Section F

Threats to livestock genetic diversity

1 Introduction

Threats to animal genetic resources (AnGR) include a wide variety of factors, ranging from inappropriate approaches to AnGR management on a local scale to major national or global economic, social and environmental trends (Gibson *et al.*, 2005; FAO, 2007a; FAO, 2009a; Alemayehu, 2013). They operate on a range of different time and geographical scales. Some AnGR populations are more vulnerable than others to particular threats. Addressing threats to genetic diversity is one of the most important challenges in AnGR management. It requires not only an understanding of the nature and scale of the threats, but also an understanding of where opportunities to address them may lie.

This section aims to update the discussion of threats to AnGR presented in the first report on *The State of the World's Animal Genetic Resources for Food and Agriculture* (first SoW-AnGR) (FAO, 2007a). The first SoW-AnGR distinguished threats arising because of relatively gradual changes in livestock production systems from those associated with acute events such as animal disease epidemics and other kinds of disasters and emergencies. A similar approach is taken in this update.

Detailed information on livestock-sector trends is presented elsewhere in the report (Part 2). Of particular relevance to the analysis of threats is Part 2 Section C, which discusses the effects of livestock-sector trends on AnGR and their management. Also relevant to the analysis of threats is the information on gene flows presented in Part 1 Section C and the information on management capacities presented in Part 3.

Subsection 2 below discusses how the various livestock-sector trends described in Part 2 can translate into threats to AnGR. Subsection 2.1 provides a general overview of the pressures that trends of this kind can exert on livestock diversity. Subsection 2.2 presents some concrete examples of how specific breeds have been affected by various threats, both recently and in the more distant past. Subsection 2.3 presents a review of the information on current threats provided in the country reports.[1] Options for addressing these threats are not discussed in detail in this section. Effectively addressing threats associated with livestock-sector trends depends on all the various elements of AnGR management, from the characterization of breeds and their production environments, to the establishment of conservation programmes for at-risk breeds and the establishment of appropriate policy and institutional frameworks. The state of capacity in AnGR management is discussed in Part 3 of the report and the state of the art in management methods in Part 4.

Subsections 3 and 4 below update, respectively, the discussions of disasters and emergencies and of disease epidemics presented in the first SoW-AnGR.

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

2 Livestock sector trends

2.1 Overview of trends and their effects on diversity

As discussed in Part 1 Section A, prior to, approximately, the mid-twentieth century, the world's livestock were raised under very diverse conditions. Animals had to be well adapted to their particular production environments if they were to survive, reproduce and meet the requirements of their owners. Moving AnGR around the world was more difficult than it is today, both in terms of transportation and in terms of establishing livestock populations in new locations. Under these conditions, global AnGR diversity flourished.

Today's livestock sector presents a different picture. A number of trends have combined to undermine the bulwarks of livestock diversity that had remained largely in place since the days when livestock keeping first spread around the world from the various centres of domestication where it originated. First, a range of technological developments have increasingly enabled production environments to be controlled. Second – again because of technological developments – it has become easier to transport genetic material over long distances. Third, in many production systems, livestock keeping is less multipurpose than it was in the past. Fourth, the livestock sector (particularly the breeding industry), along with the food-processing and retail sectors, has become increasingly dominated by a limited number of large-scale commercial companies. Fifth (again because of technological developments) the number of offspring that can be obtained from individual high-quality or popular animals (particularly male animals) has greatly increased.

While these trends largely emerged in industrialized regions, such as Europe and North America, recent decades have seen them become increasingly significant in parts of the developing world, driven by rapidly rising demand for animal products. The result has often been to create both the opportunity and the motivation to replace diverse locally adapted AnGR with those drawn from a narrow range of high-output breeds. The latter group of breeds, while their populations may be large, are not immune to the threat of genetic erosion. The fifth trend noted above has enabled the very widespread use of a limited number of popular sires. The tendency is reinforced by other trends – homogenization of production environments and breeding goals, greater capacity to transport genetic material and the consolidation of the breeding industry. The outcome has been to greatly reduced the effective population size of a number of widely used breeds (see examples in Table 1F1). Low effective population size implies a high rate of inbreeding and a loss of genetic diversity. It potentially leads to inbreeding depression and higher occurrence of genetic defects. For further information on the effects of inbreeding, see Box 4C1 in Part4 Section C.

The outcome of these trends can be seen in breed risk-status data from the developed regions of the world (see Part 1 Section B). Many breeds became extinct during the twentieth century and many others declined to the brink of extinction. These developments eventually gave rise to concerns about the loss of diversity and to the establishment of breed conservation programmes that have, with varying degrees of success, attempted to revive the fortunes of at-risk breeds (see Part 3 Section D and Part 4 Section D).

Given the experience of developed countries, the spread of industrialized livestock production into the developing world has raised concerns about the fate of the locally adapted breeds of developing regions, particularly those such as East and Southeast Asia that have been greatly affected by the so-called livestock revolution (Delgado *et al.*, 1999) – rapid expansion of large-scale "industrial" livestock production in response to surging demand. The first SoW-AnGR, for example, argued that future "hotspots" of diversity loss were likely to be found in the global "South".[2] Describing developments in Thailand, Charoensook *et al.* (2013) note that

> *"since 1981 pig breeding has steadily been industrialised ... Thus, indigenous native*

[2] FAO, 2007a, page 72. The "South" in this context refers to the developing regions of the world.

TABLE 1F1

Estimates of effective population size in transboundary breeds based on genealogical or molecular data

Species	Breed	Range of N_e estimates	References
Cattle	Holstein	49–110	De Roos *et al.*, 2008; Leroy *et al.*, 2013; Lu *et al.*, 2012; Rodriguew-Ramilo *et al.*, 2015; Thomasen *et al.*, 2013
	Jersey	110–135	
	Charolais	198–958	
Sheep	Meat Lacaune	73–835	Kijas *et al.*, 2012; Leroy *et al.*, 2013
Goat	Alpine	143–149	Brito *et al.*, 2015; Larroque *et al.*, 2014
	Saanen	113–120	
Pig	Landrace	74–91	Uimari and Tapio, 2012; Welsh *et al.*, 2010
	Yorkshire	55–113	
Horse	Thoroughbred	77–250	Corbin *et al.*, 2012; Lee *et al.*, 2014

Note: N_e = effective population size. Estimates based on various methods and datasets across the world.

pigs have been increasingly mated with imported breeds ...[they] have gradually become crossbreeds and are finally replaced by European commercial breeds as the meat-delivering end product in the pork industry."

In this context, it is important to note that countries affected by the livestock revolution are not simply retracing the trajectories followed by their more-developed counterparts. For example, as described in the first SoW-AnGR, the development of poultry production is often "discontinuous", i.e. rather than "organic" growth through which small poultry farmers gradually expand and intensify their production, "as soon as urban markets, transport infrastructure and services develop, investors ... step in and establish large-scale industrial-type units, integrated with modern processing and marketing methods."[3] Likewise, where genetic improvement is concerned, there is a tendency to make use of the genetic progress that has already been achieved in high-output international transboundary breeds[4] rather than to establish breeding programmes for locally adapted breeds (Tisdell, 2003). This means that locally adapted breeds remain far behind the newly introduced breeds in terms of their production potential in high-input systems.

Despite the significance of the changes associated with the livestock revolution, it should also be recalled that the livestock production systems of the developing world remain diverse and that not all countries have followed the same pattern of development (see Part 2). Many livestock continue to be kept by poor rural people in more or less traditional production systems. They supply a range of products and services (see Part 1 Section D) for use within the household or for sale through informal channels. Even where large-scale production has taken off, it can coexist with more traditional production in rural areas, as well as with small-scale production of various types in urban and peri-urban zones (commercially oriented small-scale dairy producers keeping a small number of cattle or buffaloes, slum dwellers keeping a few poultry, goats or pigs to supplement their livelihoods, and so on).

Many countries face the challenge of managing the use of AnGR across a range of very different production systems, sometimes co-existing in close proximity to each other. In these circumstances, one potential threat to diversity (and to effective use of currently available resources) may be a "one size fits all" approach to the use of AnGR, i.e. the increasing use of a narrow range of breeds across

[3] FAO, 2007a, page 156.

[4] Transboundary breeds are breeds that are present in more than one country. See Part 1 Section B for further discussion.

still diverse production environments. This may be exacerbated by a lack of knowledge of relative merits of different types of AnGR under different conditions. As discussed in Part 3 Section B, many breeds remain inadequately characterized. Heavy promotion of exotic germplasm by breeding companies or development agencies may also be a factor (Rege and Gibson, 2003).

The speed of change associated with the livestock revolution may also exacerbate threats to diversity. Where livestock production is in a state of rapid flux, with new production systems emerging, traditional systems being transformed and non-traditional types of AnGR becoming more accessible, breeds may fall out of use so rapidly that it is difficult for stakeholders to react and introduce measures to promote their sustainable use and conservation. Unfortunately, monitoring programmes for trends in the size and structure of breed populations and other trends that may affect their risk status (FAO, 2011b), remain inadequate in many countries (see Part 1 Section B and Part 3 Section B).

Where environmental conditions are harsh, external inputs are in short supply and animals have to serve multiple purposes, replacing locally adapted breeds with exotic alternatives continues to be relatively difficult, so some locally adapted breeds may, by default, be protected to some degree from the threat of being replaced by exotic alternatives. However, production systems of this type are not free of threats to AnGR. Rural livestock-keeping livelihoods can be disrupted by a range of factors, including degradation of natural resources, land-use changes or regulations that restrict access to grazing land and other resources, loss of livestock-keeping labour caused by outmigration in search of work, emerging animal health problems that reduce income from livestock keeping and the imposition of marketing restrictions associated with disease-control efforts. In some circumstances, pressures on natural resources may, rather than promoting the maintenance of well-adapted breeds that are relatively well able to deal with the problems associated with these pressures, increase the demand for alternative, apparently higher producing, breeds.

Production system changes feature prominently among the threats to AnGR noted in the report submitted by the African Union Interafrican Bureau of Animal Resources as part of the second SoW-AnGR reporting process (see Box 1F1).

Among environmental trends generating threats to livestock diversity, the first SoW-AnGR recognized that global climate change was likely to present a major challenge. The report noted that threats associated with climate change

Box 1F1

Production system changes as threats to animal genetic resources – a view from Africa

Changes in production systems are a major factor leading to the elimination of indigenous animal genetic resources. The switch to certain cash crops eliminates crop residues that used to be an important source of fodder. Irrigation makes two or three crops a year possible, eliminating the possibility of grazing on stubble or browsing on trees in the fields. Replacement of draught power by tractors for agricultural work or transportation is a prime cause of the gradual extinction of many draught livestock breeds. The establishment of wildlife sanctuaries, national parks and other types of protected areas almost always deprives livestock keepers of pasturelands.

Making a living from keeping livestock is hard work that ties people down day in and day out and many young people succumb to the attractions of city life. Animal-handling skills are disappearing very quickly, within one generation. Village-based breeding institutions, such as keeping a community bull, also deteriorate rapidly once economic returns are not sufficient or social networks break down. Once such institutions have disappeared, they are very difficult to resurrect.

Source: Adapted from the African Union Interafrican Bureau of Animal Resources' submission to the second SoW-AnGR reporting process. The report is available at http://www.fao.org/3/a-i4787e/i4787e03.htm.

could be associated with gradual changes in livestock-production systems (i.e. changes of the type described in this subsection) or in sudden catastrophic events (climatic disasters and disease outbreaks – see the following subsections). The significance of climate change is, likewise, noted at several points in the Global Plan of Action for Animal Genetic Resources (FAO, 2007b). However, emphasis is placed largely on the potential role of AnGR in climate change adaptation, rather than on the role of climate change as a potential threat to AnGR diversity.

Since 2007, concerns about climate change have continued to increase. In the field of genetic resources management, this was reflected in the adoption, in 2013, of the Commission on Genetic Resources for Food and Agriculture (CGRFA)'s Programme of Work on Climate Change and Genetic Resources for Food and Agriculture (FAO, 2013a) and in the publication of a set of CGRFA background study papers on the links between genetic resources management and climate change, including one on the AnGR subsector (FAO, 2011a).

Climate change affects livestock production systems in many ways. If temperatures increase, heat stress in the animals themselves may become an increasing problem (ibid.). The availability of feed and the prevalence of diseases and parasites can be affected by changes in the local ecosystem. If changes are rapid, the adaptive link between a breed and the production environment in which it has traditionally been raised may be broken. Production systems may also be affected in more indirect ways: via the effect of climate change on input prices and via the effect of climate change mitigation strategies (ibid.). The effects of climatic disasters (floods, hurricanes, etc.) are discussed in more detail below (Subsection 3).

It remains difficult to predict the impact that climate change will have on AnGR diversity. This is partly because the effects of climate change are generally difficult to predict, particularly effects on complex aspects of ecosystem function, such as the epidemiology of diseases. However, it is also true that the vulnerability of particular breeds or populations to the effects of climate change is generally not well understood, whether in terms of their distribution in relation to geographical areas likely to be affected by climate change, the capacity of particular AnGR to thrive in changed agroclimatic conditions or the capacity of relevant groups of livestock keepers to adapt their management practices. Box 1F2 illustrates the potential impact of climate change on the geographical distribution of the production environment of a Kenyan cattle breed.

Livestock-sector trends that threaten AnGR diversity are not necessarily simply a matter of the sector responding to economic, social, environmental and technological drivers of the type described above (and in more detail in Part 2). They can also be influenced by public policy. Actions taken by national or local governments can make it easier or more difficult to make a living from particular types of production system (or from livestock keeping in general). If production systems that harbour diverse livestock populations are adversely affected, whether directly or because of competition from other production systems that benefit disproportionally, public policies can constitute a threat to AnGR. The first SoW-AnGR noted, for example, that policies that promote the introduction of high external input production systems or the use of exotic animals can pose a threat to locally adapted breeds.[5] Clearly, policies of this type cannot be dismissed simply on the grounds that they might put breeds at risk. All the various pros and cons from economic, social and environmental perspectives need to be weighed up. From the AnGR management perspective, the objective should be to ensure that whatever developments are planned, the breeds used are well matched to their production environments and that potential impacts on genetic diversity are assessed so that conservation measures can be taken if necessary.

It is also possible for livestock-sector policies to have a positive effect on AnGR diversity. This may be an inadvertent consequence of polices that

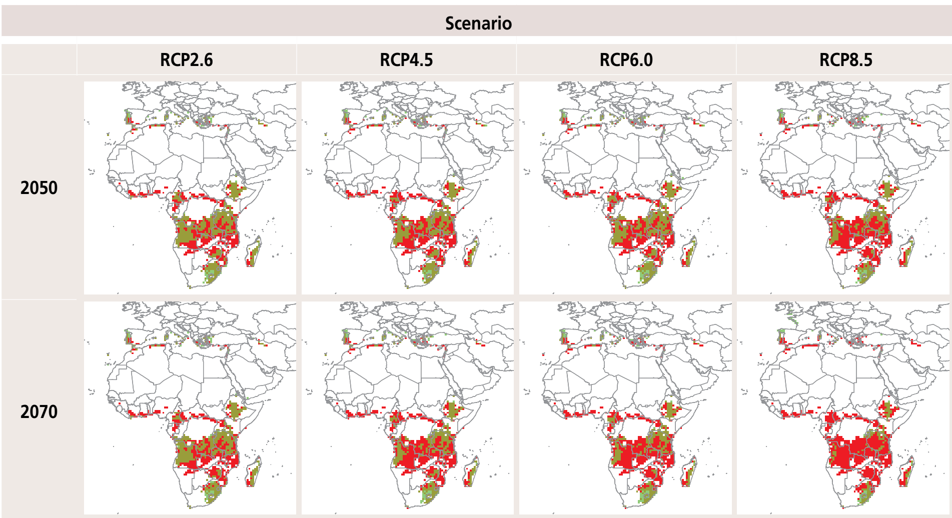
[5] FAO, 2007a, pages 117–120.

Box 1F2

The potential impact of climate change on breed distribution – an example from Kenya

The current geographic distribution of Kenyan Kamba cattle, as recorded in DAD-IS, was used to model the breed's potential distribution, taking several temperature and humidity characteristics of its production environment into account. This information served to define potential current and future habitats for this breed. Future habitats were modelled using the "Hadley Global Environment Model 2 – Earth System" and four scenarios (representative concentration pathways: IPPC, 2013a) were selected. Differences between potential current and future habitats were mapped using a simple colour scale, where areas of habitat loss appear in red, areas of no expected change in dark green and areas of habitat gain in light green. Analyses of this kind can potentially contribute to more informed decision-making on breed management in a changing climate and hence strengthen the capacity of national governments, livestock keepers and farmers to protect and enhance food security and manage their animal genetic resources sustainably.

Source: Maps based on DAD-IS (http://fao.org/dad-is) data (as of June 2014) and the Hadley Global Environment Model 2 – Earth System and four scenarios or representative concentration pathways (RCP).



(e.g. for livelihood-related reasons) promote the continued existence of diverse forms of livestock production. Alternatively, it may be the effect of conscious mainstreaming of AnGR-related concerns into other aspects of livestock development. It may also be the effect of the establishment of national strategies, plans or policies specifically intended to promote the sustainable management of AnGR. In the eyes of some stakeholders, the absence or weakness of such policies constitutes, in itself, a threat to AnGR diversity (FAO, 2009a). The argument has sometimes been taken a step further, with a lack of political will to support AnGR management programmes or to support rural communities being identified as a threat (ibid.). The links between national policies and AnGR management are discussed in more detail in Part 3 Section F.

Broad economic, social, environmental and policy drivers of change translate into a loss of AnGR diversity when they mean that livestock keepers who maintain the various breeds and populations that contribute to this diversity are no longer able or willing to do so (and if no one else is willing and able to take on the role). Even if breeds do not fall out of use, loss of diversity can occur if they are subject to genetic erosion caused by inbreeding or so-called indiscriminate cross-breeding (see below for further discussion). As discussed above, inbreeding can be an issue

Box 1F3

Animal genetic resources and access to grazing land – an example from India

In India, as elsewhere, the survival of many locally adapted breeds is linked to continued access to the communally owned grazing land in which they evolved and of which they are a part. The Raika are a community of herders in Rajasthan that have bred a number of livestock breeds, including various strains of camel, the Marwari and Boti sheep breeds, and the Nari cattle. For centuries they freely grazed their animals in the forest and on village commons, harvested fields and marginal lands. Because of their economic importance, they and other communities were accorded grazing privileges by local rulers. However, after India's independence in 1947, the forest came to be managed by a specialized department. The herders' grazing rights were curbed, the village commons were encroached upon and, due to irrigation, fallow land became more scarce.

The Kumbhalgarh Protected Area in southern Rajasthan has been at the centre of protracted efforts by the Raika to regain their customary rights. When their grazing permits were denied in the mid 1990s, the Raika, with support of a local NGO, took their case to the Supreme Court of India, making reference to Article 8j of the UN Convention on Biological Diversity (CBD), to which India is a party, to support their demand. The article commits countries to

"… subject to national legislation, respect, preserve and maintain knowledge innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity."

While the case was never concluded, India passed another piece of legislation, the "Forest Rights Act" of 2006, which provides rights not only to forest dwellers, but also to seasonal forest users, if they can prove that they have used the forest for three generations. The Raika and several other communities have claimed these rights, but the claims have not been processed.

In order to stake their claim under the CBD, the Raikas – and a handful of other communities, such as the Maldhari in Kutch (Gujarat) and a group of Lingayats living in the Bargur forest in Tamil Nadu – have developed a "Biocultural Protocol", in which they establish themselves as a local community whose lifestyle protects biological diversity. In the protocol, they document how they do this: by preventing forest fires, guarding wildlife and by keeping locally evolved livestock breeds.

The latest twist to the story is a plan to convert the Kumbhalgarh Wildlife Sanctuary into a National Park. Unless provisions for the inclusion of the Raika and other communities in the co-management of the park are made, several locally adapted breeds may become extinct.

Photo credit: Ilse Köhler-Rollefson.

Provided by Ilse Köhler-Rollefson.
For further information see LPPS, 2013.

even in breeds that remain popular and have large population sizes.

The immediate factors leading to breeds being abandoned (i.e. no longer being used) are diverse and often act in conjunction. Examples include:

- changes in demand that mean that products and services from certain types of livestock are no longer sought-after;
- competition (from other breeds, species, production systems or from outside the livestock sector);
- degradation of natural resources required to maintain particular types of livestock (or livestock in general) or livestock keepers' lack of access to these resources (see Box 1F3 for an example);
- availability of alternative livelihood options (e.g. jobs in manufacturing, services, etc.);
- additional costs associated with livestock keeping (or particular types of livestock keeping);
- sociocultural factors that make livestock keeping (or particular types of livestock keeping) unattractive as a livelihood activity; and
- other changes (e.g. to climate, disease epidemiology or husbandry practices) that mean that particular breeds are no longer well matched to their production environments.

Indiscriminate cross-breeding is widely recognized as a threat to AnGR diversity. The Global Plan of Action for Animal Genetic Resources (FAO, 2007b) notes, for example, that

> *"indiscriminate cross-breeding with exotic breeds is also rapidly compromising the genetic integrity of local populations."*[6]

It is important to note in this context cross-breeding is not necessarily a threat. Well-planned cross-breeding activities can help to keep potentially threatened breeds in use (FAO, 2010; 2013b). The word "indiscriminate" refers to a lack of attention to the choice of which animals should be mated to which. This can occur simply because animals are free roaming and mating is uncontrolled or because of unstructured attempts by individual livestock keepers to improve their herds or flocks. The problem may be exacerbated by policies that encourage artificial insemination with exotic genetics but do not ensure that this is done in a well-planned way. As well as being a threat to diversity, indiscriminate cross-breeding can also lead to problems in terms

Box 1F4
Indiscriminate cross-breeding as a threat to animal genetic resources in Egypt

Although many of the breeds present in Egypt can be placed in the "not at risk" category, it has been argued that local cattle and poultry may nonetheless be undergoing alarming genetic erosion. Census figures show that the percentage of the cattle population accounted for by cross-bred animals has been increasing, with the share of pure-bred locally adapted breeds decreasing and that of pure-bred exotics remaining more or less constant. The introgression of exotic genes into local cattle breeds is mostly indiscriminate. Surplus males from exotic breeds, as well as F1 and later generations of cross-bred males and females from planned cross-breeding projects, are sent to market and are then used for breeding. During the last ten years, local buffalo genotypes have been subjected to progressive cross-breeding using Italian buffalo semen. Given the production systems prevailing in the poultry, and rabbit industries, the situation for locally adapted breeds in these species could also be alarming, but there are no figures to substantiate this. In contrast, national efforts to conserve locally adapted chicken breeds, such as the Fayoumi, through utilization illustrate what can be done to support the maintenance of livestock biodiversity. The use of exotic sheep and goat breeds has not taken root to a degree that is likely to pose a threat to locally adapted breeds.

Source: Adapted from the country report of Egypt.

6 Paragraph 32.

of the productivity of the affected population or its resilience to shocks (droughts, disease outbreaks, etc.). The case of the Red Maasai sheep of East Africa was highlighted in the first SoW-AnGR as an example of a breed severely affected by indiscriminate cross-breeding (in this case with the Dorper breed, introduced from South Africa).[7] The potential risks associated with these developments are illustrated in the following quotation from Ojango *et al.*, 2014:

> *"The changing climatic conditions, notably the severe droughts, have been disastrous to the pastoral animal populations in general, and especially for pure and higher grades of Dorper crosses. The indigenous sheep breeds have however withstood such challenges much better."*

It is, of course, possible that "upgrading" a population via continuous cross-breeding may be chosen as an organized (as opposed to "indiscriminate") strategy. If this strategy is widely implemented it may pose a threat to the existence of the targeted breed and require the implementation of some kind of conservation programme if the breed's extinction is to be avoided.

2.2 Threats to individual breeds – examples from literature

The discussion presented above provides an overview of how livestock-sector trends are likely to exert pressures on livestock diversity. However, the global livestock sector is very diverse and each individual breed faces a particular combination of threats and opportunities and has a particular set of characteristics (strengths and weaknesses) that influence the likelihood that it will continue to be used under changing circumstances. It is therefore difficult to predict the future of an individual breed based merely on a general analysis of how the livestock sector is evolving. As discussed in Part 4 Section D, conserving and promoting the sustainable use and development of an at-risk or vulnerable breed requires a careful assessment of the concrete circumstances facing the breed and those who keep (or potentially keep) it. While there is no substitute for a thorough analysis of the characteristics of the targeted breed, its production system and the trends affecting them, it is possible that lessons can be learned from studying how, in other circumstances, factors have combined to drive specific breeds towards extinction. Unfortunately, in many cases, the factors leading to the decline of individual breeds have not been recorded in detail. This subsection present some examples drawn from scientific and historical literature (examples from the country reports can be found in Subsection 2.3 below and in Part 2 Section C).

Zander (2011) reports that sedentarization among the Borana pastoralists of Ethiopia and Kenya has led to the uptake of new livelihood activities such as crop farming, as well as providing the opportunity to purchase cattle from breeds other than the Borana. This is reported to have led to a dwindling of the breed's population, as well as to its dilution through cross-breeding. Interestingly, the same paper reports that in Kenya the main threat has been associated with exotic breeds, while in Ethiopia the main threat has been replacement and dilution by other locally adapted breeds.

Rahman *et al.* (2013), in a paper on the causes of genetic erosion among "indigenous cattle" in Mymensingh district Bangladesh, also report that indiscriminate cross-breeding is a major problem. They also note that "using various equipment and machineries in agricultural fields… seems to be a major cause of the loss of indigenous draught animals."

The case of the Sheko cattle breed of Ethiopia, as described by Taye *et al.* (2009), provides an example of how changes to the production environment can interact with a breed's particular characteristics to threaten its survival. Reduced availability of grazing land is reported to have led to smaller herd sizes and to greater use of tethering as opposed to free grazing. Smaller herd sizes meant that fewer farmers kept Sheko bulls, and this led to a shortage of bulls for breeding and more cross-breeding with "non-descript" local bulls. The Sheko is not well adapted to a tethering system, because of its aggressive nature and its lack of horns, which also contributed to the

[7] FAO, 2007a, Box 95 (page 444).

Box 1F5

Lessons from history? Breed extinctions and near extinctions during the nineteenth century

The following quotations taken from old books and articles on the history of livestock describe some of the factors that drove breeds towards extinction:

Cattle

"The cross [Aberdeen Angus × Shorthorn] … became a craze throughout northeastern Scotland [sometime after 1810], with the result that the **Aberdeen-Angus** were nearly wiped out of existence. However, during this critical period, a few breeders and one in particular, kept faith in the Aberdeen-Angus breed." (Vaughan, 1931)

"During the last half of the nineteenth century the Galloway country very largely gave up beef production in favour of dairying and the feeding of crossbred sheep. Ayrshire cattle displaced the **Galloways** to a considerable extent, and the breed would have become extinct, except for the efforts of a few persevering breeders, and as it was, the breed was greatly reduced in numbers." (Vaughan, 1931)

"[Extinction] was to be fate of the **Glamorgans**; when the pastures were broken up, the cattle chosen for feeding were of those modern breeds which mature more quickly." (H.E. in 'The Field', 1893).

"The **Irish Maoiles** [Irish Moiled] – Hornless cattle of the old Irish race are found here and there chiefly in the west and the north: from the level of Roscommon to Donegal and Antrim. Their numbers are now small, and there being no systematic attempt to breed them pure unless by a very few owners of small herds, their extinction seems only a matter of not very many years." (Wilson, 1909)

Sheep

"The **Ryeland**, as you are doubtless aware, is one of the oldest of British breeds of sheep, and some fifty years ago was the leading breed in this district. A desire for new breeds springing up, it was almost allowed to become extinct, but by a few good old judges refusing to part with their stock for other blood the breed has been saved its existence." (Wrightson, 1913)

Horses

"When the railways were established the [**Hackney**] breed suffered a setback, being too light for use exclusively as a farm horse. Later a succession of bad seasons from 1875 to 1885 resulted in the sale of much good breeding stock that should have been retained. It is said that the breed might have become extinct were it not for the loyalty of a few old admirers who later reaped a rich reward for their perseverance." (Vaughan, 1931)

"With the coming of the railroad and the river boat, the **Conestoga** horses and wagons were quickly displaced and no further efforts were made to breed heavy horses in America until about 1870. The blood of the Conestoga was absorbed into the common stock of the country and the type became extinct." (Vaughan, 1931)

Pigs

"In speaking of the breeds of pigs belonging to this county, we must not omit the now extinct **Rudgwick swine**, which … were some of the largest hogs produced in England. They fattened but slowly, and were consequently deemed unprofitable, but yielded excellent meat and in considerable quantities. They have, however, passed away before the alterations produced by the general aim of the present system of breeding." (Youatt *et al.*, 1865)

"… two breeds of pigs which had classes provided for them at the Royal and some other Shows have become extinct. These were the Small White and the Small Black breeds – the sole cause of their disappearance being the unsuitability of the pigs of the breeds to supply the present requisites of the consumer." (Sanders, 1919)

"This breed [the **Old English Hog**] is nearly extinct having been crossed successively by Chinese and other good breeds …" (Allen, 1865)

"The old English breed of this name [the **Cheshire**] is virtually extinct, having been crossed upon by smaller and earlier maturing breeds." (Shaw, 1900)

Box 1F6
The near extinction of the Cleveland Bay horse of the United Kingdom

The Cleveland Bay horse of northern England almost became extinct twice during the nineteenth century. On the first occasion, during the early part of the century, rising grain prices led farmers to want heavier horses for use in ploughing heavy soils converted from pasture and for carting grain to market. At the same time it became fashionable to use "big upstanding" horses for carriage driving. Both factors led to the cross-breeding of the Cleveland – on the one hand with "cart horses" and on the other with Thoroughbreds – to such an extent that it almost disappeared as a pure breed. On the second occasion, in the 1860s, the growth of the iron trade created demand for heavy horses, well adapted for drawing heavy loads on the roads and in the mines. Cart horses were improved and the Clevelands increasingly neglected. At this point "foreigners came in, and bought what they could of the best, and the men who kept their mares, bred hunters from them, and crossed them out of recognition."

Source: Adapted from Blew *et al.*, 1898 (direct quotations are taken from this source).

Box 1F7
The near extinction of the Lleyn sheep of the United Kingdom

Prior to the Second World War, the Lleyn sheep was a popular breed in northwestern Wales in the United Kingdom. The war years brought a policy of compulsory ploughing of a third to a quarter of all ploughable land on every farm, which meant that there was less land for grazing, and for sheep production in particular. Wartime demand for food led to cross-breeding with breeds such as the Southdown "to produce an early maturing lamb with plenty of fat." Moreover, farmers wanted "to keep the same number of ewes that they kept prior to the introduction of the ploughing quota. The only way was to purchase the small Welsh Mountain ewe, which could be stocked at twice the density of the Lleyn and was cheaper to buy ... the Southdown was ideal for crossing with the Welsh [Mountain] ewe". The opening of a farmer-owned creamery in the area increased the attractiveness of dairy (cattle) farming and led to some farmers moving completely out of sheep production.

By the 1960s the breed was on the brink of extinction. Its subsequent recovery is described in a text box in the first SoW-AnGR.[1]

Source: Adapted from Rees-Roberts (undated) (direct quotations are taken from this source).
[1] FAO, 2007a, Box 96 (page 446).

decline in its use (ibid.). The Sheko is the only surviving taurine cattle breed in that part of Africa and has numerous characteristics that are reportedly appreciated by farmers (e.g. relatively high milk yield, disease tolerance, draught stamina, less-selective feeding behaviour, attractive appearance, ability to maintaining good body condition, short inter-calving period and long lactation period). Nonetheless, at the time the Taye *et al.* (2009) study was undertaken (2004–2005), a lack of appreciation of the breed's importance and a lack of intervention to support its sustainable management were reported to be among the threats to its survival. Ethiopia's country report indicates that the current situation is more promising in this respect, with an *in situ* conservation programme in operation based on extension activities to improve management, awareness-raising activities and the use of artificial insemination using Sheko semen to help overcome the shortage of bulls. For further information on threats to the Sheko and other Ethiopian cattle breeds, see Box 1F8.

As noted above, detailed information on the factors currently threatening individual breeds is not widely available. On the other hand, numerous snippets of information can be found in more historical literature about how breeds in developed countries (when they were relatively less "developed") were driven towards extinction. Breed replacement,

Box 1F8
Threats to animal genetic resources in Ethiopia

Overview
Exotic cattle and chicken breeds, and to a limited extent sheep and goat breeds, have been introduced into the country. Lack of a breeding policy, uncontrolled use of artificial insemination in cattle and extensive distribution of exotic chickens among farming communities have posed a serious threat to indigenous cattle and chicken genetic resources. Drought, occurring as a result of climate change, has been causing significant losses of animal genetic resources. Disaster risk management measures are in place, and post-disaster restocking activities are meant to involve the use of breeds that are well matched to local conditions. However, implementation is fraught with problems and restocking usually takes place without consideration to the type of species or breed used. In some pastoral areas, climate change has resulted in shift in species use from cattle to dromedaries and goats, and this is posing a threat to cattle genetic resources. Lifestyle changes, particularly a shift from mobile pastoralism to sedentary agriculture, has affected livestock's livelihood roles and led to a reduction in population sizes and changes in the species used. Human population growth has affected animal genetic resources indirectly as a result of declining availability of grazing land caused by the expansion of cropland to meet the demands of the increased population.

Threats to specific breeds
Fogera cattle used to be kept under a livestock-dominated crop–livestock production system in a wetland area. In a period of less than three decades, the breeding tract of the breed has been turned into a monoculture rice cultivation area. Rice became the major source of livelihood and grazing lands have been turned into rice fields, depriving the breed of its grazing area. As a result, the size of the Fogera population has declined dramatically. Fogera animals have been moved to other upland areas in search of feed and in these areas have been exposed to interbreeding with zebu breeds.

Photo credit: Ethiopian Biodiversity Institute.

Sheko cattle (the only short-horned cattle breed of Eastern Africa) used to be managed under free grazing in a forest area. With growth in the population and expansion of crop farming, tethering management has been introduced. Because of the aggressive nature of the breed (mainly the male) under tethering management, early castration or removal of the male has been common. This has caused a significant threat to the existence of this trypanotolerant breed.

Photo credit: Ethiopian Biodiversity Institute.

The area where **Boran** cattle are kept is being affected by climate change and there has been a significant change in the amount of rainfall and the frequency of drought. As a result, there has been a shift from cattle to dromedaries and the number of Borans kept by pastoralist households has declined significantly.

Source: Adapted from the country report of Ethiopia (the report cites Yosef *et al*., 2013 as a source of information on Boran cattle).

cross-breeding to the point of disappearance, replacement of breed function, poor management of breeding, among other factors, all played a role (see Box 1F5). In several cases, it appears that breeds were only saved by the perseverance of a small number of breeders. Driving forces of change included changing market demand and changes to the production system. However, changing fashions and "crazes" also appear to have played a role. Where relatively detailed accounts are available, they generally indicate that a combination of factors was involved (see Boxes 1F6 and 1F7).

2.3 Country-report analysis

The concluding chapter of the first SoW-AnGR[8] noted that the discussion of threats to AnGR diversity had thus far tended to remain focused on changes at the level of the livestock production system. In other words (as noted above), it generally remained unclear how broadly identified threats were operating in concrete circumstances to drive specific breeds towards extinction. It could equally have been stated that there had been little detailed analysis of which among the various threats identified were actually creating the most serious challenges for stakeholders trying to promote the sustainable management of AnGR at national level. In an attempt to fill the latter knowledge gap, countries were asked, as part of the reporting process for the second SoW-AnGR, to describe how livestock-sector trends (broadly those identified as significant in the first SoW-AnGR) were affecting the management of their AnGR. Countries were also asked to describe the factors leading to the erosion of their AnGR and to specify what breeds or species were affected. Analysis of countries' responses to the questions on livestock-sector trends is presented in Part 2 Section C.

The factors most frequently mentioned in countries' responses to the question about the causes of genetic erosion are shown in Table 1F2. The question was open-ended, i.e. countries were asked to provide textual answers. Some chose to refer to high-level drivers of change, while others focused on factors operating at the level of the production system, holding or herd, or on policy or institutional weaknesses. Thus, while the answers presumably reflect priority concerns, they probably do not present a comprehensive picture of all the factors contributing to genetic erosion in the respective countries. It should also be noted that only about 35 percent of reporting countries indicated that they regularly assess the factors leading to the erosion of their AnGR, and that assessments of this kind are far more common in Europe and the Caucasus and North America than in other regions.

The most frequently mentioned cause of genetic erosion was indiscriminate cross-breeding. The prevalence of this threat (reported particularly frequently by African countries) implies that improving the management of breeding could contribute significantly to reducing genetic erosion. However, the implementation of such improvements is likely to be challenging in many countries, particularly given that the third most commonly mentioned factor contributing to genetic erosion was a lack of, or weak, AnGR-management programmes, policies or institutions (for further discussion of capacity to implement breeding programmes, see Part 3 Section C). The second and the fourth most frequently mentioned threats were replacement of locally adapted breeds by exotic breeds and the lack of competitiveness or poor performance of some breeds (usually those in the locally adapted category). These two threats are inter-related. Lack of competitiveness or profitability is often caused by the presence of more competitive (often exotic) alternatives. The decision to start using exotic breeds is normally taken because these breeds are more profitable (or at least are expected to be so). An example of the interplay between lack of management capacity, demand for high-output animals, breed replacement and uncontrolled cross-breeding as threats to diversity is described in Box 1F9.

In addition to the above-mentioned responses related to breeds' lack of profitability, a small number of country reports (7 percent or less) mention either unspecified economic and market-related factors or broad economic trends such

[8] Part 5 Needs and challenges in animal genetic resources management (FAO, 2007a, pages 483–503).

TABLE 1F2

Factors reported in the country reports as causes of genetic erosion

Threats	Africa	Asia	Europe and the Caucasus	Latin America and the Caribbean	Near and Middle East	North America	Southwest Pacific	World
	n = 32	n = 17	n= 23	n = 14	n = 3	n =1	n = 3	n = 93
	Percentage of countries mentioning the threat in response to open-ended question							
(Indiscriminate) cross-breeding*	63	41	17	29	67	100	33	42
Introduction/increased use of exotic breeds	22	29	35	64	33	0	67	34
Lack of/weak AnGR management policies, programmes or institutions	19	41	22	14	100	0	33	26
Breeds not profitable/competitive or have poor performance	3	12	48	7	0	100	0	17
Intensification of production or decline of traditional production systems or small farms	0	12	39	29	0	0	0	16
Disease/disease management	28	12	13	7	0	0	0	16
Loss/lack of grazing land or other elements of the production environment	9	24	13	21	0	0	0	14
Inbreeding or other problems in the management of breeding	3	6	26	7	0	0	0	10
Migration from countryside/uptake of alternative employment	3	18	17	0	0	0	0	9
Changes to consumer/retailer demand/ habits	0	12	17	0	0	100	0	8
Mechanization	3	24	9	14	0	0	0	8
Value of locally adapted breeds not appreciated	6	18	0	0	0	0	0	8
Unspecified economic/market factors	3	18	9	0	0	0	0	6
Climate change	16	6	0	0	0	0	0	6
Globalization, trade liberalization or imports	0	12	9	7	0	0	0	5
Lack of infrastructure or support for production, processing or marketing	3	6	4	0	0	100	0	4
Aging farmers or lack of interest among the young generation	0	0	13	0	0	0	0	3

Note: The cells are coloured according to a graded scale from red (100%) to green (0%).
Additional factors reported by a small number of countries included theft, lack of public/policy-maker awareness, high costs of inputs (including labour), urbanization, specialization of production, species replacement, drought, unspecified natural disasters, war, marketing restrictions (due to disease), livestock being regarded as environmental problem, improved disease prophylaxis, excessive slaughter during religious events, extension activities focusing on production not sustainability, inappropriate husbandry practices, unspecified cultural issues, unspecified production system issues and unspecified social constraints.
*Some countries specified that the cross-breeding causing the threat is indiscriminate.
Source: Country reports, 2014.

Box 1F9
Threats to animal genetic resources in Mozambique

In the past, selection and cross-breeding studies were conducted, with the aim of identifying the best genetic resources for use in the production sector. However, because of war and lack of expertise, funds and infrastructure, there was no follow up to these studies, and the resulting progeny were used for indiscriminate breeding and uncontrolled cross-breeding. As a result, with the exception of some commercial/private farms, the animals in the current population have various (and unknown) levels of exotic × native blood, and reductions in productivity have been reported. Because of this reduced productivity and the need to increase output in order to satisfy growing consumer demand, farmers tend to replace native breeds with exotic breeds, with all the problematic consequences of introducing temperate breeds into harsh tropical conditions. The replacement of native breeds and uncontrolled breeding is placing these breeds at risk of extinction or at least genetic erosion.

Source: Adapted from the country report of Mozambique.

as globalization, trade liberalization or increasing levels of imports. A few mention specific changes in consumer demand that have led to falling demand for the products or services of particular breeds or species. The examples are quite diverse and include cases from both developed countries and developing countries (see Box 1F10). They also include shifts both away from and towards demand for higher-quality products.

After lack of profitability, the next most commonly mentioned threat (16 percent of responses) was intensification of production or decline of traditional or small-scale production systems. This threat was more frequently mentioned in the country reports from Europe and the Caucasus (39 percent) than in those from other regions, although also quite frequently mentioned in the reports from Latin America and the Caribbean (29 percent).

Box 1F10
Shifting consumer demand as a threat to animal genetic resources – examples from around the world

Country-report responses to a question about the causes of genetic erosion included a number of references to specific changes in consumer demand:

China: "The products ... from locally adapted breeds do not meet the consumption demands of contemporary people."

Ireland: "The downturn in the economy is leading to excess production of all equines and a reduction in customer demand."

Portugal: "The current crisis leads consumer to choose cheaper foods rather than higher-quality products."

Tajikistan: "A lack of demand for Karakul skins."

United Kingdom: "Retailer-driven specifications for commodity animal products are causing rapid and substantial introgression of external genetics into some breeds – notably dairy and beef cattle breeds."

United States of America: "A strong consumer shift towards higher demand for eating quality (primarily tenderness and flavour) has resulted in a rapid decline in the population size of the Hampshire pig breed, which is associated with lean carcasses with low water-holding capacity, resulting in less palatable meat."

Sources: Country reports of China, Ireland, Portugal, Tajikistan, the United Kingdom and the United States of America.

Another threat to the production systems that underpin AnGR diversity – loss of grazing land or other components of the production environment – received the same number of responses. The country report from Guinea, for example, notes that the area available for pastoral grazing is being reduced by the expansion of the agricultural frontier and the spread of mining operations. The country report from South Africa notes that mining is reducing the availability of grazing land and also affecting water quality and that wildlife ranching is also encroaching on grazing land. Further examples are provided in Boxes 1F1, 1F3 and 1F8 and in Part 2 Section C.

Box 1F11
Threats to animal genetic resources in the United States of America

Across species, consumer-demand drives the success or failure of livestock breeds. The vast majority of consumers demand low-cost animal products. Breeds capable of supplying products at the lowest cost (usually expressed on a per animal basis) have successfully captured larger shares of the market. However, as segments of society generate demand for livestock produced locally or with lower levels of production intensity, pockets of demand have been created for breeds that provide products at lower quantities per animal or with greater bio-economic efficiencies.

For beef cattle, there are a few large breed associations that generate enough revenue to maintain staff, and have breeders that can afford a full-scale programme. However, small breed associations struggle to maintain an office, databases of registered animals, germplasm preservation, etc.

The loss of the government price-support system for wool and fibre has had a detrimental impact on some sheep and goat breeds. In the goat industry, the importation of the Boer goat has resulted in extensive cross-breeding with landrace breeds, especially the Spanish goat, and this has resulted in a threat to the survival of these breeds in pure-bred form.

A shift towards demand for meat with higher eating quality has resulted in a rapid decline in the size of the Hampshire pig population (see Box 1F10). Conversely, it has led to an expansion in the population size of the Berkshire breed, which has high levels of intramuscular lipid, resulting in enhanced eating quality. A small countervailing force is the expansion of niche markets, which can be exploited by small-scale farmers delivering pork products to local consumers. At-risk breeds are frequently utilized in these niche-production programmes.

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

Box 1F12
Threats to animal genetic resources in Peru

Alpacas and llamas: Genetic erosion is being caused by the absorption or replacement of coloured types by those that produce fine white fibre. Herds producing coloured fibre or fibre that is highly variable in its fineness have been shrinking and in some cases have lost colours or shades.

Criollo cattle: The introduction of exotic breeds into the country has led to a reduction in the size of criollo populations. The distribution of criollos has become restricted to extreme environments where availability of forage and water is restricted.

Native guinea pig: The growing market for guinea pig meat has led to priority being given to the use of breeds genetically improved for meat production. It is anticipated that this will affect the numbers and the genetic diversity of native breeds.

Other species: Threats to locally adapted breeds of sheep, pigs, goats, horses, ducks, etc. are mainly related to the increasing use of exotic breeds.

Source: Adapted from the country report of Peru.

Disease or disease-control measures were also mentioned in 16 percent of responses. Details of the mechanisms involved were not always provided. However, in some cases the country reports indicate that culling measures are a threat (see Box 1F13 for an example). The threat posed by disease epidemics is discussed in further detail below (Subsection 4).

A number of responses (10 percent) mention problems related to the inappropriate management of breeding programmes, particularly practices that lead to inbreeding. This answer was more common in country reports from Europe and the Caucasus than in those from other regions.

Another threat mentioned in a similar number of responses (9 percent), mostly in reports from Asia and Europe and the Caucasus, is migration from rural areas or uptake of alternative employment. For example, the country report from China, notes that

Box 1F13
Threats to animal genetic resources in Botswana

Factors leading to genetic erosion in Botswana include indiscriminate cross-breeding with exotic breeds. This occurs because most livestock in the country is found in communal areas where controlled breeding is hard to practice. As such, indigenous Tswana breeds of various species (cattle, sheep, goats and pigs) are at risk because most farmers want to farm with "improved" stock due to their high growth performance and economic returns.

Animal diseases outbreaks also erode the country's animal genetic resources, especially cattle, because of the stamping out (eradication of disease through mass slaughtering) that occurs in affected regions.

Source: Adapted from the country report of Peru.

Box 1F14
Effects of predation on sheep production in Norway

The sheep population is decreasing due to poor profitability and conflicts with the wolf and other predators. Most of the sheep farming in Norway is based on letting the sheep out in outlying and mountainous areas during the grazing season (approximately four months). With the return of predators such as bears, wolves, lynx and wolverine, and with hunting them being prohibited, many sheep farmers cannot or will not let their flocks graze on outlying land without herding. The areas where the sheep used to graze are enormous, so herding is difficult and expensive. This is part of the explanation for the decrease in the number of sheep and sheep farmers during the last decade (7 percent and 20 percent, respectively). The number of sheep farmers in 2013 was 14 000.

Source: Adapted from the country report of Norway.

"thousands of families in rural areas have quit animal rearing ... The accelerated withdrawal of backyard farmers will inevitably lead to reduction or even extinction of local genetic resources."

A related factor mentioned in a smaller number of responses (3 percent – all from Europe and the Caucasus) is ageing of the faming population and a lack of interest in livestock keeping among the younger generation.

Mechanization of agriculture and transport leading to the decline of breeds used for draught was mentioned in 7 percent of responses overall, but considerably more frequently among those from Asian countries (24 percent). Climate change, in contrast, was mentioned most frequently in responses from African countries (16 percent, as compared to 6 percent for the world as a whole). Species replacement as a result of climate change is noted, for example, in the country report from Ethiopia (see Box 1F8). The report from Mali notes that climatic changes have led to changes in transhumance patterns, with pastoralist herds remaining for longer in the southern part of the country. This in turn has led to degradation of natural resources, conflicts over resource use and indiscriminate cross-breeding between breeds from the north of the country and those from the south. The potential for climate change to increase risks associated with meteorological disasters is further discussed below (Subsection 3).

A range of other threats were mentioned by a limited number of countries. One issue that is causing some concern in parts of Europe is the threat from predator animals, the populations of some of which are expanding in some areas because of restrictions on hunting (see Box 1F14).[9] The threat to livestock has been exacerbated by changes in management – larger flocks per shepherd – that have increased animals' vulnerability. Elsewhere in the world, the country report

[9] Predation was not mentioned in response to the question in the country-report questionnaire directly referring to the causes of genetic erosion and therefore does not feature in Table 1F2.

from South Africa notes that predation, along with theft, remains a major challenge and some farmers have moved from conventional livestock keeping to wildlife ranching as a result. It further notes that an in-depth scientific evaluation of predation is being undertaken with the aim of developing more acceptable control methods.

3 Disasters and emergencies

As noted in the introduction to this section, the first SoW-AnGR distinguished threats associated with gradual changes to productions systems from those associated with acute events such as climatic disasters. These two different types of threat present quite distinct challenges in terms of AnGR management and it is therefore useful to discuss them separately. In reality, however, there are many connections between the two. A gradual trend may make an acute disaster more likely, increase its impact or increase the vulnerability of a given livestock population to its effects. This subsection updates the discussion of disasters and emergencies presented in the first SoW-AnGR. Threats of this type and efforts to manage them are not discussed in any detail elsewhere in the report. This subsection therefore presents a relatively detailed analysis of developments in this field.

It is well recognized that a catastrophic event that kills large numbers of animals can pose a threat to AnGR diversity, particularly to breeds or populations that are concentrated within a limited geographical area. This kind of threat was discussed in some detail in the first SoW-AnGR. The report noted that impacts on AnGR can occur both because of the direct effects of an "inciting event", such as a hurricane or earthquake, and because of longer-term disruptions associated with a "state of emergency" brought about by an event of this kind. It also recognized that actions taken to deal with an emergency situation, particularly the restocking of livestock populations, can have a significant effect on AnGR diversity. A distinction was drawn between "acute" and "chronic" emergencies. The former correspond to the above-described pattern: a major inciting event that occurs in a short, discrete, period of time is followed by a longer, but finite, period of disruption. A chronic emergency, in contrast, involves an ongoing state of disruption caused by continuing, or periodically recurring, problems (e.g. intermittent droughts, intermittent military conflicts or the effects of human-health problems such as HIV/AIDS). Chronic emergencies, while they may not involve such devastating impacts in terms of livestock mortality, can have a significant effect on AnGR diversity, both because of disruptions to livestock-keeping livelihoods and because of associated livestock-related development interventions, such as projects that introduce exotic animals.

In addition to the direct effects that they can have in terms of livestock deaths and disruptions to livelihoods, disasters can also disrupt the delivery of livestock-related services and the operation of management programmes, including those related to the sustainable use and development of AnGR. The following quotation is taken from Liberia's National Biodiversity Strategy and Action Plan:

> *"Skills essential for environment and biodiversity management were lost through death, incapacities and migration. Records and publications (biodiversity information) important for the conservation and sustainable use of biological resources were destroyed. The only research institution, CARI, was vandalized and destroyed during the war, resulting in loss of crop and livestock genetic materials. Domestic animals were decimated, including pets like cats and dogs."(Government of Liberia, 2004).*

Another potential threat is that a large-scale disaster, such as a war, may create such urgent demand for food that animals are slaughtered indiscriminately without sufficient attention being paid to the need to retain high-quality breeding animals. This effect is reported to have threatened the survival of several British pig breeds during the First World War (Wiseman, 2000).

Disasters and emergencies did not feature prominently among responses to the country-report question on causes of genetic erosion (Table 1F2). A few countries mentioned military conflicts, and this threat was also noted in the reports submitted by both AU-IBAR and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) as part of the second SoW-AnGR reporting process.[10] As noted above, several countries mentioned climate change as a threat, but generally these responses did not refer explicitly to disaster risk. Several countries (e.g. Ethiopia, the Islamic Republic of Iran and Kenya), noted drought as a significant threat.

In terms what can be done to protect AnGR from the effects of disasters and emergencies, the first SoW-AnGR recognized that at the height of major acute emergency, interventions to protect animals would rarely be a priority. The importance of taking precautions in advance was therefore emphasized. If possible, breeds or populations that are vulnerable to the effects of disasters should be included in *ex situ* conservation programmes under which cryoconserved material and/or live animals are kept at a location (or preferably more than one location) outside the disaster-prone area. In the case of emergencies that have a slower onset or are less severe in terms of their effects on the human population, the first SoW-AnGR noted that there might be more scope for taking action to protect at-risk breed populations from destruction. However, it also recognized that this would generally require a degree of advanced planning and good knowledge of where threatened populations are located. The need to improve knowledge of breeds' geographical distribution was one of the main recommendations of the first SoW-AnGR with respect to the threats posed by disasters and emergencies.

In addition to establishing *ex situ* conservation schemes, disaster preparedness can also include practical steps to mitigate the effects of disasters. Examples include the creation of fodder banks in areas that are prone to climatic disasters such as droughts or severe winter weather, and contingency plans for the provision of feed, water and veterinary services in the event of a disaster. Disaster early-warning systems may help to give people the time needed to implement measures to protect their animals. Further information on livestock-related emergency preparedness measures can be found in the *Livestock and emergency guidelines* (LEGS, 2009) published by the Livestock and Emergency Guidelines and Standards Project.

In some cases, preparedness measures may include the establishment of facilities that can be used to physically protect animals from the immediate effects of a disaster. For example, in Bangladesh, where more than 1 million cattle were killed by Cyclone Sidr in 2007, the Swiss Agency for Development and Cooperation has constructed a number of multipurpose cyclone shelters that can house both people and animals (IRIN, 2012). Another measure taken in some parts of Bangladesh is to construct elevated earth structures, known as *killas*, upon which livestock can be kept during cyclones (Choudhury, 1993; Floreani and Gattolin, 2011). Where naturally safer ground is accessible, specialized constructions may be unnecessary. For example, in the wake of Hurricane Isodore, which struck Mexico in 2002, local municipalities in Yucatan purchased areas of land a few kilometres away from the coast and promoted the relocation of animals from vulnerable coastal areas (UNISDR, 2013). In Indonesia, when the Mount Merapi volcano erupted in 2010, local authorities provided livestock feed and shelter in safe areas so that animals did not have to be left in villages threatened by the eruptions (Husein *et al.*, 2010).

Measures taken to protect animals from the physical effects of a disaster need to be well adapted to local circumstances and feasible in terms of the resources available. Taking Bangladesh again as an example, the current number of cyclone shelters is insufficient to protect the whole human population in cyclone-affected zones, and therefore construction of relatively elaborate combined human–animal shelters may not always be regarded as a priority (IRIN, 2012). *Killas*, on the other hand, are

[10] Reports from international organizations are available at http://www.fao.org/3/a-i4787e/i4787e03.htm.

simple constructions, but tend to fall into disrepair when not in use. People may also be unwilling to take their animals to *killas* if they are located far away from human shelters. It has been argued that some kind of combination of a shelter for the people and a *killa* for the animals is the preferable option in these circumstances (Choudhury, 1994; Floreani and Gattolin, 2011).

Preparedness measures, if taken at all, will generally focus on protecting livestock in general rather than on protecting AnGR diversity *per se*. However, increasing the proportion of the livestock population protected will, by default, tend to increase the probability that particularly significant subpopulations (e.g. breeds that are rare or have unique features) will be protected. If such populations have been identified and their locations are known, it may be possible to take steps to ensure that they are covered by whatever preparedness measures are in place in the local area, or even to prioritize them.

In the case of post-disaster restocking, choosing appropriate breeds or species is an important part of the planning process. It may be tempting to use the restocking exercise as an opportunity to "improve" the local livestock population. However, given the difficult conditions that are likely to prevail in a post-disaster situation, introducing animals that require higher levels of care and inputs may be a risky strategy. Even at the best of times, introducing a new breed requires careful planning to ensure that the animals and the production system are well matched (FAO, 2010). Using locally adapted rather than exotic breeds for restocking is likely to reduce the potential for negative consequences for AnGR diversity. However, even in these circumstances, it is possible that restocking may have negative effects on specific breeds. The ability to identify any such potential threats is, again, likely to depend on the availability of good knowledge of the characteristics, distribution and demographics of local livestock populations.

Where interventions that aim to address more chronic emergencies or longer-term post-disaster development are concerned (i.e. actions taken once the disruptions of the immediate aftermath have subsided), the "standard" AnGR-related advice applies (see for example FAO, 2010): any breeds or crosses that are introduced must be appropriate for the local production environment and the needs of the local livestock keepers; potential impacts on the AnGR of the local area should be assessed and, if necessary, conservation measures (FAO, 2013b) should be implemented.

While, given the destructive power of many disasters and the geographical concentration of some breed populations, the existence of a potential threat to AnGR diversity appears to be quite clear – and is widely recognized among those involved in AnGR management – the first SoW-AnGR noted that the scale of this threat was unclear. In fact, it was difficult to find any documented examples in which the risk status of specific breed populations had been significantly worsened by a disaster or emergency. The main exception to this was a case study on the effects that the 1992 to 1995 war in Bosnia and Herzegovina (and subsequent efforts to rehabilitate the country's livestock sector) had had on AnGR, particularly the Busha breed of cattle, whose population reportedly declined from over 80 000 in 1991 to below 100 in 2003.[11] This kind of "before versus after" analysis is, clearly, reliant on the existence of reasonably precise and up-to-date figures for the size of the respective breed population in the run up to the emergency and on there being sufficient capacity to assess the post-emergency situation (i.e. to carry out some type of population survey). Breed-specific data on the number of animals killed by acute disasters are, not surprisingly, rarely available – and no such examples were presented in the first SoW-AnGR.

[11] In 2011, "BushaLive", a regional project (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, Serbia and The Former Yugoslav Republic of Macedonia) aiming to promote the conservation of the Busha, was chosen to receive funding under the Funding Strategy for the Implementation of the Global Plan of Action for Animal Genetic Resources (for more details, see http://www.fao.org/ag/againfo/programmes/en/genetics/first_call.html).

The first SoW-AnGR cited sources (IFRC, 2004; EM-DAT database)[12] indicating that the frequency of many types of disaster had been increasing over the preceding years and decades.[13] Recent data indicate that, while at global scale there may be a downward trend in human mortality rates associated with hydrometeoroligical disasters, overall economic and livelihood losses associated with disasters are increasing rapidly (UNISDR, 2013; Lavall and Maskrey, 2013). In very broad terms, it seems that improved early warning systems, along with better developed infrastructure, health care systems, etc. have often allowed more human lives to be saved,[14] while little progress has been made in terms of the land use planning and environmental-management measures that might reduce exposure to certain types of disaster (UNISDR, 2013). Disaster trends also vary greatly from one region to another. For example, in contrast to the general trend, flood mortality rates in sub-Saharan Africa have been increasing consistently in recent decades. Increases in the hazard exposure of "produced capital" have been particularly marked in areas where economic growth has been rapid (e.g. in parts of Asia) (ibid.).

Disaster risk is also probably being affected by climate change. The Intergovernmental Panel on Climate Change, in its special report on managing extreme events and disasters (IPCC, 2013b), concluded that, at global scale, climate change can be expected to increase the frequency and/or severity of several types of extreme weather events and other potentially disastrous phenomena (e.g. slope instabilities and lake outburst floods caused by glacial retreat or permafrost degradation) in the coming decades (see Box 1F15). Certain other types of extreme event are, however, predicted to become less frequent. There are also expected to be shifts in the geographical distribution of certain types of event.

[12] http://www.emdat.be

[13] FAO, 2007a, Figure 36 (pages 120–121).

[14] Mortality rates in the event of an earthquake are closely correlated to building collapse. In contrast to mortality rates associated with hydrometeorological disasters, human earthquake mortality rates have been increasing globally in recent years.

The advice on disasters and emergencies presented in the first SoW-AnGR was, in broad terms, taken up in the Global Plan of Action for Animal Genetic Resources (FAO, 2007b), which calls for the establishment of "integrated support arrangements to protect breeds and populations at risk from emergency or other disaster scenarios, and to enable restocking after emergencies, in line with the national policy."[15] It also calls for the establishment of backup *ex situ* conservation systems for "protection against the risk of emergency or disaster scenarios."[16] According to the country reports, 30 percent of countries have put arrangements in place to protect breeds and populations that are at risk from natural or human-induced disasters (FAO, 2014). However, the scope of these measures is in some cases limited to measures such as the provision of compensation to livestock keepers affected by natural disasters or the implementation of broad disaster-management strategies.

Another field in which there have been significant developments since the publication of the first SoW-AnGR is the assessment of geographical distribution as a factor affecting breeds' risk statuses. The significance of geographical concentration was, for example, highlighted in a paper by Carson *et al.* (2009), which showed that out of 12 British sheep breeds assessed, 10 had 95 percent of their population numbers concentrated within a radius of 65 km or less (in some cases less than 30 km). Geographical concentration was subsequently incorporated into the United Kingdom's breed risk classification system (Alderson, 2009). In another study, Bahmani *et al.* (2011) analysed the distribution of the Markhoz goat in the Islamic Republic of Iran and discovered that 77 percent of its population was concentrated within a circle with a radius of 7 km. In this case, natural disasters such as droughts are reported to have already contributed to the decline of the breed's population (ibid.).

[15] FAO, 2007b, Strategic Priority 10, Action 2.

[16] FAO, 2007b, Strategic Priority 23, Action 3.

Box 1F15

Projections for the risk of climatic disasters

The Intergovernmental Panel on Climate Change's special report *Managing the risks of extreme events and disasters to advance climate change adaptation,* published in 2013, includes a number of projections of future trends in the occurrence and severity of extreme climatic events. The main predictions are summarized in the following quotations.

"Models project substantial warming in temperature extremes by the end of the 21st century. It is *virtually certain* that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur in the 21st century at the global scale. It is *very likely* that the length, frequency, and/or intensity of warm spells or heat waves will increase over most land areas ..."

"It is *likely* that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe. This is particularly the case in the high latitudes and tropical regions, and in winter in the northern mid-latitudes. Heavy rainfalls associated with tropical cyclones are *likely* to increase with continued warming. There is *medium confidence* that, in some regions, increases in heavy precipitation will occur despite projected decreases in total precipitation in those regions ..."

"Average tropical cyclone maximum wind speed is likely to increase, although increases may not occur in all ocean basins. It is *likely* that the global frequency of tropical cyclones will either decrease or remain essentially unchanged."

"There is *medium confidence* that there will be a reduction in the number of extratropical cyclones averaged over each hemisphere. While there is *low confidence* in the detailed geographical projections of extratropical cyclone activity, there is medium confidence in a projected poleward shift of extratropical storm tracks ..."

"There is *medium confidence* that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration. This applies to regions including southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil, and southern Africa. Elsewhere there is overall *low confidence* because of inconsistent projections of drought changes (dependent both on model and dryness index) ..."

"Projected precipitation and temperature changes imply possible changes in floods, although overall there is *low confidence* in projections of changes in fluvial floods. Confidence is low due to *limited evidence* and because the causes of regional changes are complex, although there are exceptions to this statement. There is *medium confidence* (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in local flooding in some catchments or regions."

"It is *very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future. For example, the *very likely* contribution of mean sea level rise to increased extreme coastal high water levels, coupled with the likely increase in tropical cyclone maximum wind speed, is a specific issue for tropical small island states."

"There is *high confidence* that changes in heat waves, glacial retreat, and/or permafrost degradation will affect high mountain phenomena such as slope instabilities, movements of mass, and glacial lake outburst floods. There is also *high confidence* that changes in heavy precipitation will affect landslides in some regions."

"There is *low confidence* in projections of changes in large-scale patterns of natural climate variability. For example, confidence is low in projections of changes in monsoons (rainfall, circulation) because there is little consensus in climate models regarding the sign of future change in the monsoons ..."

Source: IPCC, 2013b.

More generally, access to data on breed distribution will be improved by the development of the production environment descriptors (PEDS) module of the Domestic Animal Diversity Information System (DAD-IS),[17] which will allow National Coordinators for the Management of Animal Genetic Resources to record the distribution of their countries' breeds on electronic maps. The importance of collecting data on the distribution of breed populations is emphasized in FAO's guideline publications on surveying and monitoring of AnGR and on phenotypic characterization (FAO, 2011b; FAO, 2012a).

Once breed distribution data are available, a potential next step is to relate these data to the geographical distribution of disaster risk.[18] This might, for example, help provide an indication of the scale of the potential threat and draw attention to areas where risk-reduction activities for AnGR are particularly needed. It should, however, be borne in mind that sophisticated risk-mapping exercises are not necessarily a prerequisite for action. As some of the examples presented above suggest, basic knowledge of how risk is geographically distributed on a local scale can provide a basis for preparedness measures to protect livestock (and potentially to protect specific breed populations).

To what extent has awareness of AnGR management issues spread beyond the "AnGR community" and into the consciousness of a wider layer of stakeholders involved in the management of disasters and emergencies? The first SoW-AnGR noted that disaster-preparedness and risk-management activities had, in general, tended to include few specific recommendations for the livestock sector, although some efforts were being made by some international agencies to address these deficiencies. The report also noted that while post-disaster rehabilitation activities often involve livestock-related interventions, the literature on the subject included little mention of AnGR issues.

As noted above, since the publication of the first SoW-AnGR, the literature on general livestock-related interventions to assist people affected by humanitarian crises has been augmented by the work of the Livestock Emergency Guidelines and Standards (LEGS) Project. The LEGS Handbook (LEGS, 2009) recommends that animals used for restocking should be from locally adapted breeds, both because of their good capacity to thrive in local conditions and because local people will know how to manage them. However, it offers no guidance on how to address threats to specific AnGR that may arise because of a disaster or emergency or because of response measures. This pattern – recognition of the importance of using appropriate locally adapted animals for restocking, but no more specific AnGR-related advice – reflects much of the earlier literature on the topic (e.g. Heath *et al.*, 1999; Simpkin, 2005; Nyariki *et al.*, 2005). It is unclear whether awareness of AnGR-related issues among practitioners involved in restocking projects or in implementing other disaster-related interventions has increased in recent years. Practical implementation seems to remain a problem, at least in some countries (see Box 1F8 for example).

At national level, many countries have plans or strategies[19] – and in some cases also legislation[20] – related to the management of disasters and emergencies. As part of a survey on legal and policy frameworks affecting AnGR management conducted by FAO in 2013 (see Part 3 Section F for more details), countries were asked whether they had any legal or policy instruments related to

17 http://fao.org/dad-is

18 The global electronic disaster-risk maps produced by the Global Risk Data Platform (http://preview.grid.unep.ch/) might be useful in this respect. Data on disaster-related livestock deaths recorded in DesInventar (http://www.desinventar.org/) databases can also be displayed on maps at the level of within-country administrative areas. About 30 countries, mostly in Latin America and the Caribbean, are covered.

19 Many national strategy documents can be accessed via the PreventionWeb website (http://www.preventionweb.net/english/professional/policies/) operated by the United Nations Office for Disaster Risk Reduction (UNISDR).

20 Many laws and regulations on disaster management can be accessed via the Disaster Law Database operated by the International Federation of Red Cross and Red Crescent Societies (http://www.ifrc.org/en/publications-and-reports/idrl-database/).

disasters and emergencies and whether these had any impact on AnGR management. The results indicate that 76 percent of the 48 responding countries have legislation on disaster prevention measures either in place or under development and almost as many (74 percent) have policies in place or under development. A number of countries reported that these instruments include provisions related to the protection of livestock and in several cases also specifically to the protection of AnGR. In some cases, however, it appears that these measures relate only to the control of animal disease epidemics and in others that the only measures taken are precautionary gene banking.

One of the few reported laws that specifically addresses the protection of AnGR from a range of natural and human-induced disasters is Slovenia's Livestock Breeding Act (2002),[21] which states that

> *"if due to the state of emergency or state of war, or due to natural or other disasters the preservation of the breeding materials necessary to ensure, to a minimum extent, the reproduction of domestic animals is endangered, or if the biological diversity of domestic animals in the Republic of Slovenia is endangered to a larger extent, the Minister may assign to breeding organizations and breeders, as well as to other recognized and approved organizations hereunder special technical and other tasks in order to prevent such endangering."*

Another example is Viet Nam's Ordinance on Livestock Breeds (2004),[22] which refers to "the restoration of livestock breeds in cases where natural disasters or enemy sabotages cause serious consequences."

Several of the survey responses mention that national disaster prevention policies include provisions related to the protection of livestock or that this task falls within the mandate of disaster-protection agencies. However, few details are provided. Several responses note the need to introduce AnGR-specific measures into disaster-related policies. The protection of livestock in general is mentioned, for example, in Bulgaria's Disaster Protection Act (2006),[23] which refers to "temporary evacuation of persons, domestic animals or livestock" and "providing food and temporary shelter to victims of disaster, domestic animals and livestock" and Viet Nam's Law on Natural Disaster Prevention and Control (2013),[24] under which basic provisions for dealing with droughts and seawater intrusions include "adjusting the structures of plants, animals and crops based on forecasts, warnings and developments of drought and seawater intrusion" and for disasters associated with cold weather include "ensuring sufficient feed for livestock."

Looking beyond the survey results, most national policies on disasters and emergencies make no specific references to the protection of animals from the effects of disasters. Exceptions include Uganda's National Policy for Disaster Preparedness and Management, which includes measures related to the provision of emergency feed supplies during droughts, as well as to the control of cattle rustling and disease epidemics.[25] Nepal's National Strategy for Disaster Risk Management includes among its priorities for action the establishment of a monitoring system for crops and livestock in high-risk areas and improvements to

[21] Zakon o Živinoreji (ZŽiv) (available in Slovenian at http://tinyurl.com/o6o4pbw and in English at http://tinyurl.com/n2thv8c).

[22] PHÁPLỆNH GIỐNG VẬT NUÔI (Số: 16/2004/PL-UBTVQH11) (available in Vietnamese at http://www.moj.gov.vn/vbpq/Lists/Vn%20bn%20php%20lut/View_Detail.aspx?ItemID=19426 and in English at http://tinyurl.com/k6t74qu).

[23] Закон за защита при бедствия (available in Bulgarian at http://www.mi.government.bg/library/index/download/lang/bg/fileId/304 and in English at http://www.ifrc.org/docs/idrl/867EN.pdf).

[24] LUẬT PHÒNG, CHỐNG THIÊN TAI (Luật số: 33/2013/QH13) (available in Vietnamese at http://tinyurl.com/oyl48me and in English at http://tinyurl.com/kapdwca).

[25] A number of national policies treat animal disease epidemics as a class of disaster in their own right. Plans for dealing with epidemics are, of necessity, oriented towards the livestock sector. However, this does not necessarily mean that the sector receives any particular attention in the respective country's plans for dealing with other kinds of disaster.

animal feed storage systems and animal shelters (Government of Nepal, 2009). India's Standard Operating Procedure for Responding to Natural Disasters refers to the need to "devise appropriate measures to protect animals and find means to shelter and feed them during disasters and their aftermath" (Government of India, 2010). India has taken a number of initiatives in this field in recent years. In 2013, the country's National Disaster Management Authority co-organized an event entitled "National Conference on Animal Disaster Management – Animals Matter in Disasters" with the World Society for the Protection of Animals (NDMA, 2013). A model district disaster management plan developed for the Madhubani district of Bihar, and published in 2013, includes detailed plans for action by the Animal and Fisheries Department and by local livestock management committees, covering emergency actions such as rescue and evacuation of animals and the provision of veterinary care, fodder and water, as well as livestock-related risk-reduction activities (DDMA, 2013).

4 Animal disease epidemics

This subsection updates the discussion on animal disease epidemics as threats to AnGR diversity presented in the first SoW-AnGR. Epidemics share some of the features of other kinds of disaster and emergency (see Subsection 3). They have the potential to kill large numbers of animals in a short period of time. They are a particular threat to breed populations that are concentrated within a limited geographical area. They often trigger a burst of activity on the part of national authorities and these responses can in themselves sometimes be a threat to AnGR. However, unlike many other kinds of disaster and emergency, in the case of an epidemic, livestock are not marginal to response efforts. They are the main focus of attention. Concretely, the acute threat associated with disease epidemics is that large numbers of animals, potentially a large proportion of a given breed population, will die, either directly because of the effects of the disease or because of a culling programme implemented to control the disease.

Other things being equal, large epidemics (affecting a large number of animals and a wide geographical area) pose a greater threat to AnGR than smaller epidemics. Likewise, epidemics that produce a high mortality rate in the affected areas pose a greater threat. Culling campaigns can be particularly problematic in this respect because, if carried out thoroughly, they kill 100 percent of the animals of the relevant species in the area designated for the cull. However, certain diseases, African swine fever, for example, produce very high mortality rates even if there is no culling.

While the effects of large-scale epidemics are likely to be the most serious, the potential threat from epidemics that are relatively limited in terms of the size of the area they affect and the mortality rates they produce should not be overlooked. For an at-risk breed or a breed that is close to falling into an at-risk category, the death of a few thousand, a few hundred or even a few tens of animals can be devastating.

During the decade preceding the publication of the first SoW-AnGR there were a number of extremely serious epidemics in various parts of the world, several of which resulted in the deaths of millions or hundreds of thousands of animals.[26] In many cases, the number of culled animals was far larger than the number of deaths caused by the disease itself. During the period since 2007, while there have been no incidents on quite the same scale in terms of livestock deaths as the United Kingdom foot-and-mouth disease epidemic of 2001 or the avian influenza outbreaks that struck parts of Southeast Asia in 2003/2004, disease epidemics have continued to inflict enormous losses on the livestock sector. In terms of shifts in the distribution of major epidemic diseases with the potential to devastate livestock populations, one of the most worrying recent developments has been the spread of African swine fever into the Caucasus and the Russian Federation (FAO, 2012b).

[26] FAO, 2007a, Table 40 (page 128).

The effect of climate change on the distribution of animal diseases is an area of study that is receiving increasing attention. Vector-borne and waterborne diseases are the most likely to be affected (World Bank, 2014). Given the high mortality rates associated with some of these diseases, it is possible that shifts in disease distribution driven by climate change could pose a threat to AnGR. However, because of the potential for complex interactions between the climate and pathogens, vectors, host animals and other ecosystem components, in addition to the effects of a range of human activities that may increase or decrease the likelihood that a disease will spread to a new area, it is generally difficult to predict how severe such effects are likely to be (FAO, 2011a; 2013c). Nonetheless, some attempts have been made to predict outlooks for specific diseases in the context of climate change (World Bank, 2014). It is argued that conducting studies of this kind is "important when building long-term disease mitigation plans as it provides a framework for governments to invest in research in order to reduce uncertainties and to develop disease mitigation efforts" (ibid.). Early warning systems for individual outbreaks of climate-sensitive diseases are likely to become increasingly necessary and a number of such systems are reported to be under development (ibid.). One disease that is causing some concern as a potential threat to AnGR in Europe is bluetongue, which appeared in northern Europe for the first time in 2006 (European Commission, 2013).

As discussed above, diseases and disease management featured prominently among the factors reported by countries as causes of genetic erosion, particularly in the case of African countries (see Table 1F2). In many cases, it is not clear whether these reports refer to the acute effects of epidemics or to the more general effects of disease problems as constraints to livestock-keeping livelihoods. Few countries provide examples of specific breed populations that have been severely affected by disease outbreaks. However, the report from Latvia notes that an outbreak of swine brucellosis led to the death of more than half the sows belonging to the Latvian White breed. The report from Botswana includes the following comment on the effects of post-epidemic restocking:

> *"Disease outbreaks in certain zones have led to mass slaughter of animals … This reduces population size and also affects … diversity since restocking has to be done using animals from other zones. Furthermore, … the restocking exercise brings in improved animals not indigenous ones which are adaptable to the local production environment. This … was … evident in North East District where 25 000 sheep and goats (mostly indigenous) were replaced by crossbreds and exotic breeds."*

More general effects on AnGR management are noted in the country report from Mauritius: an African swine fever epidemic in 2007 is reported to have wiped out 70 percent of the country's pig population. A relaunch programme based on the importation of exotic breeds reportedly led to indiscriminate cross-breeding and the production of poor-quality piglets. Further action on the part of the government was then required in order to rectify the problem.

The first SoW-AnGR noted that there had been some recognition of the potential need to protect rare or valuable breed populations from the effects of compulsory culling measures, for example in some European Union legislation. However, it also noted that the success of any attempts to "rescue" breed populations in affected areas once an epidemic had begun were likely to depend heavily on a high level of advanced planning. While there have been some initiatives in this field over recent years (see for example Box 1F16), the evidence provided in the country reports, the responses to the survey on legal and policy measures conducted by FAO in 2013 (see Part 3 Section F) and the reports received from international organizations[27] suggest that, overall, progress has been limited. As in the case of other types of disaster, the establishment of back-up *ex situ* conservation measures is

[27] For details, see "About this publication" in the preliminary pages.

Box 1F16
The European Livestock Breeds Ark and Rescue Net

The European Livestock Breeds Ark and Rescue Net (ELBARN) was envisioned as a network of stakeholders and farms that would perform two main functions:

- rescuing animals belonging to rare breeds if they are threatened by a crisis; and
- creating an online guide to places where indigenous livestock breeds can be seen by the public.

A third objective was to develop and promote a concept for protecting indigenous livestock breeds from culling during disease epidemics.

ELBARN began in 2007 with a three-year project funded by the European Commission. The most sustainable part of the project has been the online guide (www.arca-net.info), which now (June 2014) has 623 entries from 46 European countries. Every year, members are invited to update their information, so that Arca-Net is kept up to date.

The "rescue" aspects are more difficult to implement without adequate financial support. The principles of rescue were discussed at an international workshop in 2008. It was concluded that rescue is a temporary act: animals must be moved back into farming systems as soon as possible. Rescue must be done professionally, and a network of experts needs to be put in place to accomplish the task. Emergency funds need to be available so that action can be taken quickly. Veterinarians should be educated about threatened breeds, so that they are able to identify important breeds and set a rescue action in motion if the breeds are threatened by an epidemic.

It is clear that rescue can only be successful with prior planning. Both animals and holdings need to be recorded and registered, and contingency plans need to be prepared. Any person serving in a decision-making capacity during an animal disease epidemic should have received training about threatened breeds. Countries developing new regulations concerning disease control should consider including provisions related to the protection rare breeds. It would also be a positive development if such provisions were included in the Terrestrial Animal Health Code of the World Organisation for Animal Health (OIE).

The lessons learnt from ELBARN are that, without adequate funding, ideas cannot be implemented, even if they are supported by all stakeholders. The long-term goal is still to anchor the protection of indigenous breeds in national and international regulations. However, the austerity measures put in place following the global economic crisis of 2008 have led to a focus on self-sustaining measures such as Arca-Net.

Provided by Elli Broxham, SAVE Foundation.

an important means of reducing the risk of total extinction as a result of a disease outbreak.

5 Conclusions

Information on threats to AnGR diversity remains far from complete. As discussed in Part 1 Section B, the risk status of the majority of breeds is classified as "unknown" and even where population trends are monitored detailed assessments of threats to specific breeds are not common. It is therefore difficult to draw firm conclusions regarding the relative significance of different threats, particularly given that in most cases a range of interacting factors are likely to be involved. It is also difficult to determine whether particular threats have become more or less prominent during the period since the first SoW-AnGR was prepared. Country-reporting exercises during the intervening years (the second SoW-AnGR reporting process and the 2012 assessment of progress in implementing the Global Plan of Action) have highlighted the role of indiscriminate cross-breeding as a major problem, particularly in developing countries. Many countries consider that the weakness of their AnGR management programmes, policies and institutions constitutes a threat in its own right. As described in Part 3 of this report, there is ample scope for improvements in these fields, and in many countries strengthening institutions and improving breeding policies and strategies are likely to be prerequisites for tackling the problem of indiscriminate cross-breeding.

Economic and market-related factors are also frequently highlighted by stakeholders as threats to AnGR. The most direct threat to the survival of many breeds is that they can no longer be raised profitably because of some shift in market demand or increase in the level of competition from other breeds, species or non-livestock sources. Shifts of this kind are an inevitable part of social and economic change and thus there are always likely to be some breeds that are at risk of declining towards extinction if no action is taken. In some cases, it may be necessary either to intervene directly to maintain the breed through *in situ* or *ex situ* conservation measures or to accept that it may become extinct. However, there may also be measures that can be taken to reduce economic threats either by "valorizing" individual at-risk breeds via marketing initiatives, genetic improvement or the identification of new roles, or by more general policy interventions such as eliminating support measures that create economic incentives for breed replacement.

Given the major roles of small-scale livestock keepers and pastoralists in maintaining AnGR diversity, factors that undermine the sustainability of smallholder and pastoralist production systems constitute significant threats to AnGR. These threats include both market-related factors and problems related the degradation of (or lack of access to) natural resources. Given the importance of livestock keeping to the livelihoods of many of the world's poorest people and the major significance of livestock keeping areas (e.g. grasslands) in the provision of ecosystem services (carbon sequestration, water cycling, provision of wildlife habitats, etc.), the sustainable development of these production systems is clearly a challenge that extends beyond the immediate field of AnGR management. Balancing different objectives is unlikely to be easy. However, there may be scope for synergies in efforts to promote AnGR-management, livelihood and environmental objectives.

Concerns about climate change have increased yet further since the time the first SoW-AnGR was prepared. Some countries report that they have already experienced climate-driven changes in AnGR management, including species substitutions. However, it remains difficult to predict how climate change will affect the future of livestock production and what the consequences will be for AnGR diversity. The uncertainty of climatic projections is a major constraint, but on the AnGR side there is also frequently a lack of adequate data on breeds' characteristics, their distributions and their production environments.

Similarly, while it is expected that climate change will increase the frequency of extreme weather events, the extent that this poses an additional threat to AnGR is difficult to estimate. In general, information about the level of threat posed to AnGR by disasters and emergencies remains limited. Lack of information on breed distributions is again a constraint. In some countries, there appears to be increasing interest in disaster-management strategies for the livestock sector. As noted in the first SoW-AnGR, if anything is to be done to protect specific breed populations (e.g. at-risk breeds), it will require advanced planning and good knowledge of where the relevant herds and flocks are located. Given that in many disaster situations organizing rescue efforts for animals will be impractical, efforts should be made to establish appropriate *ex situ* conservation measures for any breeds that are identified as being under serious threat from disastrous events.

The extent of the threat posed to AnGR by animal disease epidemics is, likewise, difficult to estimate accurately. Disease and disease-management measures, however, featured relatively prominently among causes of genetic erosion reported in the country reports, particularly among reports from African countries. These cases do not necessarily all refer to the threat posed by major epidemics that devastate breed populations in a short period of time. However, given the concentration of some breeds in limited geographical areas and the high mortality rates associated with some diseases, the acute threat from disease epidemics should not be ignored. The potential threat posed by compulsory culling campaigns was noted in the first SoW-AnGR. While there is some indication that awareness of this threat has increased, there is little evidence that governments have taken many practical steps towards the establishment of rescue procedures for at-risk breeds threatened in this way.

Threats to specific breeds often arise because of a combination of factors associated with the changing nature of livestock production systems and the particular vulnerabilities of the respective breeds. Improved understanding of breeds characteristics, their production environments and how they are used thus needs to be combined with better understanding of livestock-sector trends and the demands and constraints that these place on the use of particular types of AnGR. Strategic Priority 5 of the Global Plan of Action for Animal Genetic Resources calls, *inter alia*, for "assess [ment] of environmental and socio-economic trends that may require a medium and long-term policy revision in animal genetic resources management."[28] Assessments of this kind should help countries identify existing and upcoming threats to their AnGR and potentially also identify strategies for countering some of these threats.

References

Alderson, L. 2009. Breeds at risk: definition and measurement of the factors which determine endangerment. *Livestock Science*, 123: 23–27.

Alemayehu, K. 2103.Threats, attempts and opportunities of conserving indigenous animal genetic resources in Ethiopia. *African Journal of Agricultural Research*, 8(23): 2806–2813.

[28] FAO, 2007b, Strategic Priority 5, Action 1.

Allen, R.L. 1865. *Domestic animals: history and description of the horse, mule, cattle, sheep, swine, poultry and farm dogs; with directions for their management, breeding, crossing, rearing, feeding, and preparation for a profitable market; also, their diseases and remedies together with full directions for the management of the dairy.* New York, USA, O. Judd Company (available at http://chla.library.cornell.edu/cgi/t/text/text-idx?c=chla;idno=3058099).

Bahmani, H.R., Tahmoorespur, M., Aslaminejad, A.A., Abbasi, M.A. & Ebnabbasi, R. 2011. Assessment of demographic, geographical and genetic risks in Markhoz goat population. *Journal of Animal and Veterinary Advances*, 10(2): 162–168.

Blew, W.C.A., Dixon, W.S., Fleming, G. & Shaw, V. 1898. *Light horses. Breeds and management*. Third edition. Livestock Handbooks No. II. London, Vinton & Company Ltd. (available at https://archive.org/details/lighthorsesbreed00blewrich).

Brito, L.F., Jafarikia, M., Grossi, D.A., Kijas, J.W., Porto-Neto, L.R., Ventura, R.V., Salgorzaei, M. & Schenkel, F.S. 2015. Characterization of linkage disequilibrium, consistency of gametic phase and admixture in Australian and Canadian goats. *BMC Genetics*, 16: 67.

Carrington, W.T., Gilbert, G., Morton, J.C., Murray, G., Spencer, S. & Wortley-Axe, J. 1919. *Livestock*. Eighth edition. London, Vinton & Co. (available at http://chla.library.cornell.edu/cgi/t/text/text-idx?c=chla;idno=3080643).

Carson, A., Elliott, M., Groom, J., Winter, A. & Bowles, D. 2009. Geographical isolation of native sheep breeds in the UK – evidence of endemism as a risk factor to genetic resources. *Livestock Science*, 123(2-3): 288–299.

Charoensook, R., Knorr, C., Brenig, B. & Gatphayak, K. 2013. Thai pigs and cattle production, genetic diversity of livestock and strategies for preserving animal genetic resources. *Maejo International Journal of Science and Technology,* 7(01): 113–132.

Choudhury, J.R. 1994. *Cyclone shelter and its multipurpose use*. Nagoya, Japan, UN Centre for Regional Development (available at http://tinyurl.com/qj6ssul).

Corbin, L.J., Liu, A.Y., Bishop, S.C. & Woolliams, J.A. 2012. Estimation of historical effective population size using linkage disequilibria with marker data. *Journal of Animal Breeding and Genetics*, 129: 257–270.

Country reports. 2014. Available at http://www.fao.org/3/a-i4787e/i4787e01.htm.

DDMA. 2013. *District disaster management plan – Madhubani. Volume 4. Specific action plans for line departments, gram panchayat committees and other non-govt. stakeholders*. Madhubani, Bihar, India, District Disaster Management Authority (available at http://tinyurl.com/paqz3tb).

De Roos, A.P.W., Hayes, B.J., Spelman, R.J. & Goddard, M.E. 2008. Linkage disequilibrium and persistence of phase in Holstein–Friesian, Jersey and Angus cattle. *Genetics*, 179: 1503–1512.

European Commission. 2013. *Preserving genetic resources in agriculture. Achievements of the 17 projects of the Community Programme 2006-2011*. Brussels (available at http://tinyurl.com/npb2y4s).

FAO. 2007a. *The State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B. Rischkowsky & D. Pilling. Rome (available at www.fao.org/3/a-a1250e.pdf).

FAO. 2007b. *The Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration*. Rome (available at http://www.fao.org/docrep/010/a1404e/a1404e00.htm).

FAO. 2009a. *Threats to animal genetic resources – their relevance, importance and opportunities to decrease their impact.* Commission on Genetic Resources for Food and Agriculture Background Study Paper No. 50. Rome (available at ftp://ftp.fao.org/docrep/fao/meeting/017/ak572e.pdf).

FAO. 2009b. *Development of country-based early warning and response systems for animal resources.* Working Document, Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture, Fifth Session, Rome, 29–30 January 2009 (CGRFA/WG-AnGR-5/09/4). Rome (available at http://www.fao.org/docrep/meeting/021/K3812e.pdf).

FAO. 2010. *Breeding strategies for sustainable management of animal genetic resources.* FAO Animal Production and Health Guidelines. No. 3. Rome (available at http://www.fao.org/docrep/012/i1103e/i1103e00.htm).

FAO. 2011a. *Climate change and animal genetic resource for food and agriculture: state of knowledge, risks and opportunities*. Commission on Genetic Resources for Food and Agriculture Background Study Paper No. 53. Rome (available at http://www.fao.org/docrep/meeting/022/mb386e.pdf).

FAO. 2011b. *Surveying and monitoring of animal genetic resources*. FAO Animal Production and Health Guidelines. No. 7. Rome (available at http://www.fao.org/docrep/014/ba0055e/ba0055e00.htm).

FAO. 2012a. *Phenotypic characterization of animal genetic resources.* FAO Animal Production and Health Guidelines No. 11. Rome (available at http://www.fao.org/docrep/015/i2686e/i2686e00.htm).

FAO. 2012b. *African swine fever (ASF) recent developments and timely updates. Worrisome dynamics: steady spread towards unaffected areas could have disastrous impact*. EMPRES Emergency Prevention System. Focus on (electronic bulletin). No. 6. September 2012. Rome (available at http://www.fao.org/docrep/016/ap372e/ap372e.pdf).

FAO. 2013a. *Report of the Fourteenth Regular Session of the Commission on Genetic Resources for Food and Agriculture, Rome, Italy, 15 – 19 April 2013.* CGRFA-14/13/Report. Rome (available at http://www.fao.org/docrep/meeting/028/mg538e.pdf).

FAO. 2013b. In vivo *conservation of animal genetic resources*. FAO Animal Production and Health Guidelines. No. 14. Rome (http://www.fao.org/docrep/018/i3327e/i3327e.pdf).

FAO. 2013c. *World Livestock 2013. Changing disease landscapes*. Rome (available at http://www.fao.org/docrep/019/i3440e/i3440e.pdf).

FAO. 2014. *Synthesis progress report on the implementation of the global plan of action for animal genetic resources – 2014*. Information Document, Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture, Eighth Session, Rome 26–28 November 2014 (CGRFA/WG-AnGR-8/14/Inf.5). Rome (available at http://www.fao.org/3/a-at136e.pdf).

Floreani, S. & Gattolin, G. 2011. *Mud and bamboo: cyclone shelter as sustainable adaptation strategy to climate change*. Venice, Italy, Univeristà IUAV di Venezia (available at http://tinyurl.com/qdzhjyx).

Gibson, J., Gamage, S., Hanotte, O., Iñigueze, L., Maillard, J.C., Rischkowsky, B., Semambo, D. & Toll, J. 2005. *Options and strategies for the conservation of farm animal genetic resources*.

Report of an international workshop, Agropolis, Montpellier, France, 7–10 November 2005. Rome, CGIAR System-wide Genetic Resources Programme/ Bioversity International.

Government of India. 2010. *Standard operating procedure for responding to natural disasters.* New Delhi, Ministry of Home Affairs, Disaster Management Division (available at http://ndmindia.nic.in/SOP-NDM-2010.pdf).

Government of Liberia. 2004. *Liberia's National Strategy and Action Plan*. Monrovia (available at http://tinyurl.com/phedtq2 and http://tinyurl.com/p7kqmqw).

Government of Nepal. 2009. *National strategy for disaster risk management, 2009*. Kathmandu, Ministry of Home Affairs (unofficial English translation available at http://tinyurl.com/oct4yh7).

H.E. in 'The Field'. 1893. The farmer. The hardier breeds of cattle. *Bruce Herald*, Volume XXIV, Issue 2467, 14 April 1893, p. 4 (Newspaper article: available at http://tinyurl.com/nyaj2md).

Heath, S.E., Kenyon, S.J. & Zepeda Sein, C.A. 1999. Emergency management of disasters involving livestock in developing countries. *Revue scientifique et technique de l'Office international des Epizooties*, 18(1): 256–271.

Husein, A., Nashir, M. & Arriani, A. 2010. *Indonesia: Red Cross responds to double disaster*. Article on the website of the International Federation of Red Cross and Red Crescent Societies (http://tinyurl.com/onzpfkt) (accessed 15 October 2013).

IFRCS. 2004. *World Disasters Report 2004. Focus on community resilience.* Geneva, Switzerland, International Federation of Red Cross and Red Crescent Societies (available at http://tinyurl.com/nkrdewt).

IPCC. 2013a. Annex III: Glossary, edited by S. Planton, *In* T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley, eds. *Climate change 2013: the physical science basis*. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press (available at http://tinyurl.com/p7d6xwb).

IPCC. 2013b. *Managing the risks of extreme events and disasters to advance climate change adaptation.* Special report of the Intergovernmental Panel on Climate Change, edited by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgley. Cambridge, UK and New York, NY, USA, Cambridge University Press (available at http://tinyurl.com/o7fvl8k).

IRIN. 2012. *Bangladesh: cyclone shelters for livestock too*. Website of IRIN humanitarian news and analysis, a service of the UN Office for the Coordination of Humanitarian Affairs (available at http://tinyurl.com/pnkzdl6) (accessed 18 November 2013).

Kijas, J.W., Lenstra, J.A., Hayes, B., Boitard, S., Porto Neto, L.R., San Cristobal, M., Servin, B., McCulloch, R., Whan, V., Gietzen, K., Paiva, S., Barendse, W., Ciani, E., Raadsma, H., McEwan, J., Dalrymple, B. & International Sheep Genomics Consortium Members. 2012. Genome-wide analysis of the world's sheep breeds reveals high levels of historic mixture and strong recent selection. *PLoS Biology*, 10: e1001258.

Larroque, H., Barillet, F., Baloche, G., Astruc, J., Buisson, D., Shumbusho, F., Clement, V, Lagriffoul, G., Palhiere, I., Rupp, R., Carillier, C., Robert-Granie, C. & Legarra, A. 2014. Toward genomic breeding programs in French dairy sheep and goats. In *Proceedings of the 10th World Congress of Genetics Applied to Livestock Production, 17–22 August 2014, Vancouver, Canada.*

Lavell, A. & Maskrey, A. 2013. The future of disaster risk management. An ongoing discussion. In *Draft synthesis document, meeting notes, background papers and additional materials from a scoping meeting for GAR 2014, San José, Costa Rica 18th to 19th April 2013,* pp 3–23. San José, United Nations Office for Disaster Risk Reduction (UNISDR) Facultad Latinoamericana de Ciencias Sociales (FLACSO) (available at http://tinyurl.com/qx67xnx).

Lee, Y.S., Lee, J.W. & Kim, H.B. 2014. Estimating effective population size of thoroughbred horses using linkage disequilibrium and theta (4Nμ) value. *Livestock Science*, 168: 32–37.

LEGS. 2009. *Livestock emergency guidelines and standards*. Rugby, UK, Livestock Emergency Guidelines and Standards Project, Practical Action Publishing (available at http://tinyurl.com/nlmy8wj).

Leroy, G., Mary-Huard, T., Verrier, E., Danvy, S., Charvolin, E. & Danchin-Burge, C. 2013. Methods to estimate effective population size using pedigree data: examples in dog, sheep, cattle and horse. *Genetics Selection and Evolution*, 45: 1.

LPPS. 2013. *The camels of Kumbhalgarh. A biodiversity treasure*. Sadri, India, Lokhit Pashu-Palak Sansthan (available at http://tinyurl.com/pax5kyy).

Lu, D., Sargolzaei, M., Kelly, M., Li, C., Vander Voort, G., Wang, Z., Plastow, G., Moore, S. & Miller, S.P. 2012. Linkage disequilibrium in Angus, Charolais, and crossbred beef cattle. *Frontiers in Genetics*, 3: 1–10.

NDMA. 2013. *Community resilience is not possible unless we address the animal disaster management issues*. Press release 17 April 2013. New Delhi, National Disaster Management Authority.

Nyariki, D.M., Makau, B.F., Ekaya, W.N. & Gathuma, J.M. 2005. *Guidelines for emergency livestock off-take. Handbook*. Arid Lands Resource Management Project, Office of the President. Nairobi, Agricultural Research Foundation.

Ojango, J., Oyieng, E., Audho, J. & Okeyo, A.M. 2014. *Indigenous sheep to help improve market access and livelihood security among pastoralists in Kenya: results of a baseline survey.* Nairobi, International Livestock Research Institute (available at http://tinyurl.com/puk3khb).

Rahman, M.M., Hoque, M.A., Saha, N.G. & Faruque, M.O. 2013.Studies on management system and identification of the causes of genetic erosion of indigenous cattle in Mymensingh district. *Bangladesh Journal of Animal Science*, 42(1): 23–28.

Rees-Roberts, T. undated. *History of the Lleyn*. Article on the website of the Lleyn Sheep Society (available at http://www.lleynsheep.com/society/history/) (accessed 28 July 2014).

Rege, J.E.O. & Gibson, J.P. 2003. Animal genetic resources and economic development: issues in relation to economic valuation. *Ecological Economics*, 45(3): 319–330 (available at http://tinyurl.com/nzl9k3w).

Rodríguez-Ramilo, S.T., Fernández, J., Toro, M.A., Hernández, D. & Villanueva, B. 2015. Genome-wide estimates of coancestry, inbreeding and effective population size in the Spanish Holstein population. *PLoS ONE*, 10(4): e0124157.

Sanders, S. 1919. *The pig. Breeding, rearing and marketing*. London, C. Arthur Pearson Ltd. (available at http://tinyurl.com/p2rhwqt).

Shaw, T. 1900. *The study of breeds in America: cattle, sheep and swine*. New York, USA, Orange Judd (available at http://tinyurl.com/pel2kyb).

Simpkin, S.P. 2005. *Regional livestock study in the Greater Horn of Africa*. Nairobi, International Committee of the Red Cross (available at http://tinyurl.com/ngcqbgm).

Taye, T., Ayalew, W. & Hegde, B.P. 2009. Status of Ethiopian indigenous Sheko cattle breed and the need for participatory breed management plan. *Ethiopian Journal of Animal Production*, 9(1): 1–12. (available at http://tinyurl.com/os3va5p).

Thomasen, J.R., Sørensen, A.C., Su, G., Madsen, P., Lund, M.S. & Guldbrandtsen, B. 2013. The admixed population structure in Danish Jersey challenges accurate genomic predictions. *Journal of Animal Science*, 91: 3105–3112.

Tisdell, C. 2003. Socioeconomic causes of loss of animal genetic diversity: analysis and assessment. *Ecological Economics*, 45(3): 365–376 (available at http://tinyurl.com/otvvjss).

Uimari, P. & Tapio, M. 2011. Extent of linkage disequilibrium and effective population size in Finnish Landrace and Finnish Yorkshire pig breeds. *Journal of Animal Science*, 89(3): 609-614–28.

UNISDR. 2013. *From shared risk to shared value – the business case for disaster risk reduction. Global assessment report on disaster risk reduction.* Geneva, Switzerland, United Nations Office for Disaster Risk Reduction (available at http://tinyurl.com/oh8s4tg).

Vaughan, H.W. 1931. *Breeds of live stock in America*. Columbus, Ohio, USA, R.G. Adams and Company (available at http://tinyurl.com/omwhybj).

Welsh, C.S., Stewart, T.S., Schwab, C. & Blackburn, H.D. 2010. Pedigree analysis of 5 swine breeds in the United States and the implications for genetic conservation. *Journal of Animal Science*, 88(5): 1610–1618.

Wilson, J. 1909. *The evolution of British cattle and the fashioning of breeds*. London, Vinton & Company (available at http://tinyurl.com/pqc7wwo).

Wiseman, J. 2000. *The pig. A British history*. Second Edition. London, Gerald Duckworth & Co. Ltd.

World Bank. 2014. *Reducing climate sensitive disease risks*. Agriculture and Environmental Services Discussion Paper 07. World Bank Report Number 84956-GLB. Washington DC (available at http://tinyurl.com/knmj6ww).

Wrightson, J. 1913. *Sheep breeds and management.* London, Vinton & Company Ltd. (available at http://tinyurl.com/pb7mavk).

Youatt, W., Martin, W.C.L. & Stevens, A. 1855. *The hog: a treatise on the breeds, management, feeding, and medical treatment of swine: with directions for salting pork and curing bacon and hams.* New York, USA, Orange Judd (available at http://tinyurl.com/nt6vjlx).

Yosef, T., Mengistu, U., Solomon, A., Mohammed, Y.K. & Kefelegn, K. 2013. Camel and cattle population dynamics and livelihood diversification as a response to climate change in pastoral areas of Ethiopia. *Livestock Research for Rural Development,* 25: Article 166 (available at http://www.lrrd.org/lrrd25/9/yose25166.htm).

Zander, K.K. 2011. Attitudes of livestock keepers to breeding strategies – threats and opportunities for on-farm conservation of the Borana cattle breed. *Journal of Agricultural Science*, 3(2): 3–12.