Section E

Methods for economic valuation

1 Introduction

The large number of AnGR at risk in developing countries, together with the limited financial resources available for conservation and sustainable use, means that economic analysis can play an important role in ensuring an appropriate focus for conservation and genetic improvement efforts. In this regard, important tasks include, *inter alia*:

- determining the economic contribution that AnGR make to various sectors of society;
- supporting the assessment of priorities through the identification of cost-effective measures which might be taken to conserve livestock diversity; and
- assisting in the design of economic incentives and institutional arrangements for the promotion of AnGR conservation by individual farmers or communities.

Swanson (1997) notes that human societies have been expanding and developing over time through a process involving biodiversity depletion. This process can be understood in terms of a trade-off between maintaining the stock of diverse biological resources, and the benefits to human society derived from the depletion of this stock. AnGR erosion can, thus, be seen in terms of the replacement of the existing slate of livestock with a small range of specialized "improved" breeds. Such replacement occurs not only through substitution, but also through cross-breeding and the elimination of livestock because of production system changes. Genotype choices and threats to AnGR, therefore, need to be understood in the context of the evolution of production systems (including biophysical, socio-economic and markets changes). See Part 2 for a further discussion of trends in livestock production systems.

From an economic point of view, AnGR erosion can be seen as a result of drivers generating a bias towards investment in specialized genotypes, which in turn results in under-investment in a more diverse set of breeds. Economic rationality suggests that investment decisions will be determined by the relative profitability of the two options (assuming risk neutrality and well-functioning markets). However, from a farmer's perspective, the relevant rates of return are those that accrue to him/her rather than to society or the world as a whole. To the farmer, the loss of a local breed will appear to be economically rational in a situation where the returns from the activities that lead to the loss are higher than those from activities compatible with genetic resource conservation – especially as returns from the latter may consist of non-market benefits that accrue to people other than the farmer. This divergence will be further compounded by the existence of distortions in the values of inputs and outputs such that they do not reflect their economic scarcity.

The above-described divergence between private and public returns is important. As Pearce and Moran (1994) note, the recognition of the broader total economic value (TEV – see Box 93) of natural assets can be instrumental in altering decisions about their use, particularly in investment decisions that present a clear choice

Box 93
Economic values

Livestock keepers benefit from the conservation of livestock diversity because of their need for animals that are able to produce in diverse agro-ecosystems, and fulfil a range of functions. In addition to supplying products for sale or home consumption, livestock provide input functions related to other farm/household activities. Livestock provide manure to enhance crop yields, transport for inputs and products, and also serve for traction. Where rural financial and insurance markets are not well developed, they enable farm families to smooth variation in income and consumption levels over time. Livestock constitute savings and insurance, buffering against crop failure and cyclical patterns in crop-related income. They enable families to accumulate capital and diversify, and serve a range of sociocultural roles related to the status and the obligations of their owners (Jahnke, 1982; Anderson, 2003). Livestock also play a role in the maintenance of ecosystems; for example, managed grazing is increasingly viewed as an important tool for conservation.

The values mentioned in the above paragraph are components of direct or indirect use value. Other values are not related to use, but simply to the existence of the breeds (existence and bequest values). Another type of value arises from the notion of uncertainty about the future. The latter result from the motivation to avert risk (option value), and from the irreversibility of the loss of a breed and the related loss of information.

The "Total Economic Value" (TEV) is formally equal to the sum of all direct and indirect use values plus non-use and option values:

TEV = DUV + IUV + OV + BV + XV where:

Direct Use Values (DUV) are the benefits resulting from*, inter alia*, actual uses, such as for food, fertilizer and hides, as well as cultural/ritual uses.
Indirect Use Values (IUV) are the benefits deriving from ecosystem functions. For example, some animals play a key role in the dispersion of certain plant species.
Option Values (OV) are derived from the value given to safeguarding an asset for the option of using it at a future date. It is a kind of insurance value (given uncertainty about the future and risk aversion) against the occurrence of, for example, a new animal disease or drought/climate change. Subtly different from, but related to, option values are quasi-option values. The latter relates to the extra value attached to future information made available through the preservation of a resource. Quasi-option values arise from the irreversible nature of breed loss (after which no further learning can take place); they are not related to the risk aversion of the decision makers.
Bequest Values (BV) measure the benefit accruing to any individual from the knowledge that others might benefit from a resource in the future; and
Existence Values (XV) are derived simply from the satisfaction of knowing that a particular asset exists (e.g. blue whales, capybaras or N´Dama cattle).

Some asset values may overlap between these categories, and double counting has to be avoided. Attempts to isolate option, bequest and existence values can be problematic. Underlying principles and procedures for such valuation are still debated.

Sources: adapted from Arrow and Fisher (1974); Jahnke, (1982); Pearce and Moran, (1994); Anderson, (2003); Roosen *et al.*, (2005).

between erosion/destruction or conservation. When the activity of biodiversity (and genetic resource) conservation generates economic values that are not captured in the market place, the result of this "failure" is a distortion in which the incentives are against genetic resource conservation, and in favour of the economic activities that erode such resources. Such outcomes are, from an economic viewpoint, associated with market failure (i.e. distortions arising from the "missing markets" in the external benefits generated by biodiversity conservation); intervention failure (i.e. distortions caused by government actions in intervening in the workings of the market place, even where those appear to serve some social purpose); and/or global appropriation failures (i.e. the absence of markets/mechanisms to capture globally important external values). Note that global missing markets can co-exist with local market failure and intervention failure. The loss of biodiversity and genetic resources is a case in point.

It is apparent from the above typology of values that current economic decisions are largely based on the first category, direct use values, although the other categories may be of equal or greater importance. For example, it has been estimated that approximately 80 percent of the value of livestock in low-input developing-country systems can be attributed to non-market roles, while only 20 percent is attributable to direct production outputs. By contrast, over 90 percent of the value of livestock in high-input developed-country production systems is attributable to the latter (Gibson and Pullin, 2005). By focusing exclusively on direct use values, biodiversity and genetic resource conservation are likely to be consistently undervalued, resulting in a bias towards activities that are incompatible with their conservation.

2 Development of methodologies for economic analysis

Although there is a large body of literature on the economic benefits of improved breeds in intensive (largely developed-country) commercial agriculture, the importance of indigenous breeds and trait values in the subsistence production systems typical of developing countries have been much less studied. There is an extensive amount of conceptual and theoretical literature concerning sources of value arising from genetic resources and biodiversity in general (usually referring to plants and wild animals). However, it is only since an FAO/ILRI workshop (ILRI, 1999) identified potential AnGR valuation methodologies, and subsequent initiatives by ILRI (Economics of AnGR Conservation and Sustainable Use Programme) and its partners to test these methodologies, that significant research into the matter has been carried out.

Such tools and their findings have, as yet, rarely been put to use in situations that influence policy-making and farmer livelihoods. Further research is urgently needed to better understand implications for genotype preferences of an increasingly dynamic context characterized by, *inter alia*:

- globalization of markets;
- climate change and environmental degradation;
- the occurrence of new epidemic animal diseases;
- developments in the field of biotechnology; and
- policy developments related to the CBD.

Global efforts to eradicate poverty, as embodied in the Millennium Development Goals, also require an improved understanding of the potential contributions of alternative genotypes to poverty alleviation, in order to improve pro-poor targeting of AnGR programmes. In this context, research supporting institutional innovations and technology-adoption also play an important role. Such areas are critical for the management of AnGR and have important socio-economic dimensions.

There are a number of reasons for the relatively slow development of the economics of AnGR, including: the fact that the measurement of the benefits of germplasm diversity to livestock development is difficult; the limited availability of the data required to carry out economic analysis; and the importance of considering non-market values of livestock – obtaining such data frequently requires the modification of economic techniques for use in conjunction with participatory and rapid rural appraisal methods.

Despite the difficulties, there are a range of analytical techniques from other areas of economics that can be adapted for carrying out such analyses. These methodologies are reviewed

TABLE 102
Overview of valuation methodologies

Valuation methodology	Purpose	Contribution to conservation and sustainable use of AnGR
Group 1: Methodologies for determining the actual economic importance of the breed (mostly of interest to policy makers and breeders, as well as some farmers)		
Aggregate Demand & Supply	Identify value of breed to society.	Value potential losses associated with AnGR loss.
Cross-sectional Farm and Household	Identify value of breed to society.	Value potential losses associated with AnGR loss.
Aggregated Productivity Model	Determine farmer net returns by breed.	Justify economic importance of given breed in the context of multiple limiting inputs.
IPR and Contracts	Market creation and support for "fair and equitable" sharing of AnGR benefits.	Generate funds and incentives for AnGR conservation.
Contingent Valuation Methodologies I (e.g. dichotomous choice, contingent ranking, choice experiments)	Determine farmer trait value preferences and net returns by breed.	Justify economic importance of given breed.
Market Share I	Indicate current market value of a given breed.	Justify economic importance of given breed.
Group 2: Methodologies for determining the costs and benefits of AnGR conservation programmes and for targeting farmers for participation (mostly of interest to policy makers and farmers)		
Contingent Valuation Methodologies II (e.g. dichotomous choice, contingent ranking, choice experiments)	Identify society's willingness to pay (WTP) for the conservation of AnGR. Identify farmer willingness to accept (WTA) compensation for raising indigenous AnGR instead of exotics.	Define maximum economically justified conservation costs.
Production Loss Averted	Indicate magnitude of potential production losses in the absence of AnGR conservation.	Justify conservation programme costs of at least this magnitude.
Opportunity Cost	Identify cost of maintaining AnGR diversity.	Define opportunity cost of AnGR conservation programme.
Market Share II	Indication of current market value of a given breed.	Justify conservation programme costs.
Least Cost	Identify cost-efficient programme for the conservation of AnGR.	Define minimum cost of conservation programme.
Safe Minimum Standard	Assess trade-offs involved in maintaining a minimum viable population.	Define opportunity cost of AnGR conservation programme.
Group 3: Methodologies for priority setting in AnGR breeding programmes (mostly of interest to farmers and breeders)		
Evaluation of Breeding Programme	Identify net economic benefits of stock improvements.	Maximize economic benefits of conserved AnGR.
Genetic Production Function	Identify net economic benefits of stock improvements.	Maximize expected economic benefits of conserved AnGR.
Hedonic	Identify trait values.	Value potential losses associated with AnGR loss. Understand breed preferences.
Farm Simulation Model	Model improved animal characteristics on farm economics.	Maximize economic benefits of conserved AnGR.

Source: adapted from Drucker *et al.* (2001).

by Drucker *et al*. (2001) who broadly categorize them into three (non-mutually exclusive) groups on the basis of the practical purpose for which they may be used (see Table 102):

- group 1) determining the actual economic importance of the breed at risk;
- group 2) determining the costs and benefits of AnGR conservation programmes, and targeting farmers for participation; and
- group 3) priority setting in AnGR breeding programmes.

A number of these methodologies have significant conceptual shortcomings and intensive data requirements (see Drucker *et al*., 2001 for a detailed description). However, they have been shown to produce useful estimates of the values that are placed on market, non-market and potential breed attributes of the type useful for designing breeding and conservation strategies. The following section presents an overview of the methodologies. The objective is both to show the potential usefulness of the methodologies, as well as to provide information (inevitably location-specific) on the economic importance of indigenous AnGR. To this end, a number of specific studies are presented as illustrative examples of the application of the various tools. Many of the findings give useful insights into the value of particular indigenous livestock breeds within the production systems studied. Salient conclusions are highlighted at the start of each subsection. A more detailed overview can be found in Drucker *et al*. (2005), and an annotated bibliography of literature in this field is provided by Zambrano *et al*. (2005).

3 Application of economic methodologies in animal genetic resources management

The following examples are presented in the context of the classification presented in Table 102.

3.1 Value of animal genetic resources to farmers[9]

- Adaptive traits and non-income functions form important components of the total value of indigenous-breed animals to livestock keepers.
- Conventional productivity evaluation criteria are inadequate to evaluate subsistence livestock production and have tended to overestimate the benefits of breed substitution.

Tano *et al*. (2003) and Scarpa *et al*. (2003a; 2003b) used stated preference choice experiments (CE) to value the phenotypic traits expressed in indigenous breeds of livestock. Adaptive traits and non-income functions are shown to form important components of the total value of the animals to livestock keepers. In the study carried out by Tano *et al*. (2003) in West Africa, for example, the most important traits for incorporation into the goals of breed improvement programme were found to be disease resistance, fitness for traction, and reproductive performance. Beef and milk production were less important. The results of these studies also show that it is possible to investigate values of genetically determined traits that are currently not widely recognized in livestock populations, but are desirable candidates for breeding or conservation programmes (e.g. disease resistance).

Karugia *et al*. (2001) used an aggregate demand and supply approach covering both national and farm levels. They argue that conventional economic evaluations of cross-breeding programmes have overestimated their benefits by ignoring subsidies, the increased

[9] Using Group 1 valuation methodologies (see Table 102).

costs of management such as veterinary support services, and the higher levels of risk and socio-environmental costs associated with the loss of the indigenous genotypes. Applied to dairy farming in Kenya, the results suggest that at the national-level, cross-breeding has had an overall positive impact on society's welfare (based on a consumer/producer surplus measure), although taking important social cost components into account substantially lowers the net benefits. Farm-level performance is, however, little improved under "traditional" production systems by replacing the indigenous Zebu with exotic breeds.

Comparing the performance of different genotypes (indigenous goats vs. exotic crosses), Ayalew *et al*. (2003) come to a similar conclusion. The secondary importance of meat and milk production traits in many production systems leads these authors to argue that conventional criteria for the evaluation of productivity are inadequate for subsistence livestock production systems, because:

- they fail to capture non-marketable benefits of the livestock; and
- the core concept of a single limiting input is inappropriate to subsistence production, as multiple limiting inputs (livestock, labour, land) are involved in the production process.

The study involved the use of an aggregated productivity model to evaluate subsistence goat production in the eastern Ethiopian highlands. The results show that indigenous goat flocks generated significantly higher net benefits under improved than under traditional management, which challenges the prevailing notion that indigenous livestock do not adequately respond to improvements in the level of management. Furthermore, it is shown that under the subsistence mode of production considered, the premise that cross-bred goats are more productive and beneficial than the indigenous goats is wrong. The model, thus, not only underlines the value of indigenous AnGR to farmers, but also provides a more realistic platform upon which to propose sound improvement interventions.

3.2 Costs and benefits of conservation[10]

- The costs of implementing an *in situ* breed conservation programme may be relatively small, both when compared to the size of subsidies currently being provided to the commercial livestock sector, and with regard to the benefits of conservation. However, few such conservation initiatives exist, and even where the value of indigenous breeds has been recognized and support mechanisms implemented, significant shortcomings can be identified.
- Similar work regarding the costs and benefits of the *ex situ* (cryo)conservation of livestock remains limited. However, under the assumption that technical feasibility brings the cost of cryoconservation and regeneration of livestock species to within the same level of magnitude as that of plants, extensive conservation efforts would be justified on economic grounds.

In situ *conservation*

Cicia *et al*. (2003) show that a dichotomous choice stated preference approach can be used to estimate the benefits of establishing a conservation programme for the threatened Italian Pentro horse. A bio-economic model was used to estimate the costs associated with conservation, and a cost–benefit analysis was subsequently realized. Benefit estimates were based on society's willingness to pay for conservation and, therefore, may be associated, in this particular case, with an existence value. The results not only show a large positive net present value associated with the proposed conservation activity (benefit/cost ratio > 2.9), but also show that this approach is a useful decision-support tool for policy-makers involved in allocating scarce funds to a growing number of animal breeds facing extinction.

A case study of the endangered Box Keken pig breed in Yucatan, Mexico revealed large net present values associated with conservation (Drucker and

[10] Using Group 2 valuation methodologies (see Table 102).

TABLE 103
Conservation benefits and costs under a range of valuation methodologies – the case of the Box Keken pig (Yucatan, Mexico)

Valuation methodologies*	Measure of conservation and sustainable use benefits US$ *per annum*	Measure of conservation costs US$ *per annum*
Market share	US$490 000	
Production loss averted (Yucatan State only)	US$1.1 million	
Contingent valuation (consumer taste test)	US$1.3 million	
Contingent valuation (producer choice experiment) and least cost/ opportunity cost approach		US$2 500–3 500

Source: Drucker and Anderson (2004).
*See Table 102.

Anderson, 2004). Three methodologies for valuing the benefits of conservation and sustainable use of the breed – market share, production loss averted and contingent valuation (consumer taste test) – were tested and critically assessed. The costs of conservation were estimated with the use of contingent valuation (producer choice experiment) and least cost/opportunity cost approaches. A shortcoming of the first two techniques for valuing the benefits is that they are not based on consumer surplus measures, i.e. do not account for price changes and substitution possibilities should breed loss occur. Despite the identified shortcomings, and the fact that values can only be approximated, the study indicates that the benefits of conservation clearly outweigh the costs in this case (Table 103).

Even where the value of indigenous breeds has been recognized and support mechanisms implemented, significant failings can be identified. Signorello and Pappalardo (2003), in an examination of livestock biodiversity conservation measures and their potential costs in the EU, report that many breeds at risk of extinction according to the FAO World Watch List are not covered by support payments as they do not appear in countries' Rural Development Plans. Furthermore, the results show that where payments are made, they do not take into account the different extinction risks faced by the different breeds. Moreover, payment levels are inadequate, meaning that it can still remain unprofitable to rear indigenous breeds. Ideally, support payments should be set at a level that reflects society's willingness to pay for conservation, but this is not usually the case and may not always be necessary to ensure profitability.

The lack of adequate incentives for the conservation of indigenous breeds is despite the fact that conservation costs have been shown, in a number of case studies described by Drucker (2006), to be relatively small. Drawing on the safe minimum standards (SMS) literature, the framework used in this study assumes that the benefits of indigenous livestock breed conservation can be maintained, as long as a minimum viable population of the breed is maintained. In general, the costs of implementing an SMS are made up of the opportunity cost differential (if any exists) of maintaining the indigenous breed rather than an exotic or cross-breed. In addition, the administrative and technical support costs of the conservation programme also need to be accounted for. Empirical cost estimates were obtained using data from economic case studies (Italy and Mexico), based on an SMS that is equivalent to the FAO measure of "not at risk", i.e. approximately 1 000 breeding animals. The results support the hypothesis that the costs of implementing an SMS are low (depending on the species/breed and location, these ranged from between approximately Euro 3 000 and 425 000 *per annum*), both when compared with the size of subsidies currently being provided to the livestock sector (less than 1 percent of the total subsidy) and with regard to the benefits of conservation (benefit/cost ratio greater than 2.9). The costs proved to be lowest in the developing country, which is encouraging given that an estimated 70 percent of the livestock breeds existing today are in developing countries, and that this is where the risk of loss is highest (Rege and Gibson, 2003).

More extensive quantification of the components required to determine SMS costs nevertheless needs to be undertaken before it can be applied in practice. Such economic valuation needs to cover both the full range of breeds/species being considered, and ensure that as many as possible of the elements making up their total economic value are accounted for.

Ex situ *conservation*

Similar work regarding the costs and benefits of the *ex situ* (cryo)conservation of livestock remains limited. Cryopreservation technologies for livestock, although advancing rapidly, are still well-developed only for a handful of species. Nevertheless, Gollin and Evenson (2003) argue that assuming that technical feasibility brings the cost of cryoconservation and regeneration of livestock species to within the same level of magnitude as that of plants, "there cannot be much doubt that the economics would justify extensive conservation efforts" (i.e. option values are likely to be much higher than conservation costs).

3.3 Targeting of farmers for participation in *in situ* breed conservation programmes[11]

- *In situ* conservation programmes play a crucial role in the context of AnGR.
- Household characteristics play an important role in determining differences in farmers' breed preferences. This additional information can be of use in designing cost-effective conservation programmes.

Wollny (2003) argues that community-based management approaches are likely to be required to play an increasingly important role in strategies that aim to improve food security and to alleviate poverty through the conservation of AnGR. This is because the utilization of indigenous livestock populations depends, in large part, on the ability of communities to decide on and implement appropriate breeding strategies. The community-based management of AnGR is also considered to play a critical role in poverty alleviation (FAO, 2003).

In the context of crops (Meng 1997), proposed that conservation programmes should target those households that are the most likely to continue to maintain local varieties. As these households will be the least costly to incorporate into a conservation programme, a "least cost" programme can be identified. The cost of an *in situ* conservation programme can, thus, be expressed as the cost necessary to raise the comparative advantage of such breeds above that of competing breeds, species, or off-farm activities. A relatively small investment may suffice to maintain their advantage in a particular farming system.

This conceptual approach to identifying low-cost conservation strategies has recently been applied to estimate conservation costs for creole pigs in Mexico (Scarpa *et al*., 2003b; Drucker and Anderson, 2004) and Boran cattle in Ethiopia (Zander *et al*., forthcoming).

[11] Using Group 2 valuation methodologies (see Table 102).

Scarpa *et al*. (2003b) show that for creole pigs in Mexico, the respondent's age, years of schooling, size of the household, and the number of economically active members of the household, were important factors in explaining breed trait preferences. Younger, less-educated, and lower-income households placed relatively higher values on the attributes of indigenous piglets compared to exotics and their crosses (Drucker and Anderson, 2004). Pattison's (2002) findings further corroborate these results. In the context of a ten-year conservation programme that would bring the creole pig population to a sustainable size considered "not at risk" under the FAO classification system; the findings indicate that small, less well-off households would require lower levels of compensation, or even (in 65 percent of cases) no compensation at all. The premise of this set of studies is that continued conservation of genetic resource diversity on-farm makes most economic sense in those locations where both society and the farmers who maintain it benefit the most.

Mendelsohn (2003) argues that where there is a divergence between private (farmer) and public values, conservationists must first make the case for why society should be willing to pay to protect apparently "unprofitable" AnGR, and then must design conservation programmes that will effectively protect what society treasures.

3.4 Priority setting in livestock conservation programmes[12]

- Conservation policy needs to promote cost-efficient strategies, and this can be achieved through the development of "Weitzman-type" decision-support tools. Such tools permit the allocation of a given budget among a set of breeds such that the expected amount of between-breed diversity conserved is maximized.

[12] Using Group 2 valuation methodologies (see Table 102).

Simianer *et al*. (2003) and Reist-Marti *et al*. (2003) provide one of the few examples of the conceptual development of a decision-support tool in the field of AnGR. Recognizing the large number of indigenous livestock breeds that are currently threatened, and the fact that not all can be saved given limited conservation budgets, a framework is elaborated for the allocation of a given budget among a set of breeds so that the expected amount of between-breed diversity conserved is maximized. Drawing on Weitzman (1993) it is argued that the optimum criterion for a conservation scheme is to maximize the expected total utility of the set of breeds, which is a weighted sum of diversity, extinction probabilities and breed conservation costs (see Section F: 8.2 for further discussion of this approach). Drawing on Group 2 valuation methodologies (see Table 102) is currently postulated as a means of estimating conservation costs. However, Group 1 methodologies could be used should a livelihoods rather than a conservation cost approach be adopted. Both this, and the original Weitzman study, used measures of diversity based on genetic distances. Note, however, that alternative measures of diversity could also be used – for example, measures that include both between and within-breed diversity (Ollivier and Foully, 2005) or those drawing on functional diversity, based on the existence of unique attributes in certain breeds (see Brock and Xepapadeas (2003) for a plant genetic resource illustration). Implications for the choice of breeds for inclusion in conservation programmes may well differ depending on how the diversity index is constructed and the overall goal of the conservation programme (conservation of genetic diversity *per se*, maximizing the number of unique traits conserved, or maximizing the livelihood contribution of the livestock diversity conserved). Where such models are sufficiently specified and essential data on key parameters are available (currently lacking for conservation costs and benefits or contribution to livelihoods), the framework can be used for rational decision-making on a global scale. See section F:8 for further discussion of methods for priority setting in conservation.

3.5 Priority setting in livestock-breeding strategies[13]

- Economic analysis has demonstrated the magnitude of the contribution of genetic selection, for example using selection indices, to increased production.
- Methods are needed not only to account for the current set of economic objectives, but also to include foreseeable and even unpredictable future needs.
- Hedonic approaches[14] are useful to evaluate the importance of certain attributes or characteristics to the value of animals or animal products including their influence on selection strategies.

Breeding programmes have long used a selection index as a device for multiple-trait selection in livestock. For example, Mitchell *et al*. (1982) measured the value of genetic contributions to pig improvement in the United Kingdom by determining the heritability of important characteristics, and isolating the genetic contributions to improved performance. Using linear regression techniques to compare control and improved groups over time, they found that the returns were substantial, with costs in the region of £2 million *per annum* relative to benefits of £100 million *per annum*. The use of cross-breeding in commercial production was estimated to contribute approximately £16 million *per annum*. Farm-level simulation models have been built for several species under high-input management, and have also focused on valuing heritable trait gain.

Smith (1985), in the context of the importance of accounting for option values in genetic production function models, argues that genetic selection based on the current set of economic objectives is suboptimal in an intertemporal context. Instead, given uncertainty about future needs, selection should be "directed to cater for foreseeable and even unpredictable futures" (Smith, 1985, p. 411). In particular, Smith (1984) advocates the storage of stocks with traits that are currently not economically desirable because of temporary market demands and/or production conditions (e.g. market or grading requirements, carcass or product composition, or special behavioural adaptations to current husbandry conditions).

Using hedonic approaches, Jabbar *et al*. (1998) show that in Nigeria, although there were some differences in prices that were solely because of breed, most variation in prices was because of such variables as wither height and girth circumference that vary from animal to animal within breeds. Variation because of type of animal or month of transaction was also greater than that because of breed. Jabbar and Diedhiou (2003) show that a hedonic approach used to determine livestock keepers' breeding practices and breed preferences in southwest Nigeria, confirms a strong trend away from trypanotolerant breeds. Richards and Jeffrey (1995) identified the value of relevant production and type traits for dairy bulls in Alberta, Canada. A hedonic valuation model was estimated, which modelled semen price as a function of individual production and longevity characteristics for a sample of Holstein-Friesian bulls.

3.6 General policy analysis[15]

The current rapid rate of loss of AnGR diversity is the result of a number of underlying factors. While, in some cases, changes in production systems and consumer preferences reflect the natural evolution of developing economies and markets, in other cases, production systems, breed

[13] Using Group 3 valuation methodologies (see Table 102).

[14] Hedonic approaches are based on the idea that the total value of an animal can be decomposed into the values of individual characteristics. Statistical methods are used to estimate the contribution of each characteristic to the total value based on the market prices paid for animals with different combinations of characteristics.

[15] Potentially using Group 2, as well as Group 1 valuation methodologies (see Table 102).

choice and consumer preferences have been distorted by local, national and international policy. Such distortions may arise from macroeconomic interventions (e.g. exchange and interest rates); regulatory and pricing policy (e.g. taxation, price controls, market and trade regulations); investment policy (e.g. infrastructure development); and institutional policy (e.g. land ownership and genetic resource property rights). While the impact of policy factors on AnGR is readily discernable in broad terms, little is known about their relative importance.

4 Implications for policies and future research

The above studies reveal not only that there are a range of methodologies that can be used to value livestock keeper breed/trait preferences, but that they can be of use in designing policies that counter the present trend towards marginalization of indigenous breeds. In particular, it becomes possible to, *inter alia* (Drucker and Anderson, 2004):

- recognize the importance that livestock keepers place on adaptive traits and non-income functions, and the need to consider these in breeding programme design;
- identify those breeds that are a priority for participation in cost-efficient diversity-maximizing conservation programmes; and
- contrast the costs involved with the large benefits non-livestock keepers place on breed conservation.

Nevertheless, as recent advances in economic valuation for livestock genetic resources have eased some (but by no means all) methodological/analytical constraints, the issue of data availability has become relatively more critical. Data requirements imply the need to *inter alia*:

- measure breed performance parameters;
- characterize actual and potential breeding systems;
- identify uses and farmers' trait preferences (including eliciting the values that farmers place on specific market/non-market traits and the trade-offs they are willing to make between traits) for local breeds under different production systems, as well as the forces influencing such factors and the use of alternative breeds;
- identify factors affecting livestock demand and prices, including the impact of policy-induced changes in agricultural commodity (e.g. forage/crop) prices and external (e.g. veterinary) input costs in the context of different breed use;
- carry out *ex ante* analysis of the effects on livelihoods of using alternative breeds, together with constraints to adoption and potential access/dissemination mechanisms;
- consider the role of such factors as land tenure, agricultural potential, population density, market access and integration, licensing requirements, tax regimes, credit and extension programmes and education; and
- improve understanding of the importance of continued access and trade in livestock germplasm for research and development purposes, together with the nature of the costs and benefits arising from AnGR research.

Despite a wealth of livestock production data at the national level, such information tends to be limited to the principal breeds and largely ignores important non-market contributions. Information on local breeds in developing countries is extremely limited. Initiatives such as FAO's DAD-IS and ILRI's DAGRIS systems are supporting national-level programmes.

The challenge is now to raise awareness regarding the important role of economic analysis in improving farm AnGR conservation and sustainable use. National capacities must also be strengthened in order to enable the application of the relevant methodologies/decision-support tools, and to integrate them into the wider national livestock development process. In this way, further work on the economics of AnGR (including in dynamic systems evolution contexts and integrated with other components of agrobiodiversity), and the subsequent design of appropriate incentive mechanisms, can be applied in contexts where the results can be taken up so as to actively benefit farmers and support the work of national researchers and policy-makers.

References[16]

Anderson, S. 2003. Animal genetic resources and sustainable livelihoods. *Ecological Economics*, 45(3): 331–339.

Arrow, K.J. & Fisher, A.C. 1974. Environmental preservation, uncertainty, and irreversibility. *Quarterly Journal of Economics*, 88(2): 312–319.

Ayalew, W., King, J.M., Bruns, E. & Rischkowsky, B. 2003. Economic evaluation of smallholder subsistence livestock production: lessons from an Ethiopian goat development program. *Ecological Economics*, 45(3): 473–485.

Brock, W. & Xepapadeas, A. 2003. Valuing biodiversity from an economic perspective: a unified economic, ecological and genetic approach. *American Economic Review*, 93(5): 1597–1614.

Cicia, G., D'Ercole, E. & Marino, D. 2003. Costs and benefits of preserving farm animal genetic resources from extinction: CVM and bio-economic model for valuing a conservation program for the Italian Pentro horse. *Ecological Economics*, 45(3): 445–459.

Drucker, A.G. 2006. An application of the use of safe minimum standards in the conservation of livestock biodiversity. *Environment and Development Economics*, 11(1): 77–94.

Drucker A.G. & Anderson, S. 2004. Economic analysis of animal genetic resources and the use of rural appraisal methods: Lessons from South-East Mexico. *International Journal of Sustainable Agriculture,* 2(2): 77–97.

Drucker, A.G., Gómez, V. & Anderson, S. 2001. The economic valuation of farm animal genetic resources: a survey of available methods. *Ecological Economics*, 36(1): 1–18.

Drucker, A.G., Smale, M. & Zambrano, P. 2005. *Valuation and sustainable management of crop and livestock biodiversity: a review of applied economics literature.* SGRP/IFPRI/ILRI. (available at www.ilri.org).

[16] See www.ilri.org for full text versions of a number of these papers.

FAO. 2003. *Community-based management of animal genetic resources.* Proceedings of the workshop held in Mbabane, Swaziland, 7–11 May 2001. FAO/SADC/UNDP/GTZ/CTA. Rome.

Gibson, J.P. & Pullin, R.S.V. 2005. *Conservation of livestock and fish genetic resources.* Rome. CGIAR Science Council Secretariat.

Gollin, D & Evenson, R. 2003. Valuing animal genetic resources: lessons from plant genetic resources. *Ecological Economics*, 45(3): 353–363.

ILRI. 1999. *Economic valuation of animal genetic resources.* Proceedings of an FAO/ILRI workshop held at FAO Headquarters, Rome, Italy, 15–17 March 1999. Nairobi. International Livestock Research Institute.

Jabbar, M.A. & Diedhiou, M.L. 2003. Does breed matter to cattle farmers and buyers? Evidence from West Africa. *Ecological Economics*, 45(3): 461–472.

Jabbar, M.A., Swallow, B.M., d'Ieteren, G.D.M. & Busari, A.A. 1998. Farmer preferences and market values of cattle breeds of west and central Africa. *Journal of Sustainable Agriculture*, 12: 21–47.

Jahnke, H.E. 1982. *Livestock production systems and livestock development in Tropical Africa.* Kiel, Germany. Kieler Wissenschaftsverlag Vauk.

Karugia, J., Mwai, O., Kaitho, R., Drucker, A., Wollny, C. & Rege, J.E.O. 2001. Economic analysis of cross-breeding programmes in sub-Saharan Africa: a conceptual framework and Kenyan case study. *Animal Genetic Resources Research* 2. Nairobi. International Livestock Research Institute.

Mendelsohn, R. 2003. The challenge of conserving indigenous domesticated animals. *Ecological Economics*, 45(3): 501–510.

Meng, E.C.H. 1997. *Land allocation decisions and* in situ *conservation of crop genetic resources: The case of wheat landraces in Turkey.* University of California, Davis, California, USA. (PhD thesis)

Mitchell, G., Smith, C., Makower, M. & Bird, P.J.W.N. 1982. An economic appraisal of pig improvement in Great Britain. 1. Genetic and production aspects. *Animal Production*, 35(2): 215–224.

Ollivier, L. & Foulley, J. 2005. Aggregate diversity: new approach combining within- and between-breed diversity. *Livestock Production Science*, 95(3): 247-254.

Pattison, J. 2002. *Characterising backyard pig keeping households of rural Mexico and their willingness to accept compensation for maintaining the indigenous Creole breed: A Study of Incentive Measures and Conservation Options.* University of London. (MSc thesis).

Pearce, D. & Moran, D. 1994. *The economic value of biodiversity.* London. Earthscan.

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.

Reist-Marti, S., Simianer, H., Gibson, G., Hanotte, O. & Rege, J.E.O. 2003. Weitzman's approach and breed diversity conservation: an application to African cattle breeds. *Conservation Biology*, 17(5): 1299–1311.

Richards, T. & Jeffrey, S. 1995. *Hedonic pricing of dairy bulls – an alternative index of genetic merit.* Department of Rural Economy. Project Report 95–04. Faculty of Agriculture, Forestry, and Home Economics. Edmonton, Canada. University of Alberta Edmonton.

Roosen, J., Fadlaoui, A. & Bertaglia. M. 2005. Economic evaluation for conservation of farm animal genetic resources. *Journal of Animal Breeding and Genetics*, 122(4): 217–228.

Scarpa, R., Drucker, A.G., Anderson, S., Ferraes-Ehuan, N., Gómez, V., Risopatrón, C.R. & Rubio-Leonel, O. 2003a. Valuing genetic resources in peasant economies: the case of 'hairless' Creole pigs in Yucatan. *Ecological Economics*, 45(3): 427-443.

Scarpa, R., Ruto, E.S.K., Kristjanson, P., Radeny, M., Drucker, A.G. & Rege, J.E.O. 2003b. Valuing indigenous cattle breeds in Kenya: an empirical comparison of stated and revealed preference value estimates. *Ecological Economics*, 45(3): 409–426.

Signorello, G. & Pappalardo, G. 2003. Domestic animal biodiversity conservation: a case study of rural development plans in the European Union. *Ecological Economics*, 45(3): 487–499.

Simianer, H., Marti, S.B., Gibson, J., Hanotte, O. & Rege, J.E.O. 2003. An approach to the optimal allocation of conservation funds to minimise loss of genetic diversity between livestock breeds. *Ecological Economics*, 45(3): 377–392.

Smith, C. 1984. Genetic aspects of conservation in farm livestock. *Livestock Production Science*, 11(1): 37–48.

Smith, C. 1985. Scope for selecting many breeding stocks of possible economic value in the future. *Animal Production*, 41: 403–412.

Swanson, T. 1997. *Global action for biodiversity.* London. Earthscan.

Tano, K., Kamuanga, M., Faminow, M.D. & Swallow, B. 2003. Using conjoint analysis to estimate farmer's preferences for cattle traits in West Africa. *Ecological Economics*, 45(3): 393–407.

Weitzman, M.L. 1993. What to preserve? An application of diversity theory to crane conservation. *The Quarterly Journal of Economics*, 108(1): 157–183.

Wollny, C. 2003. The need to conserve farm animal genetic resources through community based management in Africa: should policy-makers be concerned? *Ecological Economics*, 45(3): 341–351.

Zander, K., Drucker, A.G., Holm-Muller, K. & Mburu, J. (forthcoming). Costs and constraints of conserving animal genetic resources: the case of Borana cattle in Ethiopia.

Zambrano, P., Smale, M. & Drucker, A.G. 2005. *A selected bibliography of economics literature about valuing crop and livestock components of agricultural biodiversity.* SGRP/IFPRI/ILRI.