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Socioeconomic Causes of Loss of Animal Genetic Diversity: Analysis and Assessment

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SUMMARY

The number of breeds of domesticated animals, especially livestock, have declined rapidly. The proximate causes and processes involved in loss of breeds are outlined. The path-dependent effect and Swanson's dominance-effect are discussed in relation to breed selection. While these help to explain genetic erosion, they need to be supplemented to provide a further explanation of biodiversity loss. It is shown that the extension of markets and economic globalisation have contributed significantly to genetic loss of breeds. In addition, the decoupling of animal husbandry from surrounding natural environmental conditions is further eroding the stock of genetic resources, particularly industrialised intensive animal husbandry. Recent trends in animal husbandry raise very serious sustainability issues, apart from animal welfare concerns.

Keywords: Biodiversity loss, breed selection, economic globalisation, intensive agriculture, market extension, path dependence.

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NON TECHNICAL SUMMARY

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1. Introduction

This article focuses on the socioeconomic factors and processes that have contributed to the loss of genetic diversity of domesticated animals, particularly livestock. These are animals that primarily have, or used to have, direct use value for humankind and contrast with much wildlife possessing mainly non-use values. Nevertheless, it is possible for some breeds of livestock, especially if rare or endangered, such as Scottish Highland cattle, to have significant non-use values as well. In some countries, rare breeds are being conserved in protected areas (The World Monitoring Centre, 1992, p.397)

Despite the fact that most domestic animals and their products are private goods, many breeds have been lost in the last 100 years or so. The World Conservation Monitoring Centre (1992, p.397) reports

"Pursuit of higher production targets, the commercial success of particular breed promoters, and, in developed countries, changes in consumer preferences have led to livestock development activities becoming concentrated in few breeds and breed groups. The corollary of this is that more breeds are declining in importance, many have been lost and the survival of many others is in considerable doubt. Concern for rare breeds has been most marked in northern temperate countries with a history of specialised livestock production, but it is becoming increasingly evident that declining breeds in less developed countries also represent genetic resources of great significance".

There is considerable uncertainly about the magnitude of the loss in biodiversity of domestic animals but no doubt that loss is considerable. According to the website for the Civil Society Organisations and Participation Programme of the UNDP, "Half of all Europe's domesticated animals have become extinct in [the 20th] century. A third of all remaining livestock species in both Europe and North America are endangered" (UNDP/CSOPP, undated, p.2). The NGO, Genetic Resources Action International (undated, p.2), reports "Livestock breeds are disappearing at an annual rate of five percent, or six breeds per month. In Europe, half of all breeds of domestic animals existing in 1900 are gone, with 43 percent of those remaining endangered".

In some respects, these figures could exaggerate the loss. FAO (undated, pp.44-45) suggests that some lists of extinct or endangered animal species include non-indigenous species and breeds that have never left the research station, e.g. the *FAO Worldwatch List* (Scherf, 1996). These are not species involved in co-evolution. This FAO document (p.44) points out: "The breeds most relevant to biodiversity concerns are those that have co-evolved with a particular environment and farming system and represent an accumulation of both genetic stock and management strategies in relation to particular environment. These have usually taken a long time to evolve and have characters such as humidity resistance, that cannot be easily developed". On the other hand, there appear to be or to have been breeds in developing countries that have not been identified and which could have already been lost.

Despite this, according to data collected by the World Conservation Centre (1992) there were 3,237 extant livestock breeds in 1992 and 617 breeds had become extinct since 1892. This suggests that almost one in six breeds became extinct in this time period. In addition, another 474 breeds were considered to be rare and endangered. This suggests that within a period of 100 years about 28 percent of livestock breeds either became extinct or rare or endangered. Therefore, the magnitude of the loss is considerable, even on the basis of conservative efforts.

To a large extent this loss appears to have been accelerated by the extension of market systems and associated processes of globalisation. These processes together with the nature of technologies associated with particular breeds have encouraged global concentration of economic activity on fewer breeds. Furthermore, the changing structures of societies, such as increased urbanisation in developing countries may favour breeds and associated technologies found initially to be of economic value by higher income countries. Development of the livestock industry in developing countries may be 'biased' in favour of breeds and technologies from higher income countries because of their 'prime-mover' advantage and the presence of the breed-technology 'lock-in' effect (Swanson, 1984, 1995a, 1995b).

In this article the proximate causes of breed losses and the processes involved are outlined and the relevance of Swanson's theory (Swanson,1994) of species extinction is considered. Then follows a discussion of how the extension of markets and economic globalisation accelerates the loss of breeds and encourages the tendency to concentrate on a few breeds. Finally, the growing practice of decoupling the husbandry of animals from their natural environmental is examined. This is partly a market-driven phenomenon mostly involving industrial-type livestock production. It further adds to genetic erosion and raises serious sustainability issues.

2. A Review of Proximate Causes of Breed Losses and the Processes Involved

Breed replacement or substantial replacement of extant breeds can occur as a result of straight replacement by other existing ones considered to be superior from an economic point of view, by the formation of synthetic breeds that eventually replace existing breeds, and by stabilised cross-breeding (World Conservation Monitoring Centre, 1992, p.395). The latter, however, requires pure breeds of parent stock to be maintained and so, unless genetic introgression occurs in the breeding stock, is not a force for breed loss *per se*. However, it is possible that the crosses have superior quality and that results in some breeds being entirely replaced by the crosses.

Apart from breed substitution, economic change can result in the elimination of livestock in some regions in favour of other forms of agriculture such as the growing of crops. In such cases, breeds specific to a region undergoing land-use changes may disappear.

Hammond and Leitch (1996) identify the factors listed in Table 1 as sources of the erosion of livestock biodiversity. Some of these sources have an economic basis e.g. specialisation, some are technologically based (but this change may be ultimately driven by economic considerations) and others depend on political and natural events.

Table 1 here

Table 1 does not sufficiently emphasize the economic and market factors that accelerate erosion of biodiversity. The following economic factors can be important in biodiversity loss.

(1) As discussed later, the extension of markets via economic globalisation encourages regional economic specialisation. This may result in particular types of livestock production becoming relatively uneconomic in a particular region with loss of breeds peculiar to that region.

(2) With economic globalisation, it has become less costly to transfer breeds across international boundaries and this increases the possibilities for breed substitution.

(3) Factor 2 enables the Swanson dominance-effect (discussed in the next section) to operate more easily. The Swanson dominance-effect suggests that breeds selected in more developed countries will tend to replace those in less developed countries.

(4) The law of specialisation by comparative advantage suggests that specialised breeds will tend to replace multi-purpose breeds as markets expand and market transaction costs fall.

(5) Changing tastes and demands can hasten breed erosion. Consumer preference for leaner meat is resulting in the demise of breeds of pigs that have a fatter meat.

(6) Changes in the availability and price of imports e.g. food for livestock can change the economics of keeping different breeds.

(7) The scope for altering environments in which livestock are held can change the economics of selecting different breeds. To a large extent, livestock in developed countries has been decoupled from dependence on its surrounding natural environment. Much livestock in developed countries (and increasingly so in developing countries) is maintained in an artificial environmental capsule protected from the natural environment in intensive-farming systems. Few of its

inputs, even its food, may be produced locally due to forces making market extension possible.

Thus, the scope for economic forces to contribute to breed losses is very wide. Economic impacts are closely associated with the strengthening of the forces of globalisation and market extension. Furthermore, the pattern of breed losses may be influenced by the Swanson dominance-effect. Consider the Swanson dominance-effect in this context.

3. The Swanson Dominance-Effect and Breed Loss

Swanson (1994) identified two important factors contributing to biodiversity loss generally. The first was the loss of natural habitat due its conversion to human-use, mainly for agriculture. Tisdell (1999, Ch.4) suggests that in addition to this, man-made activities have increased the uniformity of extant environments and that this has contributed, amongst other things, to reduced diversity of species.

A further influence is the selective approach of humankind to conserving and husbanding species. As Swanson (1994, pp.99-100) states:

"……… the entire roster of species is not being considered for use on any given parcel of land. It is more likely that the choice is only for a handful of 'commercialised' crops and livestock. The roster of species used to appropriate photosynthetic products for humans has converged to this very small select group of plants and animals".

Swanson (1994, pp.101-106) argues that path dependence (a situation where initial conditions heavily influence the subsequent development path), as had been observed in relation to the development and survival of new technologies (David, 1985), is important in the survival of species. If this is so then, by analogy, it should also be important in relation to the survival of domesticated animal breeds.

Swanson (1994) argues that learning, investment and experience in developing the use of a species tends to be species-specific. It cannot be easily shifted to other species but it may be shifted to other geographical regions. A similar situation may exist for breeds of livestock.

Swanson (1995a, 1995b) further elaborates on his hypothesis that choices of the species developed depend on the prime-moving regions and determine the choices made and paths taken by many subsequent societies. Specifically Swanson (1995a, 1995b) argues that "the degree of conversion witnessed in developing societies is predetermined by the conversion decision made by the first-developing societies. These societies selected a set of locally available natural assets around which to develop, but many subsequent asset selections have taken their shape in response to those initial decisions. Now societies that are 'catching up' attempt to leapfrog intermediate stages of development made by previous developers in their own territories. In this way development is biased toward the conversion of natural environments to the same set of assets across the globe. This is diversity decline as a result of the uniformity of the development process across heterogeneous states".

Presumably, by analogy, the Swanson path-dependence hypothesis would also extend to the selection of different animal breeds. As economic development occurs, one might expect to witness increasing global dominance of breeds selected in higher income countries and the displacement of breeds specific to less developed countries.

Swanson (1994) largely attributes these lock-in effects of choice of utilised species to non-rivalry in the use of knowledge and dynamic externalities of the type mentioned by Romer (1987, 1990a, 1990b), but in fact foreshadowed earlier by Myrdal (1956). In line with Romer's view, Swanson suggests that this leads to a non-convexity in development. Increasing returns (in contrast to decreasing returns) by specialising in the production and development of particular products provides an example of a non-convexity. Alternatively, this phenomenon could also be envisaged as involving a form of hysteresis, that is reduced plasticity or flexibility in the relevant system. Furthermore, lock-in can conceivably arise in the absence of knowledge externalities. The latter could happen where, for instance, a monopolist obtains effective property-rights to new breeds or varieties of crops.

Because the initial selection of breeds or species for development tends to be partial and to a large extent uncoordinated, breeds or species may be selected for development that from a global perspective do not maximise economic returns. The array of breeds developed, although having some economic advantages, may not constitute the economically optimal choice. But lock-in occurs and species fail to survive which would have been superior from an economic viewpoint if developed in time.

This can be illustrated by Figure 1. Two breeds I and II are assumed to be available initially and a 'decision' is to be made to develop one or the other. If no breed development takes place, the flow of the net economic value of Breed I might be as indicated by line CD and that breed II as indicate by line AB. If Breed II is developed rather than breed I, the flow of net economic value from it might be as indicated by line EFG. On the other hand, if Breed I is developed, the flow might be as represented by line HJK.

INSERT FIGURE 1

It can be seen from Figure 1 that if Breed II is developed and Breed I is neglected that eventually the flow of economic benefits from Breed II overtake those from Breed I. The opportunity cost of developing Breed I increases given the development of Breed II and the sunk costs of investment in this. Consequently, as time passes, it becomes increasingly clear that the development of Breed I is no longer economical. Its inherent superior genetic position is eroded as time passes by its relative neglect.

In the case illustrated in Figure 1, the initially inferior breed is shown to always remain inferior for the same level of investment in its development as the initially superior breed. In practice, this may not be so. The potential for what appears initially to be the inferior breed to respond to development may be greater than for the breed initially appearing superior in terms of its net economic value. Nevertheless, lock-in can occur in either case.

Systems involving path-dependence can be extremely complex, particularly if coupled with the presence of radical uncertainty. They certainly add force to Clark's observation that "predicting the future is a risky business at best, particularly where human activities are involved" (Clark, 1995, p.143).

In his work, Swanson (1994, 1955a, 1995b) stresses that initial choices of species and associated technological development are the prime influences on biodiversity loss. While these processes and mechanisms are important, his approach does not provide sufficient emphasis on the role of market extension, and associated economic globalisation, as a contributor to the extent of biodiversity loss..

4. Market Extension and Economic Globalisation as a Source of Biodiversity Loss

Market extension can help to magnify the types of initial persistent genetic biases identified by Swanson. In addition, market extension creates new avenues for extinction of breeds and species by eliminating economic niches (cf. Tisdell and Seidl, 2001) and unleashing other competitive forces. In fact, the patterns of breed and species elimination arising from the extension of markets can be quite varied and complex. Here it is only possible to identify some of these patterns.

The spread of the market system favours selfish competitive forces and individual survival often depends on the economic entities participating in economic rivalry. These forces also favour the adoption of least-cost technology (Svizzero and Tisdell, 2001). Thus when the market system is introduced to a region using a regional-specific breed inferior in productivity compared to an exotic breed, if introduced to the locality, the exotic breed will replace the regional breed. Therefore, the regional breed will become extinct.

This is illustrated by the simple supply and demand curve analysis shown in Figure 2. Once the local region gets linked to wider markets, the demand for its livestock produce might be as represented by the curve marked DD. The local breed of livestock has the supply curve for this produce of S_1S_1. But because of enhanced global links, the local region can obtain an exotic breed (new technology) for which the supply curve of the region's livestock produce is as shown by S_2S_2. The exotic breed can produce livestock output at lower cost. Consequently, competition will result in it replacing the local breed. The local breed is driven to extinction by economic change. It matters not at all in this context whether the replacement breed has been made superior by the Swanson bias-type process.

INSERT FIGURE 2

Economic globalisation, the process of extending markets, as extolled by Adam Smith and seen by David Ricardo as a powerful force for reducing economic scarcity, encourages regional and international specialisation in production. However, at the same time, it is a powerful force for loss of genetic diversity. Two different types of illustration follow.

In the case shown in Figure 3, as a result of the extension of markets or economic globalisation, it becomes cheaper in a region to import livestock produce rather than supply it locally. The cost curve for supplying the produce locally might be as shown by S_1S_1 whereas the supply curve of the produce from outside the region is as indicated by S_2S_2. Thus if DD represents the demand for livestock produce in the region, all livestock produce will be imported. If there is an endemic livestock breed, it will disappear.

INSERT FIGURE 3

Figure 4 illustrates the matter in a more holistic way. Assume that individuals in a region are identical and have the same resources, preferences and production opportunities. Any one individual is representative of all. In Figure 4, the line ABC may represent the production possibilities available to an individual and the indifference curves marked I_1I_1 and I_2I_2 represent individual preferences. In the absence of trade, a mixed production system corresponding to the combination of crop and livestock production at B is ideal. But with the opening up of interregional trade, individuals in this region can engage in exchange, and exchange opportunities represented by the line CEF become available. This indicates that this region has a comparative advantage in crop production. It specialises therefore in crop production and livestock production ceases. Hence, with market development individuals can move to equilibrium, E, and be 'better off'. However, if there is a specialised local breed, it becomes extinct.

INSERT FIGURE 4

FAO (no date) provides a relevant example. It states: "In many areas in Southern Nigeria, rising prices of tree-crops such as cocoa and palm-oil have caused the communities to dispense with their traditional dwarf cattle and goats to concentrate on these profitable crops" (FAO, no date, p.45). These local breeds are in danger of disappearing. This FAO report continues with the following relevant value-laden statement: "This is a perfectly rational medium-term strategy on their part. But it would be short-sighted of the national government to lose the genetic resource these livestock represent because of a temporary pattern in world trade". It is argued that this loss will reduce economic flexibility in an uncertain world and options should rationally be kept open at the national level by, at least, conserving a portion of this genetic resource.

It has been observed that with the extension of markets and economic development, there is a general switch from multi-purpose breeds to specialised breeds. There may occur for several reasons. One may be the path of development and differentiation of technology ancillary to the different types of specialised produce of special breeds. The technology and knowledge of husbandry needed for efficient milk production from cattle now differs to a considerable extent from that required for efficient beef production. Thus the Swanson-technology driving factor can eliminate multi-purpose breeds.

A second reason may have to do with market development. In a non-exchange subsistence economy, keeping multi-purpose breeds to meet human needs in a balanced way is likely to be an advantage. Market exchange may be absent in such economies because of the social system or because high market-transaction costs make markets uneconomical. But once markets become an economical possibility, pre-existing constraints to specialisation are removed.

This case can be illustrated by Figure 5. Assume that three breeds of cattle A, B and C are available in a local region, and that initially it is a non-exchange economy. For simplicity, assume that all in the region have the same resources and preferences. Their preferences are only for milk and beef. The indifference curves I_1I_1 and I_2I_2 in Figure 5 represent these individual preferences. Production possibilities if breed A only is used, is represented for each resource-holder by point A in Figure 5. Similarly for breeds B and C.

INSERT FIGURE 5

In the absence of exchange and assuming that mixed herds are not genetically or economically viable (that is, a divisibility problem exists), farmers will maximise their welfare by keeping multi-purpose breed B. A choice of A or C would place them on a lower indifference curve than I_1I_1. But if exchange became possible with zero (or minor market transaction costs) farmers can gain by specialising in milk or meat production, that is by having a herd either consisting entirely of breed A or breed C. For example, if the exchange line is ADC, they can reach point D on the indifference curve I_2I_2. Consequently, the multi-purpose breed, B, is eliminated. In fact, in many cases the specialisation goes so far that none of the by-product of one breed is marketed. For example, beef producers in specialised conditions do not also supply milk to markets.

In many developing countries, farming is actually of a semi-subsistence type rather than pure subsistence or entirely non-exchange in nature. In such cases, there are many additional ways by which local breeds disappear as market systems expand. For example, in Asia, breeds of livestock have traditionally been kept for multiple purposes. Cattle and buffalo, for example, provide fertilizer, draught power and at the end of their working life may be sold for meat to obtain cash. In addition, they provide a store of value. But with the extension of market systems, the value of one or more of these functions may be reduced. For example, market extension makes chemical fertilizer available as a substitute for animal manure, the availability of motorised vehicles, stationary motors, and electricity reduces the demand for animal draught power, and increased competition from other meat supplies may reduce the 'retirement' price of an animal. All these circumstances also reduce the utility of an animal as a store of value. Furthermore, the extension of the cash economy and banking provides an alternative and in many respects, more convenient means to store value. Thus, because of changing economic circumstances fostered by market extension, it may no longer be economical for a farmer to keep a local breed. In addition, the increasing possibility of off-farm work may accelerate the loss of traditional local breeds.

5. Decoupling of Breeds and Animal Husbandry from Local Natural Environments

Modern agricultural technologies tend to decouple agriculture from the surrounding natural environment. This they do partly by the creation of man-made environments for domestic animals such as the provision of artificial housing, regulated water and food supplies for livestock managed under industrial-type farming. But even in the case of less intensive modern agriculture, livestock is much protected as a rule from its surrounding natural environment e.g. via vaccinations and veterinary care, improved pastures. Furthermore, for intensively managed livestock in particular, and intensive poultry production, it is possible that none of the food used comes from the local environment. For instance, there may be a heavy reliance on imported grains and food additives. The environmental decoupling phenomenon is most pronounced for poultry and pigs kept in intensive conditions but can also be important for dairy cattle and beef lot cattle.

This form of animal husbandry seems to have been initially developed in higher income countries. It favours breeds that are highly productive under such conditions and may cause the Swanson genetic-bias factor to develop strongly in their favour. Thus a breed with very little environmental tolerance, say breed I, is likely to be favoured in comparison to a breed with a high degree of environmental tolerance, say breed II. In Figure 6, for example, curve ABC may represent production from species I in relation to a range of environmental conditions and the corresponding curve for breed II might be as indicated by curve DEF. Such curves reflect the biological law of tolerance (Tisdell, 1983). If it is economic by human manipulation to hold environmental conditions at or in the neighbourhood of x_1, breed I will be favoured and breed II may disappear. Thus a high-yielding risky situation is chosen. Nevertheless, if for some reason, farmers cannot sustain ideal or near ideal environmental conditions for breed I, production from it collapses. In contrast, breed II is more tolerant and robust (cf. Tisdell, 1999, pp.38, 46-47).

INSERT FIGURE 6

From a long-term point of view, it is possible that concentration on high-yielding environmentally-sensitive breeds will create a serious problem for the sustainability of livestock production. There is the problem already mentioned. In addition, it is possible that farmers will lose their ability at some time to manipulate natural environmental conditions. If all environmentally tolerant breeds are lost in the interim, the level of livestock production could collapse.

The decoupled environmental nature of modern animal husbandry has another consequence. It may tend to further widen market competition. It increasingly enables much livestock production to become footloose. Such production is no longer tied necessarily to local environmental conditions and to local food supplies for animals. This footloose tendency is happening increasingly in the broiler industry. To the extent that this raises market competition, it is liable to add to the demise of breeds not ideal for intensive husbandry. It accelerates genetic erosion.

This erosion may now become a major social problem given growing opposition in many higher income countries to industrial animal husbandry, and increasing demand for products from animals kept under more natural conditions, e.g. increased demand for free-range eggs. Many of the breeds best suited for natural conditions may already have been lost or be in danger of being lost. But to some extent, changing consumer tastes in higher income countries could reverse past trends in livestock husbandry in more developed countries. It is not clear, however, that the tendency towards concentration of breeds will be completely offset worldwide, especially given that modern supermarketing of food products puts a high premium on products conforming to regular set standards. Breeds able to deliver standardised products are favoured in such systems.

6. Concluding Remarks

Observe that the article has not tried to address the question of what breeds of domesticated animals should be saved from extinction. This is a large, complex and important topic in itself and cannot be addressed adequately in the space available here. However, the World Conservation Monitoring Center (1992. p.404) states that “a breed can be conserved (a stock maintained which continues to represent the foundation stock without too much genetic drift or inbreeding) for surprisingly small cost compared with possible economic benefits". Smith (1984) demonstrates that the net economic benefits of conserving livestock breeds can be very great. Nevertheless, it is unlikely to be economical to conserve all breeds and difficult selection choices cannot be avoided (cf. Tisdell, 1990). At the same time, it is clear that human selection given current social mechanisms, including market systems, is unlikely to result in an optimal social choice of breeds to be conserved, if the utility of humankind alone is considered (cf. Perrings et al., 1995).

To conclude: This article argues that the Swanson lock-in or path dependence effect developed by him in relation to species selection is also important in relation to the conservation of breeds of domesticated animals. In fact, it may be even more important at this level than at the species-selection level. It was, however, demonstrated that this is only one contributor to biodiversity loss. In addition to this effect, the extension of market systems is a powerful force for biodiversity loss, especially for the loss of breeds. This is not to deny that the system may result in the development of new breeds better suited for marketing. However, this outcome may merely add to the erosion of existing breeds. The overall result of the extension of markets and economic globalisation appears to be to reduce the number of extant breeds and to reduce biodiversity generally. Worldwide this loss is continuing as market systems penetrate developing countries more deeply.

Swanson (1995a, p.4) claims that the choice of species for use in developing countries (and we can include here breeds of domesticated animals) are heavily influenced by the choices in more developed countries. On the whole, this seems to be so. Nevertheless, more developed countries have sometimes brought genetic stock from less developed ones to improve their stocks of domesticated animals. There have been some two-way flows. Consider, for example, the development of Brahmin cattle, Brangus cattle and so on in the United States and Australia.

It has also been noted that much development of animal husbandry in recent decades has resulted in its being decoupled from local natural environmental conditions. As a consequence, processes of co-evolution have largely been circumvented. This brings with it new environmental dangers and social problems (Tisdell, 2000). Apart from concerns for animal welfare (and in some cases human health) raised by industrialised animal husbandry systems, they may constitute a time-bomb for the collapse of livestock production. One cannot safely ignore the sustainability consequences of such methods of economic production. Whether or not consumer backlash against such methods will change such trends and result in more varied breeds being conserved is not clear, but it might do this. It might also be observed that hobbyists and enthusiasts in Western countries play a role in conserving rare and endangered breeds, but their role may be marginal. This is probably also true of the conservation of such breeds in protected areas. Nevertheless, these ‘aberrations’ in self-seeking economic market systems make some positive contribution to the conservation of breeds, and could, therefore, have social merit.

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Table 1 Causes of Erosion of Livestock Biodiversity

Factor	Description
Development interventions	Preference given to high-input, high output breeds developed for benign environments. Commercial interest in donor countries promote use of relatively temperate-adapted breeds and create unrealistic expectations in developing countries
Specialisation	Emphasis on a single productive trait, e.g. dairying, leading to exclusion of multi-purpose animals
Genetic Introgression	Crossbreeding and accidental introgression leading to loss of indigenous breeds
Technology	Machinery replaces work animals
Biotechnology	Cryopreservation equipment inadequate to store germplasm of threatened breeds. Artificial insemination and embryo
Political instability	Can eliminate local breeds owned by vulnerable population
Natural disaster	Floods, drought and epizootics preferentially affect remote or isolated human and livestock populations

Adapted from Hammond and Leith (1996) by FAO (no date)

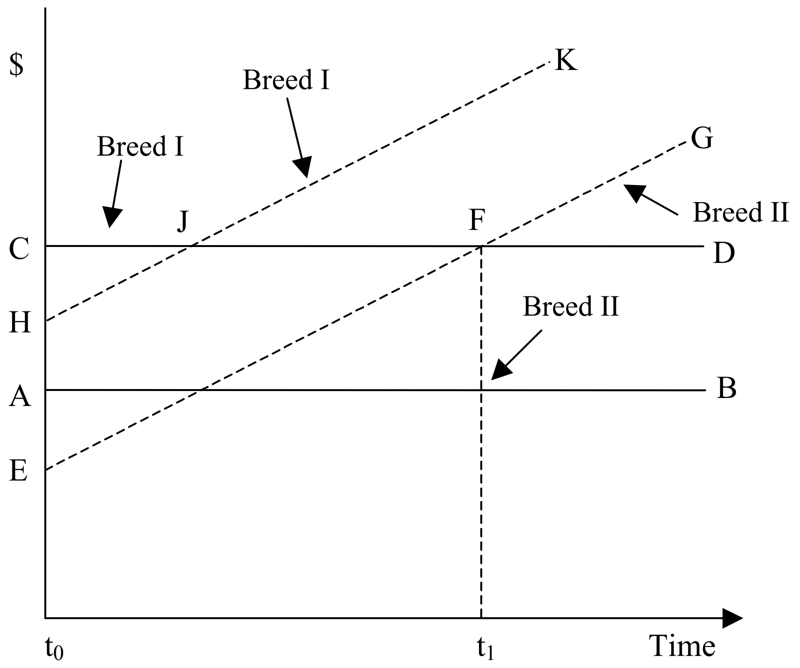

Figure 1 Illustration of the Swanson lock-in effect when applied to choice of breeds.

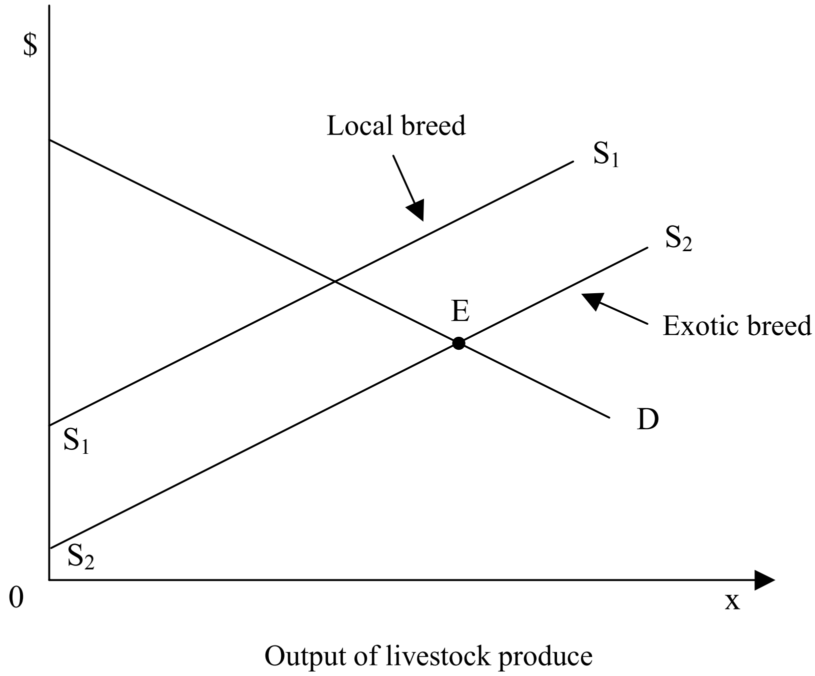

Figure 2 Market systems and global genetic opportunities result in this case in extinction of the local breed.

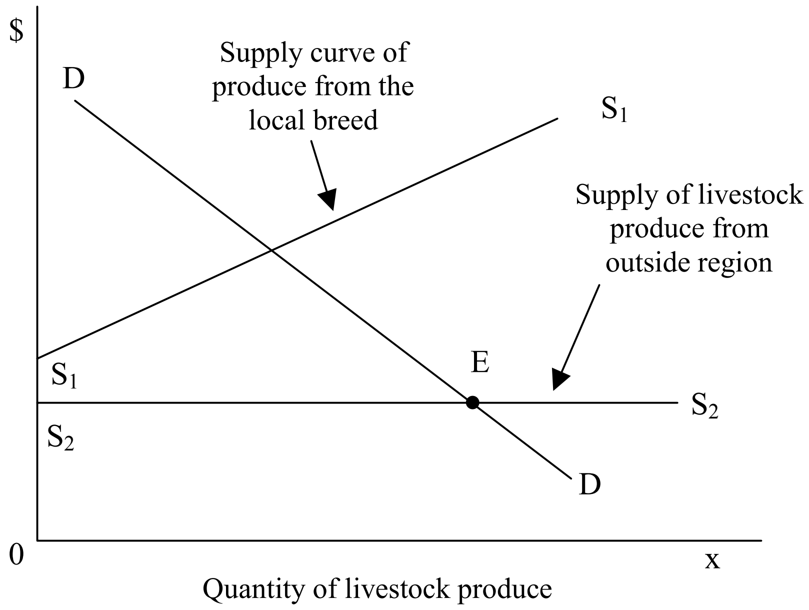

Figure 3 A case in which a local livestock breed is rendered extinct by import of livestock produce.

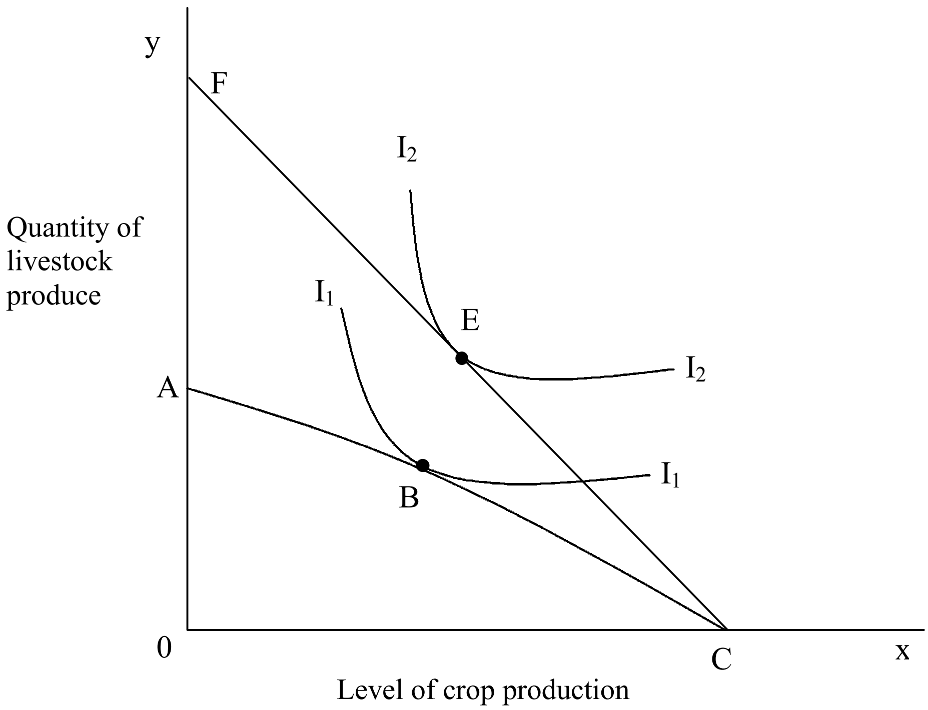

Figure 4 Another case of breed elimination as result of market extension.

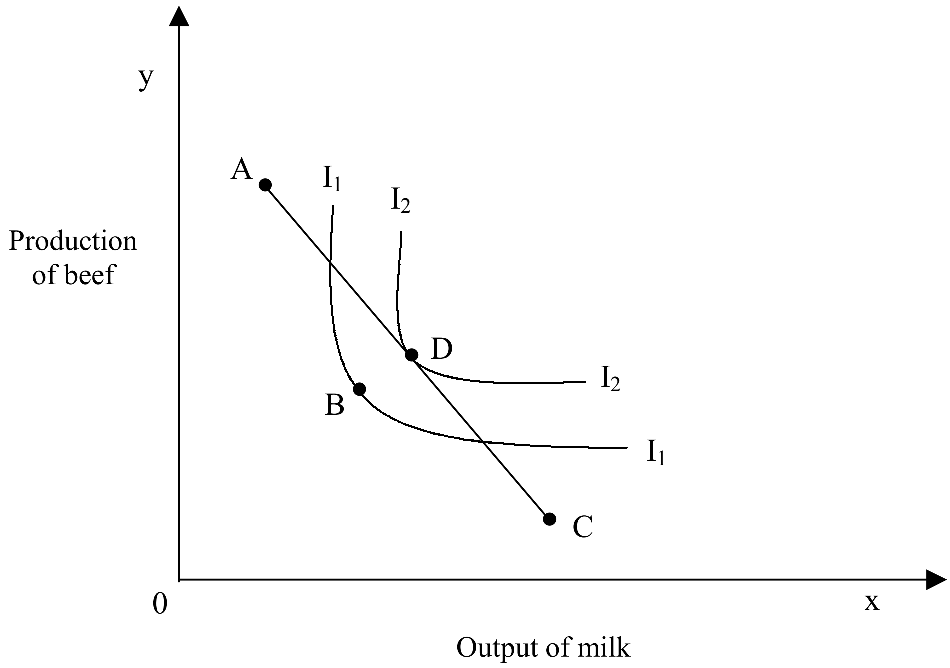

Figure 5 A case in which the creation of markets eliminates multi-purpose breeds

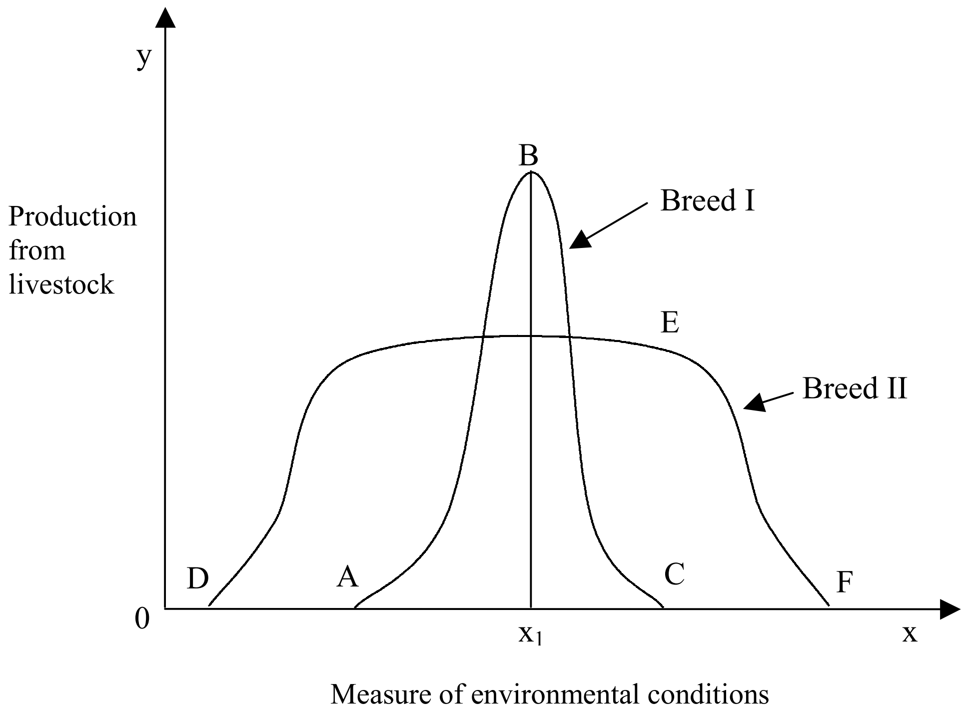

Figure 6 Modern livestock husbandry may favour breeds that are highly productive but show a low degree of environmental tolerance.

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(xxxvii) This paper was presented at the Fourth Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei, CORE of Louvain-la-Neuve and GREQAM of Marseille, Aix-en-Provence, January 8-9, 1999

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(xxxix) This paper was presented at the 3rd Toulouse Conference on Environment and Resource Economics, organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE on "Environment, Energy Uses and Climate Change", Toulouse, June 14-16, 1999

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(xlvii) This paper was presented at the RICAMARE Workshop "Socioeconomic Assessments of Climate Change in the Mediterranean: Impact, Adaptation and Mitigation Co-benefits", organised by the Fondazione Eni Enrico Mattei, Milan, February 9-10, 2001

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