one-tenth of the current trading volume of the European Emissions Trading Scheme (EU ETS).³²

- *National governments* would finance the national public goods (chapter 2). Exact data are scarce, but one comparison done in the mid-1990s shows that the budget for animal health ranged from 3 percent of the agricultural

27 For example, FAO, OIE, and WHO, the American Medical Association (AMA), the American Veterinary Medical Association, (AMVA), the U.S. National Academy of Sciences and the Institute of Medicine, and the Federation of Veterinarians of Europe (FVE) have all called for a closer integration of human and veterinary medicine, and/or have established task forces to promote the *One World, One Health* concept. On the wildlife side, the International Union for the Conservation of Nature (IUCN) and the Wildlife Conservation Society have also established a close cooperation.

28 www.alive-online.org.

29 www.fao.org/docrep/x5303e/x5303e0d.htm.

30 AGRA-CEAS-CIVIC consulting (2007) [www.oie.int/eng/OIE-WB_Conference_1007/OIE%20Economic%20Studies/OIE%20-%20Global%20Fund%20\(Part%20II\).pdf](http://www.oie.int/eng/OIE-WB_Conference_1007/OIE%20Economic%20Studies/OIE%20-%20Global%20Fund%20(Part%20II).pdf).

31 Estimated lower than the current global market, because of presumably higher transaction costs.

32 www.eex.com/en/about%20EEX/Cooperation%20EEX%20and%20Eurex/Background.

budget in Morocco to 9 percent in New Zealand, clearly out of line with the contribution of the sector to GDP. Greater advocacy and closer integration of the sector stakeholders into the national policy dialogue are therefore needed.

SUMMARY

Clearly, business as usual without strengthening the ability to impose corrective measures will lead to mounting problems. Concerted action to create awareness, and to establish the correct incentive frameworks as outlined in this document, supported by investments, are needed if the livestock sector is to make a significant, positive contribution to the future and well-being of humankind.

This report analyzes the issues involved in the management of market failures in the livestock sector and provides policy makers and practitioners with viable policy and investment options to address these issues. It finds that the recent growth in

the livestock sector has been almost entirely driven by private sector investments, with little or no supporting public sector involvement. This phenomenon has exacerbating significant negative externalities, such as major land degradation, biodiversity erosion, water pollution, and greenhouse gas emission. In addition, as shown in recent years, the sector is also a major source of public health risks. There is, therefore, a need for urgent mitigating public policies and investments to redress the above adverse impacts of developing countries governments' benign neglect of the sector.

The report concentrates on: (a) the public sector needs, because of the target audience, and the need to start addressing the imbalance between private- and public sector investments; and (b) the negative effects of the sector, because of the priority now to be given to provide the appropriate enabling environmental, social, and public health framework in which the private sector can develop. The report's main conclusions and policy recommendations are summarized in matrix form in the appendix.

Appendix: Overview of Main Policy Instruments

Policy Instrument	Specific Measure	Issue/Public Good to be Addressed/Comment
<i>Motivation and general awareness instruments</i>	Promoting awareness at the international, national, and local levels regarding the need to make the livestock sector more sustainable.	Skewed Information: To cover both the positive and negative effects of the sector. Highlighting only the negative effects might discourage investments, whereas emphasizing only the positive effects will be ineffective as it is viewed as sector-interested advocacy.
<i>Institutional instruments</i>	Developing a better understanding and seeking a common agreement among all stakeholders on which “goods and bads” produced by the livestock sector are respectively of a global, national, local public, or private nature.	Addressing overlapping responsibilities.
	Promoting improved institutional architecture, arrangements, and processes at the national and international levels, which seek to operationalize the <i>One World, One Health</i> concept, and bring together human, animal, and ecosystems health institutions.	Addressing disease spillover from one sector to another.
	Developing a global support mechanism for capacity-building on early detection and response to emerging and reemerging infectious zoonotic diseases.	Addressing global public good in major diseases.
<i>Financial instruments</i>	Strengthen national veterinary services in surveillance, early-warning, and early-response capacity.	Addressing national public goods.
	Introducing and enforcing a stricter application of the “polluter pays and provider gets” principle for the environmental impacts of the livestock sector, including: <ul style="list-style-type: none"> • Introducing gradually a greenhouse gas-emission tax on livestock products, which could be offset by payment through carbon sequestration in grassland or emission reduction through biogas; • Introducing payment for the environmental services that the sector can provide, for example, in addition to carbon sequestration and energy, for landscape management. • Increasing cost recovery for the non-public-good services in animal health at the local and farm level, to increasingly enable the funding of public goods to be destined to public funds. The emphasis in the public sector should be on doing “less but better.” 	Internalizing environmental externalities in product.
	Establishing equitable treatment for smallholders: <ul style="list-style-type: none"> • Eliminating financial advantages (subsidies, differential import and export incentives), which large operators often enjoy. • Supporting (in the form of matching grants, other incentives) activities and capacity-building that encourage collective action (input and marketing cooperatives). 	Unclear distribution of responsibilities between the public and private sectors.

(Table continued on following page.)

Policy Instrument	Specific Measure	Issue/Public Good to be Addressed/Comment
<i>Regulatory instruments</i>	<p>Establishing environmental, food safety, and health standards, which are appropriate to the local conditions and are enforceable.</p> <p>Establishing and enforcing stricter antipollution of “end-of-the-pipe” discharge of intensive livestock farms and processing operations.</p> <p>Developing the capacity to define and implement zoning policies:</p> <ul style="list-style-type: none"> • In the industrial systems, bringing livestock waste production in line with the absorptive capacity of the surrounding land (“intensify, but don’t concentrate”), i.e., shift to more intensive systems of production, but promote a wide spatial distribution of those units; • In the grazing systems, negotiating land use agreements, which spare the sensitive areas, eventually with tradable rights. 	<p>Avoiding unenforceable standards.</p> <p>Spillover effects of individual livestock husbandry and processing practices on common sources, such as land and water.</p>
<i>Property instruments</i>	<p>Ensuring access to land and water with laws and institutions appropriate for the prevailing production system—for example, with adequate opportunity for pastoralists to move and use the different ecological niches of their lands efficiently, and for smallholders in land-constrained situations to consolidate into larger units.</p>	

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