Economics of AnGR Conservation and Sustainable Use: Importance and Application

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Abstract
Animal genetic resource (AnGR) diversity contributes in many ways to human survival and well-being. However, 32% of livestock breeds are threatened. Such an irreversible loss of genetic diversity reduces opportunities to improve food security, reduce poverty and shift towards sustainable agricultural practices.

The large number of AnGR at risk in developing countries, together with the limited financial resources available for conservation, means that economic analysis can play an important role in ensuring an appropriate focus for conservation efforts. In this regard, important tasks include, *inter alia*: 1) determining the economic contribution that AnGR make to various societies; 2) supporting the assessment of priorities through the identification of cost-effective measures that might be taken to conserve domestic animal diversity; and 3) assist in the design of economic incentives and institutional arrangements for the promotion of AnGR conservation by individual farmers or communities.

Nevertheless, despite the importance of the economics of AnGR conservation and sustainable use, the subject has only recently begun to receive attention, despite the existence of a conceptual framework for the valuation of biodiversity in general.

This paper briefly discusses the theoretical background, potential methodologies, data requirements and difficulties confronted in carrying out such studies, before analysing the results of a range of economics of AnGR studies recently carried out in Africa, Latin America and Europe.

These studies reveal that not only are there a range of methodologies that can be used to value farmer breed/trait preferences, but that they can in fact be of use in designing policies that counter the present trend towards marginalisation of indigenous breeds. In particular, it becomes possible to, *inter alia*: recognise the importance 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-maximising conservation programmes; and contrast the costs involved with the large benefits non-livestock keepers place on breed conservation.

The challenge is to now apply further work of this type in contexts where the results can actively benefit livestock-keepers, national researchers and policy-makers.

1. Introduction

Livestock supply some 30% of the total human requirements for food and agriculture (FAO, 1999) and some 70% of the world's rural poor depend on livestock as a component of their livelihoods (Livestock in Development, 1999). Animal genetic resource diversity thus contributes in many ways to human survival and well-being, with differing animal characteristics and hence outputs being tailored to suit a variety of local community needs.

However, an estimated 16% of these uniquely adapted breeds bred over thousands of years of domestication in a wide range of environments have been lost since the beginning of the 19th

century (Hall and Ruane, 1993). A further 32% (22% of mammals and 48% of avian species) are at risk of becoming extinct and the rate of extinction, currently at two breeds per week, continues to accelerate (FAO, 2000).

The large number of AnGR at risk in developing countries, together with the limited financial resources available for conservation, means that economic analysis can play an important role in ensuring an appropriate focus for conservation efforts (UNEP, 1995).

2. Framework for an economic analysis

Pearce and Moran (1994) argue that the activity of biodiversity [and genetic resources] conservation generates economic values (use and non-use) which may not be captured in the market place. The result of this "failure" is a distortion where the incentives are against genetic resources conservation and in favour of the economic activities that destroy such resources.

For example, economic rationality suggests that decisions such as the replacement of a indigenous breed of livestock with an imported breed will be determined by the relative rates of return of the two options. However, the relevant rates of return are those that accrue to the farmer rather than to society or the world as a whole. To the livestock keeper the loss of the indigenous breed appears to be economically rational because returns may simply be higher than that from activities compatible with genetic resources conservation. This is because the latter may consist of non-market benefits that accrue to people other than the farmer, as well as the fact that subsidised inputs and services (e.g. artificial insemination, veterinary treatment, etc.) may be available for the imported breed

Economic analysis can therefore help in understanding the financial incentives that livestock keepers face in making the choice between raising indigenous and/or imported breeds, as well as the interventions necessary in order to ensure that the on-going agricultural development process will be compatible with the conservation and sustainable use of livestock breed diversity.

3. Constraints to the economic analysis of AnGR conservation and sustainable use

Nevertheless, despite the importance of the economics of AnGR conservation, the subject has received only limited attention (FAO/ILRI, 1999), despite the existence of a conceptual framework for the valuation of biodiversity in general. There are a number of reasons for this.

3.1 Methodological constraints

Firstly, there are a number of methodological difficulties involved, many of which have been encountered in valuing plant genetic resources (PGR). For example, Evenson (1991) argues that the measurement of the benefits of germplasm diversity to crop development is extremely difficult. The genetic resources are seldom traded in markets and are often the product of generations of informal innovations. Thus, identifying the contribution of a particular indigenous breed to the success of an improved variety or breed would be complicated. Furthermore, the base materials used for breeding are themselves the result of a production function and identifying the returns to respective factors (e.g. labour, on-farm technology, intellectual inputs, etc.) is likely to be possible only in the most general terms (Evenson, 1991; Pearce & Moran, 1994).

There are nonetheless a range of analytical techniques for carrying our such an analysis that could be adopted from other areas of economics. These were reviewed by Drucker et al. (2001). [1]

[1] Methodologies were broadly categorised into three groups on the basis of the practical purpose for which they may be conducted. These are: i) determining the appropriateness of AnGR conservation programme costs (e.g. contingent valuation, production loss adverted, opportunity cost and least cost approach); ii) determining the actual economic importance of the breed at risk (e.g. aggregate supply and demand, cross-sectional farm and household, market share, IPR and contracts); and/or iii) priority setting in AnGR breeding programmes (e.g. breeding programme evaluation, genetic production function, hedonic approach and farm simulation models).

3.2 Limited data availability

Secondly, data availability is a constraint. In order to use these methodologies, it is necessary to, *inter alia*, realise the following activities:

- measure breed performance parameters;
- characterise actual and potential breeding systems;
- identify uses and livestock keeper trait preferences (including eliciting the values that livestock keepers place on specific traits and the trade-offs they are willing to make between them) for indigenous breeds under different production systems, as well as the forces influencing such factors and the uptake 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;
- analyse the potential impact of the uptake of alternative breeds on livelihoods, together with constraints to adoption and potential access/dissemination mechanisms; and
- 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.

3.3 Non-market data requirements and survey techniques

Thirdly, the important non-market contributions (e.g. drought and disease resistance, suitability for traction, cultural/social values, livestock as a means of finance and insurance, etc.) of livestock to livelihoods must be incorporated into economic models and analyses, as such information is critical to the identification of appropriate breeding programme goals and an assessment of the relative profitability of different breed use.

However, despite a wealth of livestock production data at the national level, such information tends to be limited to a number of the principal breeds and largely ignores the important non-market contributions. Initiatives such as the FAO Domestic Animal Diversity Information System (DAD-IS) and the ILRI Domestic Animal Genetic Resource Information System (DAGRIS) have only recently begun to address this problem.

The issue of methodological choice is thus compounded by the lack of data availability and/or the potential for acquiring relevant data.

Fourthly, the issue of data availability is also closely related to that of data "get-ability". This is because most of the benefits produced by indigenous livestock in marginal production systems are captured by producers, rather then consumers. As a consequence the genetic resources of these breeds have mostly been shaped by producers' preferences. It is therefore to the identification and characterization of these preferences that research must turn to in order to identify the implicit value of genetically determined traits as a first approximation to the value of indigenous AnGRs. In marginal production systems the breeding pressure on livestock is directed to creating animals capable of performing satisfactorily on marginal resources. Livestock performance is valued by producers, but assessed mostly in non-market terms. It is therefore this category of economic agents and non-market functions that one needs to be able to study in order to derive economic values (Scarpa et al., 2003a). The question then arises as to how this can best be done?

3.4 The need to use rural appraisal techniques

Pearce and Moran (1994, p.94) in the context of the empirical results of biodiversity valuation studies and the difficulties confronted when applying the methodologies/surveys in rural areas/sectors remote from the market economy note that*: "One area of further research involves the possible modification of economic techniques for use in conjunction with an established body of participatory and rapid rural appraisal methods"*.

Rural appraisal methods have in fact been advocated as: useful planning tools with livestock keepers (Waters-Bayer and Bayer; 1994); to facilitate better understanding of livestock keepers' breed interests and their preference for production and functional traits (Steglich and Peters; 2002); to select genetic traits in cattle improvement programmes (Tano et al.; 1998); to accomplish situation analysis and technology development (Conroy; 2003); as well as in order to facilitate processes of local innovation where the livestock keeper is the key knowledge holder (e.g. forage options in low external input systems) (Peters et al 2001).

The key is to match the type of methodology with the kind of information that is needed. In many cases, the best approach will involve combining several different PRA methods (see Drucker and Anderson [submitted] and below for an illustration of such approaches as applied to the Mexican creole pig).

4. Research findings

Notwithstanding the above constraints to the economic analysis of AnGR conservation and sustainable use, where suitable methodologies and approaches to attaining the required data have been identified, a number of interesting results have been obtained.

4.1 Decision-support tool for identifying breed conservation priorities

Recognising the large number of indigenous livestock breeds that are currently threatened and the fact that not all can be saved given limited conservation budgets, Simianer et al. (2003) develop a decision-support tool by elaborating a framework for the allocation of a given budget among a set of breeds such that the expected amount of between-breed diversity conserved is maximized. Drawing on Wietzman (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 an economically weighted sum of diversity, of breed characteristics represented in the set, and the value of the conserved breeds. The methodology is illustrated with an example of 23 African zebu and zenga cattle breeds. The results indicate that conservation funds should be spent on only three to nine (depending on the model considered) of the 23 breeds and that these are not necessarily the most endangered ones. In addition, where the models are sufficiently specified and essential data on key parameters are available, the framework can be used for rational decision-making on a global scale.

4.2 Stated preference (contingent valuation) techniques for non-market valuation

a) Obtaining the data for use in such decision-support tools and elsewhere frequently requires the development of a number of techniques capable of attributing values (as noted above) to the many unpriced inputs and outputs of household production functions. Tano et al. (2003), Scarpa et al. (2003a) and Scarpa et al. (2003b) use 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 W. Africa, for example, the most important traits for incorporation into breed improvement program goals were found to be disease resistance, fitness for traction and reproductive performance. Beef and milk production were less important. The studies also show that not only do these techniques (adapted from other areas of environmental economic analysis) function for AnGR research but can be used to investigate values of genetically-determined traits currently not widely recognised in livestock populations, but desirable candidates for

breeding or conservation programs (e.g. disease resistance). Furthermore, the papers examine how household characteristics determine differences in breed preferences. This additional information can be of use in designing policies that counter the present trend towards marginalisation of indigenous breeds. For example, they can be used to target incentives for breed conservation. In the Mexican case, the CE reveals that since the net value that backyard producers place on the creole pig is very similar to that of the other breeds, minimal incentives and interventions would in fact be needed to ensure its continued sustainable use (more on this below).

b) Cicia et al. (2003), in a developed country case study, show that a dichotomous choice stated preference approach can be used to estimate the benefits of establishing a conservation program for the threatened Italian "Pentro" horse. A bio-economic model is used to estimate the costs associated with conservation and a cost-benefit analysis is subsequently realised. The results not only show a large positive net present value associated with the proposed conservation activity but also show that this approach is a useful decision-support tool for policy makers allocating scarce funds to a growing number of animal breeds facing extinction.

4.3 Revealed preference techniques for market valuation

By contrast to the above stated preference approaches, Jabbar and Diedhiou (2003) show that a revealed preference hedonic approach can also successfully be used to determine livestock keepers' breeding practices and breed preferences. Analysing such factors in southwest Nigeria, they confirm a strong trend away from trypanotolerant breeds, especially Muturu, and identify the traits livestock keepers find least desirable in these breeds relative to other zebu breeds. The results suggest that the best hopes for implementing a conservation/sustainable use strategy for breeds at risk such as Muturu is likely to be in other areas of West Africa; for example in southeast Nigeria where trypanosomosis remains a constraint, where the Muturu is better suited to the farming systems and where a large market for this breed continues to exist.

4.4 Aggregated productivity model for comparative (indigenous vs. crossbreed) performance evaluation

The secondary importance of meat and milk production traits in many production systems leads Ayalew *et al.* (2003) to argue that conventional productivity evaluation criteria are inadequate to evaluate subsistence livestock production, because 1) they fail to capture non-marketable benefits of the livestock, and 2) 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. As many of the livestock functions as possible (physical and socio-economic) should thus be aggregated into monetary values and related to the resources used, irrespective of whether these "products" are marketed, home-consumed or maintained for later use. A broad evaluation model involving three complementary flock-level productivity indices was developed and applied 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 crossbred goats are more productive and beneficial than the indigenous goats is wrong. The model thus provides a more realistic platform upon which to propose sound improvement interventions.

4.5 *Conservation costs and benefits (various techniques)*

a) Even where the value of indigenous breeds has been recognised and support mechanisms implemented, significant shortcomings can be identified. Signorello and Pappalardo (2003), in an examination of farm animal biodiversity conservation measures and their potential costs in

the European Union (EU), report that many breeds at risk of extinction according the FAO World Watch List are not covered by support payments as they do not appear in countries' Rural Development Plans. Furthermore, where payments are made these do not take into account the different degrees of extinction risk that exist between breeds and payment levels are in any case inadequate, meaning that it can still remain unprofitable to rear indigenous breeds. EU AnGR conservation support measures thus urgently need to be reviewed if they are to meet their goals.

b) The lack of adequate incentives for indigenous breed conservation is despite the fact that conservation costs are shown to be relatively small by Drucker (*submitted)*, who draws on the safe minimum standards (SMS) literature and adapts Crowards (1998) minimax payoff matrix to consider breeds rather than species. The basic framework considers that the uncertain benefits of indigenous livestock breed conservation can be maintained, as long as a minimum viable population (the SMS – in this case the FAO measure of "not at risk", which is equivalent to approximately 1,000 animals) of the breed is also maintained. The costs of implementing a SMS are made up of the opportunity cost differential (if any exists) of maintaining the indigenous breed rather than an exotic or crossbreed. In addition, the administrative and technical support costs of the conservation programme also need to be accounted for. Empirical cost estimates are then obtained using data from the three AnGR economics case studies already mentioned above (i.e. EU, Italy and Mexico). The findings support the hypothesis that the costs of implementing a SMS are low (depending on the breed the range from between approximately Euro 3,000 – 425,00 p.a.), both when compared with the size of subsidies currently being provided to the livestock sector (<1% of the total subsidy) and with regard to the benefits of conservation (benefit-cost ratio of > 2.9). Encouragingly, the costs are lowest in the developing country, given that 70% of the livestock breeds existing today are in developing countries where the risk of loss is highest (Rege and Gibson, 2003)

The SMS approach is thus shown to have a role to play in AnGR conservation but more extensive quantification of the components required to determine SMS costs 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, as well as ensure that as many as possible of the elements making up their total economic value are accounted for.

c) Drucker and Anderson (submitted) provide additional data supporting the hypothesis that AnGR conservation costs are likely to be small compared to the benefits. In a paper that shows how data obtained through the use of rural appraisal methods[2] can be applied to some of the valuation methodologies reviewed in Drucker et al. (2001), they show that the conservation costs are in fact several orders of magnitude smaller[3] (see Table 1).

Furthermore, the low estimated annual costs for the indigenous breed pig conservation and sustainable use programme suggests that the least cost approach (Brush and Meng, 1996) does indeed provide a useful framework within which households/villages where conservation costs would be minimal can be costed into a conservation programme. A very strong economic argument for implementing a conservation and sustainable use programme can therefore be made and needs to be undertaken urgently if the breed, currently classified as "critical" on the FAO scale of risk, is not to become extinct.

[2] These included semi-structured interviews, direct observation, inventories, timelines, seasonal calendars, wealth ranking, preference ranking and pair-wise rankings. Selections of such tools were applied in focus groups, at household level, commercial farm level, market level, with key informants (e.g. local pig breeders, butchers, consumers, livestock association personnel, etc.) and were also applied longitudinally by monitoring selected households over 12 month periods.

[3] Similarly large net benefits to conservation were identified by Signorello *et al.*, 2003, in the case of the Italian Pentro horse, suggesting that this is not an isolated finding.

Table 1: Summary of results of valuation techniques using rural appraisal data related to the Yucatec (Mexico) creole pig (Euro)*

	Conservation & Sustainable Use Benefits	Conservation Costs
Market Share	0.54 million	
Production Loss Averted (Yucatan state only)	1.21 million	
Contingent Valuation (Urban Consumer Taste Test)	1.43 million	
Contingent Valuation (Producer Choice Experiment) and Least Cost approach.		<2,800 - 3,700

Source: Drucker and Anderson, submitted.
* Original US$ values converted to Euros at a rate of Euro 1 = US$ 1.1

The size of the net benefits identified also raises the question of whether the indigenous breed is, as predicted by theory, in fact being lost because they are from the farmer's private perspective less profitable than other breeds. While certain types of household (e.g. larger better-off ones) did express trait value preferences that support this theory, most households did not. Yet backyard indigenous pig production has declined across all households. It would therefore appear that the purebred population has fallen to such a low level that such factors as the lack of availability of indigenous breeding stock, rather than farmer net returns *per se* are determining breed choice.

At the level of society, the large size of the net benefits of a conservation and sustainable use plan suggest that there are also a number of very significant market failures that need to be addressed if the benefit values (e.g. indigenous breed pigs as a reservoir of disease resistance or in terms of their existence value to urban consumers) are to be harnessed for conservation purposes. In addition, the market distortions introduced by subsidising exotic breed production in the commercial sector are considerable and the levels of subsidy are of several orders of magnitude greater than the costs of indigenous breed conservation. A genetic resource of importance to the maintenance of subsistence farmer livelihoods is thus being lost for the lack of minimal funds, while vast and AnGR diversity threatening subsidies are provided to commercial farmers.

5. Conclusions

The above findings (based on a variety of species, breeds, production systems, locations and analytical approaches) show that methodologies for the economic analysis of AnGR conservation and sustainable use do in fact exist and, particularly when used in conjunction with rural appraisal methodologies can reveal useful estimates of the values that are placed on market, non-market and potential breed attributes. Such data is crucial for understanding the type and costs of the interventions necessary to promote the conservation and sustainable use of AnGR.

The challenge is to now apply further work of this type in contexts where the results can be taken up so as to actively benefit livestock-keepers and support the work of national researchers and policy-makers.

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