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Biodiversity Change and Sustainable Development: New Perspectives

by

Clem Tisdell

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Biodiversity Change and Sustainable Development: New Perspectives[1]

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Clem Tisdell[2]

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Biodiversity Change and Sustainable Development: New Perspectives

ABSTRACT

Biodiversity is usually regarded as an asset or resource, the stock of which is partly natural and partly determined by humans. Humans both subtract from and add to this stock and consequently, the change in the stock is heterogeneous. This heterogeneity is not taken account of by some authors who focus only on the loss aspect. Frequently, the conservation of this stock is seen as important for the achievement of sustainable development; sustainable development being defined (but not always acceptably) as a situation on which the welfare of each future generation is no less than that of its preceding generation. Definitions of biodiversity are quite wide but here its focus is restricted to genetic diversity. Humans alter the stock of genetic diversity by eliminating some species or varieties of these and also add to this stock by selective breeding and genetic engineering. Both direct and indirect human impacts on diversity occur. The types of possible changes in the genetic stock are classified in a simple manner. It is pointed out that not all the genetic stock has positive consequences for human welfare because some of the genetic material has negative consequences (e.g. pests) for humankind or for some groups of human beings. This can make its evaluation of the genetic stock difficult. Implications of additions to the genetic stock by human manipulation of it (e.g. by the development of GMOs and selective breeding) are given particular attention. This raises the question of how many future generations should be taken into account in making choices about biodiversity and the manner in which their welfare should be allowed for. For example, should discounting be applied? Also how much precaution is needed to allow for uncertainty, for example, is a safety first rule advisable? These issues are discussed.

Keywords: biodiversity conservation, economic mechanisms and biodiversity changes, genetic engineering, genetic stock alterations, sustainable development, valuation of genetic stock.

1. Introduction

There are concerns that loss of biodiversity may eventually result in economic development becoming unsustainable. This view is reflected, for instance, in the Millennium Economic Assessment (2005) and in the Economics of Ecosystems and Biodiversity (TEEB) Study which was designed 'to draw attention to the global economic benefits of biodiversity and to highlight the growing costs of biodiversity loss and ecosystem degradation' http://teebweb.org/. An output from the latter project includes the book *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations* (Kumar, 2010).

The stock of biodiversity represents partly a natural and partly a man-made resource, and as a whole, is an asset or form of capital because of the valuable ecosystem services which it supplies to humankind. Nevertheless, not all elements of biodiversity are valuable from a human perspective: some elements such as pests, those causing diseases, and 'hostile' ecosystems have negative value. For example, although the complete eradication of the organism causing smallpox would reduce biodiversity, other things held constant, it is a valuable reduction in the stock of biodiversity from a human perspective.

The type of factors taken into account in measuring biodiversity are wide. They include genetic diversity, ecosystem diversity, landscape diversity and other factors. In this chapter, the discussion focusses on genetic diversity. However, it is realized that genetic diversity depends on other dimensions of biodiversity such as ecosystem diversity, and in the longer term, is influenced by the diversity of niches (habitats) available for the support of life (Tisdell, 1999, Ch.4).

Initially, this chapter focuses on the categorisation or classification of the stock of genetic diversity according to whether the genetic material can be attributed primarily to human intervention or to natural processes. Then the nature of changes in the stock and the interaction between the human developed genetic stock and the wild stock is considered. Subsequently, economic mechanisms leading to loss or more generally,

change in the genetic stock are discussed. Then the economic value of genetic diversity is examined and the potential intergenerational welfare consequences of genetic manipulation are explored in the dynamic context of sustainable development.

2. Classifying the Stock of Genetic Diversity and Changes in its Composition

The stock of genetic material can be classified in many different ways. Currently, the dominant method of classification of living organisms is biological classification; a part of scientific taxonomy. It classifies organisms by biological type, such as species, genus and family (Anon, 2011a). Although the origin of such classification is usually ascribed to the work of Carolus Linnaeus, biological classifications continue to be revised with advances in scientific knowledge. The genetic classifications used here are not biologically based but are intended to reflect the extent to which genetic material depends on human beings for its existence and survival or does not do so. Earlier attempts to develop the systematics of this type can be found in Tisdell (2005, pp. 149-150, 2009).

Two different classifications of this type are possible. These are: (1) whether or not the genetic material would have come into existence without deliberate human effort to develop it, and (2) whether or not the genetic material requires continuing human management for its survival or is able to continue to survive without such assistance. Consider the first classification to begin with.

This classification may not be exhaustive because some genetic material can evolve incidentally as a result of human-induced environmental changes and the continuing existence of that genetic material often depends on humans maintaining that environmental change. However, ignoring this case, the set of extant genetic material is represented by that due to human effort, H, and that which has evolved independently of human effort, W. This is represented by the top set in Figure 1, the elements of which identify different types of genetic material. As a result of growing human activity (primarily reflected in economic growth), it is acknowledged that both prior genetic diversity developed by humans and wild genetic diversity is declining. If the set of

genetic material available at earlier date (say 100 years ago) is compared with this set at a later date (say now), the set and its components shrink. Thus, in Figure 1, the initial genetic self H (human developed genetic material) plus W (genetic material produced in the wild) shrinks after some time to a smaller set, H′ plus W′. Consequently, there is an unequivocal reduction in the pre-existing stock of genetic material and in that sense, biodiversity loss clearly occurs on a global scale.

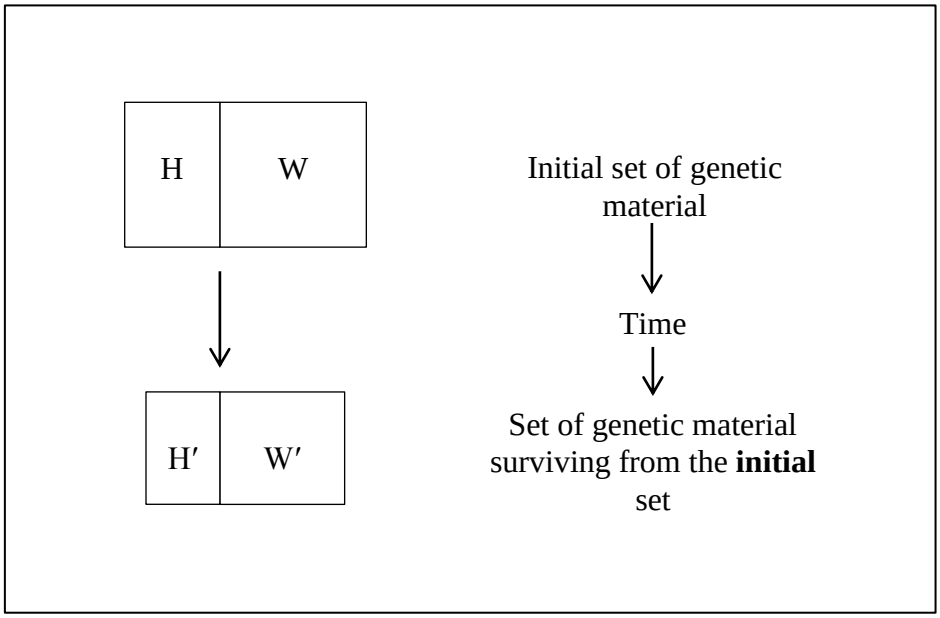

Figure 1: With the passage of time, the set of genetic material surviving from the initial set shrinks. This is true on a global scale for human developed genetic material as well as for genetic material developed in the wild.

However, Figure 1 does not fully capture the dynamics of human-induced impacts on the stock of genetic material because in a relatively short-period of time, humans are able to develop new genetic material (that is organisms unlikely to evolve in the wild) and in some cases, organisms unable to survive in the wild. With the advent of genetic modifications of organisms and genetic engineering, the scope for human development of new organisms has expanded considerably compared to the earlier process of human selection by breeding and culture of genetic material. The speed of human development of genetic material has now accelerated. Furthermore, it is now possible to explore many permutations of genetic material which are unlikely to occur in the absence of genetic engineering. Therefore, Figure 1 needs to be modified to allow for human

additions to the genetic stock. Note: it is assumed that for this time-period involved no evolution occurs in the wild stock but if it does, it can be allowed for.

One possibility is illustrated by Figure 2. There the top set represents the initial genetic stock. Now suppose that humans add to this stock a set A. In the immediate period of the addition, and possibly for some time, the global sock of genetic material increases. This is because it takes time for added genetic material to reduce the pre-existing genetic stock, if in fact, it will do that. Depending on the nature of the added genetic material, the added genetic stock may subsequently (eventually) reduce the pre-existing human developed genetic stock as well as the pre-existing wild genetic stock. Thus, both the set H and the set W could become smaller. In the case illustrated in Figure 2 by the bottom set, it is assumed that the hatched area is lost from the human developed global genetic stock and the dotted area is lost from the genetic stock in the wild so that apart from set A (which is a part of the human developed genetic stock), the surviving pre-existing stocks are reduced from H to H′ and from W to W′.

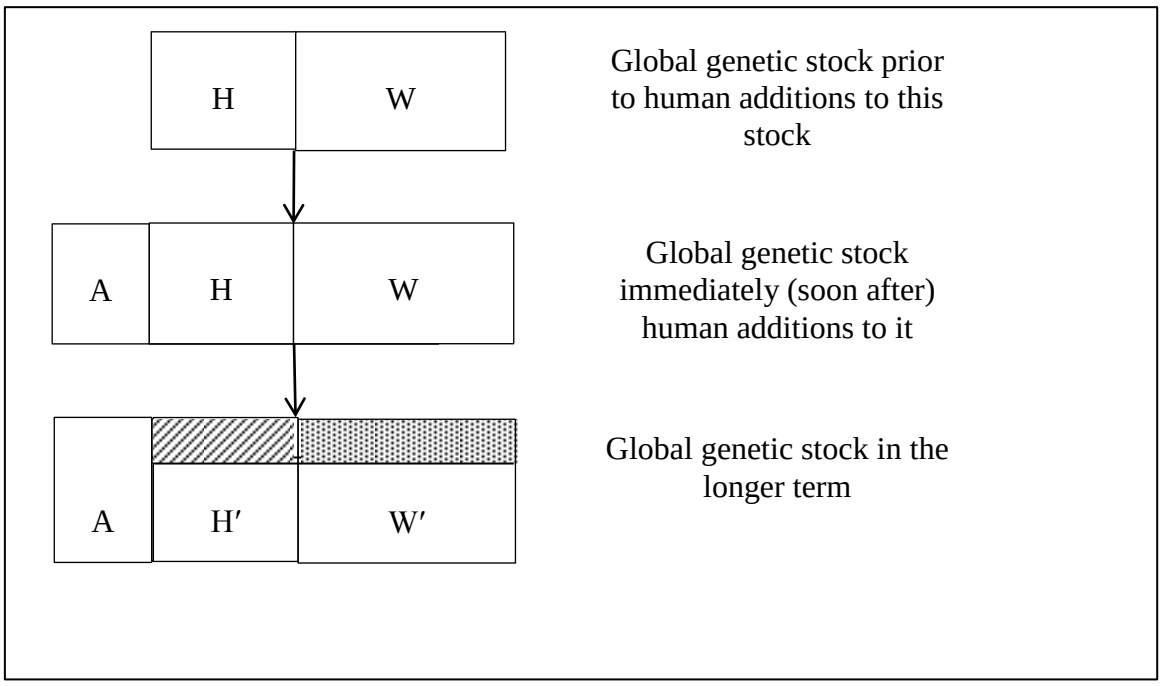

Figure 2 Possible consequences for the size of the genetic stock of human introductions of new combinations or types of genetic material. The hatched and dotted areas indicate lost genetic stock.

It is, of course, conceivable that the introduction of new genetic material into the genetic stock will neither reduce the global pre-existing stock of human developed genetic material nor result in loss of genetic material that has evolved in the wild. In that case, the genetic stock would actually expand. However, in many cases (possibly most) some reduction in the pre-existing genetic stock is likely to occur. Some of the economic mechanisms involved are discussed in the next section.

We could also classify genetic material by whether or not it relies for its survival on human management or not, or by what amounts to the same thing, whether or not this material is able to survive in the wild. Much (but not all) of the genetic material developed by humans can only survive as a result of human management. However, there is always a risk that new genetic material (organisms) developed by humans may be able to exist in the wild independent of human management or may interbreed with existing wild or domestic organisms bringing about unwanted changes in the stock of genetic material.

It is difficult to predict the type of changes in the genetic stock that are likely to come about as the result of the introduction of a new organism into that stock, for example, as a result of genetic engineering. However, some indication of the range of possibilities can be obtained from experience with the introduction of exotic organisms into a country or region. These organisms may be domesticated, cultured or wild ones. Some may fail to survive at all in the new environment. Others may only survive as a result of human management, and others may survive and increase their populations in the wild. In cases where the exotic introductions survive, the pattern of change in the genetic stock is like that shown in Figure 2, where the exotic introductions correspond to set A, set H represents the human development stock in the region and W the wild evolved stock. At the beginning of the introduction, the stock of genetic material in the region does not alter because the organisms do not spread far beyond their point(s) of introduction initially. However, eventually these introductions may result in disappearance of some of the pre-existing human developed genetic stock or some of the wild genetic stock. For example, as a result of commercial decisions by farmers, the

introduction of improved breeds of livestock or crops into developing countries often leads to a loss of local breeds and varieties of crops (Tisdell, 2003). Sometimes, introduced domestic animals escape and are able to survive in the wild displacing indigenous wild animals, as in the case of many feral animals in Australia e.g. dogs, cats, pigs, buffalo, goats and so on (see, for example, Tisdell, 1982). However, not all are capable of survival in the wild, for example, domesticated sheep in Australia. Furthermore, many examples exist of introduced exotic wild organisms becoming invasive and a threat to regional biodiversity (Anon, 2011b, Van Driesche and Van Driesche, 2004).

3. Economic Mechanisms Driving Changes in the Genetic Stock, Including Genetic Loss

In the contemporary world, a dominant influence on changes in the genetic stock is the drive for commercial gain or profit. This is the main factor resulting in reduced diversity of breeds of livestock (Tisdell, 2003) and crop varieties. A new livestock breed or crop variety able to yield a higher level of profit than an existing one or ones, will be preferred by farmers, if the demand for the produce of the alternative breeds or variables remaining unchanged. This replacement may occur even if the new organisms require a larger package of inputs to be more profitable, as is the case of high yielding varieties of rice and wheat (Alauddin and Tisdell, 1991). In effect, the introduction of the new organisms results in a change in available technology for economic production.

Figure 3 illustrates, using supply and demand analysis, the loss of one or more commercial breeds of livestock or crop varieties due to its replacement by a new breed or variety. Suppose that a product X is being produced commercially using existing organisms and that the industry supply curve for X using these organisms is as shown by line BS_1. This line represents the marginal cost of supplying X relying on these existing organisms for the production of X. The demand for product X is represented by line DF. Therefore, initially the market for X is in equilibrium at E_1 and X_1 of the product is supplied and it sells at P_2 per unit.

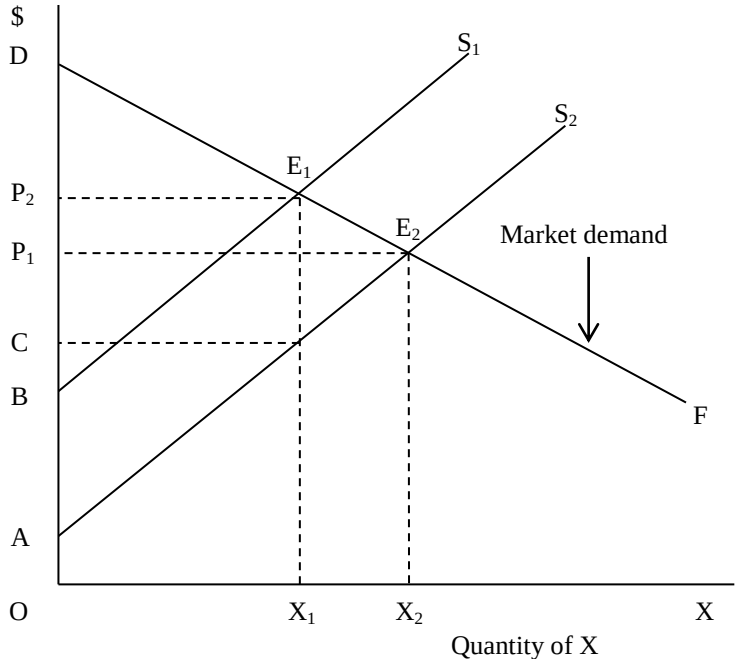

Figure 3 An illustration of the displacement of existing organisms by a 'new' organism able to produce a commercial product at a reduced cost.

Suppose now that a 'new' organism is developed that reduces the cost of producing product X and that as a result, the market supply relationship shifts from BS_1 to AS_2. Producers can now increase their profit by switching to the 'new' organism and eventually, other things being held constant, the new market equilibrium becomes E_2. Given that the continuing existence of the organisms previously used in producing X depends upon their commercial use, they will completely disappear and be replaced by the 'new' organism. The only way they might continue to survive ins by the actions of hobbyists and enthusiasts not motivated by profit.

Even if it were known that in the very long-term the new organism will be eventually less fit economically then one or more of the existing organisms, the desire for commercial gain will still most likely lead to the disappearance of the latter, given that future commercial benefits are discounted. In that case, no individual may gain economically for conserving any of the existing organisms, particularly if they do not

have exclusive rights to the use of the conserved genetic material. In general, discounting tends to discourage decisions favouring sustainable development. Nevertheless, in a wider economic context, as pointed out by Tisdell (2011a), there is not a regular relationship between the level of the rate of interest and the speed of biodiversity loss. That is because the speed of this loss depends primarily on the rate of economic growth and the rate of capital accumulation, both of which are major contributors to biodiversity loss. When the rate of economic growth or the rate of capital accumulation is high, the rate of interest may be low or high, and vice versa (Tisdell, 2011a).

Other economic factors, such as those associated with globalisation, are also involved in global biodiversity, loss of cultured organisms and so on and are discussed in Tisdell (2003). Furthermore, economic forces are the major (but not the only causes) of biodiversity loss in the wild. They result, for example, in the loss of habitats of wild species and the introduction of exotic species and organisms; major contributors to global biodiversity loss. A recent example of such losses is the effects of the expansion of oil palm plantations in tropical countries resulting in loss of tropical forests and their biodiversity; for instance, threatening the continuing existence of forest dependent species such as the orangutan (Swarna Nantha and Tisdell, 2009, Tisdell and Swarna Nantha, 2008).

4. The Economic Value of the Genetic Stock and Implications of its Composition for Sustainable Development

While it is usually suggested that a high degree of biodiversity is an economic asset because it helps in coping with uncertainty by increasing flexibility in decision making and may increase the resilience and robustness of ecosystems, not all additions or components of biodiversity are valuable from a human perspective. Some organisms have negative worth or are pests from a human perspective. Some have both positive and negative impacts on human beings, such as wild pigs (Tisdell, 1982). In these cases, it is necessary to assess their overall value to human beings (Tisdell, 2002, Ch. 12). However, in assessing the value of an organism from a human perspective, it is

necessary to take into account its indirect impacts (which can be positive) as well as direct impacts on other living things. Nevertheless, even if some of its indirect effects are of positive value, it could still be that this organism has a negative value overall. For instance, even if a 'pest' contributes to the resilience of an ecosystem, the extent to which it does this may not fully compensate for the damages it causes, the assessment being based on anthropocentric values.

The possibility also needs to be considered that loss of biodiversity could lead to unsustainable development and eventually, to impoverishment of future generations (Tisdell, 2011b). This is of concern because extinction cannot be reversed, or arguably cannot be reversed so easily.

This problem is illustrated in Figure 4. There line CFG represents the well-being that members of existing and future generations can achieve using the existing stock of genetic material. This stock enables sustainable development to be achieved assuming that the horizon for the human race ends at $t_{n.}$ Sustainable development is achieved in the sense that the well-being of human beings never declines. In fact, in the case illustrated, it continually rises. However, suppose that the existing set of genetic material can be replaced by another set which gives a higher level of well-being to generations near the present ones but a lower level of welfare to generations more distant from the present. This is represented by curve CDE in Figure 4. Current generations are likely to be tempted to replace the existing set of genetic material by the new set (which may include genetically engineered organisms) because this benefits the generations in which current generations have the greatest interest or are most concerned about. According to Pearce (1998, p.71) current generations are mostly interested in their own welfare and that of their children and their grandchildren. It may even be the sum of human well-being (if it can be measured) will be greater over the interval $0 < t < t_n$ than if the existing genetic stock is replaced rather than conserved. However, all generations after t_2 will be worse off than current generations. Furthermore, if OA represents a level of well-being below which impoverishment occurs, all generations after t_3 will be impoverished? Of course, there is uncertainty about whether this unfortunate scenario will happen but the possibility of this occurring

cannot be dismissed. Some of the issues involved are given additional consideration in Tisdell (2011b).

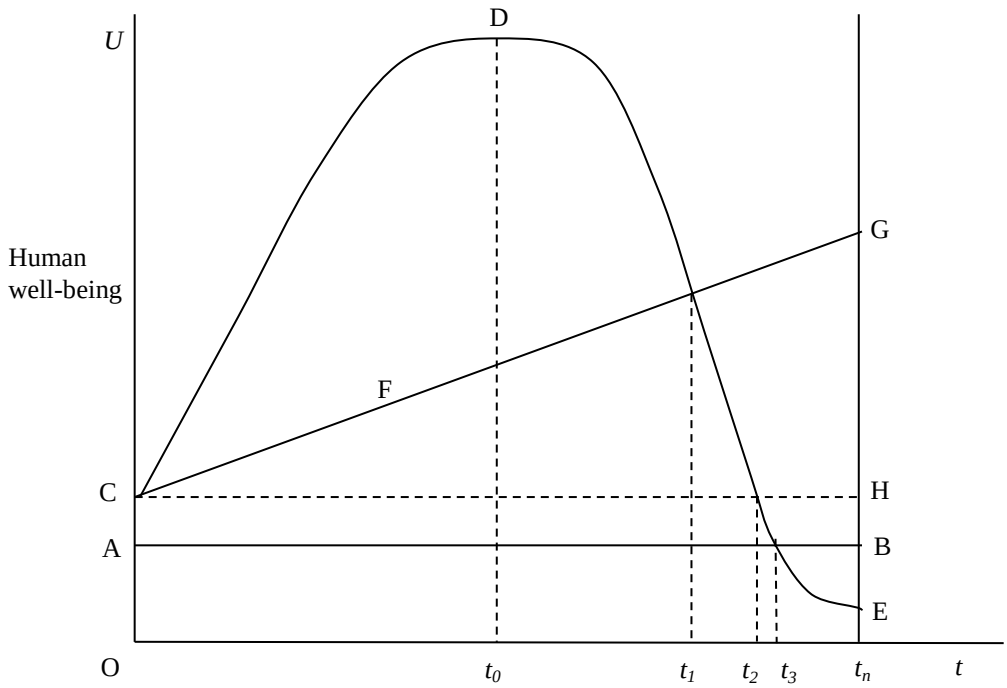

Figure 4 Possible consequence for the intergenerational well-being of human beings of a change in the stock of genetic material brought about by human action.

There are of course, other theoretical possibilities:

1. For example, after reaching point D, the curve CDE might continue to rise. This is a very favourable case because all generations are better off as a result of the change in the stock of biodiversity, and each succeeding generation is better off than its predecessor.
2. The curve CDE might still reach its maximum at D and then decline to a level above G. All future generations are better off than they would have been in the absence of a change in the genetic stock but after t_0, each generation is less well off than its predecessor.
3. Another possibility is that curve CDE declines after D but its end-point is between G and H. In this case, distant generations are worse off than they would have been

had the existing genetic stock remained unaltered. Nevertheless, they are better off than the earliest generations.

4. In this case, CDE reaches its maximum at D but its end-point, E, is between H and B. In this case, the most distant generations are worse off than the earliest generations but they are not impoverished, which would be the case if end-point E is below B.

Thus, theoretically it can be seen that several different types of development paths are possible when the stock of genetic material is altered. Given the very long time-periods involved in planning for sustainable development and our current lack of knowledge, the actual development path that will prevail is difficult or impossible to predict. Hence, the long-term impacts of changing the genetic stock remain uncertain (Tisdell, 2010;2011b;forthcoming) thereby making it difficult to choose optimal policies for regulating changes in this stock. The problem is reduced (but not eliminated) if planning for economic development or sustainable development is only to take into account the well-being of the next two or three generations, as Pearce (1998, p.75) suggests is probably the limit of the practical concern of present generations in considering desirable patterns of economic development.

Consequently, plans to achieve sustainable development are unlikely to cover a span of time much more than a 100 years into the future. Probably in most cases, the planning time-horizon for most development decisions is much shorter. Whether or not that ought to be the span of practical concern for future generations is a different matter.

5. Conclusion

While existing genetic material (both that developed by humans and developed in the wild) is lost with the passage of time, some new genetic material is also added. The speed at which this addition can be done has accelerated with the emergence of genetic modification and genetic engineering. This new genetic material frequently displaces some of the stock of pre-existing genetic material, partly for economic reasons. Economic processes are major influences on changes in the genetic stock, including loss

of existing genetic stock. The desire of farmers, and others, to increase their profit is a major influence on biodiversity loss and gain, and because businesses usually discount future profit, the sustainability of profit is not a significant consideration in business decisions about changes in the genetic stock.'

It is frequently argued that a loss in the genetic stock reduces biodiversity and, for various reasons, is an overall disadvantage to mankind. However, this does not take account of the fact that some organisms have on overall a negative value from a human point of view. In assessing this, it is nevertheless necessary not just to take into account the immediate effects of an organism but to be aware of its indirect functions within ecosystems. The fact that organisms have some positive effects, for example, help to stabilize ecosystems, is not sufficient to justify their continuing existence from a selfish human point of view.

The stock of genetic material is known to have implications for the sustainability of economic development and for development possibilities generally. Several theoretical possibilities have been identified in this chapter. It is quite possible for some changes in the stock of genetic material to result in unsustainable economic development and to lead eventually to impoverishment of future generations. However, given the long time-periods involved and the extent of our knowledge, it is impossible to predict confidently the development path that can be expected to prevail. If it is true that in practice, human policy and planning only encompasses concern for the next two or three generations, predictions for this shorter time period are likely to be more accurate, but not perfect. Therefore, humankind is taking significant (but to a large extent unknown risks) in deliberately or accidentally altering the global genetic stock. Whether it is worth the risk is not yet resolved.

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