Section D

Roles, uses and values of animal genetic resources

1 Introduction

"In recognition of the essential roles and values of animal genetic resources for food and agriculture, in particular, their contribution to food security for present and future generations; aware of the threats to food security and to the sustainable livelihoods of rural communities posed by the loss and erosion of these resources ..."

As these opening words of the Interlaken Declaration on Animal Genetic Resources (FAO, 2007a) suggest, one of the main justifications for international concern about the state of animal genetic resources (AnGR) and their management is the need to ensure that livestock can continue fulfilling the roles that make them so important to the lives and livelihoods of so many people around the world, and that the value embodied in livestock biodiversity is not lost. Understanding these roles and values is fundamental to efforts to sustainably use, develop and conserve AnGR.

The phrases "roles and values" and "uses and values" are commonly used as catch-all terms for the various qualities or factors that make AnGR important. The former features in the Interlaken Declaration and in the Global Plan of Action for Animal Genetic Resources, while the latter was the title of a section of the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* (first SoW-AnGR) (FAO, 2007b).[1] It is interesting to note that, although the phrases are used more or less interchangeably, they emphasize slightly different aspects of AnGR management, both of which are important. The word "use" draws attention to one of the most important general characteristics of AnGR, the fact that they were developed for use by humans and are subject to ongoing active management by humans in pursuit of specific objectives.[2] The fate of an individual breed is closely linked to its use. If it is no longer used, it will become extinct unless a conservation programme is established to maintain it (either as a live population or in cryoconserved form). The word "roles" has slightly broader connotations than "use" in that it implies that the benefits derived from AnGR can include not only those deliberately sought by the immediate users (i.e. the owners or managers of the animals), but also inadvertent benefits. These benefits may accrue to the owners or managers themselves, to a wider public, or to both. Because of their inadvertent nature, ensuring that benefits of this kind are supplied in an optimal manner can be challenging.

The "values" of AnGR are generally considered to extend beyond those associated with their current use (FAO, 2007b).[3] Particularly significant – and one of the main reasons why the conservation of AnGR is regarded as important – are so-called option values. This term refers to the value that arises because the continued existence of a resource increases capacity to respond to unpredictable future events. In other words, it is a kind of insurance value. In the case of AnGR, option value arises, for example, because maintaining a wide range of genetic diversity

[1] FAO, 2007b Part 1, Section D (pages 77–100).

[2] Feral populations and wild relatives of domestic species are exceptions, but are potentially of use in agriculture and food production.

[3] See, in particular, Box 93 (page 430) and Subsection 2 of Part 4 Section F (pages 442–448) of the first SoW-AnGR.

increases the likelihood that the livestock sector will be able to respond effectively to challenges such as the emergence of new diseases or climatic changes. Quantifying the values of AnGR is a complex task that involves the use of a range of economic tools. Recent developments in this field are described in Part 4 Section E. The discussion of values presented here in this section is largely descriptive.

The subsections below describe a range of different roles performed by livestock and the significance of genetic diversity in the fulfilment of each of them. The first addresses direct contributions to food production, livelihoods and economic output. Livestock's capacity to produce food and other goods and services that can be sold or used at home is generally the main reason why people choose to raise animals and why governments implement policies to support livestock-sector development. The second subsection addresses sociocultural functions. In many societies, livestock play important roles in social and cultural life: religious festivals, agricultural shows, sporting activities and so on. Some events and activities of this kind may provide income-generating opportunities for livestock keepers, but cultural activities are often pursued as ends in themselves. In many cases, benefits accrue not just to the livestock owners, but also to the general public in the local area. The third subsection addresses the ecological functions of AnGR: their roles in the provision of so-called "regulating" and "habitat" ecosystem services.[4] Livestock provide services of this kind via the effects that they have on other elements of the ecosystem as they graze, spread their dung, trample the ground and so on. The services may arise because livestock are deliberately managed so as to produce them or as a by-product of livestock management for other purposes. Benefits often accrue to the public at large rather than just to the owners of the animals that provide the services. A further subsection considers the roles of AnGR in poverty alleviation and livelihood development and their further potential to contribute in these fields.

The importance of AnGR diversity lies not only in underpinning the provision of a wide range of products and services, but also in enabling these services to be provided in a wide range of circumstances. Many harsh production environments, such as those characterized by extreme temperatures, lack of good-quality feed, high elevations, rough terrain or severe disease pressures, can only be utilized effectively by breeds that have particular characteristics that enable them to cope with these challenges. Characteristics of this type are discussed in greater detail in Part 1 Section E.

2 Contributions to food production, livelihoods and economic output

The first SoW-AnGR presented an overview of the roles of livestock in the production of goods and services for sale or for home consumption and the role of AnGR diversity in the provision of these outputs. Tables and figures provided quantitative data on the contributions of livestock to national economies (proportion of gross domestic product [GDP] supplied by the livestock sector), to food production and to international trade. These data – drawn from FAO's FAOSTAT database and from World Bank sources – were available only at species level (or in the case of GDP, for the livestock sector as a whole). In other words, the basic data shed little light on the relative contributions of different breeds (or breed categories)[5] within species to the various outputs. The data did, however, serve to illustrate the major economic significance of the livestock sector.

2.1 Food production and food security

Since 2004 (the year for which data were presented in the first SoW-AnGR), global output of food of animal origin has increased substantially (Table 1D1). Production figures are not disaggregated below species level (i.e. by breed or by breed category). However, the contribution

[4] "Provisioning" and "cultural" ecosystem services are discussed in the various other subsections.

[5] For example "locally adapted" or "exotic" breeds.

of different categories of breed and the significance of breed diversity in underpinning current production can to some extent be inferred from the way in which production is dispersed across production systems and agroclimatic zones. Figures presented in the first SoW-AnGR indicated that industrial production systems accounted for 67 percent of poultry meat production, 50 percent of egg production, 42 percent of pig meat production, 7 percent of beef production and 1 percent of sheep and goat meat production.[6] The remainder of reported production was attributed to grazing and mixed (crop–livestock) production systems. All milk production was attributed to grazing and mixed farming systems. See Part 2 Section B for further information on production-system classifications (Table 2B1) and the contributions of different systems to the output of livestock products at regional level (Figure 2B2).

Because industrial systems provide highly controlled production environments and generally supply markets that demand relatively uniform products, they make use of a narrow range of breeds. These breeds tend to belong to the international transboundary category and in many cases are considered exotic rather than locally adapted to the country in which they are kept (see Part 1 Section B for further information on breed categories). In grazing and mixed systems, production environments – and in some cases

[6] FAO, 2007b, pages 156–157. The figures, calculated in 2004 based on averages for the 2001 to 2003 period, were taken from an unpublished report (FAO, 2004). Updated figures are not available.

TABLE 1D1
Global output of animal-source foods (2004 and 2012)

Product	2004	2012	Change
	tonnes		%
Cattle meat	58 093 900	63 288 600	9
Chicken meat	68 003 800	92 812 100	36
Pig meat	92 610 000	109 122 000	18
Sheep meat	7 836 070	8 470 310	8
Goat meat	4 382 020	5 300 340	21
Turkey meat	5 199 850	5 609 530	8
Duck meat	3 093 810	4 340 810	40
Buffalo meat	2 924 490	3 597 340	23
Goose and guinea fowl meat	1 945 640	2 803 720	44
Rabbit meat	1 419 250	1 833 840	29
Horse meat	765 229	750 747	-2
Camel meat	380 947	524 390	38
Donkey meat	189 752	211 750	12
Cattle milk	529 669 000	625 754 000	18
Buffalo milk	76 872 600	97 417 100	27
Goat milk	14 368 000	17 846 100	24
Sheep milk	8 817 950	10 122 500	15
Camel milk	1 997 000	2 785 380	39
Hen eggs	55 494 700	66 373 200	20
Eggs of other birds	4 428 600	5 546 360	25

Source: FAOSTAT.

production objectives – are more diverse than in industrial systems. The output of these production systems comes from a wider range of breeds, some of which, as noted above, have to be able to survive and produce in very harsh conditions. However, where the climate is temperate and feed and veterinary inputs are available, it is often possible, even in grazing and mixed systems, to make use of high-output breeds that have no particularly specialized adaptive characteristics. Thus, global production figures for mixed and grazing systems cannot be attributed unambiguously to one or other category of breeds. They come in part from a highly diverse range of locally adapted breeds (often largely restricted to their areas of origin) and partly from a more limited range of widely distributed high-output breeds.

Increased production of animal-source foods at global or national levels does not necessarily translate into increased consumption for everyone or into health-maximizing levels of consumption for the majority. On the one hand, there are certain health risks associated with consuming excessive quantities of animal products (WHO/FAO, 2003). On the other, people may remain too poor to increase their consumption levels. Many people continue to suffer from nutritional deficiencies that might be overcome by increasing their intakes of meat, milk or eggs (Randolph *et al.*, 2007; FAO, 2014a).

Understanding the link between livestock production and food security at household or individual level requires an understanding of the role of livestock in the livelihoods of poor people. Two facts point to the significance of this role: the very large proportion of poor people that keep livestock (exact figures are not available, but a figure of 70 percent is often quoted [e.g. FAO, 2009]) and the multiple benefits that many of these people derive from their animals. The most immediate ways in which livestock contribute to the availability of food at household level are via the supply of milk, eggs, meat, etc. for direct consumption and via the supply of products and services that can be sold for cash that can then be used to buy food. For many households in mixed crop–livestock production systems another major contribution to food security comes via the supply of inputs for crop production (draught power and manure – see Subsections 2.3 and 2.4 for further discussion).

Food security depends not only on the amount and quality of food produced, but also on its being available on a continuous basis. For a household, this means the ability to produce, buy or otherwise access food through all the seasons of the year and in the face of whatever problems they may have to contend with (droughts, floods, outbreaks of crop and animal diseases, unemployment, accidents, human sickness and so on). As discussed in more detail below (Subsection 2.5), for many poor households, a flock or herd of animals serves as a form of "insurance" that can be drawn upon when problems of this kind arise. In some communities, livestock-related cultural activities, as well as gifts and loans of livestock, help to build and maintain social ties that people can draw upon in times of trouble.

The most important contribution of AnGR diversity to current[7] food production and food security – both at household and national level – probably lies in its role in enabling livestock to be raised in a wide range of production environments and in enabling production systems to better withstand shocks such as droughts and disease outbreaks. However, it also contributes to the production of more nutritionally diverse food products. This diversity is mainly at species level. However, breed-level differences do exist and have begun to attract some research attention in recent years. The FAO/INFOODS Food Composition Database for Biodiversity (FAO/INFOODS, 2012), for example, includes some data on the nutritional composition of products from different cattle breeds. Breed-level nutritional differences are discussed in greater detail in Part 1 Section G.

[7] As far as future food security is concerned, it provides the raw material for genetic improvement to increase productivity or otherwise develop the characteristics of livestock populations to meet whatever demands and challenges may arise.

2.2 Fibres, hides and skins

In terms of the value of sales and international trade, the most important non-food livestock products are fibres, hides and skins. The first SoW-AnGR included information on production levels for a range of skin and fibre products.[8] It also highlighted some examples, drawn from the country reports, of specific breeds whose distinct characteristics make them especially significant for fibre, hide or skin production. Since 2004 (the year for which data were presented in the first SoW-AnGR), total global wool production has continued its decline from a peak reached in the early 1990s. Global wool production in 2012 was almost 5 percent lower than in 2004 (FAOSTAT). However, some major wool-producing countries, such as China, Morocco, the Russian Federation and the United Kingdom, have increased their production levels over this period. In other countries, overall declines in wool production have been accompanied by increases in the production of fine, ultrafine and superfine wool (Montossi *et al.*, 2013). Demand for finer wool leads to shifts in the use of sheep genetic resources, i.e. changes in breed choice or in breeding goals (ibid.). Recent developments in genetic improvement programmes in the sheep sector are discussed in Part 4 Section C. Over the 2004 to 2012 period, world production of hides and skins from buffaloes, cattle and goats increased, but production of sheep skins fell (FAOSTAT). The figures roughly reflect population trends in these species.

2.3 Transport and agricultural draught power

In many parts of the world, animals play important roles in transport and as providers of draught power in agriculture. The first SoW-AnGR provided an overview of the significance of draught animal power in agriculture and transport, based largely on the material provided in the country reports. It was clear that animal power from a wide range of species (cattle, buffaloes, horses, donkeys, dromedaries, Bactrian camels, alpacas, llamas, yaks, reindeer and dogs – even to some extent sheep and goats) remained important in many countries, and that a range of specialized and multipurpose breeds were involved in the provision of these services. Figures quoted from an earlier FAO report (FAO, 2003) indicated a projected decline in the proportion of land cultivated using animals in most regions of the world during the period between 1999 and 2030, but an increase in sub-Saharan Africa.[9]

A more recent study prepared for FAO (Starkey, 2010) provides a systematic region-by-region analysis of the role of animal power and a discussion of factors affecting trends in its use. Overall, the study shows that the use of animal power is declining as mechanized power becomes more widely available and more affordable. However, the increasing use of draught animals in sub-Saharan Africa is again noted. In other developing regions, the use of animals for agricultural power and transport remains persistent wherever it continues to be profitable and socially acceptable and alternatives remain inaccessible or unaffordable (ibid.). This often continues to be the case for poorer sections of the population and in geographically remote areas even in countries where industrial development is relatively advanced. Trends vary markedly from country to country, with upward trends in the use of some species in some countries (e.g. the use of donkeys in parts of Central Asia) and rapid declines elsewhere (e.g. the use of donkeys in Turkey and some countries of the Near East).[10]

One interesting development in the relatively recent past was the decision taken by Cuba to promote the use of animal power in agriculture in response to the fuel shortages faced by the country following the breakup of the "soviet bloc" in the early 1990s (ibid.). This has involved the use of animal and mechanized power in a complementary manner, with oxen being used particularly for weeding – and valued for their capacity to work in wetter conditions (Henriksson

[8] FAO, 2007b, Table 28 (page 87) (annual totals per region based on FAOSTAT figures for 2004).

[9] FAO, 2007b, Table 29 (page 88).

[10] Starkey cites donkey population figures from FAOSTAT, noting that donkeys are seldom maintained if they are not used.

and Lindholm, 2000). These developments, along with the country's more general need to shift towards an agriculture that was less dependent on the use of external inputs, required changes in the use of AnGR, with an increase in the use of animals that were well adapted to local conditions (Government of Cuba, 2003).

Reliability in the face of uncertain access to (or affordability of) fuel and mechanical spare parts is one of the major advantages of animal power. However, animals are vulnerable to threats such as theft, diseases and feed shortages. Locally adapted breeds are often preferred because of their greater capacity to survive in local conditions (Starkey, 2010). These factors also affect the choice of species. One trend reported to have been occurring in parts of the world in relatively recent years is an increase in the use of draught donkeys – reasons include their comparatively low cost, ease of management, resistance to drought and the fact that they are less prone to being stolen (New Agriculturist, 2003). An increase in the use of cows or female buffaloes rather than castrated males has also been noted (ibid.).

Replacement of animal power by mechanized power is widely recognized as a potential threat to AnGR diversity. Many country reports,[11] from all regions except North America, note that the use of animal power is in decline as a result of replacement by mechanized power.[12] The strength of the trend varies from country to country. For example, the report from Lesotho notes that stock theft is leading to draught animal power being rapidly replaced by machinery. Conversely, the report from Bhutan notes that although farm mechanization is underway, the country's steep terrains mean that AnGR and their management have been affected only minimally and that future effects are also expected to be minor. The report from the Philippines states that "because of the increasing cost of oil, many farmers still rely on large animals for draught." The precise extent of the threat is difficult to estimate. Stakeholders responding to a global survey on threats to AnGR (FAO, 2009) provided information on 87 equine breeds and 212 cattle breeds. Among these, "replacement of breed functions" was ranked as the top threat in 32 equine breeds and 10 cattle breeds.[13] Relatively few country reports (7 out of 93 that include responses to the relevant question) specifically list mechanization as a major cause of genetic erosion,[14] although the figure is higher in the case of Asian countries (4 out of 17) (see Table 1F2 in Part 1 Section F).

Evidence from highly developed regions such as western Europe suggests that when breeds lose their roles as providers of transport or agricultural power, their populations often plummets towards zero. National donkey populations provide an indicator of this effect, as donkeys are rarely kept in large numbers for other purposes. To take one example, the donkey population of Italy fell by more than 50 percent between 1938 and 1968, and by 2008 had declined by 97 percent relative to the population at the time of the Second World War (Starkey, 2010). This decline is reflected in the risk status of Italy's donkey breeds, all of which, according to the figures available in the Domestic Animal Diversity Information System (DAD-IS)[15] at the time of writing, are classified as being at risk of extinction (13 breeds) or already extinct (3 breeds).

One factor that often speeds the decline of animal power (or slows its growth) is the perception that it is an old-fashioned technology whose time has passed. This perception is common both among potential users (farmers, etc.) and among development workers and policy-makers. At times, this leads to unprofitable decisions to invest in mechanized power and to the absence of support services for draught animals (Starkey, 2010). As well as leading to missed opportunities in the short

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

[12] In response to a general question about changing breed functions.

[13] Answers were chosen from a list of options. In both equines and cattle, the most frequently mentioned category of threat was "economic and market-driven threats".

[14] This was an open-ended question. Countries were not specifically asked whether mechanization is a threat.

[15] http://fao.org/dad-is

term, these attitudes are not helpful to the long-term conservation and development of AnGR in breeds and species used as sources of power.

Working animals are often ignored in national agricultural and rural-transport strategies and policies, and this means that they are often not targeted by animal health interventions, research programmes, extension activities and so on (FAO, 2014b). Their significance to people's livelihoods often remains unrecognized. Donkeys, for example – a species that tends to be particularly overlooked – provide vital services to many poor households, and to women in particular, by reducing the drudgery of domestic tasks such as transporting water and firewood and by providing a source of income (Valette, 2014). Gaps in knowledge on the livelihood roles of working animals and the extent of their economic contributions need to be addressed in order to enable the design of appropriate support measures and to help raise awareness at policy level (FAO, 2014b; Valette, 2014).

2.4 Manure and fuel

Apart from draught power, the other main animal-derived agricultural input discussed in the first SoW-AnGR was manure. Several examples from the country reports illustrated the continued (and in some situations increasing) importance of livestock as a source of manure for use in agriculture. For small-scale farmers in mixed crop–livestock production systems, securing a supply of manure can be among the most important reasons for keeping animals. For example, a study conducted by Ejlertsen *et al.* (2013) in the Gambia, indicated that among mixed farmers with fewer than ten cattle, manure supply ranked as the second most important reason for keeping cows and third for keeping bulls. Among farmers with larger herds, manure supply was reported to be the most important livestock function (ibid.).

The capacity of livestock to serve as providers of manure is normally considered at the species level rather than in terms of within-species diversity. However, breeds that struggle to survive in the local production environment or – in the case of free-grazing animals – to range over the ground where the manure needs to be spread, are unlikely to be the best providers of this service. One study that did compare the level of manure provision from two different breeds (strictly speaking, one breed and one interspecies cross) compared the amount of organic matter introduced into fish ponds by Pekin ducks and mule ducks – and found that the former provided significantly more (Nikolova, 2012). The difference arose because of the faster growing rate of the Pekin ducks and because they spent more time in the water (ibid.).

The other main use made of livestock dung is as a source of fuel, either in the form of dried dung cakes or via the production of biogas. This role, along with minor uses such as burning dung to ward off insects and the use of dung as a building material, was noted in the first SoW-AnGR. These functions were mentioned in a small number of country reports, but there was no indication that they had any significant effect on the management of AnGR aside from adding some degree of extra incentive to keep livestock and hence to keep the respective breeds in use.

The use of dung for fuel has downsides in some circumstances. It can use up dung that would otherwise help to keep soils fertile, and burning dried dung in poorly ventilated homes can cause serious human health problems (IEA, 2006). On the positive side, in production systems where manure management is a challenge in itself (this is particularly the case in so-called landless systems) the use of manure as a source of energy is increasingly being regarded as an attractive option.

2.5 Savings and insurance

Another function highlighted in the first SoW-AnGR was livestock's role in the provision of savings and insurance services, a function particularly important in areas where livestock keepers do not have access to conventional financial services. Where savings are concerned, a herd or flock of animals can serve as a kind of "bank" in which spare resources (cash or physical inputs such as feed) can be invested. Animals can then be sold from time

to time to meet household expenses. Alternatively, the herd or flock may be built up with the aim of meeting some larger expense. As noted above, livestock can also serve as a form of "insurance", in the sense that if some kind of costly misfortune (sickness, a period of unemployment, crop failure, etc.) strikes the livestock owner, animals can be sold to mobilize resources to deal with the problem. For small-scale livestock keepers in developing countries these functions can be among the most important reasons for keeping livestock. For example, the above-mentioned study in the Gambia found that among poorer livestock keepers (those having fewer than ten cattle), savings and insurance was ranked as the most important reason for keeping cattle, goats and sheep (Ejlertson *et al.*, 2013).

In principle, any kind of animal can provide savings and insurance services. When the time comes to sell, an animal that commands a higher price will obviously be preferable. However, from the perspective of risk management, keeping animals that have a good chance of surviving in the local production environment will be important. Likewise, from the perspective of accumulation, keeping animals that can reproduce well in the local production environment and can make use of low-quality (and low-cost) local feed resources will have advantages.

A few country reports (e.g. Guinea-Bissau and Mali), in response to a general question about changes in livestock functions, note that livestock's savings and insurance functions are in decline. Other reports, however, specifically note that these functions remain important (e.g. Swaziland, Tajikistan, Uganda and Zimbabwe).

3 Sociocultural roles

The country reports prepared for the first SoW-AnGR clearly indicated that livestock – and often specific breeds – play important roles in many cultural activities at both household and community levels and that in many countries native breeds and species are regarded as important elements of national heritage.

The country report questionnaire for the second SoW-AnGR did not directly ask countries to provide information on the significance of the cultural roles of their AnGR. However, as part of the assessment of the effects of livestock sector trends, countries were asked to provide comments on the effects that changes in the cultural roles of livestock are having on AnGR and their management and to provide scores for the significance of these effects over the preceding ten years and for the forthcoming ten years (see Part 2). The textual answers can be roughly grouped into four categories: no clear indication of trends (61 percent); indication that cultural significance is remaining at approximately the same level (20 percent); indication of increasing cultural significance (8 percent); and indication that cultural significance is decreasing (11 percent). These figures are clearly only very approximate indicators of trends. However, it is interesting to note that all the countries mentioning downward trends are developing countries, while eight out of the ten countries reporting upward trends are developed countries.

Where downward trends are described, the reason in most cases is reported to be a decline in traditional cultural roles. For example, Togo's country report mentions that a decline in traditional beliefs has led to a loss of interest in maintaining culturally significant livestock breeds, particularly breeds of chicken. Similarly, the report from Bhutan notes that the rearing of animals for use as sacrifices or offerings is dying away. In the case of Guinea-Bissau, economic reasons are reported to have led to a decline in the practice of slaughtering large numbers of animals at funeral ceremonies. The report from Ethiopia notes that

> *"there is a change in the role of livestock in the pastoral area. Livestock used to serve as compensation in ... [the] cultural settlement of disputes, but there is an increasing tendency to use the legal system. ... [C]ash payments are replacing other cultural roles of livestock."*

The report from Uganda notes a link between changing cultural practices and the spread of exotic cattle:

"in ... [some] parts of the country, cultural aspects of livestock have not changed at all, while in other parts the changes are marked, especially in areas where exotic [breeds] are kept. For example, in Central Uganda, cattle are no longer being used as bride-price, whereas in the western and the north eastern parts of the country, this practice goes on."

Despite these various indications of decline, it should be noted that among country reports from developing countries comments of this type are outnumbered by clear statements that significant cultural roles are being maintained. It should also be noted that the decline of a cultural role does not necessarily lead to a negative effect on AnGR diversity and that an increasing role does not necessarily have a positive effect. The country report from Ethiopia, for example, states that the reported changes have had "no significant effect on the livestock genetic resources and … [are] unlikely to have sizeable effect in the foreseeable future". The country report from Samoa notes that an increase in the use of cattle to meet cultural and social obligations has led to a decline in the number of animals available for breeding purposes.

The reported increases in cultural roles in developed countries appear to relate mostly to a growing interest in the history and traditions of rural areas. The country report from Slovenia, for example, notes that "traditional events from the past (livestock exhibitions, festivals …) are becoming more attractive to the wider public." There is also some indication of increasing interest in the use of animals for therapeutic and educational purposes (mentioned in the country reports of Italy and Japan).

4 Ecological roles – the provision of regulating and habitat ecosystem services

The first SoW-AnGR noted the many ways in which livestock contribute to the functioning of the ecosystems within which they are kept. Information on these roles was, however, limited – particularly with respect to possible breed-level differences in capacity to provide services. The report, however, noted that the provision of ecosystem services in harsh production environments, such as mountains and arid rangelands, requires animals that can thrive in local conditions, and that therefore the role of locally adapted breeds was likely to be important. It also noted the possible significance of between-breed differences in grazing and browsing habits.

Interest in the links between AnGR management and the provision of ecosystem services has increased in recent years. For example, in 2013, the Commission on Genetic Resources for Food and Agriculture requested FAO to work on the identification of ecosystem services provided by different livestock species and breeds (FAO, 2013). This led, *inter alia*, to the organization of two questionnaire surveys (one targeting Europe and the other global) on the roles of livestock in the provision of ecosystem services in grassland ecosystems. The findings of these surveys, along with an extensive literature review, are presented in a background study paper (FAO, 2014c) prepared as part of the second SoW-AnGR reporting process.

Ecosystem services can be grouped into the following categories: provisioning; regulating; habitat; and cultural (see Box 1D1). Provisioning and cultural services are discussed above and were addressed at greater length in the first SoW-AnGR. Where provisioning services are concerned, the above-mentioned background study paper emphasises livestock's capacity to convert feed sources that are not edible to humans into meat, milk and eggs. This occurs, for example, when livestock graze areas that cannot be used for crop production, when they eat crop residues such as straw, when they eat the by-products of food processing and when they eat waste food products that are no longer edible to humans. These examples can be contrasted with cases in which animals are fed on feeds such as grains that could otherwise be used directly by humans.

While the most obvious consequence of the use of human-inedible material by animals may (other things being equal) be an increase in the

Box 1D1
Categories of ecosystem services

The Millennium Ecosystem Assessment (MEA, 2005) distinguished four categories of ecosystem services:

- **provisioning services** – "the products obtained from ecosystems" (e.g. food, fibre, fuel and fresh water);
- **regulating services** – "the benefits obtained from the regulation of ecosystem processes" (e.g. air-quality regulation, climate regulation, pollination and natural-hazard regulation);
- **supporting services** – "those that are necessary for the production of all other ecosystem services" (e.g. soil formation, photosynthesis and nutrient cycling); and
- **cultural services** – "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences".

Some services (particularly supporting and regulating services) are inputs to the production of others (particularly provisioning services).

The Economics of Ecosystems and Biodiversity initiative (TEEB, 2010) subsumed supporting services within the regulating-service category. It also introduced an additional category – **habitat services** – the intention being to highlight the importance of ecosystems in the provision of habitats that, for example, allow migratory species to complete their life cycles and enable the maintenance of genetic diversity.

Source: Adapted from FAO, 2014d.

food supply, in some circumstances, the removal of unwanted plant material can constitute a service in itself. In grazing systems, the benefits concerned may relate to the removal of plant material that creates a fire hazard or to the control of invasive species (see further discussion below). In mixed systems, livestock may be used to control weeds (e.g. on fallow land) or in the management of crop residues (e.g. Hatfield *et al.*, 2011). The country report from Malaysia, for example, notes that beef cattle are raised on oil-palm estates and that their grazing and dunging reduces the need for the use of herbicides and fertilizers.

In addition to removing unwanted plant material, livestock can sometimes also play a role in the control of agricultural pests and disease vectors. Poultry, for example, can contribute to the control of ticks (Dreyer *et al.*, 1997; Duffy *et al.*, 1992). Hatfield *et al.* (2011) show the potential for using grazing sheep to control wheat stem sawfly infestations in cereal production systems in the United States of America. In China, rice–duck farming (a traditional local system) has been reintroduced in recent years, particularly in organic production, because of the benefits the ducks provide in terms of pest control (Teo, 2001; Zhang *et al.*, 2009).

The significance of livestock manure in crop production is noted above (Subsection 2.4). However, dunging also affects the health of grassland soils, which in turn is fundamental not only to the productivity of grazing systems, but also to their roles in carbon sequestration and water cycling. Outcomes depend on the particular characteristics of the ecosystem and on the type of grazing management practised. The effects of dunging have to be considered alongside the effects of grazing and trampling. Many rangelands have suffered soil compaction and erosion as a result of badly managed livestock grazing. However, appropriately managed grazing can in some circumstances contribute to improving soil health (Peco *et al.*, 2006; Aboud *et al.*, 2012).

In many countries, grazing livestock play a significant role in the creation and maintenance of fire breaks and hence in reducing the spread of wildfires (Huntsinger, 2012; Garcia *et al.*, 2013). They can also contribute to reducing the risk of avalanches (Fabre *et al.*, 2010). In addition to disaster-risk reduction, there are a number of different circumstances in which preventing the spread of particular types of vegetation may be desirable, for example in preventing the loss of wildlife habitats or particular landscape features valued for their aesthetic characteristics or for recreational use.

The use of livestock specifically for the purpose of creating or maintaining wildlife habitats has become widespread in a number of European

countries (FAO, 2014c). There are also a number of examples in North America (Schohr, 2009). The main mechanisms involved are selective grazing, nutrient redistribution, treading and seed distribution (Wrage *et al.*, 2011). While the use of livestock specifically to provide wildlife habitats is rare in the developing regions of the world, the significance of livestock has sometimes been illustrated by the unexpected and undesirable consequences of their removal from particular ecosystems. For example, in Keoladeo National Park, India, a ban on grazing by buffaloes led to uncontrolled growth of a water weed, which in turn prevented Siberian cranes, a critically endangered species, from accessing plants tubers, their main food source. This led to a dramatic decrease in the numbers of cranes in the park (Pirot *et al.*, 2000).

Studies of the provision of regulating and habitat ecosystem services by livestock have mostly focused on species-level effects, i.e. have not sought to determine whether there are any breed-level differences in capacity to provide these services (FAO, 2014c). Given that many ecosystem services are provided in production environments that are, in one way or another, harsh (mountains, arid grasslands, etc.), it can be assumed that in some cases, only locally adapted breeds can deliver the services effectively. However, there may be a number of different breeds that are able to do so, including those from outside the local area or even from other countries. This is demonstrated, for example, by the widespread use of Polish Konik horses and Scottish Highland cattle for conservation grazing outside their countries of origin. One documented case in which a breed's specific adaptive characteristics enable it to provide ecosystem services where other breeds would fail to do so is that of the Chilika buffalo, whose grazing and dunging play a vital role in maintaining the ecosystem of Chilika Lake in eastern India as a wildlife habitat and a fishing ground (Patro *et al.*, 2003; Dash *et al.*, 2010). Evidence that breed-level differences in feeding habits affect the provision of ecosystem services is limited. However, there are some cases where specific breeds are reported to be more effective than others at removing specific weeds or invasive plants (see Box 1D3 for example). There may also be other circumstances in which the use of particular breeds is important – for instance, where only lightweight breeds can be used because heavier animals would damage fragile soils (see Box 1D4 for example).

Box 1D2

The use of livestock in the provision of ecosystem services – examples from the United States of America

Livestock provide ecosystem services in a number of ways across diverse ecosystems. In the southern plains, goats and to a lesser extent sheep are used to mitigate brush encroachment. Sheep and goats are also used to manage vegetation growth (e.g. trees and shrubs) along the paths of electrical power lines in mountainous areas and thereby reduce the use of herbicides. On mountainous public lands, sheep and cattle grazing contributes to vegetation health and plant diversity. Particularly in the Great Plains, livestock grazing can stimulate plant vegetative processes that result in increased carbon sequestration. In the western half of the country, sheep are used in the biocontrol of noxious weeds. All of these roles operate at species level. They are not based on the use of specific breeds.

Source: Adapted from the country report of the United States of America.

5 Roles in poverty alleviation and livelihood development

The first SoW-AnGR recognized the widespread importance of livestock in the livelihoods of poor people, noting in particular the role of genetic diversity in underpinning the multiple services provided by livestock to many poor households and the adaptations that enable animals to thrive in harsh environments and low external input production systems. These observations appear still to be valid (see Subsection 2).

FAO's 2009 report on *The State of Food and Agriculture*, which focused on the livestock sector, noted opportunities for poverty reduction presented by the rapid growth of the livestock sector had been missed because of various institutional and policy failures. The report classified poor or small-scale livestock keepers into three groups:

1. those that have the potential to compete as commercial producers;
2. those for whom livestock continue to play an important role as a livelihood "safety net"; and
3. those who are in the process of moving out of the livestock sector.

It advocated policies and interventions to support all three groups.

Livelihood strategies with different objectives and that involve keeping animals in different production environments are likely to require different types of AnGR and any interventions aiming to support small-scale livestock keepers or pastoralists need to take this into account. While the tendency to assume that the appropriate objective in all circumstances is to introduce "improved" exotic AnGR remains prevalent, awareness of the significance of adaptedness to local conditions is probably increasing, perhaps driven in part by growing concerns about climate

Box 1D3

A special sheep breed helps to preserve centuries-old grassland in the Alps

Photo credit: Tobias Zehnder.

Reduction in land use and complete land abandonment are widespread in the mountainous regions of Europe. Shrubs and trees are expanding into montane and subalpine grassland in the Alps. In particular, the nitrogen-fixing shrub *Alnus viridis* (green alder) is currently spreading very rapidly. The shrub's ability to symbiotically fix nitrogen from the atmosphere leads to massive nitrogen enrichment, reduces biodiversity and suppresses species succession towards coniferous forests. It is nearly impossible to fight the expansion of *A. viridis* shrubs into centuries-old pastures and hay meadows that are hotspots of biodiversity and part of the region's cultural heritage. Clear-cutting is not a realistic management option given the enormous labour costs involved and the green alder's rapid "hydra-like" resprouting from its root stock. In former decades, goats browsed buds and young shoots and thus prevented the spread of the green alder. In some regions, people also used the shrubs for fuel wood. Today, goats are a marginal livestock species in the Alps and sheep are the main grazers. However, the most abundant sheep breeds feed on grass and ignore woody plants.

Once the green alder bushes are fully established – 2 to 3 metres tall and formed into dense, impenetrable thickets – specialist browsers that peel the bark are needed. An old, traditional, sheep breed known as the Engadine sheep, which was almost extinct in the 1980s (mainly because of its low slaughtering weight), does exactly this. Although it also feeds on grass, the breed appears to be addicted to young tree stems, green alder in particular. It excessively removes the bark from branches and stems, which inhibits the allocation of sugars from shoots to roots, creates open and deep wounds that are rapidly infested by diseases and ultimately causes the death of the shrubs, with almost no resprouting.

(Cont.)

Box 1D3 *(Cont.)*

A special sheep breed helps to preserve centuries-old grassland in the Alps

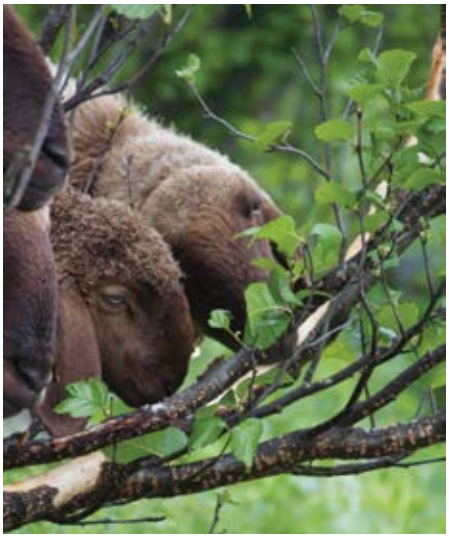

Photo credit: Tobias Zehnder.

In a controlled browsing/grazing experiment, the Engadine proved to be a very efficient land-cover engineer: a flock of ewes and lambs grazed several partially encroached pastures, with shrub coverage ranging from 25 to 55 percent (within defined paddocks), for the duration of one summer. In the following year, mortality of *A. viridis* branches (not individual shrubs) was on average 46 percent, with a maximum of 76 percent in lightly encroached pastures. A second browsing treatment increased the damage – in other words the success of the browsing treatment – even in very dense shrubland.

With a total of more than 420 000 sheep in Switzerland, even a minor replacement of common breeds by the Engadine would have great potential for fighting shrub and tree expansion into high mountain grassland, while at the same time helping to conserve a traditional livestock breed. As an additional advantage, the Engadine is very healthy and fertile, even under harsh grazing conditions. Its meat is not fatty, but the accumulated fat is rich in unsaturated fatty acids.

Provided by Tobias Zehnder, Erika Hiltbrunner, Tobias Bühlmann and Christian Körner.

Box 1D4

The use of livestock in the provision of ecosystem services – examples from Poland

There are some cases in which the provision of specific environmental services requires the use of specific species or even breeds. One example is the utilization of Polish Konik horses in vegetation control in the Biebrza National Park. It is impossible to use other species such as sheep to perform this service because of the presence of wolves. Only horses adapted to free-range grazing manage to do well in these circumstances. Another example is the Swiniarka sheep, a breed that is used to graze xerothermic grasslands in the south of Poland. These very fragile grasslands can be only grazed by animals that have a light body weight and require very little care.

Photo credit: Jacek Łojek.

Source: Adapted from the country report of Poland.

change (FAO, 2011; HPLE, 2012). Breeding strategies and programmes, including those targeting low-input production systems, are discussed in greater detail in Part 3 Section C and Part 4 Section C.

Another feature of AnGR diversity that has attracted increasing attention in recent years is its potential as a basis for the development of niche-market products. The role of niche marketing in the conservation and sustainable use of at-risk breeds is discussed in Part 4 Section D. However, it clearly also has potential implications for livestock keepers' livelihoods. Niche markets normally emerge in more affluent countries, and targeting them effectively normally requires a relatively high level of organization among producers, a reliable marketing chain, well-organized marketing campaigns and, for some types of product, an effective legal framework. Their significance in developing countries has therefore been limited. Marketing many livestock products involves particular problems because of their perishable nature and in many cases because of zoosanitary restrictions on their export to developed countries. Despite these constraints, a few examples of successful niche-market development involving small-scale livestock keepers and pastoralists keeping locally adapted breeds have been documented. Several are reported in the publication *Adding value to livestock diversity – marketing to promote local breeds and improve livelihoods* (LPP *et al.*, 2010). In addition to initiatives of this kind that target markets more or less external to the local area, it is quite common for local consumers to have long-standing preferences for food products supplied by the traditional breeds of the local area and to be willing to pay a premium price for these products. Where this is the case, the breeds in question provide their keepers with relatively high-value products to sell (in addition to contributing to the local culinary culture).

The country reports prepared for the first SoW-AnGR included several references to the role of particular species and breeds of livestock in the livelihoods of women livestock keepers. The role of women as guardians of AnGR and the role of locally adapted breeds in women's livelihoods was addressed in more detail in the FAO publication *Invisible guardians – women manage livestock diversity* (FAO, 2012). From the livelihoods perspective, two main characteristics of locally adapted breeds are highlighted as being particularly relevant to women livestock keepers. First, locally adapted breeds tend to be easier to care for than exotic breeds. Keeping these breeds can therefore more easily be combined with household and child-rearing tasks. Second, locally adapted breeds are normally better able than exotic breeds to access and utilize common property resources (because of their ability to negotiate the local terrain and make use of local feeds). This capacity tends to be particularly important for women because of the major gender inequalities that exist in terms of land ownership and hence women's greater reliance on common grazing land.

6 Conclusions and research priorities

The first SoW-AnGR concluded that while various livestock functions are gradually being replaced by alternative sources of provision, the use of livestock remained very diverse. It also noted that knowledge of these roles is often inadequate and that this hampers the development of appropriate management strategies. These conclusions remain relevant. Trends in the use of livestock products and services were not investigated in detail as part of the country-reporting process for the second SoW-AnGR. However, many country reports indicate that changes are taking place. The most frequently mentioned change of this type is a decline in the use of animal power in agriculture and transport. This implies the need to monitor trends in the population sizes of breeds used for these purposes.

As far as knowledge gaps are concerned, an important priority is to improve our understanding

of the roles of particular livestock species and breeds in the livelihoods of poor people, taking into account not only the various tangible products and services that they provide, but also their roles in risk management and the level of inputs – including the time and labour of household members – needed to raise them. Knowledge of breeds' relative capacities to produce in specified production environments needs to be strengthened. Better recording of breeds' home production environments (see Part 4 Section A) would contribute to this, as would better monitoring of the performance of exotic breeds in typical production environments in importing countries. Improving knowledge of livestock's impacts, both positive and negative, on the functioning of the ecosystems in which they are kept – carbon sequestration, regulation of water cycling, maintenance of soil fertility, provision of wildlife habitats, etc. – is another priority.

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