additional tool for disease control. Options include choosing the appropriate breed for the production environment; cross-breeding to introduce resistance into breeds that are otherwise well adapted; and selective breeding based on the choice of individual animals that have high levels of disease resistance or tolerance. Advantages of such strategies include:

- the consistency of the effect once it has been established;
- reduced expenditure on veterinary products;
- prolonged effectiveness of other control methods, as there is less pressure for the emergence of resistance among pathogens and disease vectors; and
- the possibility of broad spectrum effects (increasing resistance to more than one disease).

There is also evidence to suggest that populations that are genetically diverse in terms of their disease resistance characteristics are less susceptible to large-scale disease epidemics.

For a number of diseases, studies have shown that particular breeds are less susceptible than others. Examples include the trypanotolerant N'dama cattle of West Africa, and the Red Maasai sheep of East Africa, which show high levels of resistance to gastrointestinal worms. For some diseases (including nematodes in sheep), within-breed selection for resistance or tolerance is feasible. Molecular marker technologies offer opportunities for further advances, but practical applications in disease control have been limited to date.

Research into the genetics of resistance and tolerance to livestock disease has been limited in terms of the diseases, breeds and species investigated. The Global Databank for Animal Genetic Resources for Food and Agriculture contains many reports of breeds that are thought to show resistance to particular diseases, but many have not been subject to scientific investigation to explore their potential. If breeds become extinct before their disease-resistance qualities have been identified, genetic resources that could greatly contribute to improving animal health and productivity are obviously no longer accessible.

Threats to animal genetic resources

A number of threats to livestock genetic diversity can be identified. Probably the most significant is the marginalization of traditional production systems and the associated local breeds, driven mainly by the rapid spread of intensive livestock production, often large-scale and utilizing a narrow range of breeds. Global production of meat, milk and eggs is increasingly based on a limited number of high-output breeds – those that under current management and market conditions are the most profitably utilized in industrialized production systems. The intensification process has been driven by rising demand for animal products and has been facilitated by the ease with which genetic material, production technologies and inputs can now be moved around the world. Intensification and industrialization have contributed to raising the output of livestock production and to feeding the growing human population. However, policy measures are necessary to minimize the potential loss of the global public goods embodied in animal genetic resource diversity.

Acute threats such as major disease epidemics and disasters of various kinds (droughts, floods, military conflicts, etc.) are also a concern – particularly in the case of small, geographically concentrated breed populations. The overall significance of these threats is difficult to quantify. In the event of disease outbreaks, mortality figures are rarely broken down by breed. Nonetheless, it is clear that very large numbers of animals can be lost, and that it is often the culling measures imposed to control the epidemic that result in the largest number of deaths. For example, approximately 43 million birds were destroyed in Viet Nam at the time of the 2003/2004 outbreaks of avian influenza – the equivalent of around 17 percent of the country's chicken population. Several rare breed populations in the United Kingdom were affected by the culling measures introduced during the 2001 foot-and-mouth disease epidemic. In the case of disasters and emergencies, the initial event may kill large numbers of animals, and there is a possibility that populations confined to affected areas could be wiped out. However, the outcome in terms of the genetic diversity will often be greatly influenced by the nature of post-emergency restocking programmes.

Threats of this kind cannot be eliminated, but their impacts can be mitigated. Preparedness is essential in this context, as ad hoc actions taken in an emergency situation will usually be far less effective. Fundamental to such plans, and more broadly to sustainable management, is improved knowledge of which breeds have characteristics that make them priorities for protection, and how they are distributed geographically and by production system.

Policies and legal frameworks influencing the livestock sector are not always favourable to the sustainable utilization of animal genetic resources. Overt or hidden governmental subsidies have often promoted the development of large-scale production at the expense of the smallholder systems that utilize local genetic resources. Development and post-disaster rehabilitation programmes that involve livestock should assess their potential impacts on genetic diversity and ensure that the breeds used are appropriate to local production environments and the needs of the intended beneficiaries. Disease control strategies need to incorporate measures to protect rare breeds; revision of relevant legislation may be necessary.

Clearly, it is neither possible nor desirable that the conservation of animal genetic resources should, in itself, take precedence over objectives such as food security, humanitarian response to disasters, or control of serious animal diseases. However, it is likely that many measures with the potential to reduce the risk of genetic erosion will also promote efficient utilization of existing animal genetic resources, and so be complementary to wider livestock development objectives.

Livestock sector trends

- Livestock production systems are dynamically evolving.
- Drivers of change in livestock production systems include:
  - growth and changes in demand for animal products;
  - developments in trade and marketing;
  - technological developments;
  - environmental changes;
  - policy decisions in relevant subsectors.
- Large-scale industrialized production is rapidly spreading in developing countries.
- Diverse small-scale production remains important – particularly for the poor and in marginal environments – and requires attention.
- New livestock functions are emerging, including landscape and vegetation management using grazing animals.
- Consumer choices are increasingly influenced by environmental and welfare concerns, and by tastes for speciality products.
- Environmental challenges that need to be addressed include:
  - emission of greenhouse gases from livestock (ruminants) and their excretions;
  - deforestation for the establishment of pastures and feed production (particularly soybean);
  - pollution of land and water by livestock wastes.

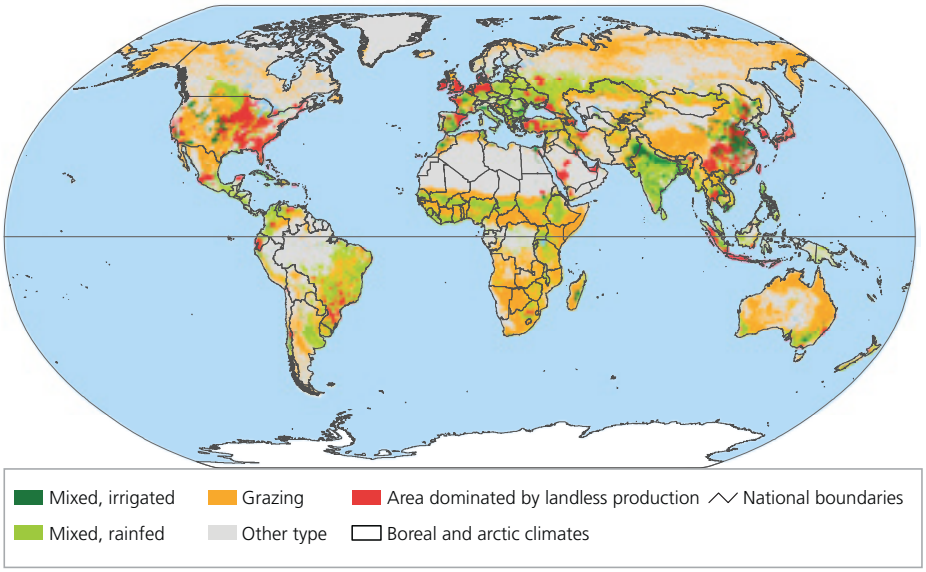
Drivers of change in livestock production systems

Agricultural systems are continuously evolving. These dynamics underscore the need to retain options for the management of these systems at present and in the future, and for the sustainable use of the associated genetic resources.

The development of the livestock sector responds to a series of drivers of change. On a world scale, the most important of these driving forces is increasing demand for food of animal origin. Global consumption of meat and milk has been rapidly growing since the early 1980s. Developing countries have accounted for a large share of this growth. The influence that increased purchasing power has on diets is greatest when it involves low- and middle-income populations. Urbanization is another contributing factor. There are also qualitative changes. Changing lifestyles, and general dietary trends, favour consumption of processed and pre-prepared convenience foods. A more recent development is the emergence (largely in more affluent countries) of significant numbers of consumers whose purchasing decisions are influenced by concerns about health, environmental, ethical, animal welfare and social/developmental issues.

International trade in livestock and livestock products has sharply increased in recent decades. Transnational companies

FIGURE 8
Distribution of livestock production systems



Source: Steinfeld *et al.* (2006)[6]

[6] **Steinfeld, H., Wassenaar, T. & Jutzi, S.** 2006. Livestock production systems in developing countries: status, drivers, trends. *Revue Scientifique et Technique de l'Office International des Epizooties*, 25(2): 505–516.

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in the retail and processing sectors are transforming the food supply chains that link producers to consumers. Globalized markets and vertical integration of supply chains imply new, often more stringent, demands for product quality, consistency and safety. Failure to meet these requirements often leads to the exclusion of small, unorganized producers from the market.

Advances in transport and communication technologies have promoted the development of global markets, and have facilitated the establishment of livestock production units that are geographically separated from the croplands that are the source of feed. Other technological advances – in nutrition, breeding and housing – have enabled livestock producers to exert increasing control over the production environments in which animals are kept.

Changing environmental conditions also influence production systems. Adapting to global climate change is likely to present a serious challenge to many livestock producers over the coming decades. The livestock sector's contribution to the emission of greenhouse gases is a very serious concern and requires decisive attention. The pastoral systems of the world's dry lands are among the most vulnerable, with climate change taking place against the background of natural environments that are already experiencing resource degradation. Livestock in these systems depends to a great extent on the productivity of the rangelands, which is predicted to decline and become more erratic. In general, climate change is likely to present significant problems for production systems where resource endowments are poorest and where the ability of livestock keepers to respond and adapt is most limited.

Public policies that affect the livestock sector are additional drivers of change. Important policy measures affecting the livestock sector include: market regulations (e.g. affecting foreign direct investment or intellectual property rights); frameworks affecting ownership and access to land and water; policies affecting the movement of populations; incentive and subsidy measures; sanitary and trade policies; and environmental regulations.

The livestock sector's response

The following paragraphs present a brief overview of the world's livestock production systems and outline the developments that are occurring in response to the driving forces described above. The distribution of the main production systems is shown in Figure 8.

Landless systems

The growth of large-scale industrialized production in many parts of the developing world is the most economically significant trend in the global livestock sector. The industrialization process involves intensification, increase in scale, and geographical and social concentration of production. The focus is on maximizing the output of a specific product. A narrow range of breeds is used, and within-breed genetic diversity may also be reduced. Geographical concentration and the separation of livestock and crop production present a number of environmental problems, particularly related to the management of livestock wastes. Small-scale landless livestock production can be found both in and around cities and in rural areas. This type of production is less globally significant than industrial systems in terms of meeting the growth in demand for animal products. However, its important contribution to household-level food security and livelihoods needs to be taken into consideration.

Grassland-based systems

Grassland-based systems are found in all the world's regions and agro-ecological zones – largely in locations where growing crops is difficult or impossible. They include the traditional herding systems of dry, cold and mountainous areas; large ranch-type operations; and the high-input systems of the temperate zones of developed countries. Environmental threats in grassland systems include rangeland degradation and the conversion of rainforests into pastureland.

Livestock breeds traditionally kept in grassland systems tend to be well adapted to the harsh conditions in which they are grazed, and to meeting the needs of their keepers. However, many pastoral production systems are under severe pressure. Natural resource degradation is widespread. Traditional management regimes and mobile grazing strategies, which make efficient use of fluctuating grazing resources, are often abandoned in the face of restricted access to natural resources, expansion of croplands, population pressure, conflict, social differentiation, and inappropriate development and land-tenure policies. Technical measures to improve productivity are usually very difficult to implement. In many situations the key issues to be addressed – such as ensuring access to pastures and water – are at policy or institutional levels. In the grazing systems of developed countries (and in some developing country contexts), growing emphasis is being placed on alternative livestock functions such as the provision of environmental services and landscape management.

Mixed farming systems

Mixed farming systems (those involving both crop and livestock production within the same farm) dominate smallholder production throughout the developing world. In these systems, livestock are generally kept for multiple purposes, with the supply of inputs to crop production being an important role. Diverse roles, harsh climates and severe challenge from diseases have given rise to a wide range of specifically adapted livestock breeds. The cycling of wastes between the crop and animal components of the system often makes mixed systems relatively benign from an environmental perspective. Nonetheless, their sustainability is sometimes threatened. Where demand for livestock products is high, landless production is expanding at the expense of mixed farming. In other circumstances – where access to markets, income sources and inputs are lacking and population is increasing – mixed systems can be threatened by severe depletion of soil nutrients and degradation of natural resources. Technological developments such as the

introduction of mechanized cultivation and the use of mineral fertilizers tend to narrow the range of services provided by livestock. However, these trends are not universal; for example, the importance of draught animals as a source of power in agriculture is increasing in many parts of sub-Saharan Africa.

Developed countries have already seen the emergence of more intensive mixed production systems involving greater use of external inputs and a narrower range of high-output livestock breeds – as well as a trend towards landless production. However, in some developed countries there is renewed interest in mixed farming in order to take advantage of the efficient nutrient cycling that is characteristic of these systems.

Implications for animal genetic resources

Pre-industrial livestock production systems gave rise to great genetic diversity among the world's livestock. The rapid spread of production based on highly controlled management conditions, and demands for product uniformity, have led to an increasing proportion of the global output of livestock products being based on a narrow range of genetic resources. However, despite the significance of these developments, the world's livestock production systems remain very diverse. This is particularly true for the smallholder and pastoral systems of the developing world. Locally adapted livestock remains important to the livelihoods of a large proportion of the world's poor. It is vital that policies affecting the livestock sector consider the needs of these livestock keepers or the animal genetic resources on which they depend. Despite good adaptation to their production environments and the livelihood strategies of their keepers, local breeds often face threats. The sustainability of production systems may be affected by the degradation of natural resources, or by inappropriate policy measures and development interventions.

Genetically diverse livestock populations are an important resource to be drawn upon as production systems change and develop. Newly emerging market trends and policy objectives are continually placing new demands on the livestock sector. The prospect of future challenges such as adapting to global climate change underlines the importance of retaining a diverse portfolio of livestock breeds.