ISSN 1327-8231

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

Working Paper No. 185

Biodiversity Conservation: Concepts and Economic Issues with Chinese Examples

by

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December 2012

THE UNIVERSITY OF QUEENSLAND

ISSN 1327-8231

WORKING PAPERS ON ECONOMICS, ECOLOGY AND THE ENVIRONMENT

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Clem Tisdell[2]

December 2012

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[1] These are revised notes used for a guest lecture given in October 2012 at the College of Life and Environmental Science, Minzu University of China, Beijing. I wish to thank Professor Dayuan Xue for inviting me to give this lecture.

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The *Economics, Environment and Ecology* set of working papers addresses issues involving environmental and ecological economics. It was preceded by a similar set of papers on *Biodiversity Conservation* and for a time, there was also a parallel series on *Animal Health Economics*, both of which were related to projects funded by ACIAR, the Australian Centre for International Agricultural Research. Working papers in *Economics, Environment and Ecology* are produced in the School of Economics at The University of Queensland and since 2011, have become associated with the Risk and Sustainable Management Group in this school.

Production of the *Economics Ecology and Environment* series and two additional sets were initiated by Professor Clem Tisdell. The other two sets are *Economic Theory, Applications and Issues* and *Social Economics, Policy and Development*. A full list of all papers in each set can be accessed at the following website:
http://www.uq.edu.au/economics/PDF/staff/Clem_Tisdell_WorkingPapers.pdf

For further information about the above, contact Clem Tisdell, Email: c.tisdell@economics.uq.edu.au

In addition, the following working papers are produced with the Risk and Sustainable Management Group and are available at the website indicated. *Murray-Darling Basin Program, Risk and Uncertainty Program, Australian Public Policy Program, Climate Change Program* :http://www.uq.edu.au/rsmg/working-papers-rsmg

For further information about these papers, contact Professor John Quiggin, Email: j.quiggin@uq.edu.au

Biodiversity Conservation: Concepts and Economic Issues with Chinese Examples

ABSTRACT

After touching on the concerns of natural scientists about biodiversity loss, this article argues that it is a mistake to believe that there are only losses of biodiversity. The process of changes in the stock of biodiversity is more complex. Furthermore, it is pointed out that not all genetic material is an economic asset. Also, it is contended that not all genetic material is natural. Some of the genetic stock is of a heritage type and a portion has recently been developed by human beings. Improved conceptualisation of the stock of biodiversity is needed. Some of the ways are listed in which economics is relevant to issues involving biodiversity conservation. General economic factors, such as market extension and economic growth, which result in loss of genetic diversity among domesticated organisms are outlined. China's recent experience with biodiversity loss highlights the importance of these factors. Some important reasons why economic factors result in biodiversity loss in the wild are identified and reasons are given why economic systems conserve less biodiversity than is ideal. Before concluding, the subject is discussed of what genetic material and other components of biodiversity should be conserved given economic constraints on what can be conserved.

Keywords: agricultural biodiversity, biodiversity change, biodiversity economics, biological extinction, China, economics of biodiversity loss, genetic diversity as an asset.

JEL Classifications: Q57, Q10.

Biodiversity Conservation: Concepts and Economic Issues with Chinese Examples

1. Introduction

Biodiversity loss caused by human impacts is of increasing global concern, and 2011-2020 has been designated the United Nations Decade on Biodiversity. According to scientists, there have been five major mass extinctions since life began on Earth. It is believed that **rapid** environmental changes have typically been the cause of these mass extinctions. We appear now to be experiencing the **sixth wave** of mass extinction (called the Holocene extinction) and this is associated with the emergence of humans. Primarily, it is the result of human impacts on natural environments, which include (among other things) habitat destruction. Many scientists believe that the rate of biodiversity in this sixth period of mass extinction equals or exceeds that in each of the five previous periods of mass extinctions. This loss is likely to be compounded in coming decades by an acceleration in global warming and the rapid environmental change associated with it. Species dependent on cold climates, such as polar bears in the Arctic and several high altitude species are likely to disappear. Other species may disappear because they are unable to migrate (or to do so quickly enough) from their existing zones to other areas that suit their needs (given changed climate). Losses in biodiversity are occurring both in the wild and among domesticated organisms. It is feared that these losses could result in the future impoverishment of mankind. They will also certainly reduce the curiosity value of the nature in the living world.

In this article, I intend to discuss the following:

1. The concept of biodiversity and the nature of changes in biodiversity.

2. Genetic diversity as an economic asset but not an entirely natural one.

3. The relevance of economics to biodiversity conservation.

4. Economic reasons for the loss of the genetic diversity of domesticated organisms.

5. Loss of genetic diversity is cultivated pests, their wild relatives and domesticated animals in China.

6. Economic reasons for loss of genetic diversity in wild organisms.

7. Reasons why economic systems conserve less existing biodiversity than is desirable.

8. Economic constraints and criteria for choosing what living things to conserve.

2. The Concept of Biodiversity and the Nature of Changes in Biodiversity

According to the Millennium Ecosystem Assessment (2005, p. 18) "Biodiversity is the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". Similar definitions appear in the relevant literature.

The definition is very wide and covers a number of unlike or heterogeneous features. Therefore, no single measure of the extent of biological diversity is likely to be entirely satisfactory. Nevertheless, it is clear that in recent decades the following has happened:

1. The extent of genetic variation within species has tended to decline.

2. The number of existing species has fallen.

3. Fewer natural ecosystems exist than previously. Many have been reduced in size and/or have become degraded.

The above list may suggest that in recent decades (say the last one hundred years), only losses in each of these items have occurred and no additions. While the number of losses in each of these categories has exceeded the additions, some additions have occurred. Some new breeds of domesticated animals have emerged as a result of selective breeding and genetic engineering has resulted in some new crop varieties. New species of bacteria and viruses seem to have evolved. New farming systems have been developed, that is new managed ecosystems.

The nature of change in the set of biodiversity can be illustrated by Figure 1. Beginning with an initial set A of biodiversity represented by the elements in the rectangle adjacent to I, a subsequent possibility is that a portion C of this biodiversity is lost with the passage of time and only the set B remains. This is indicated by the set adjacent to II. However, the set of biodiversity adjacent to III seems more likely to emerge. This indicates that while the portion C of the pre-existing biodiversity is lost, an addition, indicated by the set D, occurs. Set D is likely to be a smaller set than C and its emergence may in fact be a contributor to the reduction in the extent of pre-existing biodiversity. Set D consists, among other things, of organisms created by genetic engineering and by human selection.

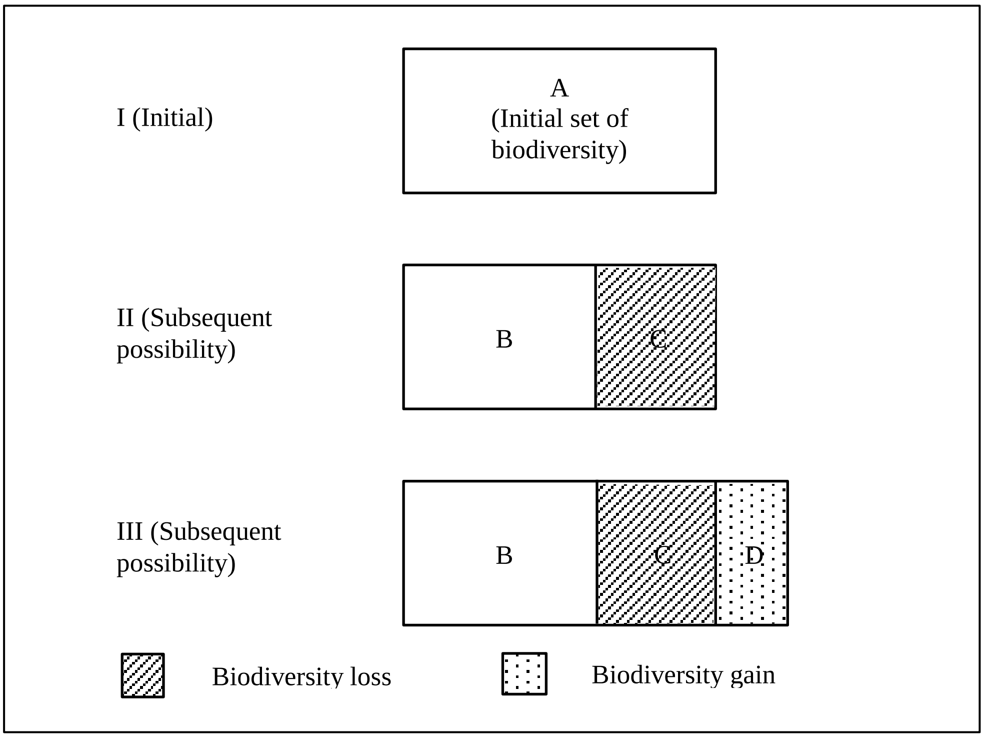

Fig. 1 It seems unlikely that recent periods of economic change have only resulted in biodiversity loss. Therefore, compared to the set of biodiversity existing initially, the outcome identified by III seems to be more realistic than that identified in the above figure by II

We can also in principle divide biodiversity into that present in managed ecosystems (such as farming systems) and that present in unmanaged systems. However, the division between the two is not a sharp one.

For some purposes, it is useful to focus on only selected features of biodiversity, for example, on genetic diversity. Such studies can be made even more specific. For example, one may focus on how the number of species in a genus has changed. Or by taking a particular species or group of species (for instance, pigs or cattle), one can study how the number of available breeds has altered.

3. Genetic Diversity as an Economic Asset

Biodiversity is regarded as a part of natural capital. Overall, it is an asset which plays a positive role in sustaining economic activity. Conserving it helps to keep options open for maintaining that part of economic production which depends on living organisms. There are fears that if the genetic base of such production becomes very narrow due to loss of crop varieties and due to the loss of different breeds of domesticated animals, possible replacements for varieties and breeds that lose their fitness may no longer exist. The options for sustaining biologically based economic production decline when the supply of available genetic material declines. In order to survive, humans must eat food, all of which is derived from living organisms. Therefore, it is vital for humans to sustain the productivity of food systems. In addition, biological production provides other economic benefit to mankind, for instance, fibres and fuel. Biological production is also renewable if ecosystems are managed appropriately.

It has been said that ‘loss of biodiversity results in loss of natural capital that supplies ecosystems goods and services” (Wikipedia, 2012, p.7). While this is probably so overall, not all organisms are assets. Some are pests or liabilities. They actually reduce the value of natural capital. Furthermore, as explained later, not all genetic material is natural capital.

However, deciding what is and what is not a pest is not an easy matter. All might agree that mosquitos are a liability and humans would be better off if they were eliminated. While elephants and wild pigs are regarded as pests by many farmers, some other members of society regard these animals as assets (see, for example, Bandara and Tisdell, 2003a;b, Tisdell, 1982). In tropical Australia, saltwater crocodiles are pests as far as graziers are concerned. They kill and maim their cattle. However, they are a protected species and they are also farmed. Therefore, they have attributes that make them both assets and liabilities (see Tisdell, 2005a, Tisdell, *et al.*, 2005).

It is difficult to know in advance whether some species regarded as pests today might be considered in the future to be assets. For instance, a species which is considered to be a weed today might in the future be found to have medicinal qualities and therefore, become an asset. There is considerable uncertainty about the likely future value of many organisms. Furthermore, the number of species yet to be discovered far exceeds the number that have been discovered so far. For example, it is estimated that there are around 1.5 million species of fungi of which only 0.075 million are known today (Hawksworth, 2001). In other words, 95% of existing fungi species are believed to be unknown. It is predicted that many species will become extinct without humans having any knowledge of them.

Although it is now commonly asserted that the stock of biodiversity is natural capital, this is not entirely accurate because a significant amount of the biodiversity associated with managed ecosystems is **heritage capital** and some is **recently acquired capital**. Many varieties of crops and breeds of animals only exist because of a long period of human selection. These can be regarded as heritage capital. They may be difficult or impossible to re-establish if they have become extinct. There is also some genetic material that has been recently developed by humans as a result of breeding programmes or genetic engineering. While many components of managed ecosystems have been inherited from the past, humans continue to evolve new systems. Therefore, it may be realistic to classify the types of capital constituting biodiversity (for instance genetic diversity) as consisting of three types of capital (natural, heritage, and recently developed) all of which overlap to some extent, as is illustrated in Figure 2. Note that recently developed biological capital may reduce the pre-existing stock of biodiversity (see Figure 1).

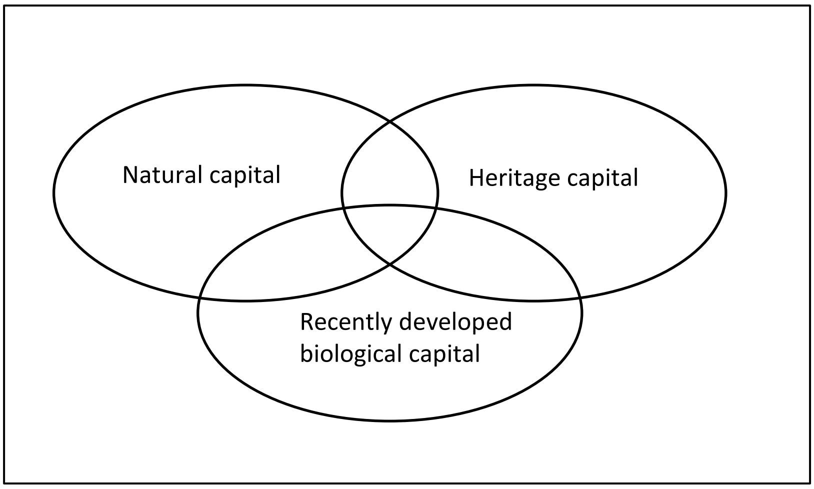

Fig 2 **The existing sets of genetic material and ecosystems do not consist entirely of natural capital. Heritage capital and recently developed biological material are also important.**

4. The Relevance of Economics to Biodiversity Conservation

The main researchers involved in the study of biodiversity conservation are biologists and ecologists. However, in recent years, several economists have begun contributing to this study, and sustained research is underway entitled "The Economics of Ecosystems and Biodiversity (TEEB)" funded mainly by the EU.

Some of the topics to which economics can make a significant contribution to research about biodiversity include the following:

1. The effects of economic systems and processes on biodiversity loss and conservation.

2. The economic value of biodiversity, including particular parts of it.

3. Decisions about what living matter should be conserved.

4. The costs of conserving biodiversity and parts of it, including the opportunity costs involved.

5. Requirements to conserve minimum viable populations of species or sets of species at **minimum** cost.

6. Analysis of whether or not the sustainable use of species will result in their conservation and in the conservation of biodiversity.

Some of these topics will be considered in this article, for example, the effects of economic systems on biodiversity loss and conservation. However, not all of these topics will be covered.

It might be noted that ecologists sometimes fail to apply basic economic principles to their policy recommendations and this can result in flawed recommendations. For example, the IUCN is the World Conservation Strategy recommended that the most productive agricultural land be reserved for agriculture and not be used for the conservation of wild species which presumably would be conserved on land which is less productive for agriculture. However, this strategy does not necessarily minimise the opportunity cost of conserving wild biodiversity (see Tisdell, 2005b, p. 35-37). It might be that some wild species would be more abundant on good agricultural land than on poor agricultural land. The ability of the land to support (high) densities of wild species needs to be compared with its productivity for agriculture. Comparative costs or relative values must be taken into account to find the least cost allocation of the available land. Similarly, land should not necessarily be allocated to the conservation of a particular species (for example, orangutans) because that land is able to support the highest density of those species (Tisdell and Swarna Nantha, 2011). To do the latter does not take into account the relative return from this land if it is used for agriculture or other purposes. The **relative** benefits or **comparative** costs of the alternative possible uses or allocations of land need to be taken into account in determining the allocation of land which will minimise the costs of conserving a wild species or set of species. This can easily be overlooked.

It is also interesting to consider whether increasing the realizable economic value (market value) of wild species will encourage their conservation. Internationally, two different approaches exist (see Tisdell, 2009, Ch. 10). On the one hand, CITES (the Convention on International Trade in Endangered Species) bans or restricts trade in endangered species. It seems to have been framed to address the over exploitation of endangered species to which there is open access. Their exploitation tends to increase with the market value of open access species and this can endanger their survival (Tisdell, 2005b, Ch. 5). Restricting the market for the catch of such species makes it less economic to harvest such species. By contrast, the Convention on Biological Diversity (CBD) searches for ways in which economic value can be added to genetic material, for example, by giving nations property rights in endemic genetic material. It is hoped that this will provide nations with an economic incentive to conserve biodiversity. However, it may not always provide countries with enough economic rewards for them to opt for biodiversity conservation. Which approach is likely to be more effective depends on the circumstances. Unfortunately, neither approach results in biodiversity being conserved in an ideal manner. It has, for example, been argued that the ban of CITES on international trade in elephant products reduced the economic incentives of African governments to conserve them because it has lowered the economic value they can extract from elephants. It has also resulted in increased poaching of elephants and illegal trade in their products.

5. Some Recapitulation and Remaining Coverage

Concerns have been expressed that we are now experiencing a major wave of extinctions of species. This has been called the Holocene extinction and coincides with the presence of humans on Earth. It was argued that the concept of biodiversity is complex and that in historic times there have been both losses and gains in biodiversity, even though the extent of the losses far exceed the gains. Although genetic diversity is often regarded as an asset and this is likely to be so overall, some parts of it are a liability – pests do exist. It is commonly asserted that extant biodiversity is a part of natural capital, and therefore its conservation is important for sustaining economic development. However, I have argued that this is too simplified. A part of the genetic stock is also heritage capital. Its loss potentially could also undermine the sustainability of economic development. A third component is recently developed biological capital e.g. obtained as a result of genetic engineering. It was also claimed that economics is relevant to several different issues involving biodiversity conservation.

In the rest of this article, I plan to specify economic factors and developments that result in loss of genetic diversity among domesticated organisms. Also some examples of such losses in China will be given. Then I'll outline economic factors and developments that result in biodiversity being lost in the wild and consider why economic systems are liable to conserve less genetic diversity (or more generally, less biodiversity) than is ideal.

6. Economic Factors and Developments Resulting in Loss of Genetic Diversity Among Domesticated Organisms

Large losses have occurred in domesticated breeds of animals and the varieties of different crops in modern times. For example,

> "According to data collected by the World Conservation Monitoring Centre (1992), there were 3237 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% of livestock breeds either became extinct or rare or endangered. Therefore, the magnitude of the loss is considerable, even on the basis of conservative estimates." (Tisdell, 2003).

Many economic factors and developments contribute to the loss of genetic diversity in domesticated organisms. These include the extension of markets and changing technologies. The decoupling of the management of domesticated organisms from their surrounding natural (local) environmental conditions further erodes the genetic diversity of domesticated organisms (Tisdell, 2003). In addition, structural changes in economies can lead to loss of genetic diversity. For example, farmers are likely to abandon marginal (or poor) agricultural land (for instance, agriculture on steeply sloping land) and migrate to other areas (mainly urban areas) as economic development proceeds. The abandonment of traditional types of agriculture in such areas can be expected to result in the loss of special varieties of organisms associated with such areas and their ecosystems.

The extension of markets (which may partly be a result of improved transport) means that there is reduced dependence of agriculture on local resources. For example, artificial fertilizer may be transported to local areas and food supplements for livestock may shipped in. Thus, resource constraints that may have favoured local varieties of crops and breeds no longer apply or become lest binding. Also new technologies, such as improved irrigation, veterinary practices, better housing of livestock tend to decouple managed organisms from their surrounding environmental conditions. Therefore, local traditional domesticated organisms are likely to be replaced by other organisms that provide greater yields under controlled conditions. This tends to result in greater genetic homogeneity in domesticated organisms. This has happened in Vietnam with its stock of pigs (Huyen, *et al.*, 2005).

New technologies can also make some types of domesticated organism obsolete. For example, the draught horse and the ox have largely been replaced by the tractor and the use of elephants for handling logs, and so on, is becoming rare globally.

To an increasing extent, the management of domesticated organisms is becoming more dependent on the use of non-renewable resources and/or the use of resources supplied from far afield, for example, oil and chemical fertilizers. Furthermore, agricultural systems are continually changing and such changes can result in biodiversity loss.

Taking livestock breeds as an example, I have noted (Tisdell, 2003, pp. 367-368) the following factors as influences on loss of breeds. A similar situation exists in relation to cultivated plants and other organisms. Some economic reasons for genetic loss among livestock are the following:

1. The extension of markets via economic globalisation encourages regional economic specialisation. This may result in the husbandry of particular types of livestock production becoming relatively uneconomic in a particular region with loss of breeds peculiar to that region. It has, for instance, been observed that the expansion of cocoa plantations in Ghana to meet the demand for the export of cocoa resulted in changed land-use and the disappearance of a local cattle breed. However, according to neoclassical international economic theory, free international trade adds to

global economic efficiency, at least in the short term. Nevertheless, it can hasten the loss in the genetic diversity of domesticated organisms.

2. With economic globalisation, it has become less costly to transfer breeds across international boundaries and this increases the possibilities for breed substitution. Thus in Vietnam local breeds of pigs have been increasingly replaced by imported breeds (see, for example, Huyen, *et al.*, 2005)

3. Growing globalisation enables the Swanson dominance effect to operate more easily. The Swanson dominance-effect suggests that popular breeds 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. Therefore, multiple purpose breeds tend to disappear.

5. Changing tastes and demands can hasten breed erosion. Consumer preference for leaner meat is resulting, for example, in the demise of breeds of pigs that have fatty meat.

6. Changes in the availability and price of imports, for example, 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, the keeping of 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. Local environments are either controlled or stabilised (e.g. by use of fertiliser) and/or inputs and

> even livestock food, may not be produced locally due to forces making market extension possible. This makes for greater uniformity of livestock environments and therefore, contributes to reduced global diversity of livestock breeds.

As mentioned earlier, "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, it is possible that none of the livestock 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." (Tisdell, 2003, p. 373). Both Vietnam and China have large imports of grain, soya beans and so on for feeding livestock.

As a result of economic development, modern varieties of crops and breeds of livestock which give high returns or yields under controlled conditions are preferred to traditional breeds which are likely to be more tolerant to a wider range of environmental conditions. Thus the yield of a modern variety of domesticated organism in relation to environmental conditions is like that identified by curve ABC in Figure 3, whereas for a traditional variety, it is like the curve marked DEF. Provided environmental conditions can be controlled sufficiently, the modern variety gives the greatest yields or return. However, if the ability to control environmental conditions is limited, then, on average the traditional variety gives higher yields. If for some reason, the ability to control environmental conditions deteriorates, it would be useful to have the traditional variety conserved. However, the traditional variety of a domesticated organism is likely to disappear unless authorities adopt measures to conserve it.

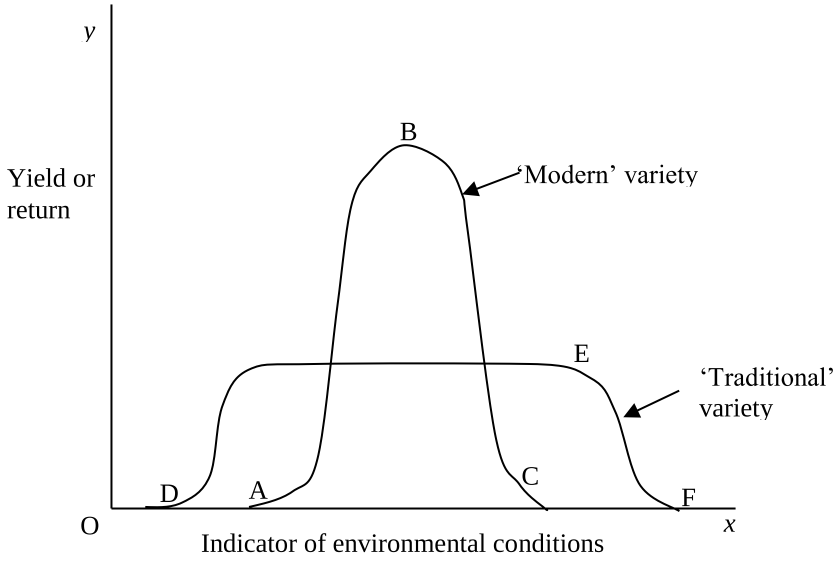

Fig. 3 **As economic development occurs, modern varieties of domesticated organisms, which respond well to environmental control, tend to be preferred to more tolerant traditional varieties which cannot achieve such high yields. In the case shown, traditional varieties of domesticated organisms display greater environmental tolerance than modern varieties.**

7. The Loss of the Endogenous Genetic Diversity of Cultivated Plants and Domesticated Animals in China as well as Their Wild Relatives

An extensive review of China's biodiversity was organized by the State Environmental Protection Administration and published in 1998. It shows that China is very rich in genetic diversity of cultivated plants and domesticated animals but that economic developments are leading to significant losses in that biodiversity. It would be useful to follow this review up by some case studies of the reasons for loss of particular genetic material in species of cultivated plants, commercially valuable wild plants, and domesticated animals.

This Chinese study points out the following:

> "The formation and establishment of domestic breeds and groups, whether mammals, birds or insects, are all closely related with the historical development of local nations and tribes, as well as their natural environments. From the same genealogical origin of one species might have been formed breeds with different economically important characters" (State Environmental Protection Administration, 1998, p. 161).

Since beginning its economic reforms in 1978 (and especially in recent years), all parts of China have become more closely interconnected as a result of improved transport systems and market extension. Significant structural change has also occurred in China's economy. For instance, considerable rural-to-urban migration has occurred. Furthermore, China's economy has become more open to the outside world. Given the observations in Tisdell (2003), these changes can be expected to result in loss of the genetic diversity of cultivated plants and domesticated animals in China. Which breeds of animals and varieties of crops are most likely to disappear and why as a result of these developments?

Important changes have been noted in the varieties of cultivated vegetables in China.

> "Before the 1980s, the main cultivated vegetables were local and normal varieties. After the 1980s, the popularisation of new hybrid varieties has had an enormous impact on the traditional and local varieties, some of which are little left; others have disappeared. In addition, no attention was paid to purification and protection, and the mixing and even loss of varieties is very serious. Furthermore, the increasing introduction of foreign species and the expansion of their cultivated areas have made it an urgent task to protect and save ancient, specific, valuable vegetable varieties and wild vegetable resources." (State Environmental Protection Administration, 1998, pp. 158-159).

Similar trends have been observed in other countries. As the marketing of vegetables occurs over a greater distance, various new qualities are required in vegetables and fruit, such as their ability to keep longer and resist bruises. This influences the varieties and types of vegetables and fruits conserved. Also the growth of supermarkets has an influence. They mostly favour standardized products. Also if mechanical harvesting becomes more common rather than harvesting by hand, this changes the desired attributes in harvested vegetables. Tomatoes, for example, must be firmer to withstand mechanical harvesting.

This Chinese biodiversity study also points out that the wild relatives of several cultivated crops are disappearing.

> "…. in recent years, the rapid growth of the economy, including the development of industry and transport and the reclamation of farmland, has resulted in environmental deterioration and the serious destruction of some wild [genetic] resources. For example, there were several thousand ha of *Glycine soja* around the Yellow River mouth, Kenli County, Shandong Province. Usually, over 1,000 kg of *G. soja* seed could have been collected by farmers in autumn. However, oil exploitation and agricultural reclamation during recent years has made *G. soja* rare. Similar misfortunes have happened to *G. soja* on the Sanjiang Plain in Heilongjiang Province. Another example is the two kinds of wild rice, *Oryza rufipogon* and *O. meyeriana*, in Jinhong County, Yunnan Province. They were found in 24 areas in 1964, in different niches and at different altitudes. Now, they are nearly extinct because of rubber cultivation and agricultural development".
> (State Environmental Protection Administration, 1998, pp. 156-157).

8. Economic Factors Resulting in Biodiversity Loss in the Wild

As noted above, economic developments also tend to result in biodiversity loss in the wild. Land is converted from having little or no specific use to serving specific economic purposes, for example, providing space for factories for urban expansion and catering for the expansion and intensification of agriculture. While this may sometimes be the most economic thing to do, this is not always the case. The problem is that the social value of conserving areas where wild genetic material exists often exceeds the private value of conserving such areas. Therefore, landholders are biased in favour of developing their land rather than conserving it. Among other things, these areas may have ecosystem values, which for example, may improve water quality and help to sequestrate carbon dioxide. These values are, however, all externalities. Consequently, they do not result in private gains to landholders and will not be taken into account by them. Furthermore, a landholder may be able to appropriate little if anything from the genetic material on his/her land and the prospect of doing so may be very uncertain and far off. Therefore, risk-averse landholders are unlikely to have any interest in conserving genetic material on their property unless they can obtain sufficient economic benefit from it in the short-run or the foreseeable future. On the other hand, governments can adopt a perspective that takes greater account of social factors. Nevertheless, governments do not operate in a social vacuum. They also have to take account of the wishes of pressure groups in society. Local governments in China for example, may prefer development to conservation. The central government can find it difficult to ignore their wishes entirely even when their interests are at odds with the national interest.

9. Reasons Why Economic Systems Conserve Less Biodiversity Than is Ideal

It is not easy to determine what parts of biodiversity should be conserved or what losses in biodiversity should be avoided. Furthermore, some value judgments must be made in undertaking such assessments. For example, should only human wants be taken into account or should some weight be given to the ethic that other species have some right to exist independently of human wishes.

The main reason why economic systems (based on individual or small group decisions) are likely to conserve less biodiversity than is ideal from a collective point of view is the following: The social benefits for conserving biodiversity (e.g. diverse genetic material) exceeds the benefit which individuals or groups of individuals are able to obtain by taking actions to conserve this material.

Social benefits may exceed private or group benefits because of the presence of externalities, the occurrence of public goods attributes in conserved living materials, and because individuals are too risk-averse compared to that which is ideal from a collective point of view. Therefore, it is believed that a situation like that illustrated in Figure 4 emerges. There, the line ABC represents the marginal benefit that individuals or groups obtain from conserving genetic diversity and line DEF represents the social marginal benefit of conserving genetic diversity. The marginal cost of conserving genetic diversity is indicated by line MBN. Private and group decisions will result in x_1 of genetic diversity being conserved whereas, conserving x_2 of genetic diversity is socially ideal. Therefore, there appears to be a case for governments to intervene to ensure that a greater amount of genetic diversity is conserved than would otherwise occur. The Chinese Government has adopted some policies to address the problem. It has, for example, established the National Genetic Bank of China as well as a variety of protected areas and nature reserves. Nevertheless, according to the State Environmental Protection Administration (1998), further efforts are desirable.

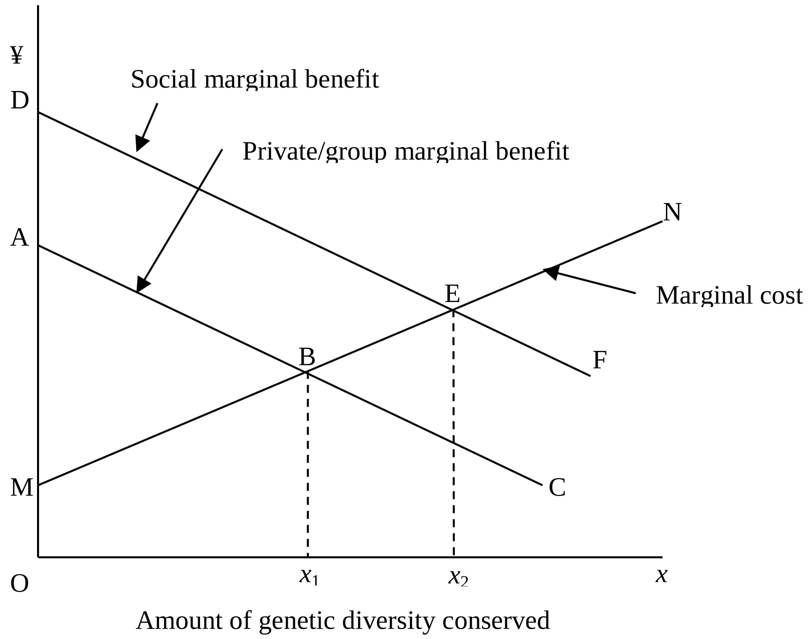

Fig 4 Private and group decisions can be expected to result in less conservation of genetic diversity than is ideal from a collective point of view

10. Deciding on What Genetic Material and other Features of Biodiversity to Conserve

While the conservation of biodiversity can have economic benefits, it does involve costs. The State Environmental Protection Administration (1998) stresses that these costs limit China’s efforts to conserve biodiversity. Given these costs, choices have to be made about what components of biodiversity are to be conserved and which components are not to be protected.

It has been argued by Ciriacy-Wantrup (1968) that all species should be protected to ensure that each has a minimum viable population. In his view, the cost of protecting a minimum viable population of each species is low and each has a potential for some unknown but large value to humans in the future. For example, substances in some plant species may provide a future cure for some forms of cancer. There are, however, problems with this approach (Tisdell, 1990). For example, the costs of conserving some species, such as orangutans, is high because to ensure a minimum viable population in the wild, a very large forested area is required and this area usually has highly valued alternative uses, for instance for growing palm oil. Insufficient resources may be available to conserve all species at a minimum viable population, let alone all varieties of individual species.

A more appropriate approach is to try to assess the social costs and benefits of conserving the components of biodiversity and to give priority in conservation to those components which display the highest benefit to cost ratios (see Tisdell, 1990). This is not to claim that such calculations are likely to be easy but this approach provides a rational basis for decision-making. It also must be recognized that in practice, political considerations can be expected to constrain the application of this cost-benefit approach.

11. Concluding Comments

The study of biodiversity conservation and the assessment of policies to influence it are complex. Even some of the ways in which changes in genetic biodiversity are often conceptualised in the literature are, in my view, inadequate. For example, contrary to some statements in the literature, not all biodiversity is a part of natural capital. A portion of it is heritage capital and also some is recently developed capital.

Alternative ways of envisaging changes in the stock of biodiversity have been suggested in this article. The problem that not all components of biodiversity are an asset (some are liabilities) has been raised and it is suggested that genetic material might be classified according to whether it is natural, of a heritage type, or has been recently developed by human intervention with nature.

Several ways in which economics is relevant to issues involving biodiversity conservation were highlighted. Economic factors and developments, such as market extension, which are instrumental in causing loss of genetic diversity in domesticated organisms, were discussed. This was followed by some observations on the loss (in recent times) of the endogenous genetic diversity of cultivated plants and domesticated animals in China as well as loss of this diversity among their wild relatives. Further issues given some consideration were the type of economic factors resulting in biodiversity loss in the wild, reasons why economic systems conserve less biodiversity than is ideal and the difficulties, given economic constraints, of deciding on what genetic material and other features of biodiversity to conserve.

It is not surprising that there are concerns about biodiversity loss in China. China has experienced rapid economic growth and structural change in recent decades. This has been accompanied by the development of policies to ensure greater reliance on the market system of organizing economic activity. As a result, all parts of China have become more interdependent economically and in addition, China has significantly increased its dependence on international trade and exchange. China no longer has a cellular-like economy, as it once had, see Donnithorne (1972) and Chai (2011, p. 147), nor it is autarchic in its economic activity. It is now a major international trading nation. All these factors (combined with China's rapid economic growth) have been contributors to its biodiversity loss in recent years, as is to be expected given the relationships outlined in Tisdell (2003). However, China's experience is by no means unique. Similar factors have been drivers of biodiversity loss in other countries.

References

Bandara, R. and Tisdell, C. A. (2003a). Use and non-use values of wild Asian elephants. *Sri Lankan Economic Journal*, **4**, 3-30.

Bandara, R. and Tisdell, C. A. (2003b). Willingness of Sri Lankan farmers to pay for a scheme to conserve elephants: exploratory study. *Journal of Science, Eastern University, Sri Lanka*, , **3**, 30-54.

Chai, J. C. H. (2011). *An Economic History of China*, Edn. Edward Elgar, Cheltenham, UK and Northampton, MA, USA.

Ciriacy-Wantrup, S. V. (1968). *Resource Conservation: Economics and Policies*, 3rd Edn. Division of Agricultural Science, University of California, Berkely, CA.

Donnithorne, A. (1972). China's cellular economy: some economic trends since the cultural revolution. *China Quarterly*, **52**, 605-619.

Hawksworth, D. L. (2001). The magnitude of fungal diversity: the 1.5 million species estimate revisited. *Mycological Research*, **105**, 1422-1432.

Huyen, L. T. T., Roessler, R., Lemke, U. and Zárate, A. V. (2005). *The Impact of the Use of Exotic Compared to Local Pigs on the Socio-economic Development of Vietnam*, Edn. University of Hohenheim and Verlag Ulrich E. Grauer, Stuttgart.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, DC.

State Environmental Protection Administration (1998). *China's Biodiversity: A Country Study*, Edn. China Environmental Science Press, Beijing.

Tisdell, C. A. (1982). *Wild Pigs: Environmental Pest or Economic Resource?*, Edn. Pergamon Press, Sydney, Oxford, New York.

Tisdell, C. A. (1990). Economics and the debate about preservation of species, crop varieties and genetic diversity. *Ecological Economics*, **2**, 77-90. Reprinted in Tisdell, C.A. (2002) *The Economics of Conserving Wildlife and Natural Areas*. Edward Elgar, Cheltenham, UK and Northampton, MA, USA.

Tisdell, C. A. (2003). Socio-economic causes of loss of animal diversity: analysis and assessment. *Ecological Economics*, **45**, 365-376.

Tisdell, C. A. (2005a). Crocodile farms and the management of saltwater crocodiles in the Northern Territory: Results of a survey of NT crocodile farmers plus analysis of secondary information., *Economics, Ecology and the Environment* Working Paper No. 131. School of Economics, The University of Queensland, Brisbane.

Tisdell, C. A. (2005b). *Economics of Environmental Conservation*, 2nd Edn. Edward Elgar, Cheltenham, UK and Northampton, MA, USA.

Tisdell, C. A. (2009). *Resource and Environmental Economics: Modern Issues and Applications*, Edn. World Scientific, Singapore, Hackensack (New Jersey), London, Beijing.

Tisdell, C. A. and Swarna Nantha, H. (2011). Comparative costs and conservation of wild species in situ, e.g. orangutans. *Ecological Economics*, **70**, 2429-2436.

Tisdell, C. A., Wilson, C. and Swarna Nantha, H. (2005). A report on the management of saltwater crocodiles (*Crocodylus porosus)* in the Northern Territory: Results of a survey of pastoralists., *Economics, Ecology and the Environment* Working Paper No. 130. The School of Economics, The University of Queensland, Brisbane.

Wikipedia (2012). Biodiversity. Retrieved 21 September, 2012 from http://en.wikipedia.org/w/index.php?title=Biodiversity&printable=yes

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