Economics of animal genetic resources use and conservation

**1 Introduction**

Economic analysis can play an important role in the sustainable management of animal genetic resources (AnGR). The first report on *The State of the World’s Animal Genetic Resources for Food and Agriculture* (first SoW-AnGR) (FAO, 2007a) included a section on methods for economic evaluation\(^1\) that provided an overview of the various types of value that can be distinguished (direct and indirect use values, option values, bequest values and existence values) and described potential methods and tools for assessing them. It also presented some examples of the use of these methods and tools and the findings obtained. This updated section provides an overview of recent developments in the economics of AnGR use and conservation. The revised title reflects the way in which this field of work has moved beyond just the development and testing of methods.\(^2\)

Significant research on AnGR-focused economic valuation methods largely began following an FAO/International Livestock Research Institute (ILRI) workshop (Rege, 1999) that identified relevant methodologies (see also Drucker et al., 2001). Work on the testing of these methods was subsequently undertaken by ILRI (Economics of AnGR Conservation and Sustainable Use Programme) and its partners. The discussion presented in the first SoW-AnGR drew on the findings generated by the ILRI programme, many of which were reported in a special issue of the journal *Ecological Economics* (Drucker and Scarpa, 2003) and in a CGIAR System-wide Genetic Resources Programme (SGRP) report that reviewed the applied economics literature related to the valuation and sustainable management of crop and livestock biodiversity (Drucker et al., 2005, subsequently published as Smale and Drucker, 2007).

The first SoW-AnGR concluded that research in this area had led to the development of a range of methods that could be used to value livestock-keepers’ breed or trait preferences and support the design of policies to counter trends towards the marginalization of locally adapted breeds. It noted that, despite the easing of some methodological/analytical constraints as a result of this body of work, data constraints remained critical. Challenges identified included the need to raise awareness regarding the important role of economic analysis in improving the sustainable use and conservation of AnGR, the need to strengthen national capacities so that relevant methods and decision-support tools could be applied and the need to integrate such tools and methods into wider national livestock development processes, including through the design of appropriate incentive mechanisms. The report also noted that there had been little practical application of such tools and methods in contexts that could influence policy-making and livestock keepers’ livelihoods.

A subsequent analysis (Drucker, 2010) of the country reports prepared for the first SoW-AnGR supported the view that the field of AnGR economics had had relatively little influence on “real-life” design and implementation of conservation policy. It indicated that, at best, there was a patchy

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\(^1\) FAO, 2007a, pages 429–440.

\(^2\) The title of the equivalent section in the first SoW-AnGR was “Methods for economic valuation”.

recognition of the importance of valuation and the potential role of economics in the design of cost-effective conservation programmes. In addition to challenges related to a lack of awareness regarding the existence of appropriate methods and tools, a lack of capacity to collect the necessary economic characterization and valuation data through participatory mechanisms and to carry out subsequent analysis was also identified as a constraint. A further conclusion was that economic characterization and valuation was also constrained by deficiencies in the broader characterization of AnGR (for example related to genetic analysis, performance recording and the monitoring of breed status and trends). Thus, while the importance of economics is recognized in the Global Plan of Action for Animal Genetic Resources (FAO, 2007b) (e.g. with regard to the development of standards and protocols, strengthening of policies, provision of support to indigenous and local production systems and establishment of national conservation policies) translating economic valuation into a mainstream activity in AnGR management would require significant awareness-raising and capacity-building. In this context, it should also be noted that calls for biodiversity valuation work and for the design of positive incentive mechanisms have been made by the Conference of the Parties to the Convention on Biological Diversity (CBD) (Decision VIII/25) and that the CBD’s Strategic Plan for 2011–2020 (CBD, 2011) calls for the removal of subsidies harmful to biodiversity. As a basis for the preparation of this section, a review of AnGR economics literature published after the first SoW-AnGR was drafted (covering the period 2006–mid-2014) was undertaken by consulting bibliographic databases and key AnGR experts, including through the Domestic Animal Diversity Network (DAD-Net) a discussion group with 2,100 members (as of December 2014), the latter with a view to identifying literature not included in bibliographic databases, including grey literature and academic theses.

In order to ensure a focus on the economics of AnGR per se, rather than the broader field of livestock economics, the scope of the literature review was limited to studies involving economic assessments focused either on the valuation (direct or indirect) of locally adapted breeds by livestock keepers or on production inputs and outputs for different breeds. Broader livestock economics studies, including a substantial body of literature based on productivity assessments (e.g. feed conversion efficiency), as well as those comparing breed performances in research-station settings, were considered beyond the scope of the review.

The literature review revealed that a significant body of work has been generated in recent years. Thirty-nine publications (including five theses) broadly related to the economic valuation of breeds were identified, covering a number of species and geographical areas and making use of a range of valuation methods; a further 35 publications related more broadly to AnGR economics and conservation policy were also identified. A large literature (65 publications identified) addressing the broader field of the economics of agrobiodiversity (i.e. covering, inter alia, concepts, ecosystem service frameworks and models related to agrobiodiversity and biodiversity in general) can also be considered relevant.

The literature identified can be grouped into the following categories:

- the economic conceptual framework for AnGR and the link between the range of AnGR economic values and specific ecosystem services;
- analytical tools used for economic valuation of breeds;
- valuation of traits to inform breeding decisions;
- public willingness to pay for conservation services; and
- incentive mechanisms for conservation services.

The following subsection provides an overview of this literature based on these categories.

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3 FAO, 2007b, Strategic Priority 2, Actions 1 and 2.
5 FAO, 2007b, Strategic Priority 6, Action 1.
6 FAO, 2007b, Strategic Priority 7.
7 The first SoW-AnGR covered references up to 2005.
8 Web of Science, Google Scholar, ResearchGate, open thesis, JURN, etc.
9 https://dgroups.org/fao/dad-net
2 Developments in animal genetic resources economics

Since 2006, a body of literature has emerged that provides a more formal economic conceptual framework within which to understand the erosion of AnGR as part of a replacement or conversion process that is amplified by a divergence between the private- and public-good values associated with the maintenance of biodiversity. These effects had previously been described in the context of biodiversity in general by Swanson (1997) (conversion process) and Pearce and Moran (1994) (value divergence), among others. The latter authors also note that recognition of the broader total economic values (TEV) associated with biodiversity can be instrumental in altering decisions about resource use.10 While evidence-based policy-making has its limitations (Sumburg et al., 2013) and biodiversity valuation is not a panacea, it may help to “recalibrate faulty economic compasses that have led to poorly informed decision-making” (TEEB, 2010).

The economic conceptual framework has provided the basis for improved understanding of the incentive mechanisms required to help reduce AnGR erosion by better aligning private- and public-good values, including through the application of payments for ecosystem services concepts to AnGR (Narloch et al., 2011a; Silvestri et al., 2012; Bojkovski, forthcoming). Such frameworks have also been used to support analysis of the economics of agrobiodiversity conservation (both animal and plant genetic resources) for food security under climate change (Pascual et al., 2011). Most of this body of literature refers to in situ/on-farm use and conservation, with only limited references (e.g. McClintock et al., 2007) to ex situ conservation.

Finally, in recent literature, the links between nature (encompassing AnGR) and the economy have increasingly tended to be described using the concept of ecosystem services or flows of value to human societies as a result of the state and quantity of natural capital (Jackson et al., 2007; TEEB, 2010). As a result, there are increasing opportunities to consider the ecosystem services concept in the context of AnGR management and the role that economic valuation of AnGR can play within such a framework. Zander et al. (2013) and Martin-Collado et al. (2014) have demonstrated how the quantification of the different components of TEV and the underlying ecosystem services with which they may be associated can provide a useful guide to the design of policies for the sustainable use and conservation of AnGR.

2.1 Economic conceptual framework and ecosystem services

Narloch et al. (2011a) – drawing on Drucker and Rodriguez (2009), Steinfeld (2000) and Swanson (1997) – note that the erosion of agrobiodiversity can be understood in terms of the replacement of the diverse existing pool of locally adapted animal and plant genetic resources with a smaller range of specialized improved ones. Given that the latter are likely to have a higher responsive-ness to external inputs, agricultural intensification (where this is possible) may make breed substitution and cross-breeding increasingly profitable (see Figure 4E1) and hence lead to a reduction in locally adapted breed numbers (Drucker and Rodriguez, 2009; Marshall, 2014).

There are a number of reasons to suppose that the replacement process is resulting in less than socially desirable levels of AnGR being maintained. In particular, it is likely that significant non-market and/or public-good values associated with the various ecosystem services provided by genetic resources (see Box 4E1) are not reflected in market prices and that this creates a bias against their maintenance. Another set of values that are often not reflected in market prices and conventional economic analyses are private-good values not directly related to production outputs, but instead associated with the role of agrobiodiversity in minimizing farm-level risks related

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10 See FAO, 2007a, Box 93 (page 430) for a discussion of TEV in the context of AnGR.
FIGURE 4E1

Breed production functions, public-good values and replacement opportunity costs

Note: “Local” AnGR (market profitability function represented by the dash–dot line [—]) outperform “improved” AnGR (market profitability function represented by the dotted line [. . .]) up to a given level of production system intensity (I*). The term “intensity” is used here in a broad sense and includes, *inter alia*, factors related to access to markets and extension services. Once the degree of intensification passes I*, livestock keepers face increasing financial incentives to replace the local AnGR with the improved ones. Accounting for public-good values not reflected in market prices would lead to an upward shift in the “Local” curve (to the position indicated by the solid line [——]), and a shift in the replacement point to I*'.

Source: Adapted from Drucker and Rodriguez, 2009, and Zander et al., 2013.

Such mechanisms could involve direct support payments, such as those provided under the European Rural Development Programmes, as well as payments for ecosystem services. In addition, private values could be enhanced through niche marketing and value-chain development for products and services (including agritourism initiatives) associated with AnGR (see further discussion below and in Part 4 Section D).

It is within this conceptual context that it becomes apparent that an understanding of non-market and public-good values is important from a conservation policy perspective (Zander et al., 2013). Accounting for TEVs can be used to determine, *inter alia*, whether the benefits of intervention outweigh the costs, as well as to determine appropriate intervention strategies, including for situations in which specific AnGR have little or no current market-development potential. Where conservation funds are limited, understanding the “true” (i.e. total) economic value of different breeds and their contribution to the public good can be an important tool in prioritization and fund allocation (Fadlaoui et al., 2006).

An understanding of the relative values of the different components of TEV can also be used to provide insight into the viability of different use and conservation strategies. It is possible to identify the relevance of different types of economic value and associated ecosystems services to different types of stakeholder and their willingness to pay for the services provided by the maintenance of breeds (Zander et al., 2013). For example, indirect use values, such as cultural and landscape maintenance values, are likely to be of more relevance to local residents and visitors to a local area, while option values are likely to be of relevance to a much broader range of stakeholders. Given the importance of the public-good values associated with breed maintenance, Martin-Collado et al. (2014) argue that, in order to maximize societal welfare, *in situ* on-farm conservation interventions and strategies need to be designed with a view to maintaining the ongoing provision of the public-good breed-related functions that people value most.

11 Narloch et al. (2011) also identify market failures (e.g. externalization of environmental impacts) leading to an overestimation of the performance of improved AnGR, as well as important intervention failures (e.g. subsidies and support prices) that increase the financial profitability of improved AnGR. Accounting for such factors would result in a downward shift (not shown) of the “Improved” curve in Figure 4E1, resulting in the socially optimal replacement point being even further to the right than indicated by I*'.

to external shocks such as extreme climatic events and disease outbreaks (e.g. Rege and Gibson, 2003).
2.3 Breed valuation studies

Given the existence of a range of economic values, many of which are non-market values, it is perhaps unsurprising that most of the 39 publications related to breed valuation identified in the literature review (see Subsection 1 for details) use survey-based preference-eliciting approaches. In other words, these studies determine the economic values of AnGR by assessing people’s preferences (often the preferences of livestock keepers). The use of stated preference methods is the dominant approach, with 20 studies using choice experiments or contingent valuation (see Box 4E2 for explanations of these terms). Hedonic pricing, a revealed preference method, is used in two studies. Eleven studies present results from preference-ranking techniques.
Without explicit monetary valuation and six studies use methods based on the production functions of different breeds to approximate values. Twenty-five (64 percent) of the 39 studies assess cattle, five poultry, five small ruminants and four pigs. Most of the studies from 2006 onwards relate to the economic valuation of traditional breeds in developing countries, where the livelihood functions of such breeds are particularly important. In fact, only eight of the 39 studies (21 percent: six in Asia and two in Europe) were not conducted in Africa.

The studies in Africa cover a range of breeds, including Ankole, Borana, Nguni and Zebu cattle (Table 4E1). While many studies focus on a single breed, Duguma et al. (2011) assessed the importance of traits in four sheep breeds (Afar, Bonga, Horro and Menz) in Ethiopia. In Europe, Zander et al. (2013) assessed the TEV of two Italian cattle breeds (Modicana and Maremmana), while Martin-Collado et al. (2014) assessed the TEV of the Spanish Alistana–Sanabresa cattle breed. The majority of studies, however, do not refer to any particular breed, but instead seek to assess the value of specific traits (such as disease resistance) that can then be linked to locally adapted breeds. Interestingly, no Latin American studies were identifiable, although Marshall (2014) (see below) cites two breeding-related studies from the region.
### TABLE 4E1
Overview of livestock breed and trait valuation studies by region (2006 to 2014)

<table>
<thead>
<tr>
<th>Method</th>
<th>Region/Country</th>
<th>Species</th>
<th>Locally adapted breed(s)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choice experiment</td>
<td>Benin</td>
<td>Chickens</td>
<td>No specific breed</td>
<td>Faustin et al., 2010</td>
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<td></td>
<td>Ethiopia, Kenya</td>
<td>Cattle</td>
<td>Borana</td>
<td>Zander, 2006</td>
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<td>Zander and Holm-Müller, 2007</td>
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<td>Zander and Drucker, 2008</td>
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<td>Zander et al., 2009a</td>
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<tr>
<td></td>
<td>Ethiopia</td>
<td>Cattle</td>
<td>No specific breed</td>
<td>Kassie et al., 2009; 2010</td>
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<td></td>
<td>Ethiopia</td>
<td>Goats</td>
<td>No specific breed</td>
<td>Amanu Abetu, 2013</td>
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<td></td>
<td>Kenya</td>
<td>Cattle</td>
<td>Zebu</td>
<td>Ruto et al., 2008</td>
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<td>Goats</td>
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<td>Kenya</td>
<td>Sheep</td>
<td>No specific breed</td>
<td>Omondi et al., 2008b</td>
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<td></td>
<td>South Africa</td>
<td>Pigs</td>
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<td>Sheep</td>
<td>Afar, Bonga, Horro and</td>
<td>Duguma et al., 2011</td>
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<td>Menz</td>
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<td>Kenya</td>
<td>Chickens</td>
<td>No specific breed</td>
<td>Bett et al., 2011</td>
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<tr>
<td>Contingent valuation</td>
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<td>Cattle</td>
<td>Tarime Zebu</td>
<td>Ngowi et al., 2008</td>
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<td>Kassie et al., 2011</td>
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<td>Sheep</td>
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<td>Terfa et al., 2013</td>
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<td>Preference ranking</td>
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<td>Wurzinger et al., 2006</td>
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<td>No specific breed</td>
<td>Dayanandan, 2011</td>
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<td>gross margin analysis</td>
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<td>Cattle</td>
<td>Orma and Sahiwal Zebu</td>
<td>Maichomo et al., 2009</td>
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<td>Asia</td>
<td>Viet Nam</td>
<td>Pigs</td>
<td>No specific breed</td>
<td>Roessler et al., 2008</td>
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<td>Choice experiment</td>
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<td>Chickens</td>
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<td>Asmara, 2014</td>
</tr>
<tr>
<td>Contingent valuation</td>
<td>Indonesia</td>
<td>Cattle</td>
<td>No specific breed</td>
<td>Widi et al., 2014</td>
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<td>Cattle</td>
<td>No specific breed</td>
<td>Islam et al., 2010</td>
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<td>Production function/</td>
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<td>Viet Nam</td>
<td>Pigs</td>
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<td>Italy</td>
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<td>Modicana and Maremma</td>
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<td>Spain</td>
<td>Cattle</td>
<td>Alistana-Sanabresa</td>
<td>Martin-Collado et al., 2014</td>
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</tbody>
</table>
2.3 Valuation of traits to inform breeding decisions

In the context of the economic valuation of AnGR, the term “breeding” refers to directing deliberate and lasting changes in the genetic constitutions of livestock populations so as to improve their utilization. In the conventional practices of breeding programmes in developed countries, economic weights of key traits are combined with estimated breeding values to derive selection indices in order to evaluate the effect of the directional genetic changes on overall profit. These tools enable livestock keepers to select, maintain and reproduce animals with the aim of maximizing overall profitability. Conceptually similar, but more loosely articulated breeding objectives, are applied in traditional production systems in developing countries, although these typically consider more diverse and often complex traits, including adaptation or resilience to biotic and abiotic stresses, multiple indirect service functions and the socio-cultural values of the animals.

In this context, it is worth noting Marshall’s (2014) overview of studies that have compared performance from the socio-economic or economic viewpoint of the livestock keeper (and of other actors in the value chain). The authors identified 11 studies from Asia and Africa (the focus of their study) that fall within the scope of the current review. These studies took what may be broadly categorized as a production function approach in order to compare the gross margins of different breeds (including cross-breeds) from the point of view of the livestock keeper. They used field, rather than research-station, data related to input costs and yield effects. Six of the studies (undertaken in Ethiopia, India and Bangladesh) focused on dairy cattle (Sayeed et al., 1994; Ali et al., 2000; Islam et al., 2008; 2010; Mondal et al., 2010; Dayanandan 2011), one on dual-purpose cattle in Kenya (Maichomo et al., 2009), one on chickens in Bangladesh (Rahman et al., 1997), one on goats in Ethiopia (Ayalew et al., 2003), and two on pigs in Viet Nam and Zimbabwe (van Eckert, 1993; Lemke et al., 2006). Two additional studies from Latin-America were also mentioned, although neither of these fall within the scope of this review, as they fail to meet the economic analysis (Madalena et al., 2012) or date (Blake, 2004) criteria.

Despite the slow progress in the uptake of the results of policy decision-support tools based on the economics of AnGR (Drucker, 2010), some analytical techniques for systematically estimating relative economic values of complex traits and attributes of AnGR have recently been adopted in mainstream animal breeding. In situations where only limited production and market data are available, the relative economic importance of key traits and attributes can be estimated using stated preference techniques (Tano et al., 2003). For example, Nielson and Amer (2007) used choice experiments to define economic weights for use in animal breeding selection indices where traditional bio-economic models for estimating profits are not practical. Other types of stated preference techniques, such as conjoint analysis and preference ranking, have also been used to identify and prioritize traits, and indeed breeds, for particular production scenarios (Desta et al., 2011; 2012; Duguma et al., 2011). These techniques can be used to capture the preferences and choices of livestock keepers for traits/attributes that are not marketed (non-market use values) and are often ignored or only given secondary consideration in the process of deriving breeding objectives and economic weights for different traits. However, further work needs to be done in order to demonstrate how the results of such stated preference methods can be applied in the development of (long-term) breeding programmes for at-risk breeds, not only in developed countries, but also in developing countries – especially for breeds found in marginal production environments (e.g. Hodges et al., 2014).

Apart from allowing the valuation of indirect use values of AnGR, economic valuation methods complement and provide relevant socio-economic context to the results of global and breed-specific molecular genetic studies. For instance, a global study into the genetic structure of cattle breeds (Bovine HapMap Consortium, 2009) has
revealed significant hybridization of the rare taurine and trypanotolerant Sheko breed with indicine breeds, which is consistent with earlier molecular genetic evidence of an alarming male-mediated introgression of zebu genes (Hanotte et al., 2000). Related trait and breed preference studies in the Sheko’s native production environments in Ethiopia showed that despite its recognized adaptedness to endemic trypanosomosis and tsetse fly challenge, as well as its superior dairy attributes (compared to other local cattle breeds) in these stressful production environments (Lemecha et al., 2006), the breed remains under sustained pressure from deliberate cross-breeding as livestock keepers choose smaller and more docile zebu bulls from adjacent highlands (Stein et al., 2009; Desta et al., 2011; 2012). This is in line with the earlier findings of Jabbar and Diedhiou (2003) from southwest Nigeria, which revealed a gradual shift of breed preferences away from trypanotolerant breeds towards cross-bred and zebu cattle. In addition to shedding light on breed preferences, such studies can also provide the evidence-base for defining breeding objectives for breeding programmes that are capable of meeting the current needs of livestock keepers.

2.4 Public willingness to pay for conservation services
As discussed above, a range of studies have investigated the values of the traits of traditional livestock breeds from livestock-keeper and breeder perspectives. In contrast, Zander et al. (2013) and Martin-Collado et al. (2014) focused on the full range of TEVs arising from the maintenance of locally adapted breeds, with a view to identifying the broader public’s willingness to pay for the breed-related ecosystem services that arise from their maintenance.

Zander et al. (2013) show that in the case of two threatened Italian cattle breeds (Modicana and Maremmana), most (85 percent) survey respondents (members of the general public interviewed either in areas where the breeds are kept or in the nearest provincial capital city) supported breed conservation, with their stated willingness-to-pay easily justifying existing European Union support. The high landscape-maintenance, existence\(^{12}\) and future-option values of both breeds (around 80 percent of their TEVs) suggest that incentive mechanisms are indeed needed in order to allow livestock keepers to capture some of these public-good values and hence motivate them to undertake conservation-related activities. The positive direct use values of both breeds (around 20 percent of their TEVs) imply that niche product markets aimed at enhancing the private-good values associated with the breeds could form an (albeit secondary) element of a use and conservation strategy.

The Spanish Alistana-Sanabresa breed was also shown to be associated with significant non-market values. The value that respondents placed on each specific public-good function was shown to vary significantly. For example, functions related to indirect use cultural values and existence values were much more highly valued than landscape maintenance values. These high cultural and existence values (again totalling approximately 80 percent of TEV) suggest that an in situ conservation strategy, as opposed to a purely ex situ cryoconservation strategy, would be required and that such a strategy would need to involve livestock-keeper incentive mechanisms (Martin-Collado et al., 2014).

2.5 Incentive mechanisms for conservation services
Given the presence of such significant non-market and public-good values associated with AnGR, it is clear that the development of positive incentives (and indeed the removal of damaging subsidies), as called for under the CBD’s 2011–2020 Strategic Framework (CBD, 2011) in the context of biodiversity in general, will often be required in order to ensure that socially desirable levels of livestock diversity are maintained.

One type of positive incentive mechanism that can potentially be used is payment for ecosystem
services. Silvestri et al. (2012) note that increased demand for, and scarcity of, some of the ecosystem services generated by livestock production systems (see Box 4E1) has created opportunities for implementing approaches of this kind. Examples of emerging and operational payments for ecosystem services in livestock production systems include those related to climate regulation, watershed management and hydrological services and conservation of non-domesticated biodiversity (ADB, 2014).

Of particular relevance to domesticated plant and animal biodiversity is the emerging concept of payments for agrobiodiversity conservation services (PACS), an approach that draws on existing concepts of payments for ecosystem services and can be defined as follows:

“an economic instrument to tackle market, intervention, and global appropriation failures associated with the public good characteristics of agrobiodiversity conservation services through the use of (monetary or in-kind) reward mechanisms in order to increase the private benefits from local plant and animal genetic resources, so as to sustain their on-farm utilization” (Narloch et al., 2011a).

PACS can be combined with prioritization protocols (such as the Weitzman approach – see earlier studies by Simianer et al., 2003; Reist-Marti et al., 2003; and Zander et al., 2009b), the application of safe minimum standards approaches (Drucker, 2006; Zander et al., 2013) and the use of competitive tenders that permit the identification of least-cost conservation service providers and transparent accounting for any efficiency–equity trade-offs that may exist in the selection of service providers (Narloch et al., 2011b; see also Bojkovski [forthcoming] for an emerging livestock application in Slovenia).

In the European context, the use of PACS approaches in the field of AnGR management is in part driven by the need for improved understanding of the type of support that needs to be provided to livestock keepers in order to permit at-risk breeds to reach population targets set under European Union legislation. Incentive payment schemes for livestock-keepers rearing traditional breeds at risk are in place in the European Union (see Part 3 Section F). However, such payment schemes have often proved to be insufficient to cover the true financial opportunity costs faced by the keepers of such breeds (Signorello and Pappalardo, 2003).

The challenges associated with ensuring the sustainable management of AnGR are compounded by the fact that agricultural production does not take place on a level playing field; large amounts of subsidy are directed (mostly) towards specialized agricultural production systems. For example, in 2012 agricultural subsidies totalled an estimated US$486 billion in the top 21 food-producing countries in the world (Worldwatch Institute, 2014). Developing-country studies of subsidies for “improved” breeds include Drucker et al. (2006), which estimated the total subsidy for imported pig breeds and their crosses in Viet Nam to be in the region of 19 to 70 percent of the gross margin typically associated with sow production. These were found to be similar to OECD-country subsidy levels (reaching 60 percent of farm receipts in some cases). Although designed with specific social goals in mind, such subsidies are “harmful” in the sense that they affect the competitiveness of locally adapted versus improved breed production systems and thereby affect the extent to which AnGR diversity is used and conserved.

In addition to the direct livestock-keeper payments that could be provided by PACS, attention is also increasingly being given to the potential of existing agricultural market channels to promote the use of at-risk genetic resources (among others, see the “Adding Value” special issue of the journal Animal Genetic Resources [FAO, 2013a]; Tienhaara et al., 2013; Lauvie et al., 2011; LPP et al., 2010; Mathias et al., 2010). Niche-marketing mechanisms, such as eco-labelling, certification and denomination of origin schemes (see Part 3 Sections D and F

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13 See www.bioversityinternational/pacs for more information on PACS.
and Part 4 Section D), may allow products from locally adapted breeds to attract higher market prices and thus help to keep the breeds in use. The Schwäbisch-Hällische pig in Germany, for example, is a locally adapted breed that was revived from close to extinction to become the foundation for a regional speciality niche-market (LPP et al., 2010). The population of the Bresse chicken in France has remained stable for decades as a result of similar niche market-based management (Verrier et al., 2005). Niche-market development is, however, often challenging, and not all breeds have the potential to supply products that closely match consumers’ current tastes and preferences. Such mechanisms alone are therefore unlikely to be able to correct fully for market failures related to the public-goods characteristics of many of the services associated with the maintenance of agrobiodiversity. Niche-market development and PACS can thus be viewed as complementary approaches (Narloch et al., 2011a). A conceptual basis for PACS financing strategies, through private- and public-sector service beneficiary and purchaser identification/mapping and dialogue, has recently been developed (Drucker et al., 2013).

3 Challenges and opportunities

Recent years have seen a number of significant developments in the field of AnGR-focused economics. An economic conceptual framework within which the erosion of genetic diversity can be analysed has been elaborated and the links between the different types of value associated with AnGR and potential contributions to different kinds of ecosystem services have been better articulated. A wide range of breed-valuation studies have been undertaken, the majority relating to developing-country breeds and livestock-keeper preferences. In line with the importance of AnGR values that are not reflected in the marketplace, these studies have focused particularly on stated preference and ranking methods. A range of AnGR economic studies have also been realized with a specific view to supporting the development of breeding programmes.

While many of the recent valuation studies have drawn on livestock-keeper and breeder preferences, methods for assessing public willingness to pay for breed conservation have also been developed, drawing on both total economic value and ecosystem service frameworks. European case studies based on these approaches have confirmed the existence of very significant non-market values, a number of which can only be secured through the implementation of in situ conservation strategies. Such strategies may also be dependent on the development of incentive mechanisms that ensure livestock keepers can capture a sufficient proportion of the non-market public good values to cover the costs they incur in providing public-good conservation services. In this context, the emergence of agrobiodiversity-focused payments for ecosystem services, so-called PACS, is of particular interest, especially as a complementary incentive mechanism alongside niche-product and market/value-chain development.

Despite the positive developments, a range of challenges and opportunities for future work in this subfield of economics remain.

Awareness raising: There is a need to promote awareness and facilitate interaction among both animal and plant genetic resources researchers and development practitioners regarding developments in the economics of genetic resources use and conservation. The development of the economic conceptual framework described above, which originated from the AnGR-focused work of Drucker and Rodriguez (2009) and Steinfeld (2000), has been used to inform analysis related to agrobiodiversity more broadly (e.g. Narloch et al., 2011a; Pascual et al. 2011; Krishna et al. 2013). Such work has also drawn on the conceptual framework to inform approaches based on agrobiodiversity-focused payments for ecosystem services, which while having been originally applied in a plant genetic resources context are now also beginning to be applied in AnGR contexts (e.g. Bojkovski, forthcoming). The somewhat different conceptual
model developed by Krishna et al. (2013) for the application of PACS in a plant genetic resources context could also be adapted to an AnGR context.

Another example of a method developed for use on one component of agrobiodiversity and later used to inform the management of another component is the Weitzman prioritization approach. Originally applied by Weitzman (1993) to non-domesticated animals (wild species of crane), this method was later adapted for application to AnGR by Simianer et al. (2003), Reist-Marti et al. (2003) and Zander et al. (2009). It has recently been usefully applied to a plant genetic resource (cacao) case study (Samuel et al., 2013). While there continues to be relatively limited interaction between animal and plant genetic resources researchers/development practitioners, it is clear that at least in the field of the economics of genetic resources use and conservation, there is high potential for mutual learning and collaboration – and that should be further encouraged.

Assigning breed types: In situations where genotypic information may be absent, as in most developing counties, identifying and verifying the breed type of a given AnGR can prove difficult. Livestock keepers tend to keep multiple genotypes to derive multiple benefits, and breeds tend to be defined in more subjective and less quantitative ways (Marshall, 2014). Under such circumstances, breed and trait valuation tools may be used to facilitate breed characterization through improved understanding of breeds and their values. In such contexts, greater collaboration between geneticists and economists may prove to be particularly valuable.

Research focus: The valuation studies discussed above mainly focused on developing countries and on-farm/in situ use and conservation strategies. While further work in these areas is still very much needed (including in Latin America, where relatively little work of this type has been undertaken so far), an increasing number of developed-country studies and studies considering the costs and benefits of ex situ conservation would also be welcome.

Costing conservation efforts: A number of studies, including Drucker (2006) for livestock and Narloch et al. (2011a) for plants, have suggested that given modest conservation goals (the recently updated FAO [2013b] “not at risk” status category requires 2,000 breeding females in species with high reproductive capacity and 6,000 in species with low reproductive capacity), the costs of conserving a priority portfolio of at-risk breeds may also be quite modest. The assessment of public willingness to pay for conservation by Zander et al. (2013) and estimates of the support payments that would be required to achieve stated conservation goals suggest that such conservation costs may well be both economically justifiable (benefits outweighing costs) and relatively low cost. In this context, it is also interesting to note the findings of a plant genetic resources case study conducted by Krishna et al. (2013), which suggest that farmer willingness to participate in genetic resources conservation activities for the public good may be more closely related to the consumption values of the genetic resources in question than to their production opportunity costs (which generally do not take into account the existence of farmers’ many non-market preferences and values). Hence, conservation costs may be overestimated if based only on conventional economic opportunity cost estimates.

Such considerations are important, as national and global level efforts to cost the resources required in order to secure priority portfolios of AnGR could help to inform policy development. Such costing exercises could address both in situ conservation strategies and complementary ex situ interventions. It should, however, be noted that the different in situ risk-status thresholds adopted by different countries imply different implicit conservation costs.14

14 Alderson (2009) notes differences between the breed status criteria adopted by the FAO and widely applied in AnGR valuation studies, and those independently developed by the European Union (EU), Rare Breeds International (RBI), the European Federation of Animal Science (EAAP) and the Rare Breeds Survival Trust (RBST). The choice of breed risk status criteria can have strong implications for overall conservation costs, insofar as such costs may be proportional to total herd size (Zander et al., 2013).
Linking conservation goals and values to the provision of ecosystem services: The articulation of the link between conservation goals, values and ecosystem services is another area where plant genetic resources and AnGR work could be mutually supportive. CGIAR research\textsuperscript{15} on the development of agrobiodiversity-focused ecosystem service indicators/metrics and on PACS includes work that is currently oriented towards plant genetic resources but also has potential AnGR applications. This work also includes consideration of the degree to which private- and public-good values and associated ecosystem services may, in certain contexts, need to be traded-off and the degree to which this can be done transparently and in a socially equitable manner.

A related area of interest for future research addresses conservation goal setting and levels of ecosystem-service provision. There is a need to overcome the current relative lack of knowledge of how different conservation goals and risk-status thresholds actually relate to the provision of specific ecosystem services. For example, one livestock-keeper with 2 000 breeding females of a particular breed maintained in a single herd/location would have quite different implications for ecosystem services related to the maintenance of landscape-level resilience, evolutionary processes/future option values and traditional knowledge and cultural practices than would 200 livestock keepers spread across the countryside, each with a herd of 10 breeding females. Once again, the existing plant genetic resources-focused CGIAR Research Programme work on ecosystem services and indicators could potentially also contribute to work in the AnGR field.

Impact assessment: Finally, in the context of impact assessment, Marshall (2014) identifies the need to provide decision-support information, both to livestock keepers and to policymakers, through increased evaluation of the impact of different livestock breed types in developing-country livestock production systems. Such assessments (which could draw on the indicator/metric development mentioned above) might address, \textit{inter alia}, food and nutrition security and environmental sustainability. It is important that gender and intrahousehold dimensions are also considered, given that the benefits derived from interventions that affect breed and genotype choices can vary both between and within households, especially in low-input production environments, where both direct and indirect use values of livestock are likely to be important.

References\textsuperscript{16}


15 Water, Land and Ecosystems and Policies, Markets and Institutions Research Programmes.


