Part 2

LIVESTOCK SECTOR TRENDS

Introduction

Livestock production systems are the context in which animal genetic resources (AnGR) are used and developed. As production systems change, new demands are placed upon AnGR, threats may arise and new opportunities for sustainable use may emerge. This part of the report reviews production system trends and their influence on AnGR management. It serves as an update of Part 2 of the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* and focuses particularly on recent developments.

Section A discusses the major drivers of change in the global livestock sector. Section B considers how these trends are affecting different production systems. Section C, drawing mainly on the material provided in the country reports,[1] looks at how AnGR management is being affected by production system trends and how this may change during the coming years. Section D offers some conclusions based on the analysis presented in the other sections.

[1] For further information on the reporting process, see "About this publication" in the preliminary pages of this report.

Section A

Drivers of change in the livestock sector

1 Introduction

The description of livestock-sector trends presented in the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* (first SoW-AnGR) (FAO, 2007a) focused on the period between 1980 and 2005, a time when the livestock sector was expanding, intensifying and scaling-up, as a result of drivers from both the demand and the supply sides. Demand-side drivers were particularly strong in developing countries, where consumption of animal-source food grew fastest. Consumption of meat, milk and eggs rose steadily in a number of developing countries as a result of growth in the human population and rising purchasing power. Growth rates were highest for poultry meat and pork, averaging 4.7 percent and 2.6 percent per year, respectively, between 1981 and 2007 (Alexandratos and Bruinsma, 2012), with consumption growth in China making an important contribution. Growing urban populations, together with changes in consumer preference, resulted in greater demand for assured food safety and quality, and this led to additional certification requirements and costs. These developments favoured large-scale production and processing units. On the supply side, low and stable feed costs made it possible to expand intensive livestock production, while breeding technology produced animals that had high output potential and were adapted to intensive production. The period was also characterized by a growing volume and value of international trade in livestock products and feed, and the emerging dominance of large retailers.

By 2005, it was already evident that livestock-sector growth was slowing. Consumption growth was projected to slow (FAO, 2006), while rising energy costs and increasingly limited land and water resources meant that production growth was becoming ever more dependent on higher productivity from each unit of resources used. These challenges still exist. In addition, the supply-side advantage of cheap feed has disappeared as grain prices have risen and become more volatile. A global economic recession has affected consumption patterns among both poor and middle-class consumers. Concerns about livestock's contribution to climate change through greenhouse gas emissions (Steinfeld *et al.*, 2006) are having an ever-increasing influence on livestock-sector policies and industry strategies. Epidemics of major livestock diseases have been a feature of the sector for decades and cause periodic disruption to the international trade on which the sector increasingly depends. All of these issues are explored in this section as it reviews the way that the drivers of change in the livestock sector have evolved in the eight or so years since the first SoW-AnGR was written.

2 Changes in demand

Demand for animal-source products continues to grow, driven by growth in the human population and dietary changes associated with urbanization. Purchasing power was affected by the food-price crisis of 2007-2008, but is recovering. Projections indicate that the consumption of poultry meat and dairy products in particular will continue to

increase. Each of these drivers is discussed in more detail in the following subsections.

2.1 Consumption trends

Projections published in 2012 (Alexandratos and Bruinsma, 2012) suggest that global meat and milk consumption will continue increasing until 2030 and beyond, although growth rates are expected to be slower than those in the past (Tables 2A1 and 2A2). Global growth of meat and milk consumption is projected to be 1.6 and 1.3 percent per year, respectively, in the 2007–2030 period, down from 2.5 and 1.6 percent in 1991–2007. There will be regional differences in these trends, with growth coming mainly from developing countries. Industrialized countries, which already have high levels of consumption of animal-source foods and where population growth is slow, are likely to see much slower growth in demand than developing countries, although their per capita consumption is expected to remain higher (Tables 2A1 to 2A3).

Meat consumption boomed between 1981 and 2007, but in most parts of the world growth in demand is slowing. In Latin America and East and Southeast Asia, annual growth in meat consumption is projected to decrease over time, reflecting economic trends, although still to remain higher than in industrial and transitional economies. In South Asia, meat consumption is predicted to grow faster than before, predominantly through increased consumption of chicken meat in India. Sub-Saharan Africa, which has previously experienced slower growth than other parts of the world, may become a new centre of consumption growth, with annual increases in meat consumption predicted to remain steady until 2050. However, given their dependence on trends in the gross national incomes of the region's countries, consumption trends for Africa are difficult to predict precisely. Estimates by Acosta (2014) suggest that there is likely to be particularly high demand in Africa for milk, poultry meat and beef, although with some potential for cross-elasticity between poultry meat and beef, meaning that a strong demand for poultry may suppress growth in demand for beef.

The poultry sector has been the most buoyant part of the livestock sector in the past few decades and this is likely to continue. Poultry are efficient feed converters (of grains) and

TABLE 2A1

Previous and projected trends in meat consumption

Region	2005/2007 1 000 tonnes *per annum*	1981–2007 % change *per annum*	1991–2007 % change *per annum*	2005/2007–2030 % change *per annum*	2005/2007–2050 % change *per annum*
Sub-Saharan Africa	7 334	2.7	3.4	3.2	3.0
Near East / North Africa	10 292	3.1	3.7	2.7	2.3
Latin America and the Caribbean	34 557	3.9	3.6	1.7	1.3
- excluding Brazil	19 995	3.1	3.4	2.0	1.6
South Asia	6 685	2.1	1.2	4.5	4.2
East Asia	86 806	6.4	4.7	1.9	1.4
- excluding China	18 967	4.6	3.7	2.4	2.0
Developing countries	146 797	4.9	4.1	2.2	1.8
Developed countries	109 382	0.7	0.7	0.6	0.4
World	256 179	2.6	2.5	1.6	1.3

Source: Alexandratos and Bruinsma, 2012.

TABLE 2A2
Previous and projected trends in milk consumption

Region	2005/2007 million tonnes	1981–2007 % change *per annum*	1991–2007 % change *per annum*	2005/2007–2030 % change *per annum*	2005/2007–2050 % change *per annum*
Sub-Saharan Africa	24	2.3	3.5	2.5	2.3
Near East / North Africa	41	2.0	2.8	1.9	1.6
Latin America and the Caribbean	72	2.6	2.6	1.5	1.1
South Asia	135	4.3	4.1	2.3	2.0
East Asia	50	6.7	7.9	2.2	1.5
- excluding China	14	4.0	3.0	2.3	1.8
Developing countries	324	3.6	3.9	2.1	1.7
Developed countries	333	-0.4	-0.1	0.5	0.3
World	657	1.1	1.6	1.3	1.1

Source: Alexandratos and Bruinsma, 2012.

hence poultry meat tends to be cheaper than other meats, whether bought or home-produced. Chicken meat and other poultry products are also very widely consumed across regions and religious and social groups. Growth in global pork consumption, which has been leading the growth of meat consumption jointly with poultry, is heavily influenced by trends in China, where growth in demand is predicted to slow (OECD/FAO, 2014). Conversely, increasing poultry consumption is a worldwide phenomenon. Per capita demand for poultry meat is projected to increase by 271 percent in South Asia, 116 percent in Eastern Europe and Central Asia, 97 percent in the Middle East and North Africa and 91 percent in East Asia and the Pacific during the 2000 to 2030 period (Table 2A3). Evolution of per capita demand for poultry in India is striking, with a predicted increase of 577 percent between 2000 and 2030. Poultry meat is also the animal-source food with the highest demand growth in high-income countries, where per capita demand for beef and mutton is expected to decrease.

Milk consumption has grown more slowly than meat consumption, except in South Asia. Over the period 1991 to 2007, global milk consumption grew by 1.6 percent per year (Table 2A2), mainly due to a surge in demand for milk in China and India. In India, per capita demand for milk is expected to increase by 57 percent between 2007 and 2030 according to one projection (Table 2A3); another estimate suggests that consumption of fresh milk will reach 170 kg per capita in 2023 (OECD/FAO, 2014). Herrero *et al.* (2014) estimate that milk consumption is likely to triple by 2050 in sub-Saharan Africa, mostly led by East Africa. The overall effect is that global consumption of milk is projected to grow slightly faster between 2007 and 2030 than it did between 1981 and 2007 (Table 2A2), with steady annual growth to 2050 in Africa and a decreasing rate of growth in the rest of the world.

2.2 Purchasing power

Purchasing power is considered the main demand-side driver for livestock products. Lower-and middle-income consumers have a strong influence on consumption trends, as the effect of increased income on diets is greatest in this group (Delgado *et al.*, 2002; Devine, 2003). Increasing incomes in developing countries were an important driver of the boom in consumption of livestock products, particularly meat.

TABLE 2A3
Growth in per capita demand for livestock products from 2000 to 2030

Region	Beef		Milk		Mutton		Pork		Poultry meat		Eggs	
	Increase (percentage and absolute value)											
	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg
East Asia and Pacific	61	3.8	55	7.6	39	0.2	61	6.3	91	7.7	48	2.8
China	103	4.3	113	10.1	37	0.8	35	11.5	94	9.1	17	2.8
Eastern Europe and Central Asia	25	10.7	20	26.2	15	0.5	28	2.0	116	11.4	36	3.8
Latin America and the Caribbean	16	17.2	27	24.7	8	0.1	34	2.5	73	13.7	45	2.6
Middle East and North Africa	42	5.5	31	20.9	31	1.6	12	0.0	97	11.2	49	2.6
South Asia	24	4.2	32	20.7	45	1.0	78	0.2	271	4.1	134	1.9
India	8	0.2	57	37.6	33	0.2	86	0.5	577	6.0	173	2.6
Sub-Saharan Africa	25	5.3	17	6.1	30	0.7	47	0.6	73	2.6	66	0.9
High-income countries	-1	-21.0	3	6.1	-10	-0.7	11	2.0	36	9.3	9	0.9

Source: FAO, 2011a.

Poultry and dairy products have been found to have higher income elasticities of demand than other animal-source foods, meaning that consumption levels are more responsive to income; this effect is particularly strong in low-income populations (OECD/FAO, 2014; Gerosa and Skoet, 2012). At a fixed income, the prices of livestock products affect consumption levels. The lower price of poultry meat relative to beef has led to a shift from beef to poultry consumption in Latin America and the Caribbean, and generally in the world (CEPAL, FAO and IICA, 2014). The food-price crisis of 2007-2008 had a significant impact on demand for dairy products, but consumption is recovering due to increasing incomes and changing lifestyles (Gerosa and Skoet, 2012). Prices of other sources of animal protein also affect demand for livestock products. For instance, future demand for meat could be affected by more competitive fish prices (FAO, 2011b).

It is hardly surprising that consumption of poultry meat and dairy products is projected to continue growing. As well as being the most income-elastic animal-source foods, they are often cheaper than other livestock products and are also the most likely to be produced for home consumption by smallholder farmers.

2.3 Demographic changes and urbanization

The world population is predicted to reach 9.6 billion by 2050, i.e. 2.5 billion more than in 2013 (United Nations, 2014). While population growth is expected to decelerate in many regions, strong growth is expected in sub-Saharan Africa. Currently accounting for 13 percent of the total world population, this region is anticipated to account for 23 percent in 2050. As discussed above (Subsection 2.1), per capita consumption of poultry products is expected to increase in this region, reversing a decline in previous decades (FAO, 2009a).

Urbanization was noted in the first SoW-AnGR as the second main factor, after purchasing power, influencing per capita consumption of animal products. It also affects consumer preferences for particular types of animal products (see further discussion below). Since 2007, the world's urban population has surpassed the rural population. It is expected to increase from 54 percent

of the world total in 2013 to 66 percent in 2050 (United Nations, 2014). Urbanization leads to a shift from cereal-based diets to energy-dense diets that include a higher proportion of animal-source food. Diets can be expected to change substantially in Africa and Asia, where urbanization is fastest. In India, a country undergoing strong urbanization, per capita consumption of dairy products was estimated to be 20 percent higher in urban areas than in rural areas in 2009-2010 (Ahuja, 2013). Urban dwellers who can afford it are likely to eat a wider variety of foods than people in rural areas, and to eat more processed food and fast food. These tend to be sourced from large-scale producers where possible, because it is easier for food retail companies to manage supply and quality from fewer, larger farms. Urbanization also leads to improvements in infrastructure and cold chains, meaning that perishable goods, such as fresh milk, can be transported further (Thornton, 2010).

While urban populations are on average richer than those in rural areas, there are still very large numbers of low-income urban families who are vulnerable to economic recession. During the food-price crisis of 2007-2008, when world prices of cereal staples rose by three to five times, the poor in many large cities cut back on food consumption and ate less animal-source food (FAO, 2011b). Current projections for consumption growth will be affected by any future volatility in the global economy.

2.4 Consumer taste and preference

Consumption preferences are affected by a variety of cultural factors and life choices. Cultural factors influence decisions as to whether to eat meat or whether to eat meat from particular species; one of the reasons for the boom in poultry consumption may be that it is acceptable in almost every society that eats meat. Cultural norms can also be related to food safety. Many consumers in developing countries prefer to eat meat from animals bought live at the market and slaughtered on the day of consumption, as where there is no reliable refrigeration or obligatory labelling this is the most dependable way of ensuring the safety and quality of the meat. Preferences are not static and are affected by demographic change. Many developing-country consumers prefer the taste of meat from traditional breeds kept extensively, but tastes are changing as middle-class urban households increasingly opt for the convenience of supermarket-purchased meat from intensive production systems.

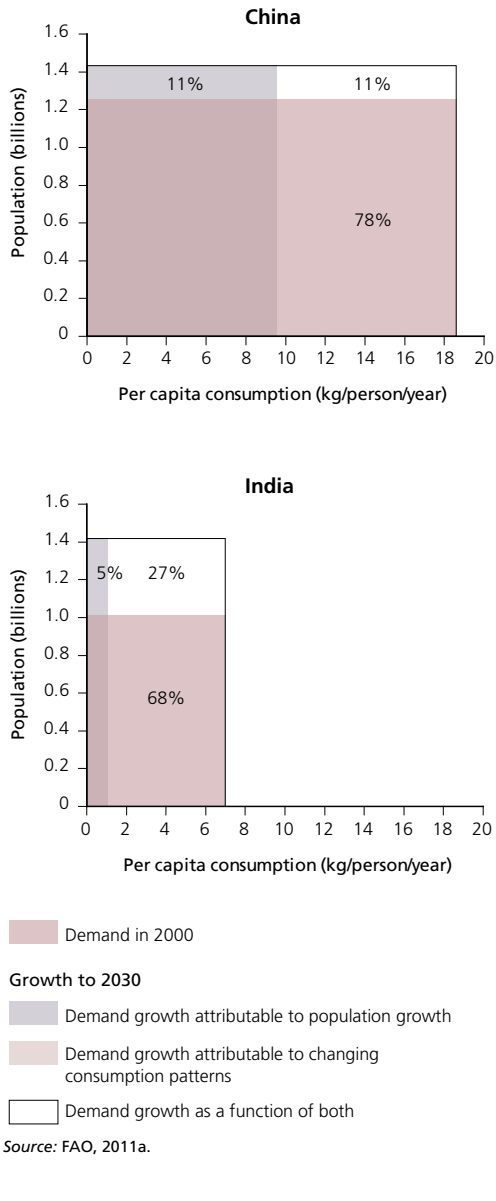
Meat and milk consumption in developed countries is increasingly affected by concerns about healthy diets, the environmental impacts of livestock production and animal-welfare issues. These concerns drive both trends and shocks in consumption and may sometimes pull in opposite directions. For example, the shift from red meat to poultry meat in high-income countries is partly explained by health concerns, as poultry is perceived to be low in fat (OECD/FAO, 2014); yet during the highly pathogenic avian influenza crisis of 2003 to 2006, demand for poultry meat experienced a short, sharp drop in Italy when consumers feared they might be infected (McLeod, 2008; Beach *et al.*, 2008). Concerns about animal welfare led to a European Union (EU)-wide ban on conventional battery cages for laying hens in 2012, which resulted in an increase in the number of free-range birds in some countries.

Concerns about health issues and food quality are increasing in developing countries due to higher purchasing power and changing lifestyles (Jabbar *et al.*, 2010) and this is already changing the livestock industry, with more standards and norms applied to production and processing (Hoffmann *et al.*, 2014). Thornton (2010) notes that animal welfare is becoming a global concern because of globalization and international trade. In 2013, concerns about animal welfare led the Australian livestock industry to suspend live exports to Egypt. In 2014, exports resumed under the Exporter Supply Chain Assurance System (ESCAS), which places responsibility on exporters to guarantee animal welfare throughout the entire supply chain (Australian Government, Department of Agriculture, 2014).

Population growth alone may not significantly change the structure of the livestock sector, provided that the ratio of producers to consumers does not change. In contrast, changes in consumption patterns are likely to affect sector structure. FAO (2011a) analysed the relative impacts of population growth and changing consumption patterns on total consumption and predicted, for example, that 78 percent of demand growth for poultry meat in China and 68 percent in India would come from increased consumption per capita (Figure 2A1). It is expected that India will respond to growth in demand for poultry by increasing domestic production from large farms, and this implies restructuring of the poultry industry.

FIGURE 2A1

Demand growth for poultry meat in China and India (2000 to 2030)



Source: FAO, 2011a.

3 Changes in trade and retailing

As demand for animal-source food has increased worldwide and advances in technology have made their transport easier, international trade and the role of large retailers have increased, creating a situation in which an increasing number of livestock producers face global competition. Some developing-country producers face high production costs because they have to import feed, and this reduces their competitiveness. Likewise, some processors are unable to invest on the scale needed to be competitive. Many smallholders and pastoralists face particular problems because they cannot meet the standards and norms required in order to sell their products to large retailers and international markets, and yet they face competition from imported products on their domestic markets. Vertical integration in the market chains controlled by large companies limits the access of smallholders to growing urban and export markets.

3.1 Flows of livestock and their products

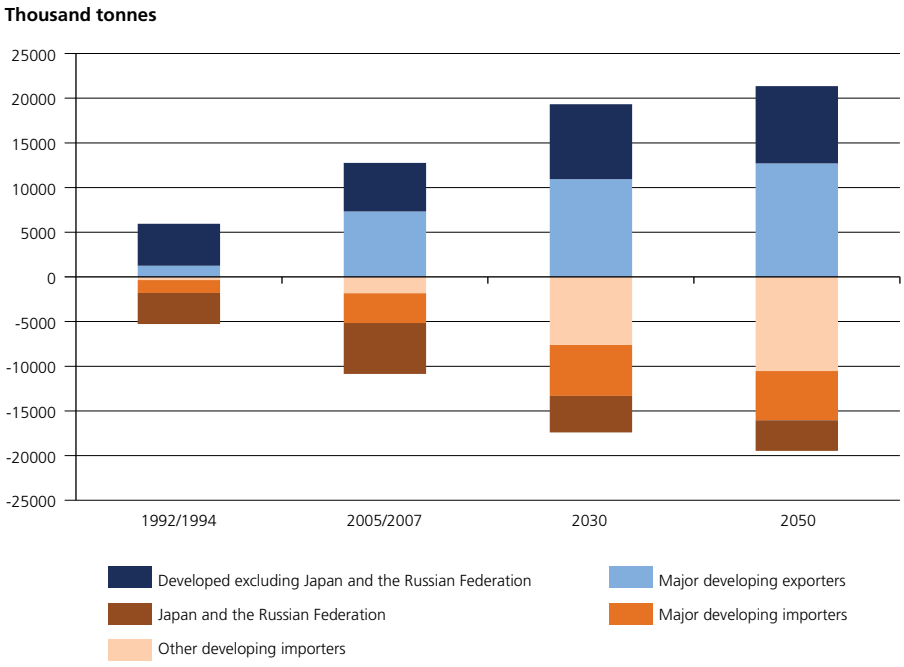
Animal products and live animals for slaughtering or breeding are traded on international and domestic markets. Domestic trade accounts for almost 90 percent of recorded trade by volume – and probably a larger percentage of total trade,

given that many local transactions in developing countries are unrecorded. However, international trade is expanding: from 4 percent of trade by volume in the early 1980s to around 10 percent in 2007 and 12 percent in 2013 (Guyomard *et al.*, 2013). Large companies dominate market chains in developed countries and are becoming increasingly important in developing countries in terms of both international trade and inward investment.

International trade in live animals and livestock products is expected to keep growing (Figure 2A2). Trade in dairy products is expected to increase, while the proportion of meat traded is anticipated to remain at around 10 percent of production (OECD/FAO, 2014). Bovine meat, which has the highest value, is the most traded meat, with about 15.8 percent of production being traded (ibid.).

Flow patterns of live animals and animal products are evolving. Live-animal exports are constrained by animal-health regulations, even more so than trade in livestock products, and by high transport costs. The most internationally traded live animals are day-old chicks, sent between large producers all over the world, and ruminants, exported from Australia and the Horn of Africa to the Middle East for halal slaughter. The latter may be restricted in the future because of animal welfare concerns. High-value breeding animals and their semen are also traded internationally (for further information see Part 1 Section C). In Africa and Southeast Asia, animals travel across national borders for slaughter in adjacent countries, not all of them officially recorded. However, this trade can be abruptly disrupted by livestock

FIGURE 2A2
Net meat trade of major importer and exporter country groups



Note: Country groups defined in source. Historical data go back only to 1992, because of the unavailability of data for the Russian Federation for years prior to 1992.
Source: Alexandratos and Bruinsma, 2012.

disease outbreaks and changes in animal-health regulations.

Dairy exports are still dominated by a few developed countries, namely Australia, European Union (EU) countries, New Zealand and the United States of America. However, Argentina, Belarus, Egypt, Saudi Arabia, Turkey and Ukraine export significant amounts of cheese to neighbouring countries, and India is expected to increase its skim milk powder exports. In Latin America and the Caribbean, dairy exports may remain limited; for example, exports from Argentina are projected to decrease by 9 percent in the next ten years (CEPAL, FAO and IICA, 2014).

Meat exports from developing countries are expected to gain market share relative to those from developed countries (Figure 2A2). A few large countries have the largest market shares. Brazil and Argentina dominate beef and veal exports jointly with Australia, New Zealand and the United States of America. Brazil and the United States of America account for around 70 percent of global exports of poultry meat (Guyomard *et al.*, 2013). India is consolidating its buffalo-meat exports, with a highly competitive sector (OECD/FAO, 2014). The EU's position as a meat exporter has weakened in recent years because of high production costs and a strong euro and may weaken further (ibid.).

A wider range of countries have become importers of livestock products, and with consumption remaining higher than production in many developing countries imports are expected to grow. Between 2005/2007 and 2050, meat imports to Africa are predicted to increase from 0.9 million tonnes to around 5 million tonnes and milk imports from 5.7 million tonnes to 10.2 million tonnes (World Bank, 2014). The proportion of consumption in Africa accounted for by imports is anticipated to reach around 15 percent for beef and 21 percent for poultry meat by 2030 (ibid.).

An important feature of international trade is that many developing countries are, or have the potential to be, both importers and exporters of livestock products – and both types of trade affect the development of their livestock sectors. Export is a costly process, with average bound tariffs[1] for meat varying from 82 to 106 percent in OECD countries and from 68 to 75 percent in non-OECD countries (Steinfeld *et al.*, 2010). Exporters therefore aim to sell their highest-quality products to premium markets in developed countries, or if that is not possible, to target regional markets with high demand, such as South Africa and China. Developed countries place strict animal-health requirements on imports and the main regional markets are also becoming increasingly demanding in this respect. Premium markets also tend to have strict requirements for quality and certification. If export is prioritized in national strategies, this tends to accelerate concentration and scaling-up and to exclude smallholders. This effect is particularly marked in the poultry-meat sector (see Box 2A2 for example). Exclusion can also occur if a disease-free zone created for export restricts the access of smallholders' animals to seasonal grazing or local markets. Where imports are concerned, a strategy of inward investment by large retailers, often in response to demand in growing cities, can also prove to be exclusionary. Supermarkets and fast-food businesses source their food products from a combination of international and domestic markets, but may impose requirements that make it hard for smallholders to supply them. Importation of livestock products can also, and separately, introduce competition when large exporting countries sell the products that are less preferred in premium markets cheaply into developing-country markets. This may not necessarily affect smallholders; it is more likely to be detrimental to small- and medium-sized commercial producers.

While exchanges of livestock products and live animals are growing, trade is becoming more challenging. One of the consequences of globalization has been a large number of protectionist policies. While in recent years there has been a general tendency towards liberalization of world

[1] "Bound" tariffs are rates of duty agreed by the World Trade Organization.

Box 2A1

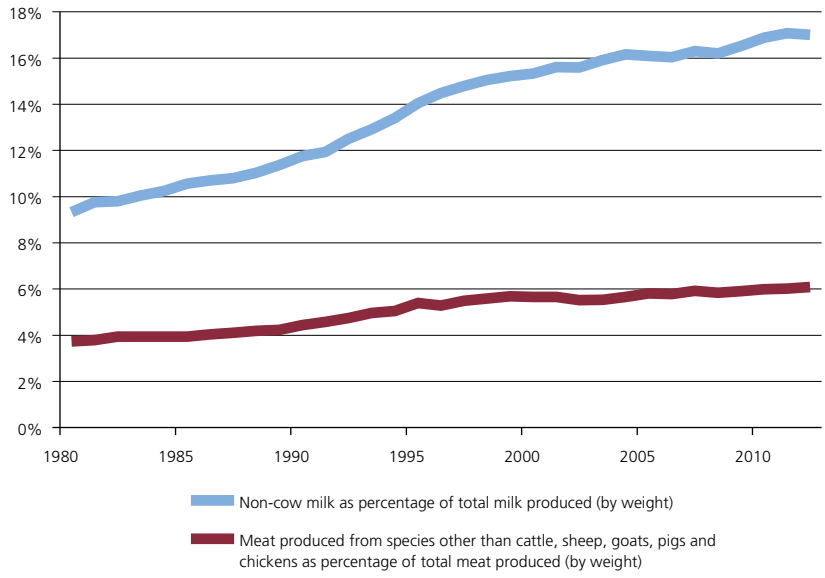
Demand for animal-source foods from minority species and breeds

The main global trends in demand for animal-source foods are assessed using data on the production and consumption of "majority" products, namely beef, pork, chicken meat and milk. These are important in providing a broad picture, but in order to assess implications for animal genetic resources and their management it is also important to look at the finer detail: to review trends for products from minority species and breeds.

The production of milk from species other than cattle and meat from species other than cattle, pigs and chickens has become more important in the past 30 years. FAOSTAT data show that milk production from buffaloes, sheep, goats, dromedaries and Bactrian camels has been increasing as a proportion of total production. Other locally important milk-producing species, such as reindeer, yaks and horses, are not included in these statistics. The proportion of meat production contributed by meat from sheep, goats, buffaloes, dromedaries and Bactrian camels and other camelids has increased by a small amount since 1980.

Equally important to genetic diversity, but harder to assess from published statistics, are breed-related changes in consumption. For the most part, these can only be surmised by observing general trends. For example, free-range egg production has recently increased in developed countries and this may result in changes to the genetic make-up of chicken populations. However, the chickens used in large-scale commercial free-range systems are not those used in scavenging backyard flocks; they have been bred to grow quickly under conditions of good care and feeding. Smallholder chicken producers – in India or Africa, for example – who wish to make a higher income than can be obtained from traditional scavenging flocks may adopt specially bred birds such as the "Kuroiler" and supplement their scavenging diets with concentrate feed.

Changes in the proportion of milk and meat production provided by minor species



(Cont.)

Box 2A1 *(Cont.)*
Demand for animal-source foods from minority species and breeds

Urbanization can result in a series of changes to consumption patterns. As cities expand, the first effect observed is that people consume more animal-source foods, which they may buy from a variety of sources, including live-animal and fresh-food markets. Rural consumers and those that are recent incomers to urban areas tend to prefer meat from traditional breeds and production systems. As supermarkets and fast-food outlets are established and live-animal markets are moved beyond city limits, purchasing patterns change and more food is bought from large retailers, much of it originating from large-scale commercial production systems. Over time, however, some consumers begin to demand specialist foods: locally-sourced; from traditional breeds; from systems perceived to be sustainable; harvested from the wild; or from "exotic" species. Although these demands are never likely to affect the main global statistics, they provide a livelihood for a limited number of small-scale entrepreneurs and opportunities to raise traditional breeds profitably.

Sources: FAOSTAT; Ahuja *et al.*, 2008; FAO, 2011b; Cawthorn and Hoffman, 2014.

trade, restrictive measures continue to be applied to animal products (WTO, 2011; 2014). As a consequence, bilateral and multilateral agreements between countries are increasingly being used. These agreements aim to preserve sanitary standards while reducing tariff barriers. For instance, in December 2013, Australia and the Republic of Korea announced a free-trade agreement including elimination of high tariffs on Australian agricultural exports such as dairy products and meat (Department of Foreign Affairs and Trade, 2013). In the same year, the EU and Canada signed an agreement aimed at promoting trade in bovine and pig meat (Government of Canada, 2013). Such arrangements have the potential to further distance smallholders from export markets.

3.2 The rise of large retailers and vertical coordination along the food chain

As discussed in the first SoW-AnGR, supermarkets have spread all over the world. In the developing world, this has mainly occurred since the early 1990s. Supermarkets and large food companies have established vertically integrated production and marketing chains involving contracts with farmers who meet their quality and sanitary standards. This enables them to reduce transaction costs. The private sector is increasingly investing in livestock production systems (Gerber *et al.*, 2010).

Meeting quality and sanitary demands is challenging, especially for smallholders in developing countries. Concerns about the exclusion of smallholders in Africa are rising, as supermarkets require frequent supplies and demand quality standards that small-scale producers may not be able to meet (Tschirley *et al.*, 2010). However, it is possible to involve smallholders in changing markets, particularly in the case of dairy products. Development projects and large retailers have invested in engaging small-scale producers in dairy-product market chains, providing advice on animal health, feeding practices, breeding and in some cases quality assurance (Gerber 2010; FAO, 2013d). In Bangladesh, a well-organized contract-farming system involves large numbers of small-scale farmers in commercial poultry production (FAO, 2013a).

4 Changing natural environment

In the context of increasing demand for food and ever greater competition for land and other resources, there are growing concerns about the sustainability of livestock production systems and their impacts on the environment.

Box 2A2

Development of the poultry sector in Thailand

The Thai poultry industry was on a fast growth trajectory until the 2004 outbreak of highly pathogenic avian influenza (HPAI). In the 1960s, the industry consisted of a network of small-scale farmers, live-bird traders and wholesalers who brought chickens from rural areas to the cities. During the 1970s and 1980s, the Charoen Pokphand company, in partnership with the American firm Arbor Acres, imported exotic chickens from the United States of America and the United Kingdom and used them to develop a nationally based breeding programme. Contract growers raising an average of 10 000 birds were important to the company and were given the security of price-guaranteed contracts. Although commercial production was expanding and scaling-up during this period, backyard production continued to be important; in 1985, 99.7 percent of chicken producers kept backyard flocks.

During the 1990s, the sector scaled-up and concentrated. By 1996, twelve companies, including the Charoen Pokphand company, controlled about 80 percent of broiler production in Thailand, with large mechanized production units providing economies of scale. Contract farming continued, but vertically integrated production was beginning to expand. The average size of farms continued to increase and new technology was used to cut production costs. The Asian financial crisis of the mid-1990s, preceded by a slump in poultry exports, further concentrated the sector. The main broiler companies came together to form the Broiler Breeding Stock Centre in order to control the supply of breeding stock. The poultry sector survived the economic crisis by shifting towards value-added, processed products. Devaluation of the local currency (the baht) was advantageous for exporters, but small and medium-sized farms, relying on a domestic market in which poultry meat consumption had declined by 20 percent, were more affected by the crisis.

From 2000 onwards, vertical integration became more common, because of the need to meet health and welfare standards demanded by export markets. By 2003, Thailand was the world's fifth-largest exporter of poultry meat by value. The trend to integration was accelerated after the HPAI outbreaks that occurred between May 2004 and August 2006. Loss of 64 million birds, mostly through culling, and loss of the export market, dealt the sector a devastating blow. In order to regain and protect the export market, new regulations were established by the Department of Livestock Development, as well as by the European Union and Japan, both major markets for Thai exports. Under these regulations, companies had more incentive to vertically integrate in order to meet the required standards at every stage of production. It is now common for medium- to large-scale companies to own feed mills and for large integrated farms to include feed-processing plants. The standards do not apply to small farmers operating within local/informal supply chains, but raising poultry and fish in integrated systems, previously common in the delta areas of the country, has been prohibited in most areas. After the HPAI outbreaks, many farmers ceased raising native chickens for sale.

The domestic market now takes approximately 65 percent of national production and export takes 35 percent. Both markets are expected to grow. Five companies supply 70–75 percent of the export market. Japan is the main export destination, but the market is diversifying as more developed countries allow Thai poultry products back into their markets. On the domestic market, chicken meat is the most consumed meat, partly because it is the cheapest. The market shares of ready-to-cook meat and fast food are growing. It is estimated that Thailand's broilers and layers consume 8 million tonnes of feed per year, including 4.8 million tonnes of maize and 2.2 million tonnes of soybeans, of which 4.6 and 0.96 million tonnes, respectively, are produced locally.

Sources: Heft-Neal *et al.*, 2010; IPSOS Business Consulting, 2013.

4.1 Climate change

Concerns about climate change, already prevalent at the time the first SoW-AnGR was prepared, have deepened still further over recent years (FAO, 2009b; Nardone *et al.*, 2010; IPCC, 2014). Livestock production systems are experiencing the effects of changes in precipitation, temperature and increasing frequency of extreme weather events. Changes of this kind can affect livestock production both directly and indirectly (e.g. by affecting feed production) (Table 2A4). The potential impacts of heat stress on livestock include temperature-related illness and death, as well as declines in production and reproductive ability (Nardone *et al.*, 2010). Extreme weather events threaten rangelands, as well as feed production for non-grazing systems. They can pose a direct threat to the survival of livestock populations caught in their paths (see Part 1 Section F for further discussion). They can also have significant effects on livestock markets (OECD/FAO, 2014).

4.2 Pressure on land and other natural resources

There is increasing pressure on land and other natural resources as a result of developments in agricultural production systems as well as urbanization and industrial development. These pressures are being exacerbated by climate change. The livestock sector accounts for approximately 3.9 billion hectares of land, divided into 500 million hectares used for feed-crop production, 1.4 billion hectares of relatively highly productive pastures and 2 billion hectares of relatively unproductive extensive pastures (Steinfeld *et al.*, 2010). The evolution of land use varies from region to region. Between 1961 and 2001, both arable lands and pastures expanded in Asia, North Africa, and Latin America and the Caribbean, while arable lands replaced pastures in Oceania and sub-Saharan Africa. In the Baltic states and the Commonwealth of Independent States, lands dedicated to pastures expanded, while croplands decreased; in western and eastern Europe and in North America, both pasture and arable land decreased (Steinfeld *et al.*, 2010). In some parts of the world, notably Africa, land degradation as a result of overgrazing added to pressures on the land resource. Between 2000 and 2010, the area under pasture grew at the expense of arable land in North America, whereas it decreased in the Southwest Pacific and in Asia (Table 2A5).

Water and fossil fuels are also finite and in high demand. Competition for these resources, a concern for the past decade, is anticipated to get stronger in the future. Developments of this kind lead to high prices for feed and energy and raise the costs of livestock production. A recent response to fossil-fuel scarcity has been the introduction of government incentives for the development of biofuel production. This may affect the livestock sector, as crops used for feed have

TABLE 2A4

Direct and indirect effects of climate change on livestock production systems

	Grazing systems	Non-grazing systems
Direct impacts	• Increased frequency of extreme weather events • Increased frequency and magnitude of drought and floods • Productivity losses (physiological stress) due to temperature increase • Change in water availability (may increase or decrease, depending on the region)	• Change in water availability (may increase or decrease, depending on the region) • Increased frequency of extreme weather events (impact less acute than for extensive systems)
Indirect impacts	Agro-ecological changes and ecosystem shifts leading to: • alteration of fodder quantity and quality • changes in host–pathogen interactions resulting in an increased incidence of emerging diseases • disease epidemics	• Increased resource prices (e.g. feed, water and energy) • Disease epidemics • Increased cost of animal housing (e.g. cooling systems)

Source: FAO, 2009a.

TABLE 2A5
Change in area of arable and pasture land (2000 to 2010)

Regions and subregions	Arable land	Permanent meadows and pastures
	%	
Africa	**11.5**	**1.2**
East Africa	31.2	-0.1
North and West Africa	6.0	2.5
Southern Africa	11.5	0.4
Asia	**-1.6**	**-4.0**
Central Asia	8.5	-5.8
East Asia	-9.2	-3.2
South Asia	-2.7	-2.6
Southeast Asia	8.9	2.4
Southwest Pacific	**-11.7**	**-13.1**
Europe and the Caucasus	**-5.3**	**0.0**
Latin America and the Caribbean	**16.1**	**1.3**
Caribbean	-5.9	-0.4
Central America	1.5	-0.3
South America	20.9	1.7
North America	**-9.9**	**5.1**
Near and Middle East	**4.5**	**0.6**
World	**-0.4**	**-1.7**

Source: FAOSTAT.

begun to be used for biofuel production. For instance, policies in the United States of America have led to a surge in the use of maize, one of the main livestock feeds, for bioethanol production (Miljkovic *et al.*, 2012). The availability of by-products from the bioethanol industry and shifts towards new feeds may, however, diminish the negative effects of biofuel production on the livestock sector (FAO, 2012a).

Feed availability and price volatility are becoming major issues. In Asia, the amount of feed protein required by the poultry and pig sectors is anticipated to double between 2009 and 2020 (Ahuja, 2013). This represents a major challenge, especially given that Asia already experiences chronic shortages of feed (ibid.).

4.3 Distribution of livestock diseases and parasites

The distribution of diseases and parasites and the emergence of new diseases are expected to continue evolving, influenced by high livestock densities, international trade, human travel and climate change. It has been argued that these drivers have led to a "booming era of emerging infectious disease" (Bouley *et al.,* 2014). Precise developments are difficult to predict. Climate change, for example, has the potential to affect all the components of disease systems, i.e. pathogens, hosts and vectors. However, it is difficult to clearly distinguish the effects of climate change from those of other drivers (FAO, 2013b). Problems related to emerging diseases and the

spread of diseases and parasites into new areas are potentially exacerbated by the spread of antibiotic resistance and resistance to treatments used against parasites and disease vectors.

5 Advances in technology

Advances in technology (e.g. those related to feeding, breeding, housing, transportation and marketing) have been major drivers of change in the livestock sector in recent decades. Feeding and breeding have been crucial, particularly in the poultry, pig and dairy industries. However, these developments have mainly been undertaken by the private sector and aimed at (relatively large-scale) commercial producers; they are therefore relatively less available to – and applicable for use by – smallholders than the technologies that led to the "green revolution" in the crop sector (FAO, 2009a).

5.1 Feed technology

Feed-use efficiencies have substantially improved in the pig, poultry and dairy industries. Moreover, low feed prices, resulting mainly from intensification of croplands and advances in feed production and genetics, have contributed to the rapid growth of the livestock sector. However, feed prices – including the prices of cereals, oilseeds and meat and fish meals – have increased sharply since 2008, and are expected to remain high because of increasing demand, land competition, water scarcity, high energy prices and climate change. Increases in feed prices particularly affect developing countries, as they are deficient in feed resources and their livestock sectors are generally dependent on feed imports. This, along with decreasing availability of arable land and increasing food–feed competition, has led to a reassessment of feeding practices and search for new protein- and energy-rich feed resources that do not compete with human food (FAO, 2012b). Potential options include insects (FAO, 2013c; Makkar *et al.*, 2014), co-products of the biofuel industry, including algae (FAO, 2012a), ensiled vegetable and fruit wastes (Wadhwa and Bakshi, 2013) and other unconventional feed resources such as moringa and mulberry leaves. A variety of different insect larvae may be suitable for processing into animal feed, and could potentially replace 25 to 100 percent of the soymeal or fishmeal in the diet – depending on the animal species – with some supplementation with methionine, lysine and calcium (Makkar *et al.*, 2014).

To promote more efficient use of available feed resources, greater emphasis is now being placed on resource assessments and characterizing feeding systems at national level (Makkar and Ankers, 2014). Other strategies include greater use of precision or balanced feeding, identification and use of smart feeding options (Makkar, 2013) and efforts to decrease feed wastage by using densified complete crop residue based feed blocks or pellets and total mixed rations instead of feeding individual feed components (FAO, 2012c).

5.2 Genetics and reproductive biotechnologies

Reproductive technologies, such as artificial insemination, embryo transfer and more recently sex-sorted semen, have been extensively used in the poultry, pig and dairy industries in developed countries (see Part 3 Section E). Molecular and quantitative genetics have provided new opportunities in animal breeding (see Part 4 Section C). Conversely, cloning and the use of genetically modified animals have been limited due to social and ethical concerns and problems with the efficiency of the procedures. Genetically modified livestock are used in research and in the production of proteins for medical purposes.

Use of genetics to improve productivity has been particularly prominent in the poultry industry, where high reproductive rates and short generation intervals have allowed rapid improvements in feed efficiency and growth rates using classical animal-breeding methods based on quantitative genetics (FAO, 2009a). In dairy cattle, the use of artificial insemination has allowed the wide diffusion of semen from a limited number of bulls with accurately estimated breeding values and has resulted in significant genetic progress.

While the main focus of genetic improvement programmes has been on increasing production, increasing emphasis is now being given to functional traits influencing the costs of production. In the future, selection goals are likely to take other traits, such as disease resistance and environmental impact, including greenhouse gas emissions, increasingly into account.

Newly developed biotechnologies offer many opportunities to improve selection, but have the potential to create certain risks (e.g. compromised food safety and animal welfare) and thus need to be regulated by adequate institutional frameworks. Some relevant national and international legal and policy frameworks have been established (see Part 3 Section F), but adequate provisions are not in place in all countries.

5.3 Animal-health technology

Animal-health technologies such as vaccines, antibiotics and diagnostic tools have supported the growth of the livestock sector by reducing the burden of diseases. However, livestock diseases continue to be a problem for both small-scale and large-scale producers. Effective control of existing diseases and emerging problems will require better and more accessible diagnostic tests (Thornton, 2010) and continued development of vaccines and drugs, as well as packaging and distribution networks that make technologies more accessible to farmers. Technology alone will not be sufficient to deal with future animal-health problems; continued investment in the infrastructure and human capacity of animal-health systems in developing countries is also needed. Moreover, the need to respond to crises has meant that chronic and endemic diseases have been neglected, particularly in smallholder and pastoralist livestock systems in developing countries (FAO, 2013b). The critical need for smallholders and pastoralists is not new technology, but animal and public health systems that are more embedded in communities.

In developed countries, the potential effects of antimicrobial resistance on public health are causing increasing concern (Rushton *et al.*, 2014). Improved surveillance in the livestock sector is needed; the latest World Health Organization report on this issue (WHO, 2014) notes the existence of significant gaps in data on antibiotic resistance in bacteria carried by livestock and in the food chain.

5.4 Future technologies

In vitro meat, also referred to as artificial meat, is currently under development and may be a contributor to the meat supply in the future, although its use will probably be limited to processed products. It has not yet been produced in a form suitable for commercial use and is very expensive (FAO, 2011b). Another technology that may affect the livestock sector in the future is nanotechnology (Thornton, 2010). This technology can be applied in animal health (e.g. drug delivery), feeding and waste management. However, as with many technologies, risks need to be assessed and addressed via appropriate legal and policy frameworks.

6 Policy environment

The first SoW-AnGR described public policies as "forces that add to the drivers described above and influence changes in the sector with the aim of achieving a particular set of societal objectives." Public policies aim to expose, contain and mitigate the hidden costs of an expanding livestock sector, including those associated with environmental degradation, livelihood disruption and threats to veterinary and human public health.

Veterinary and public health concerns have been strongly regulated internationally since the sanitary and phytosanitary (SPS) agreement of the World Trade Organization was established in 1995, and this high level of regulation can be expected to continue in the future. The agreement was developed, by negotiation between the main trading nations at the time, to protect national livestock and human populations from the most infectious livestock, zoonotic and foodborne diseases. It has been argued that SPS standards act as a barrier to export from developing countries.

They have certainly been influential in shaping the livestock sector and its trade flows; for example, in 2009, almost 70 percent of world trade in animals and meat from species susceptible to foot-and-mouth disease came from a small number of countries that were officially recognized as free of the disease by the World Organisation for Animal Health (OIE) or historically recognized to be disease free (OECD/FAO, 2009).

Regulations are evolving in ways that may be beneficial for developing countries. Historically, it was only possible to export to premium markets from countries or geographical zones that were free of disease. All producers living within disease-free countries or zones had to adhere to the same regulations, even if they did not intend to export. Within the past ten years, two new concepts have been introduced into the OIE's Terrestrial Animal Health Code (OIE, undated). "Compartmentalization" in essence permits export from a certified value chain. "Commodity-based trade", more recently introduced into international guidelines, permits products assessed as being of minimum risk to be exported, even if they come from countries where disease is present. Both concepts introduce the potential for export trade to be developed in parallel with the provision of support to smallholder farming and pastoralism, although no impact assessments based on practical experience have yet been published.

International policies and regulations on the environment are a more recent phenomenon for the livestock sector and less clear-cut than the SPS agreement. An international agreement on conservation and management of marine fish stocks has been in place since 1995, but moves towards the development of international agreements on sustainable livestock production began only relatively recently. The Global Plan of Action for Animal Genetic Resources was adopted in 2007 (FAO, 2007b) and concerns about the links between livestock and climate change are stimulating further interest in international environmental agreements addressing the livestock sector. An increasing number of public and private discussion fora are now playing an important role in shaping international norms and agreements, including the Global Agenda for Sustainable Livestock,[2] spearheaded by FAO. Issues being explored include the management of grazing livestock to provide environmental services, including the improvement of carbon markets so that individual livestock keepers can more easily benefit from them. Additional areas of interest are the management of animal manure for full recovery of nutrients and improving the efficiency of production in developing-country livestock systems, both of which will require a combination of technological, policy and voluntary action. There is also a growing body of research publications on "sustainable intensification" (Garnett and Godfray, 2012; The Montpellier Panel, 2013; Van Buren *et al.*, 2014).

Nationally, land ownership has been an important driver in shaping production systems. Assured access to land and water is important for livestock production, whether through legal ownership or customary land rights, and this will become increasingly urgent as grazing land is lost to crop production and climate change affects marginal areas where many indigenous animals are kept. A report by IFAD (2009) concluded that increased control by indigenous people over access to grazing land, water rights and land-tenure laws were all important means of preventing land degradation and ensuring sustainable land use.

Emerging policy issues in the livestock sector include animal welfare and the regulation of biotechnology (see Part 3 Section F for further discussion). There are also a number of policy areas that affect the sector indirectly. For instance, as noted above, incentives for biofuel production have already affected feed prices and created competition for land and water. A notable trend in the past ten years has been the growth of coalitions, such as the Global Agenda for Sustainable Livestock (see above) and the Global Roundtable

[2] http://www.livestockdialogue.org

TABLE 2A6

A policy framework for inclusive growth of the livestock sector

	Policy goal	Examples of policy instruments	Rationale
Context for livestock policies	Creating a conducive macroenvironment	Macroeconomic policies and institutional reforms	Sound macroeconomic fundamentals and high-quality institutions are positively associated with economic and social indicators of well-being.
Managing the basics for livestock production	Securing access to land, feed and water	State-driven land and agrarian reform Market-driven land reform Regulation of land rental markets Land titling Recognition of customary tenure Land co-management	Livestock producers need adequate and secure access to land (and associated feed and water resources).
	Providing insurance and risk-coping mechanisms	Livestock insurance Early-warning systems Contingency plans Emergency feeding Grazing reserves Destocking Restocking	Variable returns prevent livestock keepers from making efficient use of their resources and lead to adoption of conservative investment decisions.
Enhancing livestock productivity and competitiveness	Securing access to livestock/animal-health services	Decentralization Cost recovery Joint human–animal health systems Subcontracting "Smart" subsidies for private service providers Community animal-health workers Membership-based organizations "Smart" subsidies for livestock keepers	Livestock keepers are often poor, poorly educated, dispersed, and unable to demand public and private livestock services effectively.
	Securing access to credit and other inputs	Portfolio diversification Livestock as collateral for loans Warehouse receipt systems Mobile banking Branchless banking Member-based financial institutions Credit bureaus and scoring	Imperfect and asymmetric information and high transaction costs limit access to credit and other production inputs, as private agents are rarely willing to serve poor and dispersed livestock producers.
Sustaining livestock productivity and competitiveness	Promoting access to national/international markets	Livestock-keepers'/traders' associations Livestock brokers Periodic markets Contract farming Market information systems Commodity exchanges Sanitary and phytosanitary standards Disease-free export zones Commodity-based trade Trade-enhancing infrastructure Quarantine zones	Markets' capacities to indicate how livestock producers should allocate their productive resources are constrained, *inter alia*, by poor communication and transport infrastructure, lack of or limited information, and unequal bargaining power among contracting parties.
	Promoting the provision of public goods: research	Decentralization Matching research grants Levy-funded research Competitive research funds Strengthened intellectual property rights Participatory livestock research	Private research centres are willing to invest in profitable breeds/technologies, but poor livestock keepers rarely constitute an attractive market for the private sector.
	Promoting the provision of public goods: food safety, and environmental protection	Controlled grazing Co-management of common pastures Livestock zoning Discharge quotas Payments for environmental services Marketing of environmental goods Environmental taxes Education from school to university level	Livestock production systems may be associated with negative externalities, which need to be dealt with through collective actions.

Sources: FAO, 2010; FAO, 2012b.

for Sustainable Beef,[3] that aim to accommodate environmental and social concerns into sector strategy. Social concerns such as public health, animal welfare and environmental impacts are increasingly factored into private-sector voluntary agreements.

Policies aimed at supporting the livestock sector have often neglected smallholders and pastoralists, who account for a large proportion of the producers in developing countries. Smallholders are also neglected by the private sector, other than through contract-farming arrangements and limited investment initiatives. It is, however, likely that policy-makers looking to reduce poverty will, in future, increasingly aim to take the needs of smallholders into account. FAO (2010 and 2012b) has proposed an inclusive policy framework aimed at including smallholders (Table 2A6).

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[3] http://grsbeef.org

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Section B

The livestock sector's response

The drivers of change discussed in Section A induce various responses from the livestock sector. The first SoW-AnGR described these responses for each of the main livestock production systems defined by Seré and Steinfeld (1996) (Table 2B1). For consistency, the present report follows the same structure. The classification defines systems based on the proportion of feed dry matter that comes from crops, the proportion of non-livestock farming activities in the total value of farm production and the stocking rate. It differentiates grassland-based, mixed farming and landless systems. Mixed farming (rainfed and irrigated) and grassland-based systems are subdivided by agro-ecological zone.

A recent mapping by ILRI and FAO illustrates the spatial distribution of production systems around the world (Figure 2B1). Grassland-based systems are estimated to account for 26 percent of the ice-free land surface of the world (Steinfeld *et al.*, 2006). However, mixed farming and intensive landless systems account for the majority of production (Steinfeld *et al.*, 2006; Steinfeld *et al.*, 2010; Herrero *et al.*, 2014).

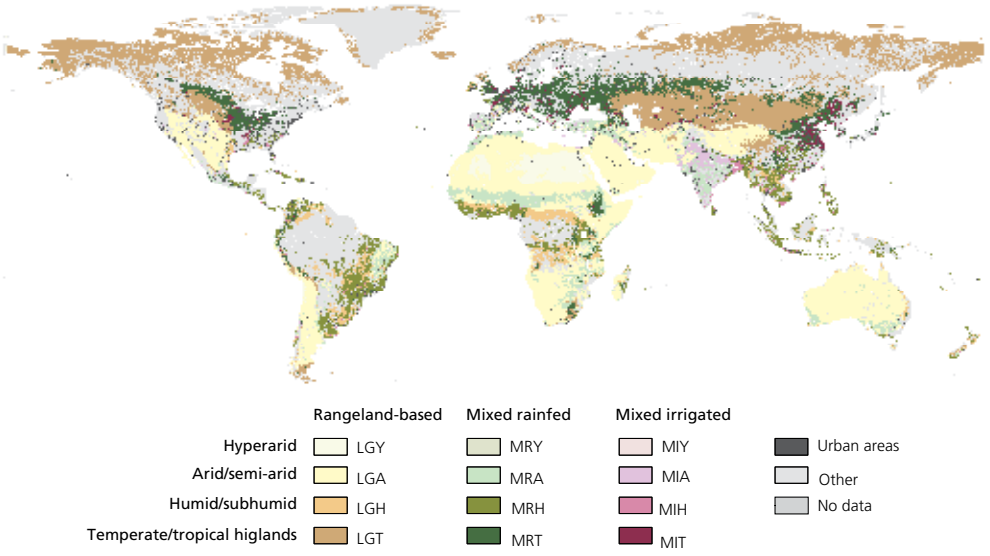
TABLE 2B1
Livestock production systems classification

First system breakdown	Second breakdown	The eleven systems
Grassland-based systems (LG): <10% of dry matter fed to animals comes from crops; and annual average stocking production rates are <10 livestock units ha^{1} agricultural land		Temperate and tropical highlands (LGT)
		Humid/subhumid tropics and subtropics (LGH)
		Arid/semi-arid tropics and subtropics (LGA)
Mixed farming systems (M): >10% of the dry matter fed to animals comes from crop by-products and stubble or >10% of the total value of production comes from non-livestock farming activities	Mixed-rainfed systems (MR): > 90% of the value of crops comes from rainfed land use	Temperate and tropical highlands (MRT)
		Humid/subhumid tropics and subtropics (MRH)
		Arid/semi-arid tropics and subtropics (MRA)
	Mixed-irrigated (MI): > 10% of the value of crops comes from irrigated land	Temperate and tropical highlands (MIT)
		Humid/subhumid tropics and subtropics (MIH)
		Arid/semi-arid tropics and subtropics (MIA)
Landless (LL): <10% of dry matter fed to animals is produced on the farm; and average stocking production rates are >10 livestock units ha^{1} agricultural land		Landless monogastric systems (LLM)
		Landless ruminant systems (LLR)

Source: Seré and Steinfeld, 1996.

PART **2**

FIGURE 2B1
Distribution of livestock production systems



Note: For explanation of the abbreviations, see Table 2B1. In this figure, hyper-arid systems (denoted with a "Y") are distinguished from arid and semi-arid systems.
Source: FAO/ILRI, 2011.

The geographical distribution of cattle, sheep, goats, pigs and chickens has also been mapped (Robinson *et al.*, 2014). Ruminants are widely distributed, although goats are mainly found in Africa, Asia and the Near and Middle East. High cattle densities are found predominantly in mixed-rainfed and mixed-irrigated systems, but can be also found in grassland-based systems. (FAO, 2013a). Chicken and pig densities follow human population densities (for further discussion of the geographical distribution of livestock species, see Part 1 Section B).

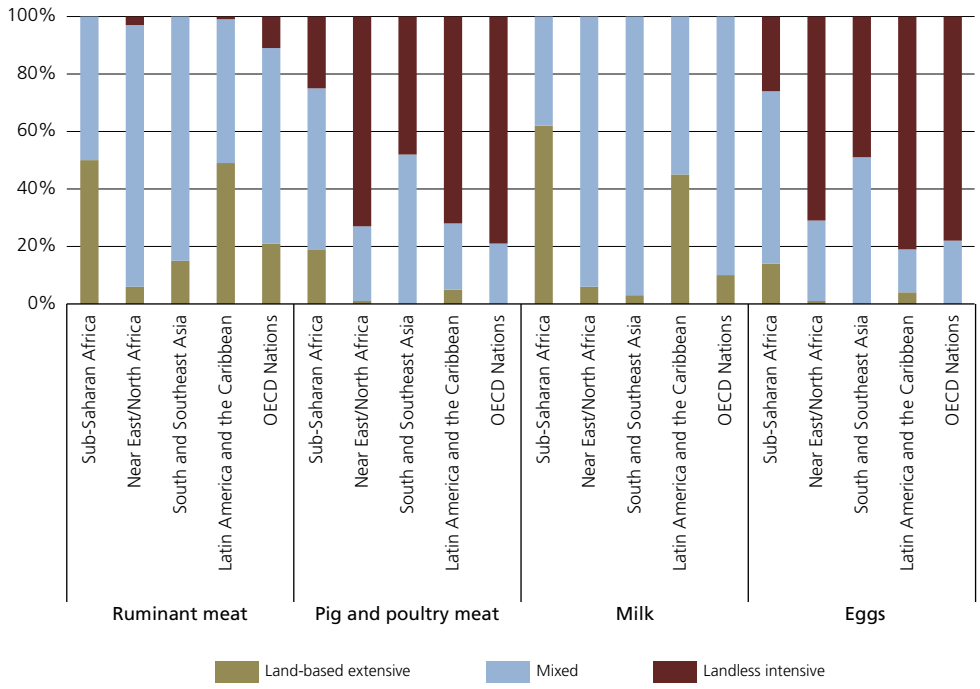
1 Landless industrialized production systems

1.1 Overview

"Industrialization" of production systems (resulting from intensification, scaling-up and geographical concentration of specialized production and processing units) has been a response to increasing demand for animal products. It began in the 1960s in developed countries and in the 1980s in developing countries. Not all landless production is industrialized, but industrialized systems are a substantial and growing part of landless systems. The trend to industrialization has accelerated since the 1990s in developing countries, but has plateaued in the rest of the world. Systems of this type are particularly dominant in the pig and poultry sectors. By the early 2000s, they already accounted for 72 percent of poultry-meat production, 55 percent of pig-meat production and 61 percent of egg production globally (de Haan *et al.*, 2010), although with great variation from region to region (Figure 2B2).

Large-scale landless production systems are economically competitive where demand is relatively high and where large retailers are well

FIGURE 2B2
Production from the main livestock production systems



Note: Land-based extensive = grassland-based.
Source: Graphic prepared using figures for 2004 published in Costales *et al.*, 2010.

established. These systems have benefited from technological advances and have advantages over small-scale production with respect to economies of scale and the ability to provide large and regular supplies to retailers. Large producers also find it easier to manage quality and sanitary standards. Food chains and large retailers have generally preferred contracting with industrial production systems and have stimulated the development of these systems. This is particularly true for poultry meat, egg and pork production.

1.2 Major trends

Expanding production to meet growing demand. Expansion has been particularly marked in monogastric systems, which since the 1980s have experienced faster growth than ruminant systems, a trend that is expected to continue until 2050, especially in the developing world. Herrero *et al.* (2014) estimated that, in 2000, 78 percent of monogastric production came from industrial systems.[1] In 2050, between 85 and 95 percent of production is likely to come from these systems. In contrast, growth in ruminant industrialized systems has been somewhat stagnant. Large-scale beef feedlots have been a feature of production systems in Australia and North America (Galyean *et al.*, 2011), but national herd sizes in these areas have declined in recent years as a result of drought. The systems are also not fully landless, as animals do

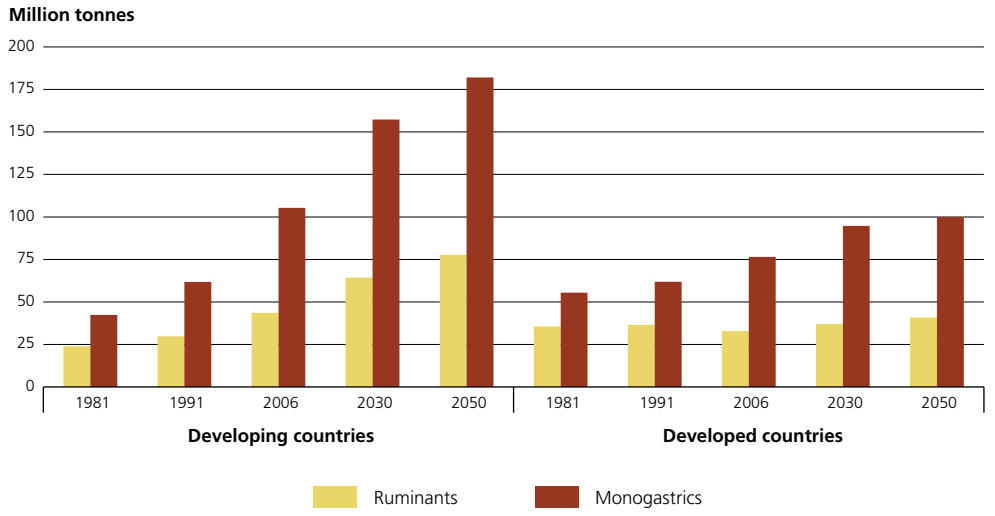
[1] For monogastric production, Herrero *et al.* (2014) differentiated industrial systems from smallholder systems. Ruminant production systems were classified as in the Seré and Steinfeld (1996) classification.

not enter the feedlot until they are one to two years old. The use of feedlots in the Brazilian beef industry has expanded in recent years, accounting for 13 percent of the country's beef production in 2012 (Millen and Arrigoni, 2013). Dairy cattle and small ruminants are much less susceptible to industrialization than monogastrics; although industrial systems exist, the majority of production still comes from mixed farms and grassland-based systems (FAO, IDF and IFCN, 2014).

Moving the production base from developed to developing countries. This trend began in the 1980s and is still evident. Monogastric production, which has historically accounted for much of the output of landless systems and lends itself to industrialization, is growing particularly sharply in developing countries (Figure 2B3). In 1980, industrial systems accounted for more than 90 percent of monogastric production in Europe and Latin America and only 33 percent in Africa and the Middle East. By 2050, industrial production systems may account for 80 percent of the production in developing countries. In Africa, the establishment of intensive poultry farms near cities is becoming more widespread (FAO, 2011a). Industrialization of the dairy sector in developing countries is very slow (Gerosa and Skoet, 2012). Two factors contribute to this effect. In some locations, including the periphery of many large cities and more generally in South and Southeast Asia, farm sizes and herds are small, making it hard to achieve economies of scale. Elsewhere, land holdings and herd sizes are larger, but grazing makes an important contribution to the animals' diets (FAO, IDF and IFCN, 2014). Exceptions to this pattern are North Africa and the Near East, where an arid climate limits the availability of grazing and dairy feedlots are common.

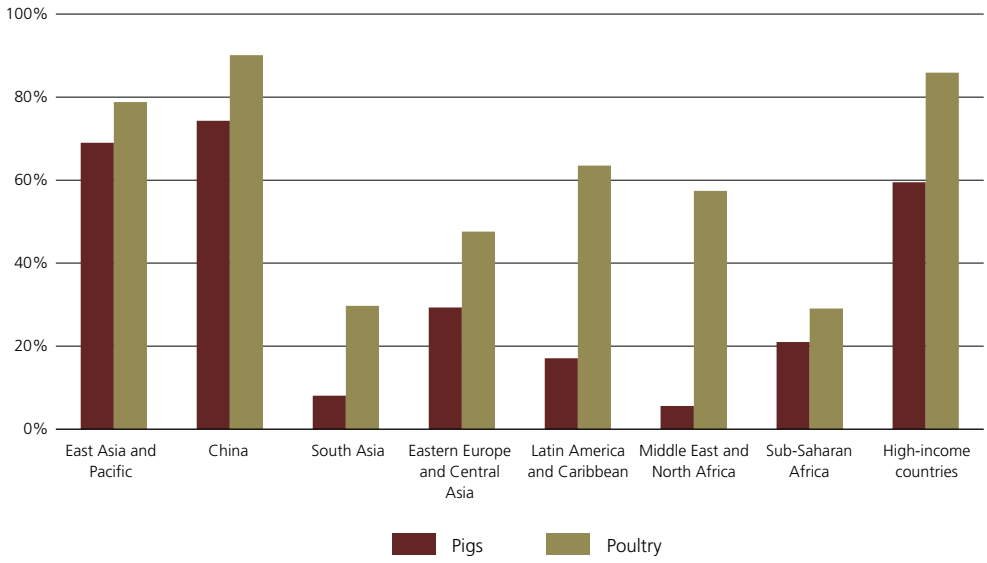
China, India and Brazil have been major contributors to industrialization. In China, for instance, 90 percent of poultry and 74 percent of pigs were raised in industrial systems in 2005, higher proportions than in high-income countries (Figure 2B4).

FIGURE 2B3
Meat production trends in developing and developed countries (1981 to 2050)



Source: Alexandratos and Bruinsma, 2012.

FIGURE 2B4
Proportion of pigs and poultry raised in intensive systems in 2005



Source: Robinson *et al.*, 2011.

Investment against future shocks. Major developing-country producers are taking advantage of developments in technology and animal-health policy to protect themselves against future shocks from disease outbreaks. Large poultry companies, such as Cobb in Brazil and Aviagen in India, are developing certified disease-free compartments, while Chile and South Africa have both introduced compartmentalization schemes for pigs. In Thailand, one of the top-ten poultry exporters before 2003, the largest poultry companies have invested heavily in processing technology, as processed meat is less susceptible to trade bans.

However, it is hard for producers to prepare for shocks caused by price volatility. Prospects for industrialized systems in developing countries will be affected by the price and price volatility of livestock feeds, as many developing countries are (or will be) feed importers (Guyomard *et al.*, 2013). Alexandratos and Bruinsma (2012) estimated a 2 percent annual growth rate in the use of cereal feed in developing countries over the 2005/2007 to 2050 period.

Changing practices in response to societal concerns. Recent years have seen animal welfare issues entering the international policy agenda and affecting livestock-industry practice to a greater degree than they have in the past. Since 2005, the World Assembly of OIE Delegates has adopted ten animal welfare standards for inclusion in the Terrestrial Animal Health Code, including standards for the transport of animals by land, sea and air, slaughter of animals, killing of animals for disease-control purposes, and animal welfare in beef cattle and broiler chicken production. While these standards apply to all livestock production systems, they are most closely scrutinized in industrialized systems. As noted above, concerns about animal welfare led to an EU-wide ban on traditional battery cages for hens in 2012, with producers switching to "enriched" cages, barn production or free-range systems.

Pig producers in Australia are voluntarily phasing out sow gestation stalls, and several large producers in North America and Europe have made small changes to improve welfare in their value chains.

Industrialized systems have also begun to respond to concerns about environmental issues. These systems require large quantities of land, fossil fuels and water to produce feed. They have also been associated with spillages of manure, which can contaminate soil and water (FAO, 2009). Contamination of pastures and croplands with heavy metals (added as supplements to livestock diets and excreted in manure) are particularly hazardous for food-chain safety. Industrial intensive systems affect biodiversity through the destruction and pollution of habitats and their expansion can contribute to the erosion of animal genetic resources (see Section C below and Part 1 Sections B and F). Advances in technology and improvements to management may mitigate some of these impacts. While practices have not yet changed a great deal, research is being carried out on the recovery of nutrients and production of biogas from manure (Cuéllar and Webber, 2008), genetic improvements to improve feed-conversion efficiency and use of alternative feed sources (FAO 2012; 2013b). Some large companies also contribute to discussion fora such as the Global Agenda for Sustainable Livestock (see Section A above).

2 Small-scale landless systems

2.1 Overview

In the developing world, many millions of landless people (i.e. rural or urban people that do not own cropland or pastures and do not have access to large communal grazing areas) keep livestock (Birthal *et al.*, 2006). Animals kept in systems of this kind can provide their keepers with food and other products for sale or home use and play a role in waste management (FAO, 2011). Various feed resources are used, including limited communal grazing, scavenged feed (from streets, yards, etc.), wastes (from kitchens, markets, etc.) and purchased feeds. Small-scale landless production does not fall neatly into widely used production system classifications, and its contribution to global output is difficult to estimate, as is the number of people practising this kind of production.

Small-scale landless producers often use locally adapted breeds, as they tend to be well adapted to scavenging, produce efficiently in backyard conditions and are able to cope relatively well with some diseases and parasites. The main exception to this is in small-scale dairying, where cross-bred cows are often preferred because – provided they receive sufficient feed and appropriate management – they give higher milk yields. Other exotic animals are sometimes raised if they can be accessed easily and production conditions are not too extreme.

Small-scale landless livestock keepers are mostly found in urban and peri-urban areas, close to demand centres. However, they can also be found in rural areas dominated by mixed farming systems where the population density is high and/or land ownership is unequally distributed. Many small-scale landless producers face significant constraints in terms of their ability to access or afford feed and animal-health services. As a consequence, their level of production is low. In rural areas, small-scale landless production is quite peripheral to livestock-sector policies and mostly ignored by government services. The exception is control of major disease outbreaks by culling, which can temporarily decimate livestock populations. In urban areas, small-scale landless production may be targeted by public health and environmental policies. Livestock in cities are a public health concern, as they may transmit zoonotic diseases and parasites. They also cause environmental problems if waste management systems cannot cope with the disposal of manure.

2.1 Major trends

Although the contribution of small-scale landless systems to global production is small, the number of producers is expected to rise in the future. In some countries, access to rural land is becoming increasingly difficult and landless livestock ownership may increase. As authorities often try to exclude livestock keeping from urban areas because of public

health and environmental concerns FAO, 2011), urbanization might be expected to reduce the numbers of landless livestock keepers. However, when rural people migrate to cities to seek new work opportunities they often bring small livestock with them. Urban poverty is still very high and livestock owning provides poor people with a source of income and food. Peri-urban dairy cattle and poultry keeping is also important in the provision of food supplies to growing cities. The first SoW-AnGR suggested that the presence of small-scale intensive systems might prove to be a transitional phase that would be superseded once large-scale production took off. At present, however, "new and old" poultry systems are coexisting in China and small-scale dairy systems remain important in India. It seems likely that this will continue to be the case, at least in the near future.

3 Grassland-based systems

3.1 Overview

Grassland-based systems are found all over the world, predominantly in areas that are unsuitable or geographically inconvenient for crop production. As these systems are highly dependent on the natural environment, livestock breeds are generally well adapted to local water availability, forage and climate. Pastoralist and ranching systems are an important source of protein, converting human-inedible forage into meat and milk (FAO, 2011). Pastoralists, estimated at around 120 million people (FAO, 2011), have developed breeds and management strategies that are well adapted to specific production environments (Watershed Organisation Trust, 2013; FAO, 2013a). In temperate areas, grazing systems are frequently rather intensive and use advanced technologies and specialized breeds (i.e. high-output breeds specializing in the production of single products). In terms of global output of animal products, grassland-based systems are of greatest importance in the cattle and small-ruminant sectors (Figure 2B2).

Grassland-based livestock systems face various pressures. They have to deal with the extreme weather events and new disease threats brought about by climate change with very limited technological options. Pastoralist systems are particularly vulnerable to livestock disease outbreaks, as they often have limited access to animal-health services. They also often have to cope with the effects of civil unrest and various kinds of social and political disruption. In addition to continuing competition from the expansion of croplands and land-use changes associated with the expansion of cities, grassland-based livestock systems face competition from other potential land uses. For example, grasslands can be managed to provide ecosystem services such as regulating water flow in rivers, recharging underground water sources, conservation of wild biodiversity and carbon sequestration, or as sites for wind turbines. In some instances these can be complementary activities to livestock raising, provided that appropriate livestock management is practised. Notwithstanding these challenges, the current consensus is that grazing systems will maintain their current land area until at least 2030 (see next subsection for further discussion).

3.2 Major trends

Maintaining land area. Letourneau *et al.* (2012) estimated that between 2000 and 2030 2.8 million km^2 of pastoral areas will be replaced with rainfed cropland systems. However, the total land area under grazing systems is expected to remain approximately constant to 2030 because of an expansion of 2.7 million km^2 into forested areas. It is likely that replacement of forest by pasture is almost over in Latin America and the Caribbean and declining in South, Southeast and East Asia (FAO, 2013b). Conversely, pastoral systems in sub-Saharan Africa are expected to continue replacing forest areas during the coming decade (ibid).

Increasing importance of arid and semi-arid grassland-based systems. Some of the world's most fragile and sensitive grassland ecosystems, such as the Brazilian and Argentinean cerrados and the savanna areas of certain parts of East

Africa, are under pressure as a result of climate change and the expansion of croplands (IPCC 2014, citing Lambin and Meyfroidt, 2011). Despite these challenges, projections suggest that arid and semi-arid grassland-based livestock systems in sub-Saharan Africa will increase their output of small-ruminant meat and milk and, to a lesser extent, beef and cattle milk (Herrero *et al.*, 2014).

Diversification within pastoralist systems. The various pressures affecting pastoralist systems are leading to changes in the lifestyles and livelihoods of livestock keepers, including a trend towards sedenterization (FAO, 2011). Economic circumstances have created a growing gap between richer and poorer pastoralists in the Horn of Africa, with some becoming contract herders, while others become more substantial livestock owners and traders (Aklilu and Catley, 2010; FAO, 2011). As the human population in Mongolia grows, it appears that herders with smaller numbers of animals are being gradually forced out of herding, while among those who remain as herding households, many are acutely vulnerable to poor climatic conditions and are likely to face periodic food insecurity (FAO, 2011). Historically, policies have generally not been helpful to pastoralists, but some changes aimed at providing appropriate rights and services to pastoralist populations are occurring, for instance in China and Senegal (Steinfeld *et al.*, 2010).

Changes in ranch systems. Ranch systems in Latin America and the Caribbean have faced changes as a result of pressure from expanding croplands and mixed systems. This has recently led to changes in Brazilian beef production systems, with increasing use of feedlots (Millen and Arrigoni, 2013).

Limited progress in mitigating rangeland degradation and deforestation. Rangeland degradation is a major issue in grazing systems and may be exacerbated by climate change, land competition and increasing grazing intensities. Over the 2000 to 2050 period, grazing intensities are expected to increase by 70 percent in Latin America and the Caribbean (Robinson *et al.*, 2011). It has been estimated that in Burkina Faso, Mali, Niger, Nigeria and Senegal, around 70 percent of rangelands are degraded (Gerber *et al.*, 2010). Preventing pasture degradation where institutions for resource management are lacking is difficult (FAO, 2011). However, policies are increasingly targeting pasture restoration and the mitigation of rangeland degradation. In China, for example, the Loess Plateau and the grasslands of Inner Mongolia are especially vulnerable to land degradation (Gerber *et al.*, 2010). Recent policies have aimed to apply partial or complete grazing bans, progressively, over 70 million hectares in Inner Mongolia (Kemp *et al.*, 2013). Overall, China is spending US$2 billion a year on grassland management and related poverty-alleviation programmes (ibid.).

Deforestation caused by the expansion of rangeland systems into forested areas leads to biodiversity loss and greenhouse gas emissions. It has been estimated that 13 million hectares were deforested for pasture establishment in Latin America between 1990 and 2006 (Opio *et al.*, 2013). Around one-third of greenhouse gas emissions from beef production in Latin America and the Caribbean during this period have been attributed to pasture expansion (ibid). At the time, Brazil and Costa Rica's policies included incentives and subsidies/credits to establish pastures on deforested land (Gerber *et al.*, 2010). However, as noted above, deforestation for grazing-land expansion in Latin America is likely to be coming to an end (Letourneau *et al.*, 2012; FAO, 2013a). For example, in Costa Rica, policies have recently addressed forest protection and recovery through the establishment of national parks and protected areas accounting for more than 35 percent of the total forest cover in 2005 (Gerber *et al.*, 2010). Deforestation remains an issue in Asia and Africa, although it appears to be declining in Asia.

Potential for diversification of livelihoods from grasslands. There is growing acknowledgment of the importance of preserving vital ecosystem services, including the provision of habitat for plant and animal biodiversity, pollination, climate regulation and the supply of potable water (Noble *et al.*, 2014). In some areas it may be possible for grassland-based livestock to co-exist with the

provision of carbon sequestration services, conservation of grassland to improve water flow in rivers or generation of electricity from wind turbines (Antle and Stoorvogel, 2011; de Jode and Hesse, 2011; Grassland Foundation, 2005; Neely and De Leeuw, 2011; World Bank, 2009). Co-use of land may require livestock to be kept at lower stocking rates, but could potentially generate higher economic returns from grassland than livestock alone. It requires careful management and functioning markets for non-livestock outputs.

4 Mixed farming systems

4.1 Overview

Mixed farming involves the integration of livestock and crop production into one system. Livestock provide manure to fertilize the soil and (in some cases) draught power for agricultural work. Crops provide feed for the animals. Mixed-rainfed systems are found particularly in temperate areas of Europe and North America, in humid and subhumid areas of Latin America and the Caribbean and Africa, in semi-arid areas of Africa and in South Asia. Mixed-irrigated systems are predominantly found in East and South Asia. Mixed farming systems account for a large share of global livestock production, making a particularly significant contribution to milk and ruminant-meat production (Figure 2B2).

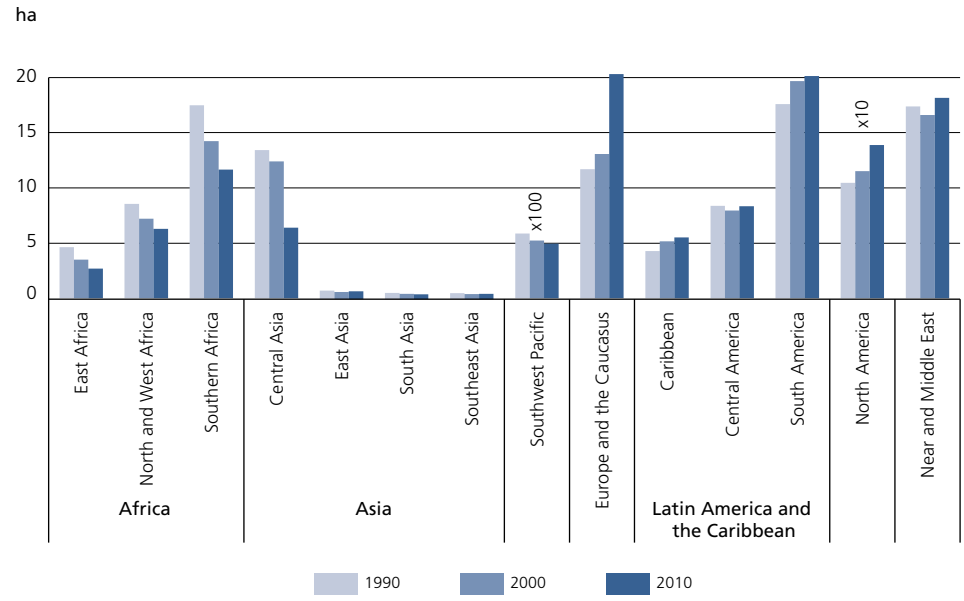
In the developed regions of the world, mixed farms are mainly intensive and production tends to be specialized. A narrow range of breeds with high production potential are increasingly used. There has been a trend towards landless production, especially for monogastric animals. In developing countries, both intensive and extensive mixed farming systems are dominated by small-scale production. Intensive mixed systems are generally market oriented. Depending on the circumstances, they may use either locally adapted breeds or cross-breeds (exotic × locally adapted). Extensive mixed farms, particularly those in marginal areas of developing countries, are predominantly subsistence or semi-subsistence oriented, with weak integration into the market. The breeds kept in these systems are mainly locally adapted, and multipurpose livestock production (meat and milk, meat and traction, etc.) remains important.

4.2 Main trends

Stagnation in developed countries. Projections suggest that most of the future growth in developed-country livestock output will be in poultry and pig production (OECD/FAO, 2014), which is concentrated mostly in landless systems. It is likely that, due to scarcity and costs of water and feed, mixed farming systems will intensify without changing into landless systems. These resource constraints will result in stagnation or even a decrease in the output of livestock products from these systems. There are indications of long-term trends towards larger farm sizes and ageing farming populations in developed countries. However, the impact of these trends is not yet clear. There are also some important nuances – including, in some countries, persistence of small and larger farms while medium-sized farms slowly disappear, and shifts in the social groups entering and leaving farming – that may affect livestock production and productivity in unexpected ways (Australian Bureau of Statistics, 2012; DEFRA, 2012; Mulet-Marquis and Fairweather, 2008; USDA, 2014).

Persistence of smallholders in developing countries. The prevalence of small-scale production in both intensive and extensive mixed farming systems in developing countries is expected to persist, as a result of continuing fragmentation of land (Steinfeld *et al.*, 2010). Agricultural land area per person economically active in agriculture has decreased over recent decades in all developing regions except Latin America and the Caribbean, reaching 0.6 ha in South and Southeast Asia, where farms are smallest (Figure 2B5). Farm sizes in Latin America and the Caribbean are expected to grow. In small mixed farms, livestock are an important source of income; it has been estimated that they typically contribute 5 to 20 percent of total household income in mixed-rainfed systems and 25 to 35 percent in mixed-irrigated systems (Steinfeld *et*

FIGURE 2B5
Agricultural land available per person economically active in agriculture



Source: FAOSTAT.

al., 2010). Smallholder mixed farming systems are predicted to remain the main producers of ruminants until 2050 (Herrero *et al.*, 2014).

Increasing pressure on intensive mixed systems in developing countries. Although consumption growth, integration into markets and new life opportunities encourage intensification and commercialization, intensive systems in developing countries are coming under increasing pressure from land fragmentation, limited resources and increasing input costs (feed and drugs). Increasing concentration of animal populations also makes disease control more challenging. It is expected that during the period to 2030 growth in crop productivity will drastically slow or even end (Herrero *et al.*, 2012). Climate change is a major challenge to sustainability and even irrigated systems are facing problems of water shortage. In Africa, semi-arid mixed-rainfed systems in the Sahel, arid and semi-arid grazing systems in East Africa and mixed and grazing systems in the Great Lakes Region may be severely affected by climate change (Thornton, 2014). Notwithstanding these various pressures, mixed systems are expected to survive, and in extensive systems productivity gains may be possible (Herrero *et al.*, 2012).

Environmental impacts. Well-managed mixed farming systems are recognized as being relatively benign in environmental terms. However, intensification, with increasing inputs and stocking rates, can lead to more severe impacts on the environment, particularly through increased demand for concentrate feeds. Over the 2000 to 2030 period, rainfed croplands are predicted to expand by 4.3 million km^2 (Letourneau *et al.*, 2012), with part of this expansion resulting from a growing need for livestock feed. The first SoW-AnGR identified several environmental problems associated with

irrigated mixed farming, including waterlogging, salinization of soils, the effects of dam building and issues linked to the disposal surplus of water.[2] These problems persist and may increase if livestock production in mixed systems continues to intensify.

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Section C

Effects of changes in the livestock sector on animal genetic resources and their management

1 Overview and regional analysis

As described above in Sections A and B, the livestock sector in many parts of the world is undergoing rapid transformation, driven by both demand-side and supply-side factors. This section aims to describe the effects that these changes are having on animal genetic resources (AnGR) and their management. The first SoW-AnGR noted, in particular, that the intensification of the livestock sector was having a major influence on AnGR management and leading to the more widespread use of a narrow range of international transboundary breeds, often exotic to the countries where they were being used. It noted that locally adapted breeds retained an important role in more traditional production systems, but that the sustainable use of AnGR in these systems was being disrupted by a number of factors, including inappropriate policies, climate change and degradation of natural resources or problems with access to these resources. On the more positive side from the perspective of maintaining AnGR diversity, it noted that cultural roles, demand for environmental services and the emergence of new niche markets were to some extent stimulating the use of locally adapted breeds and that there was potential scope for expanding these uses. It also noted the potential future significance of locally adapted AnGR in the context of climate change and other threats to the sustainability of high external input systems and the use of high-output breeds.

With the aim of obtaining more detailed information on how these broad trends are playing out at national level, the country-report questionnaire for the second SoW-AnGR[1] included questions on the main drivers of change identified in the first SoW-AnGR (see Table 2C1). Countries were asked both to describe the effects of the drivers and to provide scores for the extent of their impacts on AnGR and their management during the preceding ten years and for predicted impacts for the next ten years.

The quantitative responses are summarized in Figure 2C1. With regard to impacts over the last ten years, six of the 15 drivers – changes in demand (quantity and quality), changes in imports, factors affecting the popularity of livestock keeping, policy factors and changes in state of grazing lands – received an average score of more than 1.5 (midway between "low" and "medium"). Most of the other drivers scored between 1 and 1.5. The exceptions were changes in livestock's cultural roles and the replacement of livestock functions. The low scores for these two drivers may reflect the fact that in a number of countries these changes had largely played out more than ten years ago. The high score for quantitative changes in demand coincides with the conclusion drawn in the first SoW-AnGR that this major driver of livestock-sector trends is having a substantial effect

[1] For further information on the reporting process, see "About this publication" in the preliminary pages of this report.

TABLE 2C1

Drivers of change explored in the country-report questionnaire

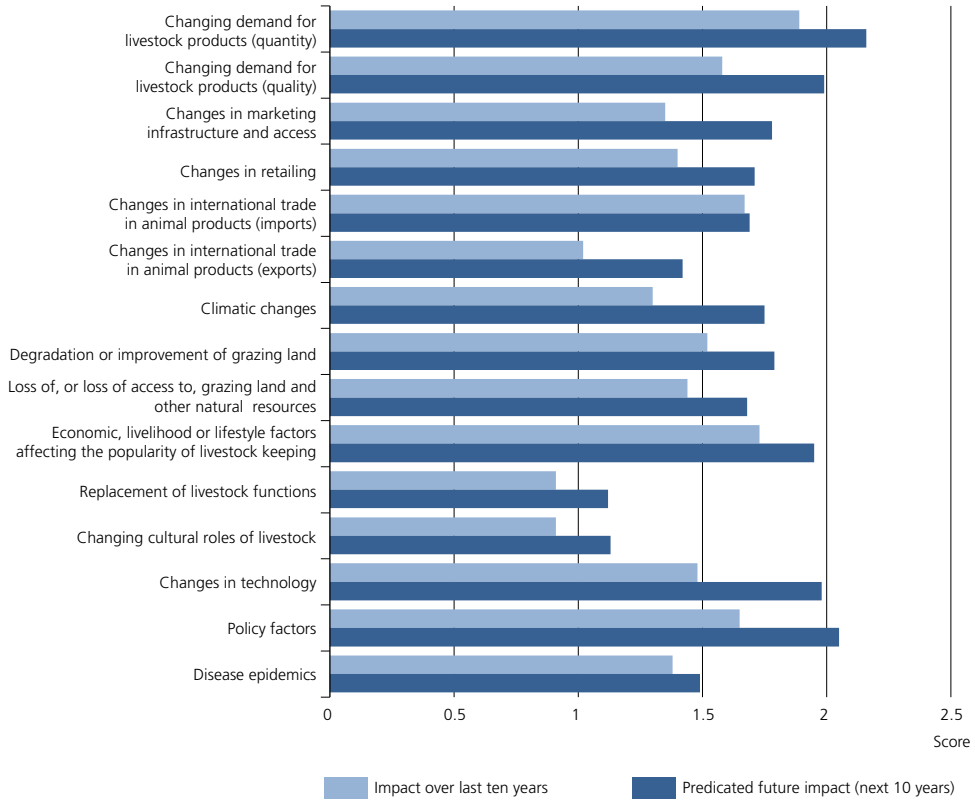
Drivers	Explanatory notes provided in the questionnaire
Changing demand for livestock products (quantity)	Changes in the quantity of product demanded by the market. For example, population growth, urbanization and higher incomes may have increased demand for meat, eggs and milk. Another possibility is that increasing availability of alternative products may have reduced demand for some livestock products.
Changing demand for livestock products (quality)	Changes in the type of products demanded by consumers (e.g. greater or lower demand for convenience foods, healthier products, animal welfare friendly products, environmentally friendly products, traditional products or other niche-market products).
Changes in marketing infrastructure and access	Changes that improve or reduce livestock keepers' access to markets for their products (e.g. better transport, better access to market information).
Changes in retailing	Changes in how animal products are retailed (e.g. expansion of supermarkets).
Changes in international trade in animal products (imports)	Increases or decreases in the importation of animal products into the country. [Respondents were reminded that imports and exports of genetic material were covered in a separate section of the questionnaire.]
Changes in international trade in animal products (exports)	Increases or decreases in the extent to which the county's livestock sector is oriented towards production for export. [Respondents were reminded that imports and exports of genetic material were covered in a separate section of the questionnaire.]
Climatic changes	Departures from the climatic patterns observed in preceding decades. These might include changes in the average temperature and levels of rainfall or changes in the frequency of events such as droughts, floods and hurricanes. [Respondents were advised that they did not have to decide whether these changes are attributable to human-induced climate change. For the future period, respondents were requested to base their answers on their knowledge of AnGR management in the respective country and its vulnerability to the effects of climate change as predicted by the best-available climatic models for the country.]
Degradation or improvement of grazing land	Changes to grazing land that make it less or more suitable for grazing livestock (e.g. erosion, changes in the species composition of the flora).
Loss of, or loss of access to, grazing land and other natural resources	Situations in which grazing lands, arable land used for fodder production or other resources such as water, are lost (e.g. because of urban or industrial development) or in which livestock keepers' access to such resources is restricted (e.g. changes in regulations may mean that pastoralists are not permitted to use certain grazing lands).
Economic, livelihood or lifestyle factors affecting the popularity of livestock keeping	This refers, for example, to changes in the availability of alternative employment activities outside livestock keeping, changes in the relative attractiveness of livestock keeping in economic terms or changes in lifestyles or lifestyle aspirations that make livestock keeping less or more attractive as an activity.
Replacement of livestock functions	Situations in which particular livestock functions are replaced by alternatives. For example: draught animal power may be replaced by mechanical power; livestock's savings and insurance functions may be replaced by banks and insurance companies.
Changing cultural roles of livestock	Changes to the roles of livestock in cultural practices and events (e.g. ceremonies, festivals, shows and sports).
Changes in technology	Technological developments and changes in access to technologies within the livestock sector (e.g. in the fields of animal health, feeding, housing, reproduction or genetics).
Policy factors	This refers to policies that affect the livestock sector. [Respondents were directed to the relevant section of the first SoW-AnGR for further information.]
Disease epidemics	Outbreaks of animal diseases: these may, for example, pose a threat to at-risk breeds (either directly or because of culling programmes). AnGR and their management may also be affected by other types of disruption associated with epidemics and their management (restrictions on marketing animal products, restrictions on animal movements, etc.).

on AnGR management, and with widespread concerns that economic and demand-related factors pose a threat to AnGR diversity (FAO, 2009a). Qualitative changes in demand scored somewhat lower, but their impact is predicted to increase considerably in the future.

The relatively high score given to the effects of imports of animal products presumably reflects the impact of competition on national livestock sectors. The impact of export trade is reported to have been relatively low, but the significance of this driver is predicted to rise

FIGURE 2C1

Past and predicted future impacts of the drivers of change on animal genetic resources and their management



Notes: Each country provided a score for the level of past and predicted future impact. The scores were converted into numerical values (none = 0; low = 1; medium = 2; high = 3).
Source: Country reports, 2014.

substantially in the future – the largest proportional increase (40 percent) among all the drivers considered. Factors affecting the popularity of livestock keeping as a livelihood activity (lifestyle changes, alternative employment opportunities, etc.) were not stressed particularly heavily as drivers of change in the first SoW-AnGR, but received the second highest average score in the country-report responses. Given that in many countries there is a tendency for small-scale livestock keepers (generally regarded as "guardians" of AnGR diversity) to move out of the sector (FAO, 2009b), the effect of this driver on AnGR is likely to be mainly negative in terms of maintaining diversity, although in some circumstances growth of interest in livestock keeping as a hobby or "alternative" lifestyle may contribute to the ongoing maintenance of non-mainstream AnGR.

The relatively high score received by policy factors coincides with the conclusion drawn in the first SoW-AnGR that livestock-sector policies

can have a significant effect on AnGR management. As discussed above in Section A, a wide range of policy areas and types of policy instruments can affect AnGR management. Over the last decade or so, discussions of general objectives of livestock-sector development have increasingly emphasized the importance of improving the efficiency of production, particularly with regard to reducing the amount of greenhouse gas emitted per unit of food produced (Steinfeld *et al.*, 2006; FAO, 2009b). There has been a tendency to regard smallholder and pastoralist systems as relatively inefficient, which if translated into concrete policies could potentially have a negative effect on livestock diversity by de-emphasizing the production systems that tend to favour the maintenance of a diverse range of AnGR. Recent years have, however, seen some alternative views put forward regarding the nature of "efficiency" in livestock production systems, including arguments related to the need to take a broader range of livestock products and services into account on the output side and the need to consider a wider range of inputs and environmental impacts (see Box 2C1). It remains to be seen whether arguments of this kind will have a significant effect on future policies.

It is interesting to note that the effects of all the drivers considered in the country reports are predicted to be greater in the future than in the past. Apart from above-noted increase in the significance of export trade, the drivers whose impact is expected to show the greatest increases are climate change (35 percent increase) (see Box 2C2 for an example), technological changes (33 percent) and changes related to marketing access and infrastructure (32 percent increase).

There are a number of regional differences in the significance of the various drivers (Table 2C2). For example, in Africa, there is predicted to be a big increase (relative to that in other regions) in the impact of drivers related to demand, marketing and retailing. This is consistent with: i) the predicted increase in demand for animal products in Africa (see Section A above); and ii) the major scope for change that exists in the management of AnGR in this region. Given this background, the finding may not be particularly surprising. However, it highlights the increasingly dynamic nature of AnGR management in the region and – given that drivers in this category are commonly regarded as threats to AnGR diversity – the need for action to ensure that changes are managed sustainably. The effects of policies and technological changes are also predicted to increase substantially in this region. This might again be interpretable as an unsurprising response to a dynamic period of development, but given the potential of both policies and the use of technology to have both positive and negative effects on AnGR diversity, it again highlights the need to ensure appropriate management, including monitoring programmes for trends in the size and structure of breed populations. Africa also generally has higher future scores for environment-related drivers (climatic changes, drivers related to grazing land, disease) than other regions. Some of these drivers (climatic changes and degradation of grazing land) also have relatively large predicted increases in their effects.

In Asia, the predicted future impacts of demand- and marketing-related drivers are mostly similar to those in Africa. The difference between the two regions is that, in Asia, most of these drivers received similar scores for their past and future impacts. A big jump in the impact of export trade is, however, predicted for Asia.

In the Southwest Pacific, drivers related to the environment and natural resources stand out in terms of their predicted future increases in impact. However, in absolute terms, the scores for these drivers are not particularly high relative to other regions. From relatively low levels in the past, the impacts of cultural change, technological change and policy factors are predicted to increase substantially.

The situation in Europe and the Caucasus is relatively stable in terms of differences between past and future impacts. The largest predicted changes

Box 2C1

Efficiency and multifunctionality in extensive livestock systems

It is sometimes argued that extensive livestock production systems are relatively harmful to the environment because of their low efficiency in terms of transforming inputs into animal products (milk and meat), which results in a relatively high carbon footprint. Recently, however, some studies assessing environmental impacts of different production systems have tried to consider other livestock functions such as manure production, draught power and insurance and savings.

If multifunctionality is taken into account, the environmental efficiency of extensive dairy systems may appear comparable, if not superior, to that of more intensive systems. For example, Weiler *et al.* (2014) estimated the carbon footprint of a Kenyan smallholder dairy system to be 1.1 kg CO_2-e (carbon dioxide equivalent) per kg milk if calculations include the allocation of emissions to a range of livelihood benefits. This amounts to half the carbon footprint estimate obtained if emissions are allocated only to food products (milk and meat) and falls within the range of results for intensive systems in OECD countries (0.8–1.3 kg CO_2-e per kg milk).

Vigne (2014) compared the efficiency (or "transformity") of different dairy production systems in terms of gigajoules of solar energy per joule of product and estimated that, despite lower production levels, the efficiency of extensive dairy systems in Mali (490 GJ of solar energy/J of product) was comparable to that of semi-intensive systems in western France (410–500 GJ of solar energy/J of product) and much more efficient than that of the intensive systems studied in Réunion (1 210 GJ of solar energy/J of product). The same study also concluded that the inputs used in the extensive systems (consisting mainly of locally available raw materials) had a higher renewability (44 percent of total resources consumed) than those of the semi-intensive and intensive systems studied (21 percent and 24 percent, respectively).

Both studies underline the necessity of incorporating multiple livestock functions into life-cycle assessments and other methodologies for estimating the environmental impact of production systems.

Box 2C2

Shift of livestock species as a result of climate change: an example from Ethiopia

Pastoral areas of Ethiopia have experienced substantial increases in temperature in recent years. Southern, southwestern and southeastern areas have undergone a decline of 15 to 20 percent in spring and summer rainfall since the mid-1970s. Yosef *et al.* (2013) report the findings of a survey of 200 pastoralists in the Afar, Oromiya and Somali Regions of Ethiopia that assessed livelihood diversification and cattle and dromedary population dynamics. Official surveys indicate a decline of 50 to 70 percent in the cattle population over the last 20 years in most of the districts covered by the study. Conversely, the dromedary population increased by between 10 and 200 percent, depending on the district. A large majority of the cattle owners interviewed stated that they intended to reduce the number of cattle they kept. One district was an exception, in that a majority reported an interest in increasing the number of cattle kept by crossing their animals with breeds that have better resistance to drought and disease. All interviewees indicated their desire to increase the number of dromedaries in their herds. Dromedaries were reported to provide a better source of income than cattle, sheep or goats. Based on the results of the survey, the authors conclude that the observed species shift could pose a threat to indigenous cattle breeds in the near future.

TABLE 2C2

Past and predicted future impacts of livestock sector trends and drivers on animal genetic resources and their management

Regions	Africa			Asia			Southwest Pacific			Europe and the Caucasus			Latin America and the Caribbean			North America			Near and the Middle East			World		
	Past	Future	Δ	Past	Future	Δ	Past	Future	Δ	Past	Future	Δ	Past	Future	Δ	Past	Future	Δ	Past	Future	Δ	Past	Future	Δ
Changing demand for livestock products (quantity)	1.9	2.5	0.6	2.2	2.4	0.2	2.3	2.1	-0.2	1.6	1.7	0.1	1.9	2.1	0.2	2	2	0	2.3	2.4	0.1	1.9	2.2	0.3
Changing demand for livestock products (quality)	1.4	2.1	0.7	1.9	2.1	0.2	1.9	1.9	0	1.6	1.9	0.3	1.6	2	0.4	2	2	0	1.6	1.6	0	1.6	2.0	0.4
Changes in international trade in animal products (imports)	1.7	1.7	0	1.9	1.8	-0.1	1.3	1.3	0	1.7	1.7	0	1.6	1.8	0.2	1	1	0	1.6	1.4	-0.2	1.7	1.7	0.0
Changes in international trade in animal products (exports)	0.9	1.5	0.6	1.2	1.8	0.6	0.4	0.9	0.5	1.2	1.4	0.2	1.1	1.6	0.5	2	2	0	0.4	0.4	0	1.0	1.4	0.4
Changes in marketing infrastructure and access	1.3	2.1	0.8	1.7	2.1	0.4	0.9	1.4	0.5	1.4	1.5	0.1	1.4	1.8	0.4	1	1	0	1	1.3	0.3	1.4	1.8	0.4
Changes in retailing	1.3	1.9	0.6	1.6	1.9	0.3	1.3	1.6	0.3	1.5	1.6	0.1	1.4	1.7	0.3	1	1	0	1.1	1.1	0	1.4	1.7	0.3
Economic, livelihood or lifestyle factors affecting the popularity of livestock keeping	1.8	2.2	0.4	1.9	2	0.1	1.6	2	0.4	1.9	2	0.1	1.5	1.7	0.2	2	2	0	0.6	0.7	0.1	1.7	2.0	0.2
Changing cultural roles of livestock	0.9	1.2	0.3	1.5	1.5	0	1	1.7	0.7	0.7	0.9	0.2	0.7	1	0.3	1	1	0	1	1	0	0.9	1.1	0.2
Replacement of livestock functions	0.9	1.4	0.5	1.4	1.6	0.2	0.6	0.7	0.1	0.9	0.8	-0.1	0.9	1.1	0.2	0	0	0	0.6	0.6	0	0.9	1.1	0.2
Climatic changes	1.7	2.2	0.5	1.5	1.8	0.3	0.7	2	1.3	0.7	1.1	0.4	1.6	2.1	0.5	1	2	1	1.3	1.3	0	1.3	1.8	0.5
Degradation or improvement of grazing land	1.9	2.3	0.4	1.8	2	0.2	0.9	1.6	0.7	1.1	1.2	0.1	1.6	1.9	0.3	0	0	0	1.3	1.6	0.3	1.5	1.8	0.3
Loss of, or loss of access to, grazing land and other natural resources	1.9	2.1	0.2	1.7	1.7	0	1	2	1	0.9	1.1	0.2	1.6	2	0.4	2	2	0	0.7	0.7	0	1.4	1.7	0.2
Disease epidemics	1.8	1.7	-0.1	1.7	1.7	0	0.7	1.3	0.6	1.1	1.4	0.3	0.7	1.1	0.4	0	2	2	1.9	1.3	-0.6	1.4	1.5	0.1
Changes in technology	1.2	2.1	0.9	1.7	2.1	0.4	0.7	1.6	0.9	1.7	1.8	0.1	1.8	2.2	0.4	3	3	0	1.7	1.3	-0.4	1.5	2.0	0.5
Policy factors	1.5	2.1	0.6	1.7	2	0.3	1.1	1.7	0.6	2.1	2.3	0.2	1.5	2.1	0.6	2	2	0	1.4	1.4	0	1.6	2.1	0.4

Note: Each country provided a score for the level of past and predicted future impact. The scores were converted into numerical values (none = 0; low = 1; medium = 2; high = 3). Dark orange = increase of 1 or more in average score from past to predicted future; light orange = increase between 0.6 and 1; dark yellow = increase between 0.3 and 0.6; light yellow = no change or increase of less than 0.3; pale blue = decrease of less than 0.3; medium blue = decrease of 0.3 or more.
Source: Country reports, 2014.

are in the impacts of climatic changes, animal diseases (perhaps to some degree connected to climatic change) and qualitative changes in demand. The driver with the most impact (both in the past and predicted for the future) is policy. This probably reflects the significance of AnGR-focused policies (i.e. policies specifically aiming to promote conservation and sustainable use) in the European Union (EU) and in some other European countries (see Part 3 Section F). This is the only region where quantitative changes in demand do not have the highest or joint highest impacts (both past ten years and predicted future).

Latin America and the Caribbean reports a pattern of past impacts that is roughly similar to those of Asia and Africa. Predicted changes from the past to the future indicate a moderate degree of dynamism, but changes in the impacts of demand and market-related drivers are generally less dramatic than in Africa. The biggest increase in impact is predicted in the policy field. Moderate increases are predicted across a range of different drivers, including those related to the environment and natural resources, exports, marketing infrastructure and qualitative changes in demand.

In the Near and Middle East, the past and future impacts of most drivers are predicted to be similar. The largest predicted increases are in the impacts of changes in marketing infrastructure and access and changes in the state of grazing land. The impact of several drivers is predicted to decrease, including, in sharp contrast to other developing regions, technological changes. The impact of disease epidemics is predicted to decline because of improvements to veterinary provisions in some countries.

2 Specific effects on animal genetic resources management – examples at country level

As noted above (see also Part 1 Section F), it is generally considered that rising demand for livestock products drives production-system changes that tend to lead to the wider use of a narrow range of breeds (those suitable for use in industrial or other high-input systems) and constitute potential threats to the survival of other breeds because of replacement (see Box 2C3) or in some cases indiscriminate cross-breeding. This analysis is generally borne out by the descriptions provided in the country reports. The report from Suriname, for example, notes that producers' desire for "quick" improvements in production has led to the introduction of exotic breeds with high yield potential, even though this has created problems associated with higher expenses for feed, housing and overall management. Despite these problems, there is reportedly "a reluctance or in some cases inability" to switch back to using locally adapted breeds. The report from Niger mentions that the effects of greater demand for livestock products, driven by population growth and urbanization, have included the emergence of a new layer of rich farmers and the impoverishment of thousands of small-scale livestock keepers that raise locally adapted breeds.

As described above in Section A, changes in income levels and lifestyles can lead to changes in the types of animal-source food sought by consumers. For example, urbanization and rising incomes tend to lead to an increase in demand for convenience foods, often mass-produced and sold by large retailers. However, a certain level of affluence, and changing fashions, may lead to growing interest in speciality food products, potentially including those that are more traditional or perceived to be so. Social and environmental concerns may start to exert greater influence on consumers' choice of products. The first SoW-AnGR noted that the homogenization of consumer demand posed a potential threat to AnGR diversity, while the emergence of niche markets offered a potential means of keeping "non-mainstream" breeds in use. The establishment of "new" niche markets for animal products has tended to be a developed-country phenomenon. However, a number of examples from developing countries have been recorded (LPP *et al.*, 2010) (see also Part 1 Section D). Moreover, in many developing countries,

Box 2C3

Animal genetic resources management in Iceland: will exotic breeds substitute locally adapted breeds?

Iceland has only one breed for most species of livestock. The roots of these breeds can be traced back to the settlement of Iceland. They are believed to have been subject to extremely limited cross-breeding with exotic breeds. Icelandic breeds are unique in that their diversity, in terms of traits such as colour, is greater than that of other livestock breeds.

Leadersheep,
a unique strain of the Iceland breed of sheep

Photo credit: Jon Eiriksson.

The utilization and breeding of these breeds today appears to be stable and sustainable, and this has been the case for a long time. There is organized, ongoing breeding work in cattle, sheep and horses, under the overall control of the Farmers Association of Iceland. Livestock breeding programmes are subject to special legislation that defines the rules of the programmes and provides for governmental funding to support breeding centres and pedigree and performance recording. There are no signs that the genetic diversity of these stocks is anything but well maintained. However, the healthy and stable state of locally adapted Icelandic breeds is threatened by recent changes in national demand for livestock products. Icelandic consumers' demand for cheaper domestic products has been prominent in recent years, and the pressure can be expected to continue in the near future.

The country's well-organized livestock breeding industry has achieved considerable success in terms of increasing the efficiency of production in recent years and this has led to lower food prices. However, it is possible that demand for more efficient production could lead to Icelandic breeds being unable to maintain their positions in the face of competition from imported higher-performing breeds. The importation of exotic cattle breeds, a subject of discussion in recent years, would completely change the position of the Icelandic cattle population.

Source: Adapted from the country report of Iceland.

long-standing preferences for the taste of products from native breeds continue to influence customer choice. While these general tendencies are widely recognized, the scale and precise nature of their effects on AnGR diversity remain unclear, particularly in developing countries.

The country reports provide a number of examples of the influence of qualitative changes in consumer demand on AnGR management. The report from Slovenia, for example, notes that increasing demand for organic, animal-welfare friendly, environmentally friendly and traditional products means that more emphasis is being given to indigenous breeds. It also predicts that the influence of these consumer demands on AnGR and their management will be higher in the next ten years than in the past. The report from the United States of America mentions that the establishment of new local or regionally based markets will create opportunities for product branding that support the use of at-risk breeds. It also notes that in the case of chickens, consumer demand for "naturally" grown meat has affected the development of new lines, enhancing diversity at commercial level, and that, in some states, animal-welfare regulations may

lead to the development of new genetic lines for cage-free production.

Among developing countries, the report from Kenya notes that indigenous chickens are increasingly being raised for organic meat production. Some other country reports – including those from Bhutan, Namibia and Nepal – note some degree of increasing interest in speciality or high-quality products and a potentially positive effect on demand for locally adapted breeds. The report from Malawi mentions that increasing consumer preference for products from locally adapted breeds is expected to have both positive and negative effects on the sustainable use of AnGR. One the one hand, livestock keepers will be motivated to continue raising locally adapted breeds. One the other, there may be pressure to sell high-quality breeding stock for slaughter. With regard to homogenization of demand and its effects on AnGR, the report from Suriname notes a link to international trade: importation of poultry-meat products has affected consumer tastes and this has led to a strong shift towards the use of exotic breeds.

The effects that changes to marketing infrastructure and market access are reported to be having on AnGR management are also diverse. The most straightforward effect of improving market access is to expose more livestock keepers to the influence of consumer demand in the relevant markets. This can magnify the above-described demand-related effects, either to the cost or to the benefit of AnGR diversity. The potential for negative effects on diversity as a consequence of locally adapted breeds increasingly being replaced by exotic breeds as market access increases is noted, for example, in the country reports from India and Kenya. Conversely, some reports (e.g. Bhutan and South Africa) note the potentially positive effect of increasing access to speciality markets. Specific campaigns to promote the marketing of speciality products or those from particular production systems (e.g. produced by smallholders) have the potential to benefit AnGR diversity. This may occur as a result of a deliberate attempt to promote conservation (see Part 4 Section D) or as a side-effect of efforts to promote livelihood development. The country report from the Netherlands, for example, notes the "potential positive impact of marketing of regional products and labelled products through specific supply chains." Advances in communication technologies are creating new marketing opportunities for some livestock keepers. For example, the report from the Republic of Korea mentions that online marketing has created links between producers and consumers and provides a marketing channel for products from native AnGR.

Several country reports, both from developing and developed countries, mention that ongoing concentration of retailing in the hands of supermarkets is negatively affecting AnGR diversity because of, *inter alia*, demand for more uniform products. However, in a number of countries there is also reported to be increasing interest on the part of supermarkets and other retailers in labelling schemes related to geographical origin, product quality, animal welfare and so on. The country report from South Africa, for example, mentions labelling schemes for grass-fed beef, free-range mutton, Karoo lamb and Klein Karoo ostrich.

Some country reports note that the import of animal products or the demands of export markets are influencing AnGR management. The precise consequences are not always clear. However, in some cases (e.g. Sierra Leone), competition from imports is reported to be discouraging livestock keeping and leading to a decline in animal populations and negative consequences for AnGR. The report from Ghana mentions the negative effects of "unfair competition from imported products" on the local pig and poultry sectors. There is, however, some uncertainty about future trends. The report from Senegal, for example, notes the potential need to ensure that the country's livestock sector is able to meet increasing local demand in the event of rising import prices. On the export side, the country report from South Africa mentions that growing emphasis on animal welfare and sustainable production in export markets is creating opportunities for marketing certified products from

locally adapted breeds. The report from Lesotho notes that export demand for wool and mohair are driving the development of breeding programmes for fibre-producing species.

Production-system trends driven by environmental changes also potentially affect demand for different types of AnGR. Where production systems become "harsher" as a result of climate change, resurgent disease problems, etc., the roles of locally adapted breeds may become increasingly important and demand for them may increase (or decline more slowly). The country report from Barbados, for example, notes that the cost of adapting production environments to provide appropriate conditions for exotic breeds is likely to increase. The report from Brazil, states that climate change is likely to increase interest in the use of locally adapted breeds for cross-breeding, although their low levels of production may hamper the implementation of such strategies. The report from South Africa highlights the effect of climate change on the incidence of diseases and parasites and the roles of resistant or tolerant locally adapted breeds such as tick-tolerant Nguni cattle and native goats that are resistant to internal parasites and cowdriosis. Other reports that mention increasing interest in locally adapted breeds as a result of climate change include those from Rwanda, Solomon Islands and Sudan.

Major environmental changes may make it more difficult to raise some breeds in the geographical areas where they have traditionally been kept and may even lead to shifts in the species raised in a given area. Developments of this kind may pose a threat to some breeds. While immediate threats to specific breeds are rarely reported (possibly because of inadequate monitoring programmes – see Part 3 Section B), many country reports mention the threat that climate change poses to livestock production, and in some cases to AnGR diversity, via the increased prevalence of climatic disasters and disease outbreaks or via more gradual changes to production systems. The report from Mongolia, for example, states that

"Occurrences of natural disasters have become frequent, which ... [adversely affects] AnGR through tremendous death of livestock. For instance, the harsh winter disaster of 2010 resulted in 10.2 million livestock losses, equivalent to 20 percent of the national herd … As the pastoral livestock system is vulnerable to any changes, climate change … will have an adverse impact on … [the system's] AnGR through [effects on] feed and water resources in the future."

Degradation or loss of grazing land is noted as a problem in several country reports. In some cases, climate change is mentioned as a contributing factor. Specific effects on AnGR management are again rarely mentioned. However, the report from Bhutan states that the quality of pastures has declined over the years, with reduced carrying capacity leading to further overgrazing, and that this may require a reduction in the use of low-producing breeds and more emphasis on high-yielding breeds. The report from the Islamic Republic of Iran notes that the main grazing area of the Systani cattle breed, wetlands in the eastern part of the country, have been affected by the construction of a dam in neighbouring Afghanistan.[2] It further notes that some Systani herds were transferred to another part of the country as part of efforts to conserve the breed. Adverse effects of rangeland degradation on locally adapted breeds are also noted in the country report from China. The report from Peru notes that rangeland degradation has led many people, particularly those living at high elevations and keeping camelids and sheep, to sell their land and animals and migrate to towns and cities. The desire to minimize the rangeland degradation caused by livestock keeping can also affect breed choice. For example, the country report

[2] Other problems affecting this area and threatening the grazing lands of the Systani cattle are reported to include reduced precipitation (apparently caused by climate change), expansion of agricultural lands, inefficient irrigation, inappropriate cropping patterns, introduction of non-native aquatic plants and overexploitation of pastures (UNDP, 2014).

from South Africa mentions the case of the Nguni cattle breed, which is considered to be much less harmful to degraded grazing areas than exotic breeds.

In addition to the effects of pasture degradation *per se*, several country reports note that loss of grazing land as a result of the expansion of other land uses is affecting AnGR management. For example, the report from Sri Lanka states that the conversion of grazing land into human settlements, cropland and wildlife parks is limiting the feed resource base for livestock. Some reports (e.g. those from Austria, Bulgaria, India and Kenya) note that developments of this kind are a threat to locally adapted breeds. The report from Peru mentions that commercially oriented quinoa production has fuelled an expansion of cropland and changes in production methods that have affected access to land for camelid husbandry. It also notes that water resources in the lands used by indigenous communities are often appropriated or contaminated by mining operations. The report from the Plurinational State of Bolivia also mentions the effect that expanding quinoa production has had in terms of the loss of pastureland used by camelids and sheep. The report from Ethiopia links the expansion of cropland into grazing areas to the growth of the human population and notes that effects on livestock include a reduction in household herd/flock sizes, poor resistance to disease and interbreeding among breeds as animals move in search of feed.

The impact of replacement of livestock roles and functions on AnGR and their management received a relatively low score in comparison to some other drivers of change (Figure 2C1, Table 2C2). However, changes of this type can have a major effect on demand for specific breeds and species. Among effects of this type, the decline of locally adapted breeds because of the replacement of draught animal power with mechanized power is by far the most commonly mentioned in the country reports (see also Part 1 Section D), although little information is provided about effects on specific breeds.

The report from Burkina Faso mentions that a decline in the savings and insurance roles of livestock is having a negative effect on locally adapted AnGR. However, several other countries indicate that livestock continue to play an important role in the provision of services of this kind. Several country reports mention that the cultural roles of livestock are declining and that in some cases that this is having a substantial effect on AnGR and their management. The report from Sri Lanka, for example, notes that exchange of livestock at the time of marriages used to be a widespread practice and that this helped to distribute livestock and maintain their diversity, but that this practice has disappeared. It also notes that concerns about animal welfare have led to some animal sports (e.g. cock fighting) being prohibited by law and that sacrificing animals at religious events is in decline because of societal disapproval, with the consequence that breeding of the types of animal used in these events is in decline. At the same time, the cultural roles of livestock remain important in many countries and in some cases are being built upon as a means of promoting the sustainable use and conservation of potentially threatened breeds (see Part 4 Section D for examples).

Some new functions are emerging that potentially increase demand for breeds that might be threatened with extinction if they had to continue relying on their traditional roles. The use of livestock in the management of landscape and wildlife habitats, for example, is creating significant demand for some locally adapted breeds in Europe (see Part 1 Section D and Part 4 Section D for examples).

The influence of economic, livelihood or lifestyle factors on the popularity of livestock keeping as an activity and on the type of livestock keeping practised is noted in a number of country reports. Consequences for AnGR management are not always described in detail. However, a number of different effects are noted. For example, several reports from European countries note a decline in the number of small farms and a declining interest in livestock keeping, particularly among young people. This trend is generally regarded

as a threat to AnGR diversity, as the production systems that have traditionally maintained a wide range of locally adapted breeds are tending to disappear. Several country reports from developing countries note the ongoing popularity of livestock keeping. However, a few (e.g. China and Eritrea) mention that changes to traditional production systems and lifestyles is threatening the survival of locally adapted breeds. The country report from the Islamic Republic of Iran notes specifically that the populations of Murkhoz goats and Bactrian camels in the western part of the country are decreasing sharply because of changes in the lifestyles of local people. The report from India offers a more general comment on the popularity of livestock keeping:

> *"New generations are losing interest in livestock keeping because of changes in lifestyle aspirations and alternative opportunities available in the country … Livestock keeping is becoming less profitable. Average herd/flock size is decreasing."*

Technological advances can affect AnGR and their management in multiple ways. Various livestock management technologies can help to create conditions in which exotic breeds can be introduced into areas where they would otherwise not flourish. The country report from Kenya, for example, notes that improved animal husbandry and management practices are leading to more widespread use of exotic breeds. Reproductive technologies, such as artificial insemination and embryo transfer, can make it easier to introduce breeds into new areas and to cross-breed with them. The country report from Zambia, for example, states that more livestock keepers are being trained in artificial insemination and that this has led to increased demand for specialized dairy cattle. Reproductive technologies can play valuable roles in AnGR management, but if breed introductions and cross-breeding are badly managed, problems can be exacerbated by their use. Indiscriminate cross-breeding and breed replacement are among the factors most frequently mentioned in the country reports as causes of genetic erosion (see Part 1 Section F).

Several country reports (e.g. China, Ghana, the Philippines and the Republic of Korea) mention the positive roles that new technologies play in various aspects of AnGR management, including characterization, genetic improvement and conservation. However, the country reports provide little detailed information on the current or predicted future effect of the introduction of genomic technologies (see Part 4 Sections B and C) on the utilization of different types of AnGR. Potential effects of the use of these technologies on the utilization of at-risk or non-mainstream breeds are discussed in Box 2C4.

Box 2C4

The potential influence of genomics on the utilization of at-risk breeds

Introducing genomic selection into a breeding programme reduces the generation interval and allows an increase in genetic progress. However, it requires a large investment and is only applied in breeds with a large critical mass in terms of population size. This may actually increase the gap in production performance between at-risk breeds and the main breeds targeted by commercial breeding programmes and hence potentially increase the risk of breed extinctions.

However, genomics may help motivate efforts to conserve at-risk breeds by facilitating the discovery and utilization of the valuable characteristics these breeds may harbour. Genetic analysis may reveal unique alleles or unique combinations of alleles (haplotypes) that are not present in mainstream commercial breeds. Moreover, the introgression of parts of chromosomes responsible for valuable traits identified in at-risk breeds into commercial breeds is potentially greatly facilitated by genomic selection (Odegard *et al.*, 2009; Amador *et al.*, 2010).

Policy factors are among the drivers reported in the country reports to be having the greatest effect on AnGR and their management, with a considerable increase in their importance predicted for the coming ten years relative to the past (Table 2C2). Impacts on AnGR vary greatly. On the one hand, policies directed at promoting the sustainable use, development and conservation of AnGR can provide valuable support to efforts to prevent breeds from becoming extinct and to maintain diversity. On the other hand, policies can constrain certain types of livestock production and thereby threaten the associated AnGR. Policies may also promote breed replacement, either directly or by promoting production system changes that lead to the introduction of exotic (or other alternative) breeds. Changes in the types of breeds and crossbreeds utilized is an inevitable consequence of the evolution of the livestock sector and these changes are always likely to be affected by a range of policies that are not all favourable to AnGR diversity. As with other drivers of change, there is a need to ensure that the impacts that policies have on diversity are monitored and that, if necessary, action is taken to adjust them or to promote by other means the conservation and sustainable use of breeds that are adversely affected.

The country reports mention a range of different policy-related factors affecting AnGR management. Several note AnGR-focused policies that are benefiting or are expected to benefit the sustainable use, development and conservation of these resources. However, some suggest that policies focus on rapidly increasing the output of animal products lack sufficient emphasis on longer term sustainable management. Some reports mention broader livestock-sector policies that are expected to influence AnGR management: for example, those related to environmental protection, animal welfare, rangeland management not, but and disease control. However, little detailed information on the effects of these policies is provided. Further discussion of the state of national and international policies and legal frameworks on AnGR management can be found in Part 3 Section F.

One issue that was recognized in the first SoW-AnGR as a potential future influence on AnGR management was the question of rising input prices. Although information on the effects of this driver was not specifically requested in the country-report questionnaire, it was mentioned in some responses. Rising feed costs are, for example, noted as a factor influencing AnGR management in the country reports from Barbados and Kiribati. The report from Ghana notes that high production costs are among the factors leading to the closure of many of the country's pig and poultry farms.

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Section D

Livestock sector trends and animal genetic resources management – conclusions

The analysis presented in Section A indicates that while growth may be slowing, global demand for animal-source foods is expected to continue increasing, and indications are that much of this demand growth will be met by production from large-scale landless systems. Meat consumption has expanded very quickly in Latin America, but future expansion is expected to be strongest in South Asia and Africa. The same regions are projected to be the main centres of growth in milk consumption. These are both very resource-constrained regions, where there are still many small-scale livestock keepers and pastoralists and where small-scale milk production has historically been strong. Growth in demand is widely viewed as one of the main drivers of change in AnGR management, and experiences from other regions suggest that dramatic increases in demand create major challenges to the sustainable use of livestock diversity.

Despite the spread of "industrial" and other intensive production systems, the livestock sector in most developing countries remains far from homogeneous. Mixed farming and grassland production systems continue to provide a substantial proportion of output, particularly in the case of ruminants. Livestock continue to play multiple roles in the livelihoods of many poor people. In some circumstances, small-scale commercially oriented producers contribute significantly to meeting growing demand for animal-source food. Production environments remain diverse in climatic and agro-ecological terms, and in many circumstances isolating animals from harsh environmental conditions is impractical. The demands placed on AnGR therefore remain diverse. However, given the evolving (in some cases rapidly evolving) nature of livestock production systems and the fact that knowledge of breed characteristics often remains inadequate, ensuring that breeds and crosses are well-matched to their production environments and to the demands placed on them is challenging. In terms of breed survival, rapid change may mean that a breed's existing role disappears rapidly and that it declines towards extinction before new roles for it can emerge or national authorities recognize the threat and take action to promote its conservation.

In addition to "demand-side" drivers, livestock production is being affected by physical changes affecting the agro-ecosystems in which it takes place. Current changes are, on the whole, creating greater challenges for livestock-keeping livelihoods. Climate change, in particular, is likely to create increasing problems over the coming years and decades. The importance of livestock biodiversity as a resource with which to adapt production systems to future changes and as a source of resilience in the face of greater climatic variability is likely to increase. Climate change, however, also poses threats to the sustainable management of AnGR.

Another widespread trend with important implications for AnGR management is the movement of people out of livestock keeping as a livelihood activity and into alternative employment. In most countries, small-scale livestock keeping is unlikely to disappear in the short or medium term. However, the pull of economic activities outside livestock keeping and of non-livestock

keeping lifestyles often adds to constraints at production-system level in reducing the economic and social attractiveness of livestock keeping. Where trends of this type are strong, AnGR associated with particular traditional types of livestock keeping or with particular communities may be threatened.

In developed countries, industrial and other intensive production systems are already dominant and several traditional livestock functions have become very marginal. Many locally adapted breeds remain at risk of extinction. However, some developments have begun to create roles for breeds that are not competitive in terms of the supply of mass-market products. The most significant trends of this type are probably the growth of niche markets for various kinds of traditional or ethically produced products and the increasing use of grazing animals in the management of wildlife habitats. Given that many developing countries have sizeable middle classes and that many livestock production systems in developing countries provide important regulating and habitat ecosystem services,[1] it is possible that developments such as niche marketing and payment for environmental services might have an increasing influence on AnGR management in the future. There are, however, many constraints to the successful implementation of such schemes in developing countries.

The evolution of livestock production systems is affected not only by economic forces and the state of the physical environment, but also by public policies. The country reports suggest that policy factors have a major effect on AnGR and their management and that this effect is likely to increase in the future. A wide range of policies may be relevant, some focused specifically on AnGR management, but others targeting other aspects of livestock keeping, rural development, consumer protection and the environment. Many may be put in place with no thought to their effects on AnGR diversity. The current state of policy frameworks, their implementation and their effects on AnGR is discussed in Part 3 Section F. There are some positive developments, such as the increasing number of countries developing national strategies and action plans for AnGR. However, weak policies and programmes are still regarded as significant drivers of genetic erosion in a number of countries (see Part 1 Section F). The future of broad livestock-sector policies may be influenced by arguments regarding the nature of efficiency in livestock systems.

Policies that aim to support the sustainable management of AnGR require a long-term perspective. Understanding livestock-sector trends is therefore a vital element of AnGR management planning (FAO, 2009; 2010; 2013). The country-reporting exercise may have helped countries to review the influence of livestock-sector trends on their AnGR and to prioritize actions that need to be taken to address future demands, threats and opportunities within different production systems and affecting different breeds or breed categories. In other countries, the reporting process may have highlighted gaps in knowledge that make it more difficult to plan effectively. Where this is the case, efforts need to be made to collect and analyse the relevant information, perhaps as part of the process of developing or updating a national strategy and action plan for AnGR.

[1] See Box 1D1 in Part 1 Section D for explanation of these terms.

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