# THE STATE OF THE WORLD's ANIMAL GENETIC RESOURCES FOR FOOD AND AGRICULTURE

*– in brief*

COMMISSION ON
GENETIC RESOURCES
FOR FOOD AND
AGRICULTURE

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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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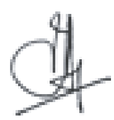
# Foreword

The wise management of the world's agricultural biodiversity is becoming an ever greater challenge for the international community. The livestock sector in particular is undergoing dramatic changes as large-scale production expands in response to surging demand for meat, milk and eggs. A wide portfolio of animal genetic resources is crucial to adapting and developing our agricultural production systems. Climate change and the emergence of new and virulent animal diseases underline the need to retain this adaptive capacity. For hundreds of millions of poor rural households, livestock remain a key asset, often meeting multiple needs, and enabling livelihoods to be built in some of the world's harshest environments. Livestock production makes a vital contribution to food and livelihood security, and to meeting the United Nations Millennium Development Goals. It will be of increasing significance in the coming decades.

And yet, genetic diversity is under threat. The reported rate of breed extinctions is of great concern, but it is even more worrying that unrecorded genetic resources are being lost before their characteristics can be studied and their potential evaluated. Strenuous efforts to understand, prioritize and protect the world's animal genetic resources for food and agriculture are required. Sustainable patterns of utilization must be established. Traditional livestock keepers – often poor and in marginal environments – have been the stewards of much of our animal genetic diversity. We should not ignore their role or neglect their needs. Equitable arrangements for benefit-sharing are needed, and broad access to genetic resources must be ensured. An agreed international framework for the management of these resources is crucial.

This report is the first global assessment of the status and trends of animal genetic resources, and of the state of institutional and technological capacity to manage these resources. It provides a basis for renewed efforts to ensure that the commitments to the improved management of genetic resources set out in the World Food Summit Plan of Action are realized. It is a milestone in the work of the Commission on Genetic Resources for Food and Agriculture. The support provided by the world's governments, exemplified by the 169 Country Reports submitted to FAO, has been particularly heartening. I am also greatly encouraged by the contribution that the process of preparing this report has already made to awareness of the topic and to catalysing activity at national and regional levels. However, much remains to be done. The launch of *The State of the World's Animal Genetic Resources for Food and Agriculture* at the International Technical Conference on Animal Genetic Resources at Interlaken, Switzerland, must be a springboard for action. I wish to take this opportunity to appeal to the international community to recognize that animal genetic resources are a part of our common heritage that is too valuable to neglect. Commitment and cooperation in the sustainable use, development and conservation of these resources are urgently required.



Jacques Diouf
FAO Director-General

# Executive summary

*The State of the World's Animal Genetic Resources for Food and Agriculture* is the first global assessment of livestock biodiversity. Drawing on 169 Country Reports, contributions from a number of international organizations and twelve specially commissioned thematic studies, it presents an analysis of the state of agricultural biodiversity in the livestock sector – origins and development, uses and values, distribution and exchange, risk status and threats – and of capacity to manage these resources – institutions, policies and legal frameworks, structured breeding activities and conservation programmes. Needs and challenges are assessed in the context of the forces driving change in livestock production systems. Tools and methods to enhance the use and development of animal genetic resources are explored in sections on the state of the art in characterization, genetic improvement, economic evaluation and conservation.

Thousands of years of animal husbandry and controlled breeding, combined with the effects of natural selection, have given rise to great genetic diversity among the world's livestock populations. High-output animals – intensively bred to supply uniform products under controlled management conditions – co-exist with the multipurpose breeds kept by small-scale farmers and herders mainly in low external input production systems.

Effective management of animal genetic diversity is essential to global food security, sustainable development and the livelihoods of hundreds of millions of people. The livestock sector and the international community are facing many challenges. The rapidly rising demand for livestock products in many parts of the developing world, emerging animal diseases, climate change and global targets such as the Millennium Development Goals need to be urgently addressed. Many breeds have unique characteristics or combinations of characteristics – disease resistance, tolerance of climatic extremes or supply of specialized products – that could contribute to meeting these challenges. However, evidence suggests that there is ongoing and probably accelerating erosion of the genetic resource base.

FAO's Global Databank for Animal Genetic Resources for Food and Agriculture contains information on a total of 7 616 livestock breeds. Around 20 percent of reported breeds are classified as at risk. Of even greater concern is that during the last six years 62 breeds became extinct – amounting to the loss of almost one breed per month. These figures present only a partial picture of genetic erosion. Breed inventories, and particularly surveys of population size and structure at breed level, are inadequate in many parts of the world. Population data are unavailable for 36 percent of all breeds. Moreover, among many of the most widely used high-output breeds of cattle, within-breed genetic diversity is being undermined by the use of few highly popular sires for breeding purposes.

A number of threats to 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 are most profitably utilized in industrial 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. 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 the sustainable management of genetic resources, is improved knowledge of which breeds have characteristics that make them priorities for conservation, 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 interventions and disease control strategies can also pose a threat to genetic diversity. 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. Culling programmes implemented in response to disease outbreaks need to incorporate measures to protect rare breeds; revision of relevant legislation may be necessary.

Where the evolution of livestock production systems threatens the ongoing use of potentially valuable genetic resources, or to safeguard against sudden disastrous losses, breed conservation measures have to be considered. *In vivo* conservation options include dedicated conservation farms or protected areas, and payments or other support measures for those who keep rare breeds within their production environments. *In vitro* conservation of genetic material in liquid nitrogen can provide a valuable complement to *in vivo* approaches. Where feasible, facilitating the emergence of new patterns of sustainable utilization should be an objective. Particularly in developed countries, niche markets for specialized products, and the use of grazing animals for nature or landscape management purposes, provide valuable opportunities. Well-planned genetic improvement programmes will often be essential if local breeds are to remain viable livelihood options for their keepers.

Implementing appropriate strategies for the low external input production systems of the developing world is a great challenge. Pastoralists and smallholders are the guardians of much of the world's livestock biodiversity. Their capacity to continue this role may need to be supported – for example by ensuring sufficient access to grazing land. At the same time, it is essential that conservation measures do not constrain the development of production systems or limit livelihood opportunities. A small number of community-based conservation and breeding programmes have begun to address these issues. The approach needs to be further developed.

Effective management of animal genetic diversity requires resources – including well-trained personnel and adequate technical facilities. Sound organizational structures (e.g. for animal recording and genetic evaluation) and wide stakeholder (particularly breeders and livestock keepers) involvement in planning and decision-making are also essential. However, throughout much of the developing world, these prerequisites are lacking. Forty-eight percent of the world's countries report no national-level *in vivo* conservation programmes, and sixty-three percent report that they have no *in vitro* programmes. Similarly, in many countries structured breeding programmes are absent or ineffective.

In a time of rapid change and widespread privatization, national planning is needed to ensure the long-term supply of public goods. Livestock-sector development policies should support equity objectives for rural populations so that these populations are able to build up, in a sustainable way, the productive capacity required to enhance their livelihoods and supply the goods and services needed by the wider society. The management of animal genetic resources needs to be balanced with other goals within the broader rural and agricultural development framework. Careful attention must be paid to the roles, functions and values of local breeds and to how they can contribute to development objectives.

The countries and regions of the world are interdependent in the utilization of animal genetic resources. This is clear from evidence of historic gene flows and current patterns of livestock distribution. In the future, genetic resources from any part of the world may prove vital to breeders and livestock keepers elsewhere. There is a need for the international community to accept responsibility for the management of these shared resources. Support for developing countries and countries with economies in transition to characterize, conserve and utilize their livestock breeds may be necessary. Wide access to animal genetic resources – for farmers, herders, breeders and researchers – is essential to sustainable use and development. Frameworks for wide access, and for equitable sharing of the benefits derived from the use of animal genetic resources, need to be put in place at both national and international levels. It is important that the distinct characteristics of agricultural biodiversity – created largely through human intervention and requiring continuous active human management – are taken into account in the development of such frameworks. International cooperation, and better integration of animal genetic resources management into all aspects of livestock development, will help to ensure that the world's wealth of livestock biodiversity is suitably used and developed for food and agriculture, and remains available for future generations.

# Introduction

Ensuring that the world's livestock biodiversity is sustainably managed and that the options these resources provide remain available for the future calls for concerted and well-informed action at both national and international levels. *The State of the World's Animal Genetic Resources for Food and Agriculture* is the first global assessment of these resources and of capacity to manage them (see Box 1 for details of the reporting process). This summary presents the main findings of the full report. Part 1 outlines the state of agricultural biodiversity in the livestock sector – origins and distribution, current population size and structure, trends in risk status, and uses and values of genetic resources, along with a discussion the significance of genetic resistance in disease control strategies, and an analysis of threats to genetic diversity. Part 2 considers the livestock production systems of which animal genetic resources form a part, how they are changing, and what this means for the management of livestock biodiversity. Part 3 – largely based on the 148 Country Reports available for analysis in July 2005 – is an assessment of institutional and human capacity in the field of animal genetic resources management, structured breeding programmes, conservation measures, the use of reproductive biotechnologies, and relevant policy and legal frameworks. Part 4 presents the state of the art in terms of the methods available for the management of animal genetic resources: characterization, genetic improvement, economic analysis and conservation. Part 5 draws together the evidence from the other four parts of the report to provide an assessment of priority needs and challenges in the management of animal genetic resources.

**BOX 1**

***The State of the World's Animal Genetic Resources for Food and Agriculture* reporting process**

In 1999, the FAO Commission on Genetic Resources for Food and Agriculture agreed that FAO should coordinate the preparation of a country-driven report on the state of the world's animal genetic resources for food and agriculture. In March 2001, FAO invited 188 countries to submit Country Reports assessing the state of animal genetic resources at the national level. Between 2003 and 2005 a total of 169 Country Reports were received.

A further important source of information was FAO's Domestic Animal Diversity Information System (DAD IS[1]) – a system that enables countries to report on the characteristics, size and structure of their breed populations.

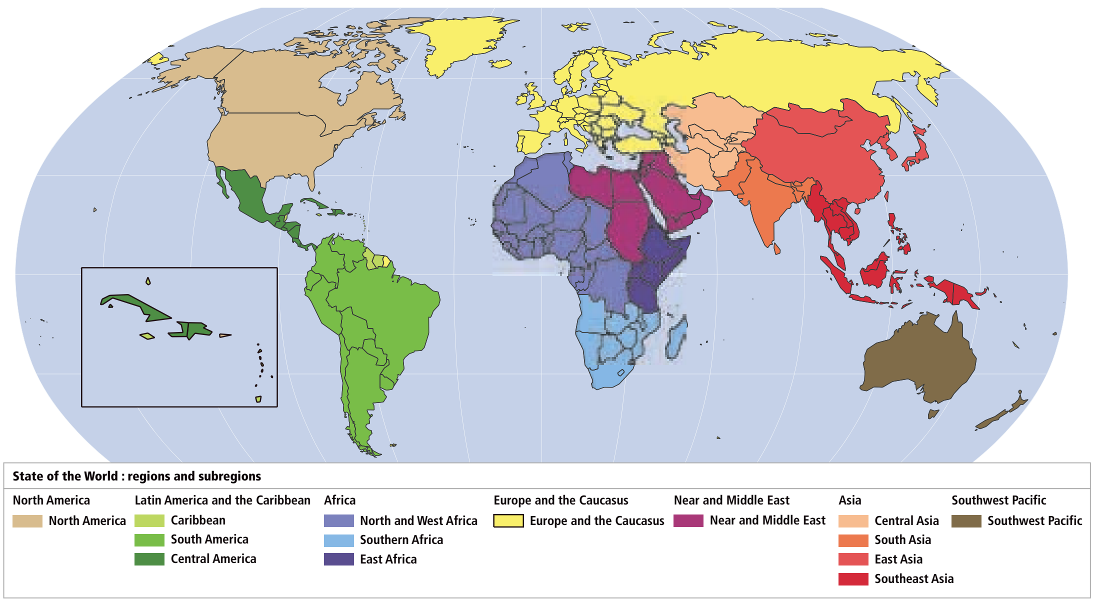
The report also draws on submissions from international organizations, specially commissioned thematic studies, FAO's statistical database (FAOSTAT[2]), and wider literature and expert knowledge. The various sections of the report went through a process of review by international experts. The first full draft was reviewed by the Commission's Intergovernmental Technical Working Group on Animal Genetic Resources at its fourth session in December 2006. The report was finalized based on the comments and proposals put forward by member countries of the Commission on Genetic Resources for Food and Agriculture. The regional and subregional assignment of countries for the purposes of the report is shown in Figure 1.

[1] http://www.fao.org/dad-is

[2] http://www.fao.org/faostat

**FIGURE 1**

Assignment of countries to regions and subregions



# The state of agricultural biodiversity in the livestock sector

- Today's livestock biodiversity is the result of thousands of years of human intervention.
- The countries and regions of the world are interdependent in their use of animal genetic resources.
- A global total of 7 616 breeds has been reported.
- Twenty percent of breeds are classified as at risk.
- Almost one breed per month was lost during the last six years.
- Population data is unavailable for 36 percent of breeds.
- The world's livestock production is increasingly based on a limited number of breeds.
- Genetic diversity within these breeds is also in decline.
- The roles of multipurpose breeds are often undervalued.
- Genetic resistance is increasingly important for the control of animal diseases.
- Important threats to animal genetic resources include:

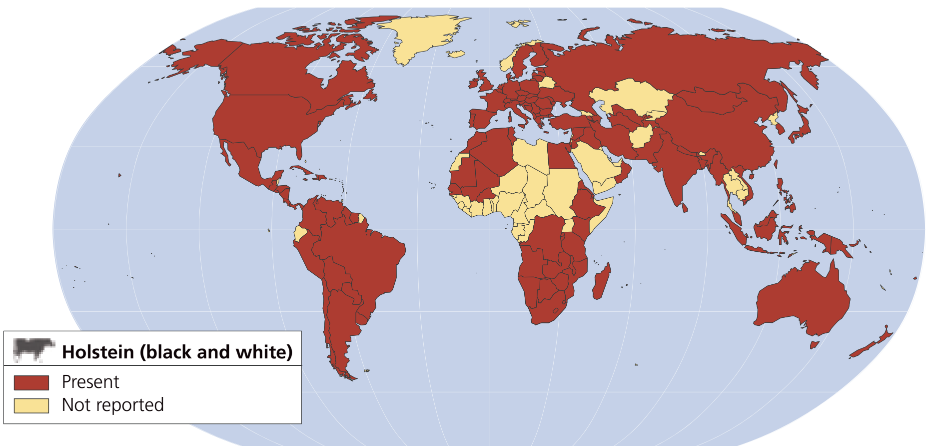
  - the rapid spread of homogenous large-scale intensive production;
  - inappropriate development policies and management strategies;
  - disease outbreaks and control programmes; and
  - various types of disasters and emergencies.
- Improved knowledge of breeds and production systems, forward planning, and greater awareness at the policy level are essential if genetic erosion is to be minimized.

## Origins and distribution of animal genetic resources

The livestock species contributing to today's agriculture and food production are shaped by a long history of domestication and development. At least 12 major centres of domestication have been identified, based on archaeological and molecular genetic research. Goats, for example, are thought to have been first domesticated 10 000 years ago in the Zagros mountains of the Fertile Crescent. Thousands of years of human migration, trade, military conquest and colonization spread livestock from their original homelands, exposing them to new agro-ecological zones, new cultures and new technologies. Natural selection, human-controlled breeding and cross-breeding with populations from other centres of domestication gave rise to great genetic diversity.

A new phase in the international movement of animal genetic resources began in the early nineteenth century, when the transfer of breeding animals around the world was boosted by the emergence (at first in Europe) of organized breeding, and by the invention of the steamship. Much of this movement was within Europe or between the colonial powers and their overseas possessions. European breeds became established in the temperate zones of the Southern Hemisphere and in parts of the dry tropics, but did not thrive in the humid tropics (except in some highland areas) because of their poor adaptation to the heat, the low-quality forage, and the local diseases and parasites. Genetic resources were also transferred between different tropical regions. An important example is the introduction of South Asian Zebu cattle into Latin America during the early twentieth century. Pure tropical breeds have been little used in temperate countries, but composite breeds based on genetic material from South Asian cattle are widely used in the southern parts of the United States of America and in Australia. A number of other composite breeds that have

**FIGURE 2**
Distribution of Holstein-Friesian cattle



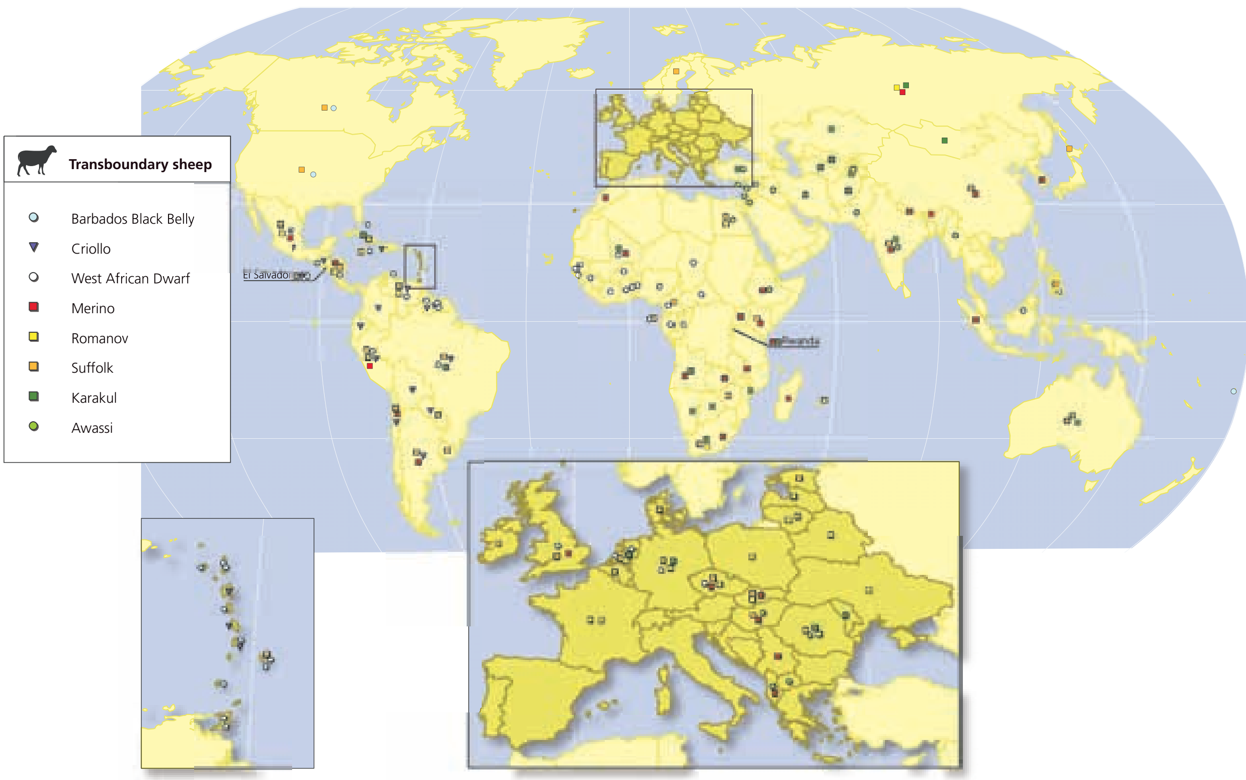
made important contributions to animal production in Africa and elsewhere (e.g. Dorper sheep, Boer goats and Bonsmara cattle) were also developed as a result of these processes of gene flow. Some pure African breeds such as Tuli and Africander cattle have spread to Australia and to the Americas. Another interesting example is the Awassi sheep from the Near and Middle East, which has spread to several countries in southern Europe, to some tropical countries and to Australia.

Developments in the late twentieth century – increased commercialization of the breeding industry, rising demand for animal products in the developing world, production differentials between developed and developing countries, new reproductive biotechnologies that facilitate the movement of genetic material, and the feasibility to control production environments independently of the geographical location – have led to a new phase in the history of international gene flows. International transfer of genetic material now occurs on a very large scale, both within the developed world and from developed to developing countries. These gene flows are focused on a limited number of breeds. There is also some movement of genetic resources from developing to developed regions for research and to be kept by hobbyists or niche market suppliers (e.g. alpacas).

Today, the world's most widespread cattle breed, the Holstein-Friesian, is found in at least 128 countries (see Figure 2). Among other livestock species, Large White pigs are reported in 117 countries, Saanen goats in 81 countries, and Suffolk sheep in 40 countries (Figure 3).

Several important conclusions can be drawn from this brief overview of historical developments. First, the countries and regions of the world have long been interdependent in their utilization of genetic resources. Second, the scale of transfers and the rate at which the genetic composition of livestock populations is transformed have increased dramatically in recent decades. Third, these transfers have the potential to narrow the genetic resource base of the world's animal production. At both national and international levels, there is a need to assess the significance of these developments so that actions can be taken to promote sustainable utilization, and, where necessary, target threatened resources for conservation.

**FIGURE 3**
Distribution of transboundary sheep breeds



## The current status of animal genetic resource diversity

The following analysis is based on FAO's Global Databank for Animal Genetic Resources for Food and Agriculture (the backbone of the DAD-IS[3] system), which is the most comprehensive global information source for livestock genetic diversity.

Assessing the status of animal genetic resources on a global scale presents some methodological difficulties. In the past, analysis of the Global Databank to identify breeds that are globally at risk was hampered by the structure of the system, which is based on breed populations at the national level. To address this problem, and to enable *The State of the World's Animal Genetic Resources for Food and Agriculture* to offer a more useful assessment, a new breed classification system was developed. Breeds are now classified as either local or transboundary, and further as regional or international transboundary (see Box 2).

A total 7 616 breeds are recorded in the Global Databank; 6 536 are local breeds and 1 080 are transboundary breeds. Among the transboundary breeds, 523 are regional transboundary breeds, and 557 are international transboundary breeds (Figure 4).

There are some regional differences in terms of the relative importance of the different breed categories (Figure 5). In most regions – Africa, Asia, Europe and the Caucasus, Latin America and the Caribbean, and the Near and Middle East – local breeds make up more than two-thirds of all breeds. Conversely, international transboundary avian and mammalian breeds dominate in the Southwest Pacific and North America. Regional transboundary mammalian breeds are relatively numerous in Europe and the Caucasus, Africa, and to lesser extent Asia, while it is only in Europe and the Caucasus that there are many regional transboundary avian breeds.

[3] http://www.fao.org/dad-is

### Box 2
### A new classification system for breed populations

Under the new system of breed classification developed for *The State of the World's Animal Genetic Resources for Food and Agriculture*, the primary distinction is between breeds that occur in only one country, which are referred to as "local" breeds, and those that occur in more than one country, which are referred to as "transboundary" breeds. Within the transboundary breed category, a further distinction is drawn between "regional" transboundary breeds – those that occur in more than one country within a single region, and "international" transboundary breeds – those that occur in more than one region. The decision as to which national-level breed populations should be considered as belonging to a transboundary breed was taken on the basis of expert judgment and reviewed by National Coordinators for the Management of Animal Genetic Resources from the relevant countries. Although some refinements are still required, the new classification has proved to be very useful as a framework for assessing breed diversity at global and regional levels.

**FIGURE 4**
Share of local and transboundary breeds in the world total

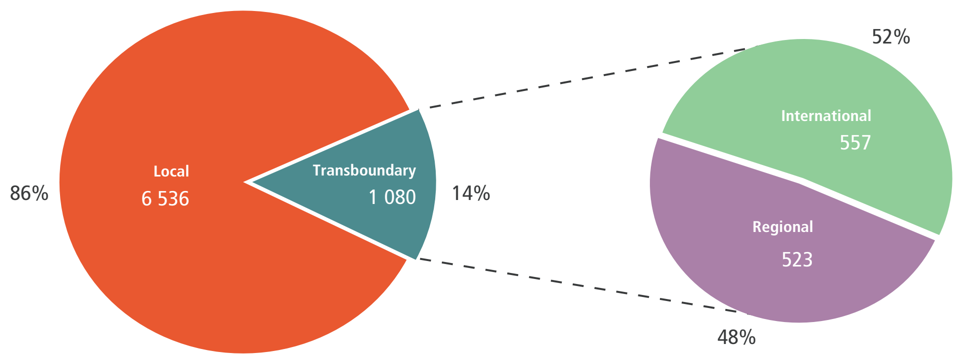
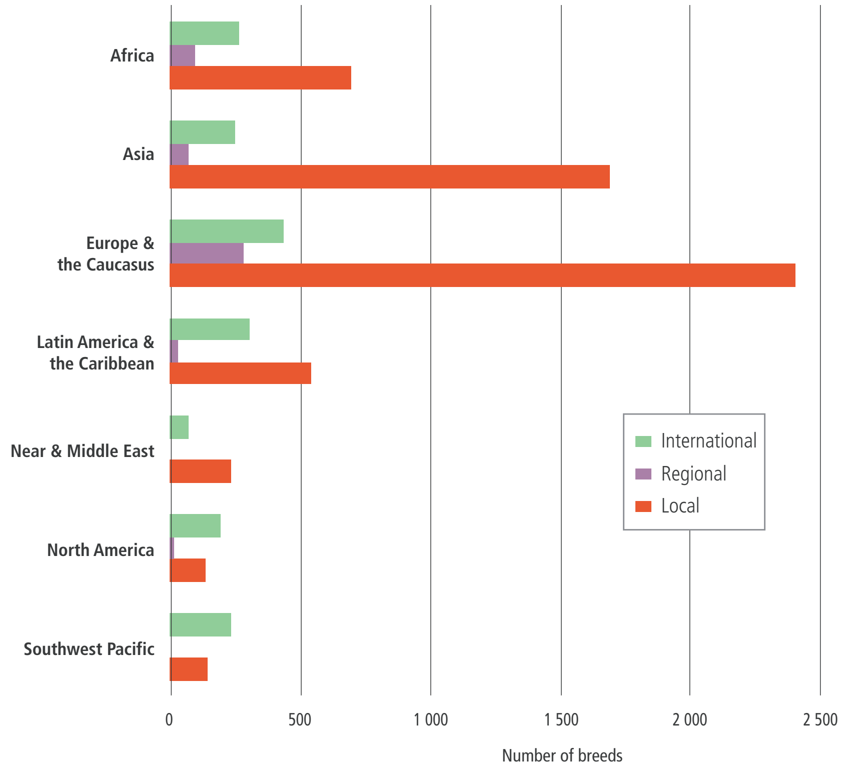


**FIGURE 5**
Regional distribution of international and regional transboundary and local breeds




Note that extinct breeds are excluded from these figures.

For most species, the Europe and the Caucasus region has a far higher share of the world's total number of breeds than it has of the world's total animal population. This is partly because in this region many breeds are recognized as separate entities even when they are closely related genetically. It also reflects the advanced state of breed inventory and characterization in this region. In many regions, work in these fields is restricted by a lack of technical resources and trained personnel.

**FIGURE 6**
Proportion of the world's breeds by risk status category

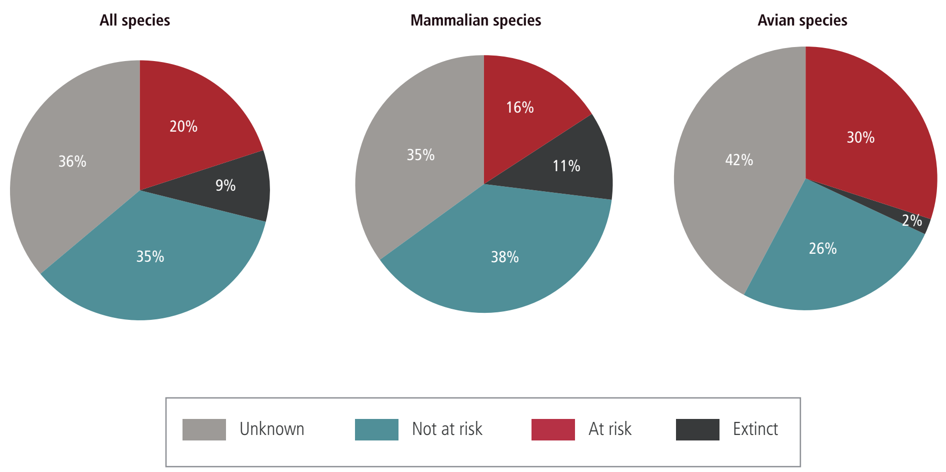
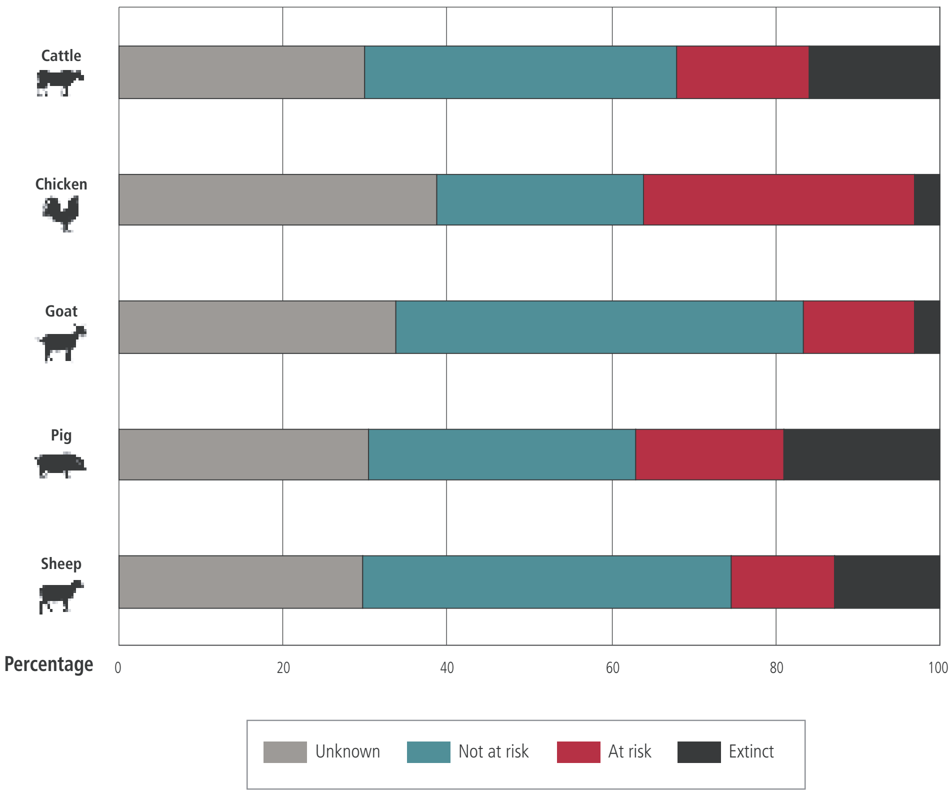


**FIGURE 7**
Breed risk status in the major livestock species




## Breed risk status

A total of 1 491 breeds (20 percent) are classified as being "at risk"[4]. The true figure will be even higher, as population data are unavailable for 36 percent of breeds. Figure 6 summarizes the proportion of breeds falling into each risk status category.

The regions with the highest proportion of their breeds classified as at risk are Europe and the Caucasus (28 percent of mammalian breeds and 49 percent of avian breeds) and North America (20 percent of mammalian breeds and 79 percent of avian breeds). These two regions have highly specialized livestock industries, in which production is dominated by a small number of breeds. In absolute terms, Europe and the Caucasus has by far the highest number of at-risk breeds. Despite the apparent dominance of these two regions, problems elsewhere may be obscured by the large number of breeds with unknown risk status. In Latin America and the Caribbean, for example, 68 percent and 81 percent of mammalian and avian breeds, respectively, are classified as being of unknown risk status. The figures for Africa are 59 percent for mammals and 60 percent for birds. This lack of data is a serious constraint to effective prioritization and planning of breed conservation measures. The problem is particularly significant in some species – 72 percent of rabbit breeds, 66 percent of deer breeds, 59 percent of ass breeds and 58 percent of dromedary breeds lack population data. There is an urgent need for improved surveying and subsequently reporting of breed population size and structure, and of other breed-related information.

A comparison at species level reveals that horses (23 percent), followed by rabbits (20 percent), pigs (18 percent) and cattle (16 percent), are the mammalian species that have the highest proportions of at-risk breeds. Among widely kept avian species, 34 percent of turkey breeds, 33 percent of chicken breeds, 31 percent of goose breeds and 24 percent of duck breeds are classified as at risk. Figure 7 summarizes breed risk status for the five most internationally important livestock species.

Cattle are the species with the highest number of breeds reported as extinct (209). Large numbers of extinct pig, sheep and horse breeds are also reported. This is probably not a complete picture of breed extinctions, as it is likely that numerous breeds have been lost without being documented.

[4] A breed is categorized as at risk if the total number of breeding females is less than or equal to 1 000 or the total number of breeding males is less than or equal to 20, or if the overall population size is greater than 1 000 and less than or equal to 1 200 and decreasing and the percentage of females being bred to males of the same breed is below 80 percent.

### Trends in genetic erosion

Trends in genetic erosion can be identified by comparing the current risk status of a set of breeds with their status in the past. The most straightforward assessment can be achieved by comparing the figures for local breeds. An analysis of trends in the risk status of these breeds over the period between 1999 and 2006 presents a mixed picture. Some breeds became more secure – 60 breeds that were classified as at risk in 1999 were classified as not at risk in 2006. However, almost as many (a total of 59) moved into the at-risk category over the same period. Even more worryingly, despite increasing awareness and action, breeds continue to be lost. Sixty-two extinctions were recorded between December 1999 and January 2006 – amounting to the loss of almost one breed per month.

Risk status figures based on population data may not reveal the full extent of genetic erosion. Within-breed diversity is also important. A weakness of the current monitoring of breed status, and one that is difficult to overcome, is that it gives little indication of the extent of genetic dilution caused by indiscriminate cross-breeding[5] – a problem that is considered by many experts to be a major threat to genetic diversity. Risk status figures also fail to show the inbreeding that may occur, even within breeds that have large total populations, as a result of the use of a limited number of breeding animals. Neither do the figures allow an assessment of the extent to which subpopulations within breeds are genetically isolated from each other – an important consideration for management decisions.

## Uses and values of animal genetic resources

In many countries, the livestock sector makes a significant contribution to national economic output. On average, this contribution is highest (between 4 and 5 percent of regional gross domestic product) in the Near and Middle East, Asia and Africa. Although the overall figures are relatively modest, it is important to note that livestock production contributes 30 percent of agricultural gross domestic production in developing countries, with a projected increase to 39 percent by 2030. Moreover, in some of the world's poorest countries, the contribution is far above the regional averages. Another significant development in recent years has been the emergence of new net exporters of milk, meat and eggs among developing countries. Production and trade figures at the national or international levels do not, however, reveal the full socio-economic significance of the livestock sector. The fact that livestock contribute to the livelihoods of very large numbers of people – many of them among the world's poor – has to be taken into consideration. From another perspective, the vast areas of land used for livestock production indicate the potential environmental and social impacts of developments in the sector. Livestock keeping is an integral element of ecosystems and productive landscapes throughout the world.

Another important consideration is that while the value of marketed food, fibre, hide and skin products is relatively well recorded, there is a danger that the many non-marketed outputs and less easily quantified benefits provided by livestock are undervalued. This is particularly the case for the smallholder production systems of the developing world. Many farmers rely on animals to provide inputs to crop production (draught power and manure). Where modern financial institutions are inaccessible, keeping animals that can be sold in times of need provides many households with the equivalent of savings and insurance services. Livestock and their products also fulfil a wide variety of social and cultural functions – they are important elements of many religious festivals, weddings, funerals and other social gatherings, and contribute to sporting and leisure activities. In many livestock-keeping societies, exchange of animals also helps to reinforce social relationships and networks that can be drawn upon in times of need. Livestock also provides key agro-ecosystem functions, such as nutrient cycling, seed dispersal and habitat maintenance.

In more affluent societies, livestock functions tend to be less varied. Nevertheless, some cultural functions remain important – including in sports and leisure (mainly horses) and in the supply of culturally significant food products. New roles are also emerging (often for traditional breeds) in tourism and in landscape management.

Although these many functions can be outlined in broad terms, there is a large knowledge gap with regard to the current roles of specific breeds, and whether they have characteristics that make them especially suited to particular purposes or production conditions. There is a need for more complete data to be collected and made available.

Multiple roles and multiple combinations of roles require diversity within the livestock population – including both specialized and multipurpose breeds. However, decision-making in the field of animal genetic resources management is often characterized by a lack of attention to multiple functions. In these circumstances, it is likely that the value of local multipurpose breeds is underestimated, and that only some elements of livestock's overall contribution to human well-being are taken into consideration.

## Animal genetic resources and resistance to disease

Among the most potentially valuable characteristics of specific livestock breeds is resistance or tolerance to disease. The sustainability of key disease control strategies, including the use of drugs and the control of disease vectors such as ticks and tsetse flies, is uncertain. Problems include the environmental and food safety impacts of chemical treatments, affordability and accessibility to poorer livestock keepers, and the evolution of drug resistance. Managing genetic diversity to enhance the resistance or tolerance found in livestock populations offers an

[5] Indiscriminate cross-breeding refers to a spectrum of actions ranging from upgrading or cross-breeding to complete replacement of a local breed with imported animal genetic resources in an unplanned manner and without adequate assessment of the performance of the respective breeds under relevant production conditions.

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.

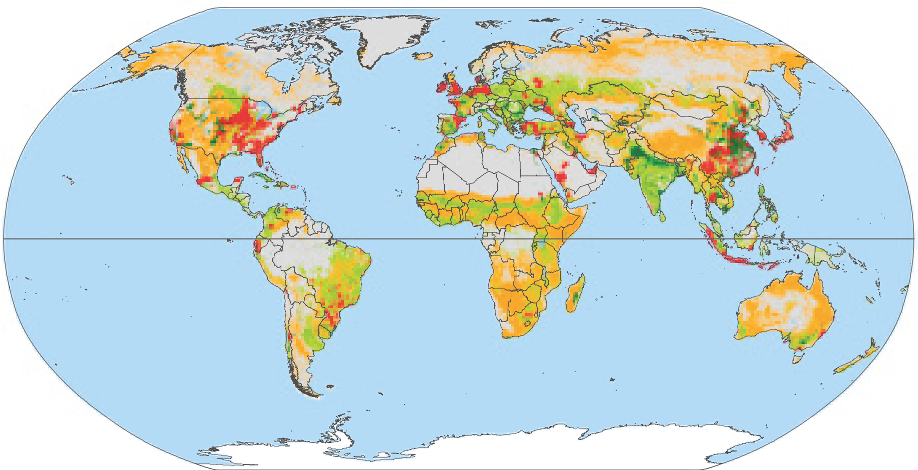
## Drivers of change in livestock production systems

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



| | | |
|---|---|---|
| Mixed, irrigated | Grazing | Area dominated by landless production |
| Mixed, rainfed | Other type | Boreal and arctic climates |

National boundaries

*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.

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.

# The state of capacities in animal genetic resources management

- Institutional and technical capacity needs to be reinforced in developing countries.
- Better education in the field of animal genetic resources management is required.
- Greater international cooperation would improve the management of shared genetic resources.
- Many countries face difficulties in establishing structured breeding programmes, and many opt for importing exotic genetic resources.
- *In vivo* and *in vitro* conservation programmes are lacking in many countries where there are significant threats to valuable resources.
- Access to reproductive biotechnologies is limited in many developing countries.
- But the use of these technologies should be carefully assessed in terms of effects on genetic diversity, and socio-economic outcomes.
- Legal and policy frameworks for the management of animal genetic resources need to be adapted and strengthened.

Effective management of animal genetic resources requires strong institutions, adequate technical facilities and well-trained personnel. The 148 Country Reports used in the preparation of this part of *The State of the World's Animal Genetic Resources for Food and Agriculture* provide details of the state of capacity at the national level, and the roles of networks and institutions at regional and global levels. They also provide many examples of initiatives taken in the field of animal genetic resources management, problems encountered and recommendations for the future. The following synthesis of information from the Country Reports provides an overview of the state of capacity, highlighting significant regional differences, specific weaknesses and lessons learned.

## Institutions and stakeholders

This section assesses the state of stakeholder involvement and institutional capacity (infrastructure, research and knowledge, and policy development and implementation) in the management of animal genetic resources at national and regional levels. Organizations and networks with a potential role in regional and international cooperation are also identified. Figure 9 provides an overview of the state of institutional capacity in the various regions of the world.

Coordination among stakeholders at national level is essential for effective management of a country's animal genetic resources. National Coordinating Committees – officially appointed bodies established as part of *The State of the World's Animal Genetic Resources for Food and Agriculture* reporting process – are key structures in this respect, but there are, sometimes, problems with their sustainability. These problems frequently stem from a lack of resources, which, in turn, often results from a lack of awareness among policy-makers of the significance of animal genetic resources. Links between officially appointed country-level institutions and the various stakeholders active in managing animal genetic resources are often limited. For example, the process of preparing the Country Reports on the state of animal genetic resources was largely accomplished by individuals from governmental or scientific backgrounds. Participation by non-governmental organizations (NGOs) and commercial operators proved more difficult to achieve. Private companies are highly active in the use of animal genetic resources and are often well organized at national and international levels. However, their involvement in national programmes tends to be limited, as their interest is focused on a narrow range of breeds. Local capacity (e.g. clearly defined and well-monitored responsibilities for local stakeholders, and the integration of local organizations in the national policy arena) is also weak in many countries (stronger involvement of NGOs and local stakeholders is found in northern and western Europe, and to some extent in the South and Central America subregions).

Institutions of the national agricultural research systems played a leading role in the Country Report preparation process. However, many Country Reports note with regret that these institutes are rarely involved in research related to animal genetic resources, and interest in the topic is often limited to isolated departments that lack adequate financial resources. There is little specialization in the field of use and conservation of animal genetic resources. Research often remains remote from local needs and indigenous knowledge, and is not well linked to the policy level.

Awareness of the value of animal genetic diversity is essential to raising the political profile of the topic and bringing about appropriate institutional change. In most countries, much remains to be done if these goals are to be achieved. Although awareness is growing among some stakeholders, it has rarely filtered through to the policy level, as can be seen from the limited numbers of policies and legal frameworks that have been developed and implemented to date.

Cooperation should be a logical consequence of shared resources. The Country Reports often mention regional cooperation as a necessity, and express a willingness to participate in such arrangements. Strong regional and subregional networks are important to ensure ongoing improvements in the management of animal genetic resources. However, there are few examples of concrete activities. In Europe and the Caucasus, networks at the governmental and non-governmental levels exist, and there is an established regional focal point for animal genetic resources. However, in other regions the situation is less favourable. The possibility of countries with stronger capacity playing an initiating or supporting role within a subregion or region needs to be further explored.

## Structured breeding programmes

Structured breeding programmes provide a key means to increase production levels and product quality, increase productivity and cost efficiency, maintain genetic diversity and support the conservation and sustainable utilization of specific breeds. However, throughout much of the developing world the impact of such programmes is very limited. Most Country Reports from Africa and Asia, for example, indicate that, where programmes exist, only a small proportion of breeds are included and that the active breeding population is small. Figure 10 shows the regional distribution of breeding programmes for important international livestock species.

In some parts of the world such as western Europe and the Americas, successful breeding programmes based on the involvement of individual breeders have been established. These programmes were established on the basis of sound organizational structures and government-backed support services. It is unlikely that such a pattern of organization will easily emerge elsewhere in the absence of public-sector support, particularly for livestock populations kept under low external input conditions.

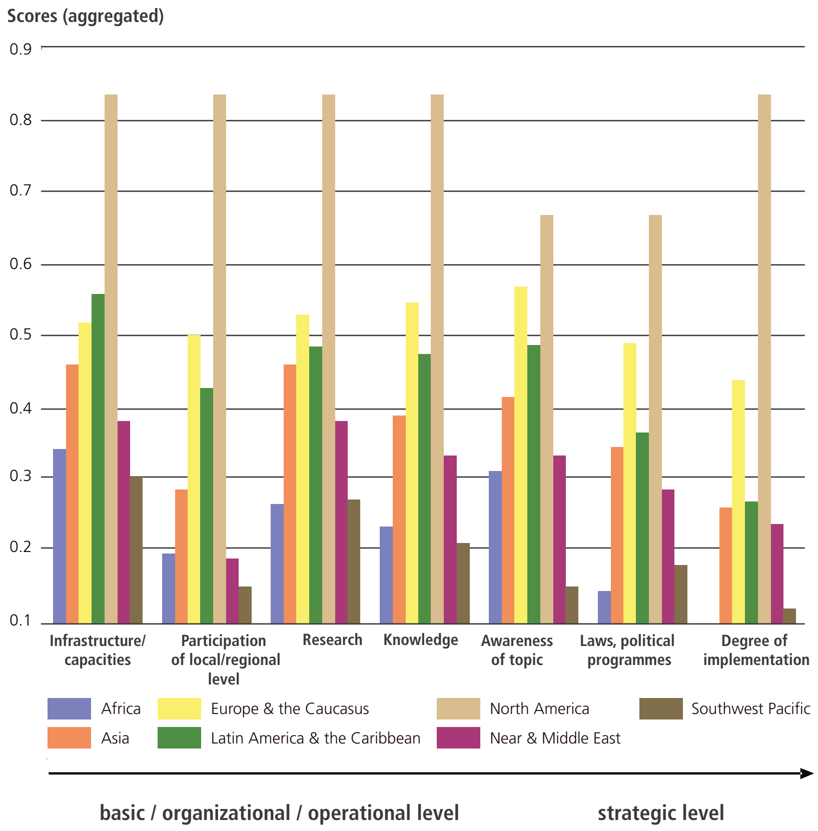
Many countries have implemented programmes based on government-owned nucleus farms (particularly in the case of ruminants). However, the effectiveness of these programmes has been limited by a lack of interaction with livestock owners, and by the priority given to research rather than development objectives.

Policy decisions in this field are not straightforward. The cost of breeding activities, the level and nature of competition, and the international availability of suitable breeding material need to be considered. Many governments have decided to rely on imported genetic material for breed development, especially in the poultry and pig sectors. Cooperation in breeding activities between countries with similar production conditions, as occurs in Europe, is an opportunity to share costs and make programmes more sustainable.

## Conservation programmes

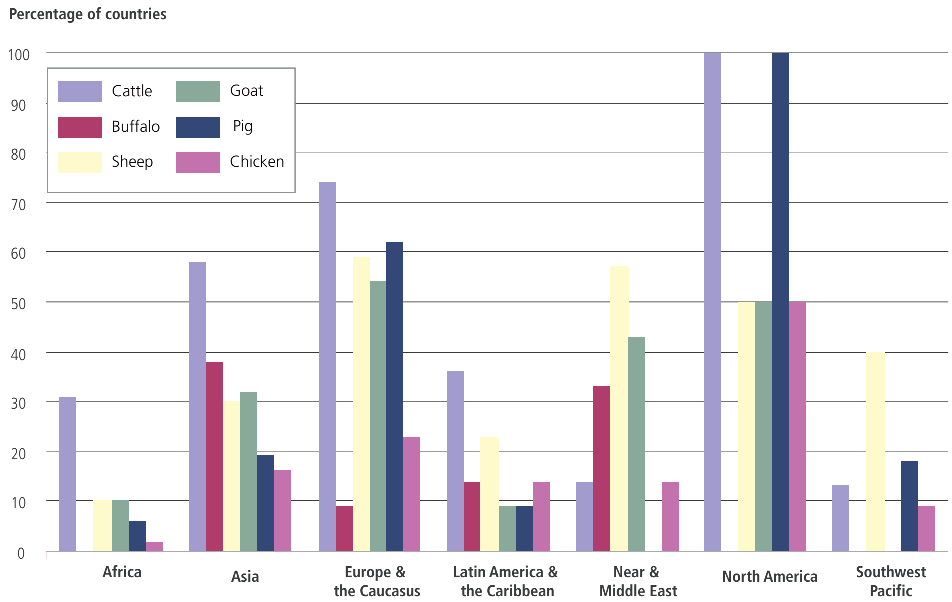
Threats to the continued existence of animal genetic resources justify conservation measures. Conservation programmes are most urgently required where valuable genetic resources are in

**FIGURE 9**
State of institutions – regional comparison




For each thematic area countries were scored 0 (none), + (little), ++ (medium) or +++ (high), based on the information provided in the Country Reports. Scores were then aggregated at regional level. The maximum score (achieved if all the countries in region scored "+++" is equal to 1, and the minimum score (if all the countries in a region scored "0") is equal to 0.

**FIGURE 10**
Regional distribution of structured breeding activities for the main livestock species

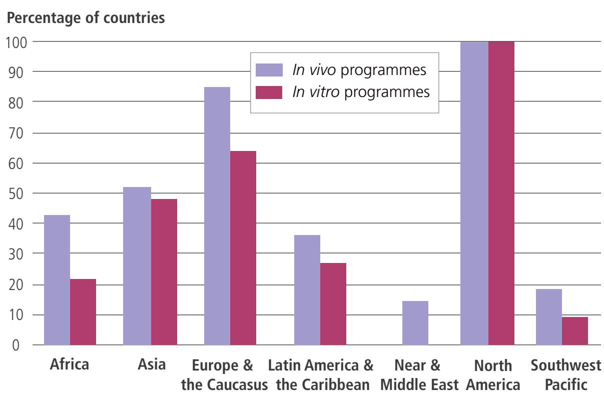



Figures refer to programmes mentioned in the Country Reports and only to countries that report the presence of the respective species.

danger of being lost. A number of approaches to conservation are available, including a range of *in vivo* methods (zoos, farm parks, protected areas, and payments or other support measures for livestock keepers who maintain animals in their normal production environments), as well as *in vitro* conservation of genetic material in liquid nitrogen.

Assessing the effectiveness of such measures requires detailed information on the breeds included in the programmes, the size and structure of the populations involved, the mating schemes practised and, in the case of *in vitro* programmes, the quantity and type of genetic material stored (semen, embryos, oocytes or tissue DNA). Information provided in the Country Reports provides a broad overview of the global distribution of conservation programmes. However, the data required for a thorough assessment of conservation needs and priority actions remain largely unavailable.

**FIGURE 11**
Regional distribution of conservation programmes




Many countries (48 percent) report no *in vivo* conservation programmes. An even greater proportion (63 percent) report that they have no *in vitro* programmes. The situation is variable from region to region. Conservation measures are much more widespread in Europe and the Caucasus and in North America than in other regions (Figure 11).

The Country Reports clearly indicate that many groups of stakeholders are involved or potentially involved in breed conservation: national governments, universities and research institutes, breeders' associations, NGOs, breeding companies, farmers (including hobby farmers) and herders. Cooperation should be encouraged and complementarities exploited. Specific support should be provided where needed. For example, hobby breeders and NGOs are often enthusiastic supporters of rare breeds, but may require education in the genetic management of small populations.

Overall, the Country Report analysis suggests that a substantial enhancement of global capacity for conservation, with new institutional models and collaboration among public institutions and between public institutions and private farmers, is required if current threats to animal genetic resources are to be adequately addressed. International and regional collaboration has a key role to play in the implementation of gene banking and other conservation measures for transboundary breeds. Cooperation would be facilitated if agreed protocols (e.g. for zoosanitary requirements) could be established for *in vitro* conservation programmes that operate on an international scale.

## Use of reproductive biotechnologies

Artificial insemination and embryo transfer have had a major impact on livestock breeding in developed countries. These technologies speed up genetic progress, reduce the risk of disease transmission and expand the number of animals that can be bred from a superior parent. The availability of these technologies varies greatly from country to country and between regions. Capacity is generally much weaker in developing countries than in regions such as Europe and the Caucasus and North America. Where reproductive technologies are used in developing countries, it is often as a means of disseminating exotic genetic material.

Many Country Reports from the developing world express a desire to expand the use of these technologies because of their potential contribution to meeting demands for increased output of animal products. However, there is also a growing recognition that their indiscriminate use, in particular of artificial insemination, can pose a threat to indigenous genetic resources. Socio-economic impacts also need to be considered. On the one hand, affordability and access have to be addressed so that poorer livestock keepers are not excluded from options that might enable them to increase the productivity of their animals. On the other, there is a need to ensure that biotechnology use does not promote the indiscriminate dissemination of genetic material that is poorly adapted to smallholder systems.

## Legal frameworks

Animal genetic resources management is influenced by legal frameworks at both national and international levels. In some cases, bilateral agreements or regional frameworks are important. The European Union, in particular, has a large body of relevant legislation.

The main international framework for biodiversity is the Convention on Biological Diversity (CBD). The CBD recognizes the specific nature of agricultural biodiversity, and that it has specific problems that call for specific solutions. In this context, it should be noted that wild genetic resources and agricultural genetic resources require different and sometimes conflicting strategies. In order to secure appropriate prioritization for animal genetic resources, international agreements and policies specifically designed to harmonize strategies for the sustainable use and conservation of these resources may be required.

Several other international legal frameworks affect the management of animal genetic resources. The field of animal health is generally the most highly regulated aspect of livestock production. At the international level, the World Trade Organization (WTO) Agreement on Sanitary and Phytosanitary Measures recognizes the World Organisation for Animal Health as the standard-setting authority for animal health matters in the context of international trade. The importance of access to international markets often motivates rigorous disease control regulations at national (or regional) level. Compulsory culling measures imposed in the event of epidemics can pose a threat to rare breed populations. Regulations in the European Union have, in recent years, begun to take account of this threat, but it is a matter of concern that throughout much of the world little attention is paid to animal genetic resources in policies and legal frameworks for disease control.

The prospect of greater exertion of intellectual property rights in the field of animal breeding and genetics is attracting considerable interest and controversy. Patents covering genes and markers associated with a range of economically important traits have been granted in several livestock species. Many ethical and legal questions remain to be resolved, and the extent of the impacts that intellectual property rights are likely to have on the management of animal genetic resources is not yet clear. However, the potential implications both for genetic resource diversity and for equity require that careful attention be paid to the issue. It should, however, be noted that under Article 27.3(b) of the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), countries are not obliged to grant patents on animals.

The Country Reports indicate great diversity in terms of the extent and nature of national legislation and policies for the management of animal genetic resources. Universal recommendations are not appropriate; provisions need to be adapted to the specific requirements and capacities of the country in question. However, it is clear that, in many countries, inadequate regulatory frameworks hamper the effective management of animal genetic resources. Legislation specifically aimed at promoting and regulating breed conservation is rare outside developed regions. Nonetheless, there are some examples of developing countries that have, in recent years, taken steps to introduce such measures. The availability of resources to implement the programmes envisaged, however, sometimes remains an obstacle.

Structured genetic improvement programmes require systems for animal identification, registration and performance recording. Identification and registration are also important for many other reasons (e.g. disease control, traceability, and administration of conservation programmes). Legal regulation can help to strengthen compliance with these requirements and ensure the availability of consistent and dependable information on which to base decisions. Many developing countries report the need for improved regulation in this field.

Many other aspects of legislation and policy affect the development of livestock production systems and the management of animal genetic resources. Small-scale farmers and pastoralists are the custodians of much of the world's animal genetic diversity. Ensuring that they are not denied the opportunity to continue performing this role will often require giving attention to policies and legal frameworks, such as those that affect access to land and water resources.

# The state of the art in the management of animal genetic resources

- Characterization of breeds and production environments needs to be improved to enhance policy decisions in animal genetic resources management.
- Decision support tools for situations where information is deficient need to be developed.
- Changing market demands and the need to maintain within-breed diversity give rise to new breeding goals and require new approaches in breeding programmes.
- Stakeholder involvement and recording systems are key elements of successful genetic improvement programmes.
- Breeding programmes adapted to low external input systems need to be further developed.
- The use of locally adapted breeds to provide environmental services, support for niche market production and subsidies for keeping threatened breeds are potential elements of *in vivo* breed conservation programmes.
- Conservation measures in low external input systems need to take account of the livelihood-support functions of livestock.
- Community-based approaches to conservation and breeding need to be further developed.
- *In vitro* conservation has the potential to be an important complement to *in vivo* methods, and reliable techniques for all livestock species need to be developed.

The management of animal genetic resources is not a clearly defined scientific discipline. It comprises the full range of actions undertaken to understand, use, develop and maintain these resources. It involves assessing the characteristics of the available animal genetic resources in the context of prevailing production conditions and societal demands. Spatial and temporal diversity and projected future trends also have to be taken into account. Decisions then have to be taken as to which of the available approaches and methods for use, development and conservation should be applied to which populations. The following sections outline the state of the art in methods for characterization, genetic improvement, economic analysis and conservation.

## Methods for characterization of animal genetic resources

Characterization involves the identification, description and documentation of breed populations and the habitats and production systems in which they were developed and to which they are adapted. One aim is to provide an assessment of how well particular breeds will perform within the various production systems found in a country or region, and thus to guide farmers and development practitioners in their decision-making. Another objective is to provide the information that is needed for planning conservation programmes. The latter requires information on the risk status of the breeds under consideration. Risk status is established primarily on the basis of population size and structure. Data on the extent of cross-breeding may also be important to assess the threat of genetic dilution, as may information on the breeds' geographical distribution, and the extent of inbreeding within the population.

Breeds that are identified as being at risk are candidates for inclusion in conservation programmes. However, funds are normally restricted and priority setting is needed. Decisions may be based on the genetic distinctiveness, adaptive traits, relative value for food and agriculture, or historical and cultural values of the breeds in question. Figure 12 shows the key information requirements at various stages of planning a national animal genetic resources management programme.

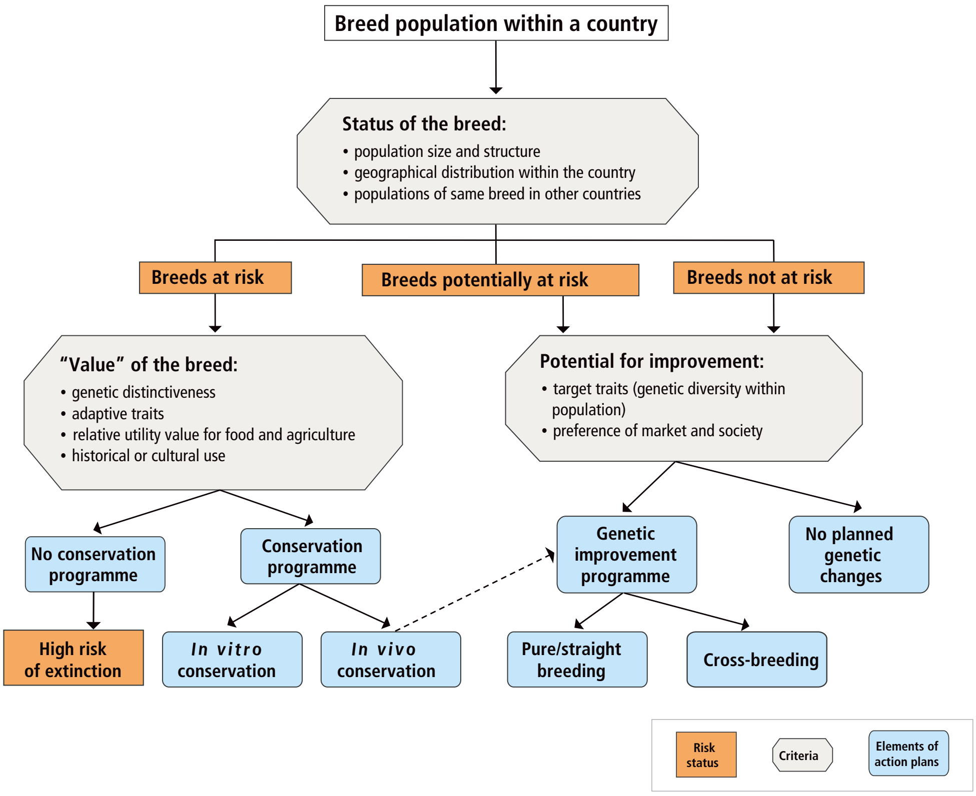
Information on the breed's specific attributes and adaptations, its genetic relationship to other breeds, its normal production environment and management practices, and any associated indigenous knowledge are all of great help in the design and implementation of conservation or breed development programmes. Characterization at the molecular genetic level offers the opportunity to explore genetic diversity within and between livestock populations, and to determine genetic relationships among populations.

Periodic monitoring of population size and structure is important, so that management strategies can be adapted if necessary. There may be opportunities to increase the cost-effectiveness of monitoring by taking advantage of existing related activities. National livestock census processes offer good opportunities for this. The next World Programme for the Census of Agriculture, which is produced by FAO every ten years to guide countries in the conduct of their agricultural census, encourages the collection of livestock data at breed level.

Another important aspect of the characterization process is to make relevant data available to a wide range of stakeholders, including policy-makers, development practitioners, livestock keepers and researchers. Existing public domain information systems need to be further developed to expand their content and allow users easier access to the data they require. Linking breed data to environment and production system maps would be an important aid to decision-making.

Ideally, tools and methods for decision-making, as well as early warning mechanisms to identify at-risk breeds, would be based on comprehensive information of the kind described above. However, given that immediate action is required to conserve and improve the management of animal genetic resources, there is a need for tools and methods that make effective use of incomplete information.

**FIGURE 12**
Information required to design strategies for managing animal genetic resources




## Methods for genetic improvement

Genetic improvement is a vital element of efforts to meet the increasing demand for livestock products. Great progress has been made in genetics and reproductive biotechnology, which has enabled rapid advances in highly controlled production systems. However, recent years have seen a growing realization that selecting solely for product output per animal leads to a deterioration of animal health, increased metabolic stress and reduced longevity. Functional traits, such as disease resistance, fertility, calving ease, longevity and behavioural characteristics, are receiving more attention. Breeding goals also need to adapt to new demands on the part of consumers, who may be concerned about animal welfare or environmental impacts, or acquire tastes for speciality food products. Ensuring that within-breed genetic diversity is not compromised is another increasingly important consideration. Genetic improvement in small populations included in conservation programmes is a field requiring specific management strategies.

New techniques are needed to ensure that breeders are able to meet these emerging challenges. Priority areas for research include breeding for disease resistance (including the practical application of selection based on molecular markers associated with resistance); selection for welfare traits (e.g. reduction of foot and leg problems in dairy cattle); and selection for increased efficiency of feed utilization.

There is urgent need to design and implement programmes that are appropriate for low external input production conditions. For many local breeds, genetic improvement is likely to be essential if their utilization is to remain economically viable. Methods for the establishment of stable cross-breeding programmes that involve the maintenance of pure-bred herds or flocks of local breeds need to be investigated.

Successful genetic improvement programmes require the involvement of all stakeholders, particularly of livestock keepers and their organizations. The establishment of breeders' associations should be encouraged. Wide consultation is essential, but within a breeding programme there should be clear definition of roles. Recording systems are vital to genetic improvement programmes, and efforts should be made to establish such systems. In the context of smallholder production systems, it is vital that sufficient consideration be given to the objectives of the livestock keepers, impacts on the environment and the wider community, the adaptation of all the animals involved to local production conditions, and the availability of infrastructure, technical resources and trained personnel.

## Methods for economic valuation of animal genetic resources

The large number of breeds that are at risk and the limited financial resources available for conservation and breed development imply that economic analysis of the value of the genetic resources at stake and of potential management interventions is necessary to guide decision-making. Important tasks include:

- determining the economic contribution that particular animal genetic resources make to various sectors of society;
- the identification of cost-effective conservation measures; and
- designing economic incentives and policy/institutional arrangements for the promotion of conservation by individual farmers or communities.

Methods to address these issues have been slow to emerge. Reasons include the limited availability of the data required. Effective economic analysis in the field of animal genetic resources requires paying attention to the non-market values of livestock. Obtaining these data frequently requires the modification of economic techniques for use in conjunction with participatory and rapid rural appraisal methods. Despite the problems, a growing number of economic studies in this field are being undertaken based on the use of techniques adapted from other areas of economics. Important points emerging from such studies include:

- Adaptive traits and non-income functions are important components of the total value of indigenous breed animals.
- Conventional criteria used to evaluate livestock productivity are inadequate to evaluate subsistence production systems, and have tended to overestimate the benefits of replacing local breeds with exotic ones.
- The costs of implementing an *in situ* breed conservation programme may be relatively small, both when compared to the size of subsidies currently being provided to the commercial livestock sector and when compared to the benefits of conservation.
- Household characteristics play an important role in determining differences in farmers' breed preferences. This information can be of use in designing cost-effective conservation programmes.
- Conservation policy needs to promote cost-efficient strategies. Decision-support tools to support this objective have been developed, but require further refinement and evaluation.

## Methods for conservation

Conservation strategies involve the identification and prioritization of targets for conservation. A critical first step is to identify the most appropriate "unit" of conservation. In the case of agricultural biodiversity, a primary objective has to be the maintenance of diversity for potential future use. Given the current state of knowledge, it is considered that the best proxy for functional diversity in livestock species is the diversity of breeds, or distinct populations that have developed in distinct environments. Moreover, cultural arguments for conservation relate to breeds rather than to genes. It is therefore reasonable that conservation decisions are usually taken at the level of the breed. However, it should be recognized that breed diversity does not represent the whole picture of genetic diversity. At the molecular level, genetic diversity is represented by the diversity of alleles (i.e. differences in DNA sequences) across the genes affecting development and performance.

Assessing the significance of a breed from the conservation perspective requires a synthesis of information from a number of sources including:

- studies of trait diversity, i.e. diversity in the recognizable combinations of phenotypic characteristics that define breed identity;
- molecular genetic studies, which provide objective measures of diversity within and between breeds, or evidence for unique genetic attributes;
- evidence of past genetic isolation; and
- evidence indicating cultural or historic importance.

Risk status is a further important consideration. Optimizing conservation strategies also requires consideration of how the available resources should be divided among the breeds under consideration, and decisions as to which is the most efficient conservation strategy from among the options available. Further work is required to develop effective tools for optimizing resource allocation in conservation strategies.

*In vivo* conservation encompasses a range of contexts and approaches. Landscape and vegetation management, organic farming approaches, participatory breeding, production for niche markets, and hobby farming all offer opportunities to keep breeds in use. Support to any or all of these may be important elements of a conservation strategy. In some cases, direct subsidies for keeping rare breeds may be necessary to prevent extinction. This approach is only feasible where resources are available; where there is political will to expend public funds to meet conservation objectives; where breed characterization is adequate to allow breed populations to be identified and classified according to their risk status; and where there is sufficient institutional capacity to allow eligible farmers to be identified, to monitor their activities and to administer payments. Careful attention to breed targeting is essential. Even where it is possible to deliver targeted subsidies, there will always be doubts regarding financial commitments over the long term, and such measures should be complemented by efforts to promote activities that offer scope for the breeds to become self-sustainable in the future.

*In situ*[7] conservation cannot be isolated from efforts to develop the production systems in which the breeds are kept and must not place restrictions on livelihood options, particularly of poorer livestock keepers. Unfortunately, little is known about how to improve production systems and infrastructure in such a way that the livelihoods of local people are improved and food security is enhanced while also conserving indigenous animal genetic resources. A limited number of community-based approaches involving intense cooperation with local livestock keepers and respect for their production objectives and knowledge have achieved some success.

Towards the *ex situ*[8] end of the spectrum of *in vivo* conservation approaches, farm parks devoted to keeping rare breeds have been established as successful tourist attractions in many (mostly developed) countries. These sites have an important role in terms of educating the public about animal genetic resources. In the developing world, the most commonly observed *ex situ in vivo* conservation activities are in herds or flocks maintained by state-owned institutions. These establishments are normally linked to ongoing use on farms, and their potential contribution in situations where breeds are no longer in use needs to be further assessed.

*In vitro* methods provide an important back-up strategy when *in vivo* conservation cannot be established or cannot conserve the necessary population size. It may also be the only option in the case of emergencies, such as disease epidemics or military conflicts. Further efforts are required to make reliable cryoconservation techniques available for all species.

[7] *In situ* conservation refers to conservation of livestock through continued use by livestock keepers in the production system in which the livestock evolved or are now normally found and bred.

[8] *Ex situ in vivo* conservation refers to conservation through maintenance of live animal populations not kept under normal management conditions (e.g. zoological parks and in some cases governmental farms) and/or outside of the area in which they evolved or are now normally found.

# Needs and challenges in animal genetic resources management

The livestock sector has to balance a range of policy objectives. Among the most urgent are: supporting rural development and the alleviation of hunger and poverty; meeting the increasing demand for livestock products and responding to changing consumer requirements; ensuring food safety and minimizing the threat posed by animal diseases; and maintaining biodiversity and environmental integrity. Meeting these challenges will involve mixing species, breeds and individual animals with the qualities needed to meet the specific requirements of particular production, social and market conditions. However, there are many constraints to meeting the goal of matching genetic resources to development needs.

Inventory and characterization are fundamental to the management of animal genetic resources, but remain far from complete, particularly in developing countries. Addressing the knowledge gaps that impede decision-making should be a priority. The current rate of genetic erosion also gives cause for significant concern. Well-targeted conservation measures to address threats to particular breeds are essential. However, there is an emerging consensus that the real requirement is for sustainable approaches to use and development, both for individual breeds and for animal genetic diversity as a whole. There is a need to establish principles and elements that underpin effective management, balance current and future use, and address economic, social and environmental concerns. Community-level programmes that both support the livelihoods of the livestock keepers involved and address global concerns about biodiversity are required. Initiatives of this type must be backed up by strengthened institutional and organizational structures, and policy and legal frameworks that support sustainable development.

## Accepting global responsibility

The countries and regions of the world are interdependent in the utilization of animal genetic resources. This is clear from evidence of historic gene flows and current patterns of livestock distribution. In the future, genetic resources from any part of the world may prove vital to breeders and livestock keepers elsewhere. There is a need for the international community to accept responsibility for the management of these shared resources. Support for developing countries and countries with economies in transition to characterize, conserve and utilize their livestock breeds is necessary. Wide access to animal genetic resources, for farmers, herders, breeders and researchers, is essential to sustainable use and development. Equitable frameworks for access, and for sharing the benefits derived from animal genetic resources, need to be put in place at both national and international levels. It is important that the distinct characteristics of agricultural biodiversity – created largely through human intervention and requiring continuous active human management – be taken into account in the development of such frameworks. International cooperation at all levels, from research to institutional and legal arrangements, and better integration of animal genetic resources management into all aspects of livestock development, can help to ensure that the world's wealth of livestock biodiversity is suitably used and developed, and remains available for future generations.

Sustainable management of the world's livestock genetic diversity is of vital importance to agriculture, food production, rural development and the environment. *The State of the World's Animal Genetic Resources for Food and Agriculture* draws on 169 Country Reports, contributions from a number of international organizations, 12 specially commissioned thematic studies and wider expert knowledge to provide the first global assessment of these resources and their management. This "in brief" version, intended for use by decision-makers and the wider public, presents a summary of the key findings of the main report.

As well as providing a technical reference document, the country-based preparation of *The State of the World* has led to a process of policy development and a *Global Plan of Action for Animal Genetic Resources*, which once adopted, will provide an agenda for action by the international community.

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