1. Economics and the living environment

1.1 INTRODUCTION

Human welfare and continuing existence depends upon the living environment because, apart from anything else, other species are biologically essential for human existence, for example, via the food chain (Owen, 1975). The presence of other living things influence human welfare, sometimes to humankind’s benefit but at other times to its detriment, as with pests. We depend on nature for continuing economic productivity, welfare and ultimately existence. Biological resources should be taken into account in socio-economic planning and evaluation of economic systems. Conversely, economic analysis can be of value in helping to determine whether to conserve or utilise living resources.

This is not to say that human welfare depends only on biological resources but rather that it depends significantly upon these resources. Furthermore, they may become of greater importance to humankind in the future as non-renewable resources such as fossil fuels are depleted. As the number of species in existence declines and the human population increases, the value of remaining species to humankind is likely to rise substantially.

This book is principally concerned with the economics of conservation, utilisation and management of natural biological resources. It deals with economic factors that should be considered in devising policies for the conservation, utilisation and management of biological resources. Such factors become increasingly important as our biological resources become scarcer from an economic point of view. As stressed in the World Conservation Strategy (IUCN-UNEP-WWF, 1980) and more recently in the Brundtland Report, Our Common Future (World Commission on Environment and Development, 1987), a strong case exists for biological conservation, even on economic grounds alone. Economics is an important consideration in biologically based activities such as wildlife conservation and use, pest control, agriculture, forestry, fisheries and living marine resources, the preservation and use of natural areas such as national parks and tourism based on natural resources. In turn these activities have further environmental consequences for humankind. For example, forests and tree cover
influence water quality, soil erosion and air quality. Indeed, economics is relevant to the whole biosphere that is ‘The integrated living and life-supporting system comprising the peripheral envelope of Planet Earth together with its surrounding atmosphere so far down, and up, as any form of life exists naturally’ (Friedman, 1985).

1.2 WELFARE ECONOMICS, ENVIRONMENT AND THE BIOSPHERE

Economics is the science which studies the allocation of scarce resources in society as a means to the satisfaction of human wants or desires. In order to deal with the essential problem of economics, one has to take account of available resources and methods of production of commodities, their exchange and the way in which income is distributed. Economics, as it has evolved, is essentially an anthropocentric (human-centred) subject. Nevertheless, this does not mean that economics can not be supportive of the conservation of the environment and in particular the biosphere. Framers of the World Conservation Strategy (IUCN-UNEP-WWF, 1980) and the World Commission on Environment and Development (1987) were correct in believing that economics can provide significant arguments in favour of conservation of biological resources. Conservation of environmental and biological resources is frequently required as a means of maximising human welfare (or at least, avoiding inferior welfare outcomes) in a world of limited resource availability. Let us therefore broadly consider the relevance of alternative types of welfare economics to biological conservation.

The major portion of the dominant theory of welfare economics is based upon the view that the wants of individuals are to be satisfied to the maximum extent possible by the allocation of resources. It is based, at least in the West, upon the view that individual preferences are to count and that human welfare is to be maximised subject either to existing property rights of individuals or to an ideal distribution of property rights.

The foundations of Western welfare economics were laid by the Utilitarian School. The Utilitarian School of economic thought believed that each individual obtains utility or measurable satisfaction from his or her consumption of commodities. It was argued that the use of society’s resources should be such as to maximise the sum of utility obtained by individuals. Therefore, given this view, since components of the biosphere itself are used as inputs to produce commodities or to provide utility directly to individuals, it follows that management of the biosphere should be subject to the strategy of maximising the grand total of utility in society.
Apart from other difficulties, the Utilitarian approach has foundered because utility has not proven to be measurable objectively and comparably between individuals.

This led to the substantial replacement of the Utilitarian approach to welfare economics by an alternative approach, sometimes called New Welfare Economics or Paretian Welfare economics after its chief proponent Vilfredo Pareto (Little, 1957). This is also an individualistic approach reliant on individual preferences but avoids interpersonal comparisons of utility. It is based upon the view that an economic system or a system for utilising resources should be efficient in satisfying human wants. Its basic tenet is that welfare cannot be at a maximum if it is possible to make any individual better off without making another worse off. Hence, a necessary condition for a maximum of human welfare is that it be impossible to alter the way in which society uses its resources to make any individual better off without making another worse off. No matter what is the distribution of property rights in society, the use of society’s resources including the biosphere should be so organised (in the light of the production or transformation possibilities open to humankind) that the welfare of no person can be increased without reducing that of another person. Many neoclassical economists argued that a system of perfect market competition would, with a few minor exceptions, achieve this social ideal. However, as discussed in later chapters, market mechanisms may fail significantly as means for ensuring a Paretian optimal use of resources, especially of those resources contained in the biosphere.

A rule closely related to Paretian optimality, is the notion of a Paretian improvement. A Paretian improvement is said to occur when as a result of a change in the use of resources some individuals are made better off without anyone being made worse off. It is usually contended that any change in resource-use which brings about a Paretian improvement is socially desirable. In practice, however, few possible changes may have this quality. It is more frequent for changes in resource-use to make some individuals worse off and others better off. For example, the acquisition of private land for a natural park or restrictions on private land-use for environmental reasons may damage the original landholders but benefit other groups.

The notion of potential Paretian improvement (sometimes called the Kaldor-Hicks criterion) was suggested as a means of dealing with this problem. It suggests that if the gainers from a change in resource-use could compensate the losers from it and remain better off than before the change, the change should be regarded as an improvement. Note that actual compensation need not be paid to the losers. If compensation is paid then of course this criterion reduces to the Paretian criterion. The criterion of
A potential Pareto improvement underlies much of social cost–benefit analysis which itself has been applied to decision-making involving the environment (Hufschmidt et al., 1983).

A difficulty with the Kaldor-Hicks criterion is that it may sanction a change in resource-use which seriously worsens the distribution of income. Cases have for example occurred in which land has been acquired for national parks without compensation or adequate compensation to the traditional users of the land who have sometimes been quite poor. In view of the income distribution question, Little (1957) has proposed that a potential Pareto improvement should only be unequivocally regarded as a social gain if it does not worsen the distribution of income. If a potential Pareto improvement is associated with a worsening of the distribution of income, one has to consider whether this is sufficient to offset the net benefits otherwise obtained.

While the above criteria (which can, for instance, be applied to piecemeal decision-making involving the environment) have an individualistic basis, the role of economising is not confined to social orderings having an individualistic basis. As Bergson (1938) has pointed out, a variety of different types of social welfare functions or social orderings are conceivable. They could for example reflect the values of particular individuals. Nevertheless, if one is to engage in economising one needs at least some preference ordering of the resource-use possibilities of society. Such an ordering need not be complete but if it is complete and transitive, it will allow an ‘optimum’ allocation of resources to be determined.

By way of introduction, consider how economics can help us conceptualise some general problems in the allocation of resources involving the biosphere and the environment. Conceptually, the natural environment or biosphere itself is able directly to produce goods and services, e.g., recreational opportunities, maintenance of a genetic stock of species, clean air and water. But in addition, humans draw upon the resources of the biosphere (uses these as inputs) to produce goods of their own creation, ‘man-made’ goods. There may therefore be a trade-off between the production of environmental natural goods and man-made goods. The production possibility frontier involving man-made goods and environmental natural goods might be of the type indicated by curve ABCD in Figure 1.1. This indicates that the provision of natural environmental goods up to a level of x* is complementary to the production of man-made goods. Such complementarity might come about for example, because the retention of natural tree cover reduces flooding and erosion and helps maintain agricultural output. Given all the techniques available, the production possibility set might consist of the set bounded by OABD. Some techniques of production may for instance be such that the
combination at point J results. Given that both more natural environmental goods and more man-made goods are desired, J is an inferior economic position. If welfare is to be maximised, society must adopt a pattern of resource-use that results in its being on its production possibility frontier in the efficiency segment BCD. Not only are combinations below the production possibility frontier socially inferior but in view of the complementary relationship so too are combinations on the segment AHB. In both these cases it is possible to produce more of all the types of desired goods by reorganising resource-use.

It seems that a complementary production relationship does exist up to a point (a segment like AHB) between the production of man-made goods and goods provided by the natural environment and this on its own would provide an argument for conservation of biological resources. However, in addition humans directly value many goods produced by the natural environment. When this is taken into account, there is an additional economic reason to be concerned with the conservation and management of natural biological resources. Given the preference indicated by the indifference or iso-welfare curves marked $W_1W_1$, $W_2W_2$ and $W_3W_3$ in Figure 1.1 (and assuming that these curves have the usual properties associated with indifference curves e.g., each indicates combinations giving an equal level of human welfare and higher curves are associated with greater welfare) (Tisdell, 1972), the combination at position C is socially optimal. This involves the production of $y^{**}$ of man-made goods and $x^{**}$ of environmental goods. Consequently it is optimal to forgo some man-made production for additional goods produced by the natural environment.

A position below the production possibility frontier such as J may come about because of the use of inferior technologies or because of a
poor allocation of resources between man-made production and natural production, e.g., some land areas comparatively suited to natural production may be allocated to man-made production and vice versa (cf. Tisdell, 1979, Ch. 1). A position such as H may be reached because of ignorance or because of common access to natural resources or in general due to deficiencies of societal mechanisms for managing resource-use. Specific reasons for such failures will be outlined in later chapters.

Recognition is growing of the high economic value of goods and services provided by natural environmental systems including those provided by ecosystems (Costanza and Farber, 2002; Arrow et al., 2000; Heal, 2000; Arrow et al., 1995). Vitousek et al. (1997) have effectively highlighted the large economic and other losses that have arisen, or which may arise, from human impairment of ecosystems given current human domination of these systems. However, social objectives for managing natural environmental resources are not entirely settled.

In some circumstances, social objectives may be expressed differently to that considered in Figure 1.1. A minimum ‘standard’ or target may be set for the production of natural goods of the environment. Economic considerations then need to be taken into account in an attempt to meet this standard if it is not already being achieved. The objective may be one of maximising some welfare function subject to the target. For example, the objective may be to maximise man-made production subject to a target level of production of goods by the natural environment. The last rule can be illustrated by Figure 1.2, which has the same interpretation as Figure 1.1. If the target level of production of environmental goods is a level of not less than x** per year, this constraint can be represented by the line KLM. Position L involving the production of y** of man-made goods and x** of goods from the natural environment is then optimal. Should however, the environmental constraint be below x* (which corresponds to point B) it will be optimal to achieve point B. For example, if the constraint is for production of goods of the natural environment of at least x’ as represented by the constraining line M’K’, it is optimal to achieve point B because of the complementarity relationship. A similar set of considerations will apply if the objective is one of maximising the production of goods from the natural environment subject to a minimum level of production of man-made goods. It is also easy to illustrate the case where a preference function of the type indicated in Figure 1.1 by indifference curves is to be maximised subject to constraints of the type just mentioned.

Cases can arise in which simultaneous constraints are placed on man-made production and production from the natural environment. Minimum levels may be set for both types of production. The basic decision-making problem then becomes one of determining whether it is possible given
available transformation possibilities for resources to meet these constraints simultaneously. Economic factors need to be taken into account to determine this.

1.3 ETHICS, VALUES AND ENVIRONMENTAL ECONOMICS: ALTERNATIVE VIEWS

In considering any of the above matters, ethical assumptions cannot be avoided. Questions about ethics are important because all prescriptions about what society ought to do in managing the environment and natural resources are ultimately based on normative considerations and therefore involve value judgments. The review given in the previous section of the application of economics to the environment accords with mainstream economic thought as, for instance, outlined by Kneese and Schulze (1985) even though they use slightly different terminology. They refer to utilitarianism as classical utilitarianism and Pareto welfare economics as neoclassical utilitarianism or the Libertarian approach and point out that both approaches are anthropocentric, that is, humans are the measure of all things. The value of natural environment is determined solely by the value placed on it by human beings and so in contrast to the naturalistic approach, non-human objects have no intrinsic values (cf. Kneese and Schulze, 1985, p. 211).

Classical utilitarianism requires that human actions be chosen from an available set of alternative actions so as to maximise the good (utility) of the whole society taking account of all individuals including future generations. It may require an individual to take an action injurious

Figure 1.2 Choosing between goods provided by the natural environment and man-made goods subject to constraints or minimum 'standards'
to himself or herself for the good of the whole society. By contrast, neoclassical utilitarianism (the Paretian criterion) sanctions no actions which make any individual worse off, given an agreed system of property rights. Kneese and Schulze (1985, p. 211), point out that classical utilitarianism may sanction projects involving nuclear waste storage because the probable damages to future generations are much less than the present gains whereas the Paretian criterion may not sanction such storage assuming that future generations have a right to a risk-free nuclear environment. Similarly, the elimination of natural resources or environments and species of living things to provide a benefit to humankind now but creating a net disbenefit to future generations may be sanctioned by classical utilitarianism but not by the Paretian criterion, it being assumed that future generations have (property) rights in existing natural environments.

The Kaldor-Hicks criterion of social choice (or criterion of a potential Paretian improvement) forms the basis for most social cost–benefit analysis and is also anthropocentric. It can give different indications to the utilitarian and Paretian criteria about desirability of social actions. For example, the Kaldor-Hicks criterion favours the destruction of a natural environment or species if gains to the current generation are more than sufficient to compensate future generations for any losses, whether or not compensation is made available. However, given that future generations have rights in present natural environments, the Paretian criterion does not support such action in the absence of compensation for these losses. The prescription of the classical utilitarian criterion depends upon the size of utility gains of beneficiaries compared to utility reductions suffered by future generations. It may not sanction a destructive action even when the Kaldor-Hicks criterion favours it.

All the above ‘economic’ criteria apart from being human-centred, assume at least implicitly that rational choices can be made by society. Mainstream economics is consequentialist focusing on the outcome of decisions. It contrasts with ‘the historical view that the prevailing institutional structures that set the social framework between persons lie beyond any process of rational, deliberative evaluation and choice’ (McLennen, 1983, p. 335). However, as discussed later, those economists rejecting the historicist view differ in their opinions about the extent to which existing social institutions limit rational choices by society.

The above overview does not capture the full diversity of choice-theoretic models used by economists, since a detailed study of choice-theoretic models would be misplaced in this context. A more detailed review, however, is given by McLennen (1983). In particular it is clear from Harsanyi (1977) and Sen and Williams (1982) that conceptions of utilitarianism
show greater philosophical variation than can be portrayed in the above introductory review.

In the current context, the contention by Cooter and Rappaport (1984) that modern economists have misinterpreted classical utilitarianism needs consideration. They claim that economists associated with classical utilitarianism (Bentham, Mill, Pigou and others) restricted economic considerations to material goods and saw economics as the science of ‘material welfare’. They imagined that goods could be arranged in a hierarchical order with purely economic or material goods at one end and the purely non-economic or non-material ones at the other end. Purely economic needs definitely include necessities such as food, clothing and shelter but as one moves along the hierarchy to consider such items as comfort and leisure their material content is less certain and it is less clear that they are subjects for economics. Cooter and Rappaport (1984) claim that economists advocating classical utilitarianism restricted its application to material goods required for human welfare and this has not been realised by many modern economists (ordinalists). Cooter and Rappaport argue that if the restrictive application of classical utilitarianism is taken into account, interpersonal comparisons are supportable.

The modern view of economics is wider than that of the ‘material welfare’ approach. Economics, in accordance with the view expressed by Robbins (1937), is now generally seen to be science concerned with the social administration or management of scarce resources in order to satisfy to the maximum possible extent human desires for commodities, whether necessities or not. Robbins’s approach to economics extended the list of goods of equally legitimate concern to economists. Provided someone does not have as much of a good as he/she desires, it is a subject for economics.

These two different interpretations of economics imply differences in its applicability to environmental conservation. The material welfare–utility approach suggests that economists (as economists) should only be concerned about environmental conservation to the extent that it affects material wealth or the supply of material goods, especially basic necessities. On the other hand, the Robbins scarcity approach sees environmental conservation of relevance to economics provided that it uses scarce resources and affects human satisfaction. For example, the preservation of a species or a cultivar which could affect future food production, shelter or health would be a concern for economists given either approach. However, the preservation of a species having no consequence for material welfare would be excluded from economic concern given the material utility approach as outlined by Cooter and Rappaport (1984) but would be included on the basis of the more modern view if the presence of the species affected human satisfaction. A species valued solely by individuals for its existence
(existence-value) is a subject for economic analysis on the basis of the modern view but not if the material utility approach is adopted. The material welfare approach since it concentrates on basic material needs seems more appropriate to a society in a general state of poverty (a less developed one) than to a more affluent one.

The influence of the materialistic school remains strong in that economic growth and increases in production of material goods as measured by GDP are often taken as indicators of rising economic welfare. As demonstrated by a number of writers (Pearce, et al., 1989; Barkley and Seckler, 1972; Boulding, 1970; Mishan, 1967) rises in Gross Domestic Product (GDP) and in the gross output of material goods and marketed goods, are sometimes associated with a decrease in welfare rather than an increase in welfare. For instance, GDP might rise and the state of the environment can decline to such an extent that welfare actually falls.

An important issue for the applicability of traditional economics to environmental issues and other matters is the extent to which goals and preferences of individuals are moulded by institutions. Traditional welfare economics respects the preferences of individuals. But to the extent that pre-existing institutions determine goals and preferences, individual preferences do not have independent status, and choice and strategies are indirectly constrained by such institutions. Kelso (1977) argues that for the last 400 years our institutions have moulded our preferences towards greater consumption, production and economic growth. He suggests that institutions and educational processes need to be altered so that preservation rather than consumption is seen as an important goal in itself. This theme is also reflected in the writings of Boulding (1966), Ciriacy-Wantrup (1968), Daly (1980) and Georgescu-Roegen (1971). While these approaches are not entirely human-centred, those of Daly and of Georgescu-Roegen emphasise the importance of natural resource conservation as a means of ensuring the longest possible period of survival for the human species. Thus to this extent, they remain human-centred.

The idea, however, that humankind has ethical responsibilities towards nature, apart from its own self-interest has gained ground in Western culture despite the anthropocentric nature of Christianity in its Western form (White, 1967; Passmore, 1974; Kneese and Schulze, 1985). Several writers claim that humankind has a responsibility to act as a steward for nature and in particular, to conserve species even in the absence of utilitarian or pragmatic benefits to humankind. For instance, Aldo Leopold (1933, 1966) argues that humankind is a holistic part of an organic community, of a web of life, and has no special right to exterminate parts of it, even species of predators. In this community one must live in harmony with the whole of nature or land. As Worster (1994) points out, Leopold’s views
about conservation were intended to contrast strongly with the utilitarian efficiency, human-centred approach to the use and management of nature. Leopold believed that his ‘land ethic’ involving respect for nature as a community was a way out of the narrow economic attitude toward nature management that had come to dominate ecology (Worster 1994).

Leopold’s view can be interpreted as one involving a moral obligation to conserve holistic natural systems independently of individual wishes or utility. It is a moral imperative of the type considered by Kant (1959) and discussed, for example, by Tisdell (1997). A related view is that all species (or at least a substantial set of species) have a right to continuing existence independent of human desires. For instance, the maintenance of biodiversity is seen as a moral obligation as advocated by Sagoff (1996).

This moral position should be distinguished from that of the ‘animal liberationists’ that all individual sentient beings have rights that should be respected, a position advocated for example by Singer (1975; 1979). For example, animals should be free of cruel abuse by humans, a value that now seems to be widely accepted in Western societies. Some advocates extend this moral obligation more widely, for instance, to prohibit the killing of all animals. The above biodiversity ethic should be distinguished from the animal rights ethic. One may adopt one without adopting the other but it is possible to adopt both types of ethics. To illustrate: some opponents to whaling object to whaling on the grounds that it may threaten the survival of some whale species whereas others object because they believe that intelligent animals are being killed in a cruel way and are deprived of life by humans when they need not be. Some object on both grounds.

One group of economists has responded to the view that the welfare of all sentient beings should be taken into account in social choice by extending welfare analysis to encompass the utility of sentient beings in addition to human beings (Blackorby and Donaldson, 1992). However, the operational value of such models is doubtful given the difficulty or impossibility of measuring utility, especially the utility of animals. But even if this were not a difficulty, supporters of the Kantian position would not usually accept the morality of maximising collective utility, even if it is extended to include all sentient beings. Thus for Kantians, utility maximisation cannot be the sole arbiter of social decisions. This position seems reasonable and is reflected in Pigou’s view that estimates based on welfare economics should not be the final arbiter of policy choices (Pigou, 1932).

In a society in which members hold very divergent moral imperatives (about treatment of living things, ecological and environmental matters and so on) intense social conflict can occur with little scope for compromise. However, such social conflicts may not last. Community values do alter (Passmore, 1974) and moral values may tend to converge, thereby reducing
social conflict, particularly since the prevailing moral or ethical dimension is likely to be reflected in choices by individuals or their expressed preferences, as for example, discussed by Etzioni (1988; 2000) and considered by Tisdell (1997) in relation to environmental issues.

As pointed out in the previous section, it is often possible to incorporate constraints on human-centred actions into rational or choice-theoretic policy models. Such choice models can be modified or varied in several ways to accommodate naturalistic ethics. However, in many cases the rights of non-human objects and naturalistic ethics are insufficiently defined for this purpose by proponents of naturalistic ethics. Furthermore, in some instances, proponents of naturalistic ethics reject the application of choice-theoretic models to public policy, some preferring to take a more romantic view of the world or to stress the limits of rationality. Conflicts about ethics tend to become sharper when resource allocation over time is at stake. Let us turn to this matter.

1.4 ECONOMIC GROWTH, DYNAMICS, UNCERTAINTY AND THE ENVIRONMENT: DIFFERING VIEWS

Opinions differ considerably about the consequences of economic growth for the natural environment and about the extent to which continuing economic growth is sustainable and desirable. A long standing question for humankind has been what are the limits to economic growth given that natural resources are an important, indeed an essential input for economic production and are limited in availability. Since at least the late 1700s a number of prominent social philosophers, including economists, have seen natural resources as the basic constraint to continuing unlimited economic growth. While the actual basis of the argument has altered somewhat and has been extended, most arguments concerning ultimate limits to economic growth are based upon the view that natural resources (such as soil, water, minerals, forests, air) either as inputs for production or receptors for human wastes, constitute the main limits to the continued expansion of economic production. In this respect, it might be noted that classical and neoclassical economists used the term ‘land’ to include all natural resources (or gifts of God).

Early arguments about such limits were based on the law of diminishing marginal productivity of land used for production. This is implicit in the thesis of Malthus (1798) that human population tends to increase in geometrical progression whereas economic production expands only in arithmetic progression. Assuming that human population tends to increase
when incomes per head are above subsistence level, Malthus was led to the gloomy view that incomes per head above subsistence level would not be sustainable in the long run unless individuals consciously controlled their reproductive activity. For instance, he suggested late marriages as one possibility.

David Ricardo (1817) developed the Malthusian model more explicitly and extended it specifically by taking account of the law of diminishing marginal productivity. With increasing population, individuals would be forced to cultivate more marginal lands, utilise less productive forest areas and fishing grounds, open less productive mines and so on. Consequently, though production might increase, it would increase at a decreasing rate in the absence of technological progress because production would extend to use natural resources of decreasing additional productive value. At the same time, intensified use of already employed natural resources would occur, again with diminishing marginal contributions to production.

The Ricardian view of limits to growth posed by natural resource scarcity can be illustrated by Figure 1.3. Imagine that the state of technological knowledge in society is such that curve OEBF (representing production function \( y = f_1(P) \)) indicates the overall level of production achievable at alternative population levels remembering that population provides labour for productive effort. Production is shown to increase with population increases but at a diminishing rate because of the operation of the law of diminishing returns. The line OD represents the total level of production necessary to sustain each level of population at subsistence level. (Its slope is equivalent to the subsistence level of income per capita.)

In this model, given that population tends to increase when income per head is above subsistence level, equilibrium is achieved when population has reached a level resulting in just enough total production to support the level of population at the subsistence level. This corresponds in Figure 1.3

![Figure 1.3 Ricardian model of limits to economic growth emphasising importance of population levels and of technological change](image-url)
with the intersection point, B, of the production function with line OD and implies an equilibrium level of population of $P_2$ and an equilibrium level of total output of $y_3$ given the conditions previously described. For example, if the population level is initially at $P_1$, income per head, $y_2/P_1$, is greater than the subsistence level, $y_1/P_1$, and population increases. As it does so, income per head falls and eventually falls to subsistence levels when a population level of $P_2$ is reached.

Ricardo, however, was aware that expansion in scientific and technological knowledge could stave off a reduction in per capita income even given population growth. This it could do in effect by shifting the production function upwards over time. As illustrated in Figure 1.3, the production curve might shift up with the passage of time to become curve OGCH which corresponds to production function, $y = f_2(P)$ and is higher than OEBF.

Note that this model has an optimistic implication: if population growth can be limited and technological progress can be maintained, income per capita can rise continually. Even in the absence of technological progress, it suggests that relatively high per capita incomes are sustainable provided that population growth can be contained.

The Ricardian model is important in highlighting the crucial importance of human population growth as an element in the sustainability of per capita incomes, even though it neglects a number of other important considerations. The Ricardian model also brings attention to the fundamental importance of growing scientific and technological knowledge as a means of overcoming the production limitations posed by natural resources. Indeed, some technological optimists dismiss concerns about population growth and deteriorating environmental conditions believing that scientific and technological progress can be relied on to overcome such possibilities. The technological optimists include amongst their numbers, Engels, Karl Marx's friend and benefactor, who rejects Malthus's fear of overpopulation and view that production increases by an arithmetic progression, claiming that

Science increases at least as much as population. The latter increases in proportion to the size of the previous generation, science advances in proportion to the knowledge bequeathed to it by the previous generation, and thus under the most ordinary conditions also in geometrical progression. And what is impossible to science? (Engels, 1959 [1844], p. 204)

In more recent times this optimistic view has been presented forcefully by Julian Simon (1981). He basically argues that the larger is the world's population, the more minds there are and the greater is growth in knowledge.
In his view, this expansion of knowledge will overcome resource-constraints to population growth. This rather simplistic view is considered in the next section.

Following Ricardo, some prominent economists continued to be concerned about the prospects for sustainable economic growth. These included John Stuart Mill (1964, reprint) who saw some virtue in having a stationary economic state, that is one in which population growth and economic production is stationary. Jevons (1972–1977) expressed his concern about the depletion of non-renewable natural resources as a result of economic growth, in particular mineral deposits especially coal. Nevertheless, by the end of the nineteenth century an optimistic view of prospects for continuing economic growth prevailed. Few economists paid much attention to natural resources as a limitation on economic growth until the late 1960s. Problems of full employment (not surprisingly in the light of the Great Economic Depression of the 1930s), inflation, market structure and competition and formal welfare economics preoccupied most economists. After World War II, the main emphasis of policies was on the need to achieve continuing economic growth so as to maintain full employment and to improve living standards. Economic growth was viewed as desirable on both grounds. By the late 1960s, however, new and renewed concerns about environmental and natural-resource limitations to economic growth began to be expressed. These concerns include the following:

1. Wastes and pollution are end-products of economic production and consumption. These end-products were ignored in earlier economic theories. With economic growth, waste emissions can be expected to rise and pollutants are likely to build up in the environment and threaten production, human health and welfare.

2. Economic growth is attained to a considerable extent by drawing on the stock of non-renewable natural resources. Stocks of some important resources used in modern production, such as oil, may become exhausted or seriously depleted in the near future and this may impede future production.

3. Living resources unless subjected to extreme conditions are normally renewable but economic growth is unfortunately subjecting an ever increasing range of living resources to extreme conditions and rendering them non-renewable. Amongst other things, this loss of genetic diversity may hamper future economic production and make current economic growth unsustainable.

4. Several flow resources, such as good quality natural supplies of freshwater are becoming comparatively scarcer, and are often more variable and uncertain in their supply than in the past. Furthermore, some such
resources, such as ocean currents, appear to be altering their nature as a result of environmental change.

5. Economic growth by reducing environmental quality can depress the quality of human existence. Let us consider each of these concerns in more detail:

1. Wastes and Pollution as End-products of Economic Activity

Economic production and human activity produce wastes. Many of these wastes are returned to the environment and may cause pollution. In the past, economists usually ignored the problem of wastes in modelling economic activity. However, continuing economic growth can lead to growing environmental pollution with adverse consequences for economic production and human health. In more and more instances, the ability of the natural environment to assimilate wastes (and in essence recycle these or render them innocuous) are likely to be exceeded as a result of rising economic production. There are also global dangers from pollution to consider such as the ‘greenhouse effect’, the possible warming of the atmosphere, as a result of such factors as rising carbon dioxide levels due to the combustion of fossil fuels and the destruction of forests. Local climatic conditions might be altered by the ‘greenhouse effect’ and it could trigger melting of the ice-caps and so result in considerable rises in sea levels. Or to take another example, nuclear production of electricity does not appear to add to the ‘greenhouse effect’ but accidents at power stations or in nuclear waste storage can involve wide spread, even global, radiation risks.

2. Depletion of Non-renewable Resources

Beginning in the 1960s, renewed concern was expressed about the possible depletion of non-renewable natural resources, especially fossil fuels such as oil and coal, as a result of economic growth. The substantial rises in oil prices in the 1970s [even though mainly a result of a cartel agreement by OPEC (Organisation of Petroleum Exporting Countries) to restrict supplies] seemed to add to the urgency of the problem. Even the National Academy of Sciences in the USA published reports predicting imminent shortages of renewable resources. One of its reports estimated that world crude oil production would peak by 1990 and that all but 10 per cent of world reserves would be exhausted by 2032. It further predicted that if petroleum products (crude oil, natural gas, natural-gas liquids, tar-sand, oil) continue to supply the bulk of the world’s energy requirements only 10 per cent of these reserves are likely to remain after 2070 (National
Academy of Sciences, 1969). The influential report for the Club of Rome, *Limits to Growth* prepared by Meadows et al. (1972) also stressed imminent shortages of minerals and metals as a result of economic growth. While these predictions have not been realised, concerns about depletion of non-renewable resources remains.

3. **Loss of Genetic Diversity**

Society has in recent years become more keenly aware of the possible and actual dangers of economic growth to the abundance, existence and diversity of living resources and their life-support systems. The dangers to living species include (a) rising levels of wastes and pollutants from agriculture (pesticides, artificial fertilisers for example), from industry such as emissions of sulphuric acids associated with acid rains, and from human consumption of products; (b) loss of space and habitat by non-human species because of its appropriation by humans for their use; (c) increased competition of humans with other species for common food sources; (d) more efficient and larger-scale direct destruction of non-human species either as pests or for utilisation by humankind; and (e) deliberate or accidental introduction by humans of exotic species that outcompete and eradicate native species. Some of these issues are addressed for example by Hardin (1960) and Myers (1979). The *World Conservation Strategy* (IUCN-UNEP-WWF, 1980; IUCN-UNEP-WWF, 1991) specifies conservation policies believed to be necessary to secure sustainable economic development and benefit humankind. Trends in the disappearance of living resources are not only worrying from the point of view of naturalistic ethics but also because in the long term the loss of genetic diversity may endanger the economic welfare of humankind (Brown and Shaw, 1982).

4. **Altered Capacity of Flow Resources to Satisfy Human Wants**

Flow resources include freshwater, wind and ocean currents, and ecosystem functions, such as nutrient recycling. These are driven to a large extent by the flow of energy from the sun. Due to global growth (both expansion in economic production and in population levels) demand for freshwater has increased substantially in relation to available supplies (Brown, 2001). Conflicts about water use have escalated and increasing re-use of water has occurred. Not only has conflict intensified between human end-users of water but natural systems and the abundance of fresh water-dependent wildlife have been adversely affected by reduced availability of water for them, or by alterations in the flow of water bodies due to greater regulation of stream flows. Some species of water birds, such as ducks, depend on
variations in water flows to induce their breeding. In addition, pollution of water bodies by human activity remains a serious issue and the sources of such pollution can be extremely varied. In some areas, loss of natural vegetation in the catchment areas of river systems has increased the variability of stream flows with adverse environmental impacts such as more serious flooding and longer periods in which streams are dry or at very low levels.

Global warming appears to be altering the patterns of ocean currents and changing weather patterns in countries bordering some oceans, such as the Pacific Ocean. The Americas and Australia are amongst areas affected. For example, Eastern Australia seems to be experiencing more frequent prolonged periods of drought.

5. Economic Production and the Quality of Life

Economists, sociologists and others have become increasingly aware of several ways in which materialistic economic growth, especially as measured by increases in GDP (Gross Domestic Product) can reduce the quality of life and human welfare. Economic growth can lead to a more polluted and less diversified environment, crowding and increased time being spent in travelling to work, reduced control by individuals and local communities over their environment, their economic fortunes, and so on. Views of this type can be found for example, in Mishan (1967). Substantial agreement exists that GDP and GDP per capita are very imperfect measures of welfare (Barkley and Seckler, 1972; Mishan, 1967), and attempts have been made to construct more suitable indices (Nordhaus and Tobin, 1979).

Widely divergent opinions exist about the extent of possible disbenefits from and limits to economic growth. [Compare for example the views of Simon (1981) with those of Mishan (1967) and of Daly (1980).] Disbenefits or costs of economic growth do not always outweigh benefits – in some circumstances economic growth improves environmental quality, judged from a human perspective. For example, in the last 150 years expected length of life in Western countries has increased partly as a result of improvements in public health, for instance as a result of better sanitation, quality of community drinking water and immunisation (Culyer, 1980, p. 209). Economic growth can, but need not, lead to a reduction in environmental quality. Nevertheless, some social philosophers believe that continuing economic growth is fundamentally unsustainable. For instance, Daly (1980) suggests if the human species is to survive for as long as possible that the appropriate policy is to promote zero population growth (ZPG) and reduce levels of the capita consumption in developed countries, that is, adopt a steady-state economic approach in which consumption resource-use is restrained. Georgescu-Roegen (1971) expresses a similar, but stronger, viewpoint.
Aggregate economic use of the world’s natural resources continues to escalate and generates concerns about their long-term availability and possible reduction in their quality. This escalation is not solely a consequence of rising global population. This now exhibits a decelerating growth rate. A major contributor to such concerns are higher levels of consumption by more and more people. In higher income countries, for example, natural rates of population increases are zero or even negative, but consumption levels per capita are high in these countries and the demands to increase these levels are widespread. Naturally, residents of countries with lower per capita incomes have a very strong desire also to raise their consumption levels. As populous countries, such as China and India, raise their levels of per capita income, global natural resource demands can be expected to intensify and global environmental problems are likely to become more pressing. While the exact evolution of future natural resource availability and states of the environment are difficult to predict, human demands on natural resources and environments will no doubt grow in coming decades with potentially serious consequences for human welfare. Uncertainty exists both in relation to macro-issues and micro-issues involving those processes.

Considerable uncertainty exists, for example, about the likely future environmental effects of economic growth and about whether economic growth will be sustainable and for how long. Because we do not fully know the future value of resources, such as species, but will learn more about their value as time passes, it can be rational (from an economic point of view) to conserve resources that otherwise might be irreversibly utilised or altered now (Arrow and Fisher, 1974). This is so even when individuals are not risk-avoiders. The argument for conservation may be strengthened even further if individuals are risk-avoiders. In practice, considerable conflict exists between individuals in society about the extent to which we should avoid collective risks, for example, from nuclear wastes or species extinction. It is essential to take account of uncertainty in most decisions involving the use of natural resources and the environment.

1.5 UNCERTAINTY, WELFARE AND ENVIRONMENTAL ISSUES

Social conflicts about policies that involve collectively borne environmental risks or uncertainties can be difficult to resolve because of different attitudes amongst members of the community to the bearing of risk and uncertainty. In addition to this, sharp differences in views sometimes occur about the current state of the environment and how it might alter as a result
of human actions. Thus conflict can occur about both normative and positive elements involved in environmental policies involving uncertainty.

For example, if there is concern about the loss of a wild species due to habitat loss, opinions may differ about the current level of the population of the species, the sensitivity of its population to habitat loss, and the degree of threat to its continuing existence occasioned by habitat loss. As well, views may differ about the degree of risk that society should take in altering the habitat available to the species.

Some argue that policy-makers should adopt a cautious approach and adopt safe minimum standards. This is particularly recommended when irreducible uncertainty is present and the potential collective costs to the community of not being cautious are very high (Ciriacy-Wantrup, 1968; Bishop, 1978). However, such an approach does not necessarily resolve social conflict about such matters. Opinions may differ, for example, about the degree of caution required and therefore the appropriate standard to adopt.

Safe minimum standards generally reflect a precautionary attitude towards environmental change. They usually favour the conservation of natural resources. Such conservation can be rational when expected gains are to be maximised provided it keeps options open and learning is expected to occur (Arrow and Fisher, 1974; Tisdell, 1996, Ch. 5). Safe minimum standards may reflect this learning aspect plus community attitudes to the bearing of risk and uncertainty.

How much precaution should be taken in relation to policies that can induce environmental change remains contentious and sometimes the appropriate precautions are unclear (Immordino, 2003). For example, while delay in acting is sometimes optimal, it is not always so (Gollier et al., 2001). In English, for example, there are two potentially conflicting adages, namely ‘he who hesitates is lost’ and ‘look before you leap’. Depending on the circumstances, each type of action can be rational. Although the precautionary principle highlights the importance of taking uncertainties into account in assessing policies affecting the environment, its implications can be quite complex, for example, its implications for policies supporting sustainable economic development.

1.6 CONCLUSION

Humankind has substantially altered the natural environment and is likely to change it further with the passage of time and economic growth. These variations can have important consequences for economic welfare and development, society and the quality of life. It is naive to believe that all such changes are bound to be beneficial to humankind although many may be.
Especially taking into account irreversibilities in resource-use, it is necessary to consider natural resource trends and make projections even though these are based on assumptions and are subject to considerable uncertainty. Economic and resource predictions need to be made and taken into account for such projections. In that respect, economics has a role to play. Furthermore, economics has a part to play in the more immediate management of the natural environment, especially in the evaluation of alternative uses of available resources.

Economic evaluations are based on particular sets of ethical assumptions. The contributions of economics therefore remain qualified. Nevertheless, in a holistic approach to environmental management and prediction, economics cannot be ignored. Economics provides useful tools to assist in environmental decision-making even though it cannot supplant the final judgment of the decision-maker. The economics discipline can make and has made a worthwhile contribution to environmental policy discussions and decisions. This book aims to illustrate this particularly for the management of natural biological resources.

REFERENCES


