Environmental economics
An elementary introduction

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environment. For example, we agree that frequently it simply isn’t right to
drain this wetland or burn that forest. But the moral argument is only one
argument for protecting the environment. We think the economic argument
is often more powerful, and especially so when, as is frequently the case, the
‘right thing’ by nature contradicts other rights such as the right to develop
economically and the right to have food and shelter.

The current book has been motivated by two factors.

First, the immense success of several of our previous publications and the
resulting mail led us to realize that a great many people simply want to know
more about environmental economics. Our textbook Economics of Natural
Resources and the Environment (Pearce and Turner, 1990) which has been
reprinted numerous times with a new edition planned soon, is for under-
graduate students, not the wider audience. Other volumes (Blueprint for a
Green Economy by Pearce, Markandya and Barbier (1989) and Blueprint II
edited by Pearce (1991)) have enjoyed a similar success. Whereas these were
aimed at a wider audience, they still did not explain the groundwork of
environmental economics, the economic way of thinking. That is the aim of
this book which is targeted at non-specialists whether they are students or
not. Students interested in economics will probably want to spend more time
on the introductory chapter and suggested reading than the general reader.
The latter can skim this chapter as succeeding chapters contain more detail
and general explanations.

Second, we have become deeply conscious that academics spend too little
time explaining their subject. Academic professions tend to frown on
textbooks, especially those aimed at the wider audience. We think that view
is fundamentally mistaken and in contradicition to one of the very rationales
for academics teaching. We accept that in making things simple many caveats
and complications are glossed over. But everyone has to start somewhere and
it is best to get the message across first and make things complicated later on,
rather than create a sea of confusion at the outset and hope that some people
will swim through it.

We hope you enjoy this book and we welcome your comments. We have
tried to explain what is often a difficult subject as simply as possible. We shall
be especially interested to hear from readers who feel we have not been clear
enough and who, perhaps themselves, have ways of making things more
simple still.

A very brief economic history lesson

This book’s primary objective is to introduce to a general audience the basic
concepts and principles of what has become known as environmental
economics. For all practical purposes, the origins of environmental economics
lie in the 1960s at the time of the first wave of modern popular ‘green’
thinking and policy perceptions within developed countries, known as
environmentalism (O’Riordan, 1983). This is not to say, of course, that the
foundations of environmental economics appeared de novo during the 1960s.
It is a branch of economics and shares with its parent discipline a common
history. Some of the fundamental ideas that provide a framework for
environmental economics go back at least to the eighteenth century.

A minority of citizens have always worried about the state of, and rate of
use of, the natural environment whether locally, nationally or internationally,
and have usually been ignored by their contemporaries. But elements of their
message may be more relevant today than ever before.

While seemingly obvious, it is of crucial importance for an understanding
of environmental economics, that we recognize that our economic system
(which provides us with all the material goods and services necessary for a
‘modern’ standard of living) is underpinned by and cannot operate without
the support of ecological systems of plants and animals and their interrela-
tionships (collectively known as the biosphere), and not vice versa.

Thus environmental economics views the real economy in which we all live
and work as an open system. What this means is that in order to function
(i.e. provide goods and services or wealth for its human operators) the
economy must extract resources (raw material and fuel) from the environ-
ment, process these resources (turning them into end-products for consumption)
and dispose of large amounts of dissipated and/or chemically trans-
formed resources (wastes) back into the environment. This so-called materials
balance perspective on the economy is fundamental to environmental
Economic limits on the economy

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There is a very real but ultimate sense in which economic activity is ‘limited’ or ‘bounded’ by the capacities of natural environments. Now the ‘limits’ concept has its origins in the work of thinkers such as Malthus (1798), Ricardo (1817) and Marx (1867). Malthus worried about absolute limits or scarcity. He believed that as the economy developed, population growth would always tend to outgrow the means of subsistence (food produced by agriculture) and a state of misery, the ‘stationary state’, would be the inevitable end result. Ricardo took a more sophisticated and slightly more optimistic perspective when he argued that relative limits or scarcity was the real problem for a growing economy. In Ricardian analysis, limits are set by rising costs as the highest grade resources (i.e. best agricultural land, purest deposits of minerals, etc.), which are exploited first, become exhausted and have to be substituted for by successively lower grade resources. The costs of exploitation (including pollution costs, see Chapters 1 and 3) escalate as the ‘grade profile’ of resources declines.

Later in the nineteenth century, Marx highlighted the possibilities that economic growth might be limited because of social and political unrest within the national economy and associated society (this was later expanded by his followers into an international, global economic context). The ‘social limits’ to growth theme was picked up again by some economists during the development of environmental economics in the 1970s. In the early 1970s, opinion poll evidence in the developed countries, for example, seemed to indicate that despite huge absolute increases in the material standard of living, people on average said they did not feel much happier with their lives, the Easterlin paradox (Easterlin, 1974). It turned out that the ‘feel good factor’ was a complex phenomenon influenced as much by relative income and social status as by absolute quantities.

The ‘social limits’ theme was also further extended and elaborated on during the 1970s with the addition of moral concerns connected with economic growth and development. Ethical issues (i.e. questions of right and wrong) surfaced on the potentially negative impact of the fast growth modern economic system, the prospects of future human generations and non-human nature, as well as on exacerbating declining moral standards in contemporary society (see Chapter 2).

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Our very brief historical survey should also include mention of one other influential nineteenth century thinker, J. S. Mill (1857). Mill, like previous political economists, believed that the economic growth process would end in the ‘stationary state’. At this point there would be a static population level serviced by a fixed amount of housing, infrastructure, farms and other industrial plants. In economic terms, there would be a constant stock of human capital (people) and a constant stock of physical capital (machines, buildings, etc.). Incidentally, Mill argued that it was quite possible to conceive of this stationary state society as socially desirable, given people the time and space to enjoy the spiritual, artistic and educational aspects of the human condition.

The ‘constant stock’ idea was another notion that reemerged during the 1970s, when it was popularized by Daly (1973) in a book advocating the deliberate creation of a no-growth steady-state economy. For Daly, the key policy question becomes, how big (i.e. physical scale or size of the human presence in the ecosystem) should the economy become (given that it is a subsystem of the environment) relative to the overall system (i.e. the biosphere, economies plus ecosystems and all their interrelationships)? He is critical of conventional economics because, as he sees it, the discipline fails to provide a proper analysis of the economic ‘scale’ issue (population x per capita resource use).

A significant caveat is in order at this point in the introductory discussion of the evolution of environmental economics. While the ‘limits’ and ‘constant stock’ (steady-state) concepts have been and remain important foci for analysis and debate, a belief in them is not a necessary feature of modern environmental economics. Indeed our position is that it is not necessary to totally embrace the steady-state philosophy (we set out the reasons why in Chapter 3) in order to adequately safeguard the environment on which we all depend.

It is also the case that environmental economics is not a static body of knowledge but an ongoing process of change, refinement and debate. Most recently, over the last five years or so, a split has occurred which has led some analysts to comment that a potentially separate subdiscipline called ‘ecological economics’ has begun to emerge. There is, however, no clear consensus on what ecological economics embraces or how it differs from environmental economics. We will not in this introductory text attempt to set out in any rigorous way the possible differences between the two approaches. At the risk of great oversimplification, it is, we suppose, possible to argue that ecological economics can be viewed as a reaction to, and rejection or modification of, certain of the assumptions that tend to characterize environmental economics. Daly’s advocacy of the steady-state economy and the vital importance of the ‘scale’ issue, is an example of how ecological economics might diverge from environmental economics. We will flag some other potential points of divergence in succeeding chapters (see in particular
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Chapters 2, 4 and 8) but will stop well short of any comprehensive position. The bulk of the analysis in this text is devoted to an elementary exposition of the principles and policy perceptions of environmental economics.

Before we outline the basic structure and organization of the succeeding chapters we return to our historical survey in order to highlight a number of other important concepts which have been assimilated into modern environmental economics thinking.

Environmental pollution as an external cost

Because the economy is an open system its three basic processes (extraction, processing/fabrication and consumption) all involve the generation of waste products that eventually find their way back into the environment (the air, water or onto land). Too much waste in the wrong place at the wrong time (or over too long a time) will cause biological and other changes in the environment (known as contamination) which themselves may then cause harm or damage to animals/plants and their ecosystems (pollution). If these environmental damage effects then serve to harm human health or negatively affect human wellbeing in some other way (i.e. reduce the pleasure of outdoor recreation, etc.) economists would recognize the existence of economic pollution.

The economic definition of pollution is dependent upon both some physical effect of waste on the environment and a human reaction to that physical effect. In economic parlance, there has been an uncompensated loss of human welfare (wellbeing) due to the imposition of an external cost (i.e. health damage, morbidity or mortality increases, less pleasurable recreation experiences, etc.) related to the emission to the air or discharge to water or onto land of waste substances. So the physical presence of pollution does not mean that ‘economic pollution’ exists. Further, even if economic pollution was present, it is far from always being the case that it should be eliminated. We expand on this argument in Chapters 5 and 10.

It was Pigou (1920) who first formalized the impact of pollution on the working of the economy. His analysis distinguished between the private costs of production and consumption activities (encapsulated in fuel, raw material, labour costs, etc.) and the full social costs (i.e. on society as a whole) of such activities. What he saw was that pollution gives rise to external costs, which drive a wedge between private and social costs. So the social costs of production or consumption are made up of private costs plus any external costs that may be present. The socially optimal level of external costs is unlikely to be zero (zero pollution) because of the natural capacity of the environment to absorb some waste and the cost of controlling pollution. Zero pollution is desirable, however, when the predicted damage from the disposal of certain toxic and hazardous substances is thought to be catastrophic in some sense. Unfortunately, real world pollution situations are often beset by a lack of data and/or understanding over just how dangerous some released substances will turn out to be over the long run. Making decisions under uncertainty is a complex task and we outline some of the issues involved in Chapters 9 and 14.

Non-renewable and renewable resource use

On the basis of the materials balance model of the economy/environment interface, resource extraction (and harvesting) activities start off the process of economic activity. Resources may be simplistically classified as exhaustible (or more properly non-renewable) or as renewable. The former are fixed in overall quantity, so that use of them in a given time period means that there is less of them available for other time periods. The basis of the economics of non-renewable resources was formulated by Gray (1914) and Hotelling (1931). Their analysis was developed in the context of the underlying historical concern that the world’s exhaustible resources (minerals, forests and other resources – renewable and non-renewable) might be being extracted too rapidly and sold too cheaply.

Most of the non-renewable resource theory relating to the activities of mineral extracting firms is primarily concerned with the best (‘optimal’) rate at which resource deposits or fields should be extracted, and also with the optimal amount of the resource that should be extracted. What Gray and Hotelling showed was that in the case of, for example, the minerals-extraction industry, the production in any given period is not independent of production in any other period. They proved that because the current rate of extraction of a mineral actually affects the amount of that mineral that may be extracted in future periods, the current costs of extraction (and rates of extraction) are subject to a set of quite complicated forces. Thus, current extraction costs depend on current input costs (fuel, labour, etc.), and also on past rates of extraction and on the effect of current extraction on the future profitability of the mineral deposit. The owner of the mineral deposit will try to maximize total profits over a given time horizon (known as the ‘net worth’) rather than simply maximize profit in any given period.

Because of the assumption of a fixed amount of a given mineral resource, Gray reasoned that extraction costs (usually analyzed in terms of marginal cost, i.e. costs per unit of additional output) would include an additional element. He developed a concept that we now call user cost, the notion that possible future use of a non-renewable resource is necessarily sacrificed if units of the resource stock are exploited and used today. So in strict economic terms the cost of using a non-renewable resource (e.g. coal, gas, oil and other mineral deposits) is therefore made up of the sum of its extraction costs (e.g. cost of mines, drilling rigs, etc.) and the user cost element.
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It was noted that the owner of a mineral deposit might well maximize total profits by postponing extraction (conserving resources for the future) if, for example, it was expected that the price of the mineral would increase substantially in the future (i.e., increase in user costs); or if extraction costs due to a new technology were thought likely to fall in the future. On the other hand, if current interest rates paid out on financial investments were to increase then this would serve to increase current rates of mineral extraction in known deposits. The owner could now invest any current profits derived from extraction and gain the higher rates of interest. Profits now have been made more valuable relative to future profits, with the latter now being more heavily discounted by the owner. Discounting is a very important general concept in economic analysis and it reflects the fact that we tend to regard costs and benefits in the future as being of less importance than costs and benefits now (see Chapter 7). It turns out that the discount rate (how much less valuable future costs and benefits are) is of prime importance in determining the rate at which non-renewable and renewable resources are used (see Chapters 15 and 16). Hotelling (1931) showed that under certain conditions the rent or royalty on a resource (the price net of extraction costs) would increase over time at a percentage rate equal to the resource owner's discount rate.

Changes in the rate of interest in the real world will affect not just the value of profits, but also the level of effort that mineral firms will put into exploring for and developing new sites for future extraction. They also influence investment in new capital equipment, both in deposits already being worked and at new deposits. There can therefore be a number of offsetting forces to the increased rates of extraction of known deposits.

Carlisle (1954) brought the question of the optimal amount of the total resource deposit to extract to the fore. He emphasized the point that no mining/drilling firm would ever extract the entire amount of a deposit. Carlisle's analysis showed that the optimal rate of extraction varies with the level of extraction and vice versa, and that the existence of uncertainty complicates the problem even further. Modern economic optimal resource use analysis reflects these complications and we deal with it in outline form only in Chapter 16 (the published literature is technically very demanding).

Hotelling's work served to highlight another important set of factors in environmental economics analysis. He showed that in situations related to free or easy access/entry to the resource deposit (or for that matter to a renewable resource such as a forest or a fishery) too rapid a rate of extraction would result. Open access is possible because either property rights do not exist or are easily challenged. So if many firms can drill an oil field, for example, no firm is induced to hold back and the field is exploited too rapidly; oil and gas are also lost. The open access problem has, unfortunately, been confused in the environmental economics literature by frequent references to the common property problem and the tragedy of the commons problem. In fact common property is property owned by a community and is often subject to usage rules or social norms (see Chapter 13). We therefore prefer the term the 'traedy of open access' and link it not just to the problem of the best rate of resource exploitation, but to the problem of pollution and the rate at which the environment's assimilative capacity (i.e., its ability to 'absorb' wastes produced by the economy without exhibiting signs of excessive change and stress and therefore physical and economic pollution) could itself be depleted or destroyed (see Chapters 10 to 14).

In the case of renewable resources (e.g., fisheries, forests or livestock, and rangeland), the rules for optimal use over time were first comprehensively formulated by Gordon (1954). He compared the utilization of a fishery under open access and single ownership conditions and showed that under the former regime, resource rents would be exhausted and the resource itself would be pushed close to extinction. In the renewable resource case, decisions about the optimal amount of the resource to harvest and when to harvest it are interdependent. This is because the resource itself (strictly its biomass stock) grows through time and this increases the potential harvest yield the longer is the delay in harvesting.

From 'cowboy economy' to 'Spaceship Earth'

In 1966 Boulding wrote an essay on 'Spaceship Earth' which combined economics and some science in order to bring together the view of the economy as a circular resource flow system, and of the environment as a set of limits, resource stocks (or sources) and natural assimilative capacities (or sinks) for wastes. Boulding argued that we must cease to behave as if we lived in a 'cowboy economy', with unlimited new territory (i.e., resources, sources and sinks) to be conquered and learn to treat planet earth as a 'spaceship'. The spaceship is a circular system in which every effort has to be made to recycle materials, reduce wastes, conserve exhaustible energy sources and tap into potentially limitless energy sources such as solar power.

Boulding's synthesis work was formalized in the materials balance models of Ayres and Kneese (1969) and Kneese et al. (1970). Their additional contribution was to show that wastes are pervasive throughout the economic system. Since the discharge and emission of wastes into the environment is inevitable, pollution externalities effects are also potentially pervasive. Some form of government intervention to 'control' the rate and extent of pollution is therefore required. Control could be exercised via regulations and laws and/or via economic incentive instruments such as taxes and permits (see Chapters 10 to 14). Government intervention is, however, no panacea for environmental degradation problems and uncoordinated policies (intervention failure) can make matters worse (see Chapter 6).

Because environmental economics has accepted the hypothesis that there is

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The content above is a continuation of the text from the previous pages, discussing the economic aspects of mineral resources and their extraction, the role of interest rates, and the implications of access to resources. It also references the work of Gordon and Boulding in terms of environmental limits and the 'spaceship' analogy for resource management.
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an extensive interdependence between the economy and the environment, some of its analysts have also pointed out that the design of economies (free market, planned or mixed) offers no guarantee that the life support functions of natural environments will persist. The materials balance model shows clearly that the environment provides three basic functions: it supplies resources (renewable and non-renewable); it assimilates waste products; and it provides humans with natural services such as aesthetic enjoyment, recreation and even spiritual fulfillment. These three functions can also be regarded as components of one general function of natural environments – the function of life support.

All these environmental functions are economic functions because they all have a positive economic value: if we bought and sold these functions in the market-place they would all have positive prices. Mistreatment of natural environments often arises because we do not recognize the positive prices for these economic functions, as there are no markets and therefore no market prices for many environmental goods and services (market failure, see Chapter 5).

We lack information and analysis that could demonstrate whether any particular economy is consistent with the natural environments, which are necessarily linked to that economy. We do not have what we could call an existence theorem that relates the scale and components of an economy to the set of environment–economy interrelationships underlying that economy. Without this theorem we run the risk of degrading and perhaps destroying environmental functions. If we are interested in sustaining our economy over time, it becomes important to establish some principles and then practical rules for sustainable economic development (see Chapter 4).

The valuation of environmental functions, which are generally unpriced, is an important task in order to help correct economic decisions which treat natural environments as if they were free goods and services, and therefore lead to overuse. Some of the methods and techniques that have been developed in order to value these environmental assets in monetary terms are reviewed in Chapter 8. Economists generally advocate what they call cost-benefit thinking, which can be applied to individual projects (new dams, roads, power plants, etc.) or to policies or even wider courses of action. Simply put, the idea is to compare all the relevant benefits from, say, the building of a new water supply reservoir with the costs (construction and running costs) of such a project (including the environmental effects). Both costs and benefits are translated, as far as is feasible, into monetary terms and discounted over a given time horizon. Only projects with benefits greater than costs are acceptable (see Chapter 7).

Environmental economics merely deploys cost-benefit thinking in the context of environmental problems and issues. So 'benefits assessment', i.e. the monetary evaluation of the environmental benefits of environmental policy, or its obverse 'damage cost assessment', has had two main uses: first, to integrate the unpriced but valuable functions of natural environments into cost-benefit analysis of real world projects, and, second, to illustrate the kinds of economic damage done to national economies by resource depletion and pollution (see Chapter 3).

Once society has decided on an 'acceptable' level of environmental quality assisted by, among other factors, economic cost-benefit analysis, there are still further problems to be resolved. To transform the decision into reality requires a change of behaviour on the part of producers and consumers. Again a continuing debate exists in environmental economics concerning the relative merits of command and control regulations (CAC) and market-based incentives to control pollution.

Norton (1984) has summarized the position as follows. In choosing a pollution control policy, we need to determine:

(a) what policy instruments and technologies for abatement of pollution are available;
(b) what the objectives of the pollution control policy are, with particular reference to the type of pollution and the degree of environmental risk posed, the extent and reliability of pollution control methods, the full social costs of pollution control, and the social incidence of the costs and benefits (i.e. distributional effects);
(c) how cost-effective are the different policy instruments with respect to these objectives.

The regulatory approach (CAC) is based on the issuing of orders by some central government agency to do or not to do something (i.e. install and operate a piece of equipment or new process), known in the United Kingdom as the application of Best Practicable Means (BPM) and Best Available Technology Not Entailing Excessive Cost (BATNEEC), or in the United States as Best Available Control Technology (BACT) (see Chapter 14). The regulations may also cover the following issues:

(a) limits in terms of maximum rate of discharge from a pollution source;
(b) pollution discharge bans related to pollution concentration measures or damage costs;
(c) specification of inputs or outputs from a given production process.

Economic incentives require not action but payments, and, in principle, encourage the economically rational polluter to change behaviour by balancing reduced payments (of say a pollution tax) against increased costs incurred in reducing pollution discharges. Early economic work in the field of pollution control stressed the desirability of the economic incentive approach (Kneese, 1964). Given certain assumptions it can be shown that the most efficient (strictly the most cost-effective) way of achieving some predetermined level of environmental quality is via the imposition of a pollution tax or related economic incentive instrument. However, when some of these assumptions are relaxed and criteria such as distributional equity and ethical
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Considerations are introduced, the case in favour of the incentive approach is much less clear cut (Bohm and Russell, 1985).

The rest of this book is organized in the following way:

- Part I (Chapters 1 to 4) covers a range of basic issues ending up with a discussion of the concept of sustainable economic development.
- Part II (Chapters 5 and 6) deals with the causes of environmental problems which are analyzed in terms of two interrelated 'failures' concepts, market failure and government policy failure.
- Part III (Chapters 7 to 9) covers cost-benefit analysis and its application to environmental issues. The methods and techniques that have been applied, in the absence of market-based price/value data, in order to value environmental assets in monetary terms are reviewed, and the section ends with a discussion of the problems caused by uncertainty.
- Part IV (Chapters 10 to 14) deals with various forms of government intervention that are possible in order to protect environmental quality. A range of policy instruments, taxes, charges, permits and regulations are appraised in terms of their economic efficiency and other criteria.
- Part V (Chapters 15 and 16) covers the basic analytics of natural resource usage and sustainable management.
- Part VI (Chapters 17 to 23) is composed of a series of mini case study chapters on various 'local' and 'global' scale environmental management topics.

References


PART I

Economics and the environment
According to the authors of a recent non-conventional economics text it is important to recognize that human communities are part of a larger community that encompasses both them and non-human nature (Daly and Cobb, 1990). From this perspective, 'the industrial economy is only part of the "Great Economy" - the economy that sustains the total web of life and everything that depends on the land' (Daly and Cobb, 1990, p. 18). It is this big economy that is of ultimate importance.

Conventional economics textbooks often convey a very misleading picture of the relationship between an economic system (a set of institutions and activities designed to efficiently allocate scarce resources among things that provide benefits, thereby satisfying human wants and desires) and the environment (made up of ecosystems or interrelationships between living species themselves and with non-living or abiotic structure) that surrounds and underpins it. Basically, simple economic models have ignored the economy–environment interrelationships altogether. The economy is portrayed as a closed and linear system shown in Box 1.1. This, of course, is physically impossible and the implications of how an economy does in fact sustain itself over time lies at the core of environmental economic thought. In reality the opposite is the case. The economy is an open and circular system which is only able to function because of the support of its ecological foundations. A working economy must extract, process and discard large amounts of physical materials. This means that the economy is subject to physical constraints.

**The materials balance perspective**

Environmental economics takes as its starting point, the lessons to be drawn from the 'laws' of thermodynamics. The economy–environment interactions are best portrayed via the materials balance model, based on the First and
Second Laws of Thermodynamics, as shown in Box 1.2. The model represents the economy as a materials processing and product transformation system. 'Useful' materials are drawn into the economic system (e.g. non-renewable resources such as fossil fuels can be extracted until their stocks are exhausted and renewable resources such as fisheries and forests can be harvested) and then undergo a series of changes in their energy and entropy (i.e. usefulness) states. Eventually after a time lag, the non-product output of the system can be partially recycled with the residual 'useless' materials (wastes) returned to the environment from various points in the economic process, see Box 1.3.

The materials that first enter the economic system are not destroyed by production and consumption activities; they are, however, dispersed and chemically transformed. In particular, they enter in a state of low entropy (as 'useful' materials) and leave in a state of high entropy (as 'useless' materials, such as low temperature heat emissions, exhaust gases, mixed municipal wastes, etc.). At first sight, the entropy concept seems counter-intuitive and it is not used formally or defined rigorously in this discussion. In lay terms, entropy is a certain property of systems which increases in any irreversible process. When entropy increases, the energy in the system becomes less available to do 'useful work'. No material recycling processes can therefore ever be 100 per cent efficient (Ayres and Kneese, 1989). Once the materials balance perspective is adopted, it is easy to see that the way humans manage their economies impacts on the environment and, in the reverse direction, environmental quality impacts on the efficient working of the economy.

The multifunctional nature of environmental resources

Environmental economists are seeking to expound the principle that natural systems are multifunctional assets in the sense that the environment provides humans with a wide range of economically valuable functions and services:

- a natural resource base (renewable and non-renewable resources);
- a set of natural goods (landscape and amenity resources);
- a waste assimilation capacity;
- a life support system.

The principles of scarcity and opportunity cost, as well as the objective of an efficient allocation of scarce resources, can now be applied to the complete collection of environmental goods and services: waste assimilation functions, peace and quiet, clear air and water, unspoilt landscapes, etc. If environmental resources are becoming more scarce then economic analysis can play a role in devising strategies to mitigate some of the consequences of that process. A balance will be required between the interests of people wishing to use the environment now in a direct way (e.g. as a source of raw materials or a waste sink) and those wishing to enjoy it now in an indirect use sense (e.g. to
Box 1.2 Simplified materials balance

In this model, the economy is portrayed as an open system pulling in materials and energy from the environment and eventually releasing an equivalent amount of waste back into the environment. Too much waste in the wrong place at the wrong time causes pollution and so-called external costs (externalities).

Box 1.3 Simplified materials flow chart
The laws of thermodynamics lead to two propositions that are important in environmental economics:

1. All resource extraction, production and consumption eventually result in waste products (residuals) equal in matter/energy terms to the resources flowing into these sectors.

2. There is no possibility of the 100 per cent return (recycling) of these waste products to enter the resource flow again because of the second (entropy) law of thermodynamics.

All economic systems contain a number of recycling flows, although the level of recycling effort and activity varies between national economies. Recycling flow (1) is known as the 'home scrap' flow because the recycled 'secondary' material never leaves the processing plant. Home scrap recycling rates are very high. Recycling flow (2), 'prompt scrap' flow also has a high activity rate, but does require the intervention of a secondary material merchant firm to facilitate the collection of scrap and its redirection back into basic processing. Recycling flow (3), 'commercial scrap' is composed of packaging waste and is the staple business of the recycling merchant firms. Recycling flow (4), 'post-consumer scrap' is the potentially recyclable components of the household and small commercial premises waste stream (municipal solid waste, MSW). Activity rates associated with this type of recycling have historically been low in all industrialized economies (typically less than 10 per cent of the total MSW until quite recently, with the spread of bottle, can, paper and even plastics recycling banks). Recycling flow (5), 're-use' is a practice that has all but disappeared in modern economies and is now restricted to returnable bottles and a limited number of other examples.

Why is it that type 1, 2 and to a lesser extent 3, recycling operates at a high activity rate, while types 4 and 5 remain at relatively low levels of activity? Much of the answer is due to four physical factors (characteristics) and the influence of thermodynamics. The four factors are mass (volume of recyclable materials), homogeneity (the level and consistency in quality terms (known as grade) of the recyclable materials), contamination (the degree to which different materials and other substances are mixed together), and location (the number of points at which the materials are first discarded as waste). Compare home scrap (flow 1) and post-consumer scrap (flow 4). The former is characterized by large mass, high homogeneity, low contamination and single location. The latter is characterized by small mass, low homogeneity, high contamination and multiple locations. In financial (private cost) terms the profitability of recycling flows 1, 2 and 3 will be much higher than flow 4; indeed the latter will often incur net financial costs. All this is not to say that recycling of MSW may not yield net social benefits sufficient to outweigh the private costs and therefore represent an economically efficient activity. Nevertheless, the message is clear, 100 per cent recycling is not feasible and very high overall rates of recycling may not necessarily be socially desirable (we expand on this argument in Chapter 18).

The extent of recycling in a national economy will also be determined by

| Table 1 Britain's place in EEC recycling league (1989) |
|---|---|---|
| | Paper | Glass (tonnes) | Aluminium |
| Belgium | 691000 | 208000 | n.a. |
| Denmark | 311000 | 58000 | n.a. |
| France | 2881000 | 760000 | 2331000 |
| Germany (FRG) | 5627000 | 1538000 | 527000 |
| Great Britain | 2975000 | 310000 | 220000 |
| Greece | n.a. | 14000 | n.a. |
| Ireland | n.a. | 11000 | n.a. |
| Italy | 1733000 | 670000 | 390000 |
| Netherlands | 1488000 | 299000 | 129000 |
| Portugal | 273000 | 34000 | n.a. |
| Spain | 1591000 | 287000 | 77600 |

Note: On tonnage/capita basis, however, Britain fares less well. It was fifth out of nine countries in paper recycling, eighth out of eleven for glass, and joint fourth out of six for aluminium.

Overall, the best recycling performance was turned in by West Germany and the Netherlands. Their recycling rates on a per capita basis were about twice as good as Britain's for paper and aluminium, and three to five times as good for glass.

Source: Enders Data Services (1990)
other factors, such as the relative prices of secondary (recycled) and primary raw materials as inputs into production processes; the end-use structure (number of uses and the grade of material required) for any given secondary material: typically lower grade secondary materials, e.g. mixed waste papers and mixed colour glass, and the small number of uses that are available; technical progress in both secondary and primary materials industries; historical and cultural factors which condition the degree of ‘environmental awareness’ in society – see Table 1.

The basic idea of a national recycling rate is given by the ratio:

\[ R = \frac{\text{tonnage recycled annually}}{\text{annual tonnage available for recycling}} \]

But matters are made more complicated by, among other things, the existence of international trade in secondary materials. If imports of secondary material are included in the calculation, then a recycling activity rate (the ‘utilization rate’) has been calculated. If imports are not included, then a recycling effort rate (the ‘recovery rate’) has been calculated. These two rates are often confused in debates about recycling between different materials and countries. Taking the example of waste paper, the UK recovery rate in 1990 was 30.4 per cent, while its utilization rate was 53 per cent.

In 1989, Britain was in the lower half of the European Community recycling league for paper, glass and aluminium. The figures in Table 1 show that, on a tonnage basis, Britain performed reasonably well. It was second out of nine countries in the paper recycling league, third out of eleven for glass, and fourth out of six for aluminium.

appreciate a scenic landscape or tropical forest kept in as natural a state as possible). Further, the needs of the present generation of people will have to be balanced against future generations’ needs.

The question of how, and under what conditions, free markets can help achieve this balance has spawned a long and extensive literature (Norton, 1984; Pearce et al., 1989). Economic theory demonstrates that given certain assumptions the market mechanism is capable of achieving efficient resource allocations, provided that externalities are not present (see Box 1.4). When externalities are present and/or when public-type goods (to be defined below) require allocation, markets can fail the efficiency test (see Chapter 5).

Box 1.4 Market mechanism

Buyers (demand) and sellers (supply) coming into contact via a voluntary decentralized exchange process can, given the right conditions, determine an equilibrium price and an efficient allocation of resources (i.e. there is no alternative allocation that leaves everyone at least as well off and makes some people better off).

Panel (a) Demand and supply relationship.

\[
\begin{align*}
P & \rightarrow \text{equilibrium} \leftarrow \text{quantity bought/sold} (Q_d, Q_s) \\
& = \text{marginal willingness to sell} = \text{marginal willingness to pay} \\
& = \text{marginal costs of production} \quad [\text{marginal opportunity costs of resources used up in production and sale}]
\end{align*}
\]

Panel (a) illustrates a situation in which the price of a good is taken to be of primary importance in determining just how much of a good people are prepared to buy, and conversely how much of the good firms are prepared to offer for sale. All other factors which could influence demand and supply are assumed constant (i.e. income, price of substitute goods, etc.). So

\[
\begin{align*}
Q_d &= f(P) \\
Q_s &= f(P)
\end{align*}
\]

At position e, \( Q_d = Q_s \) given a market price \( P \).

At \( e \), the marginal willingness of consumers to pay (their valuation of the good) is just equal to the marginal costs (labour, raw materials, energy, etc.) of producing that good and efficiency is maximized as long as the structural conditions for perfect competition are satisfied:

(a) large numbers of buyers and sellers;
(b) perfect information;
(c) goods being exchanged can, in principle, be individually owned;
(d) the full costs of production and consumption are reflected in market prices.

Price has adjusted until at \( e \) the amount that people demand of something is equal to the amount that is supplied. Resources are allocated sufficient to produce an amount \( 0Q \). There is no alternative allocation that leaves everyone at least as well off and makes some people better off.
Pollution externality: the case of a recycled paper production plant

Market failure is related to the absence of structural condition (d) listed above.

Panel (b) The true cost of recycling paper.

In the real world, all markets are not freely competitive and the structural conditions necessary for perfect competition are not present. In the case of the recycled paper plant, the price would operate, if there were no government controls (laws, regulations or taxes) on pollution, would be $P$ and the amount of the good bought and sold would be $Q$. Now this position would not represent an efficient allocation of scarce resources if externalities also existed. It is likely that a pollution externality (social costs) would exist in this situation. Unfortunately, recycling paper and board plants produce a potentially damaging liquid waste as well as the ‘environmentally friendly’ paper products.

In the absence of pollution control regulations or some other official control instrument, let us assume the plant discharges its liquid effluent straight into the local river. Assume further, that downstream of the recycling plant another plant takes water out of the river in order to process food products, and further downstream again a nature reserve and recreational swimming and boating area also exist. The downstream users (e.g. the food plant and the birdwatchers and recreationalists) suffer costs due to the water pollution caused by the recycling plant. The food plant has to install more expensive water purification equipment, and the boating and swimming enthusiasts have to put up with a poorer quality experience or may even have to give up swimming in that location altogether. If the pollution is particularly severe, wildlife may disappear altogether from the nature reserve areas.

The full costs of producing and consuming the recycled goods were not reflected properly in the price level $P$. The recycling plant’s private costs of production should be augmented by the extra social costs (in monetary terms) involved, shifting $S$ to $S_t$. Once the social costs have been internalized and the supply curve shifted to $S_t$, a new price is determined at $P_t$. The efficient allocation of resources (properly reflecting the waste assimilation service of the environment) required a higher price of $P_t$ and a lower output level of $Q_t$.

Correcting for externalities in practice requires a set of government interventions in the market system via some combination of regulations and pollution taxes (Pearce et al., 1989).

Externalities and public-type goods

Externalities are usually defined as unintentional side-effects of production and consumption that affect a third party either positively or negatively. For example, the factor that pollutes the surrounding local atmosphere to such an extent that the local incidence of some respiratory illnesses increases, has created a negative externality (external cost). An activity by one agent (the production plant) has caused a loss of welfare to another agent (the people made ill) and the loss of welfare is involuntary and not compensated for. Identifying and assessing the significance of pollution externalities in practice is often a very difficult task. Particularly troublesome issues are raised in situations where people have been exposed to a pollutant in very small doses over prolonged periods of time. Identifying and measuring the risks involved is far from easy, and very often decisions have to be taken on the best available evidence, which may not be very substantial.

The crucial feature of externalities is that there are goods people care about (e.g. clean air and water, landscapes, etc.) that are not sold on markets. The majority of environmental goods fall into a category in which market values are not available (public-type goods). Public goods generally have the characteristics of joint consumption and non-exclusion. What this means is that when the good is consumed by one person, it does not diminish the amount consumed by another person. So, for example, one person’s consumption of clean air does not diminish any other person’s consumption. Non-exclusion means that one person could not prevent (‘exclude’) another from consuming the resource.
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The very characteristics of many environmental goods have meant that their 'true' value (total economic value) has been underestimated or ignored altogether. They have remained unmeasured and unpriced, and have therefore been inefficiently exploited. It is also the case, however, that by no means all negative externalities are due to market failure. Think about the damage (loss of habitats and landscapes, and water pollution due to fertilizers and pesticides) done by agricultural practices to the environment. In this context, it is intervention failure that is significant. The Common Agricultural Policy has involved governments in the European Community intervening in agricultural markets to control prices and support farmer incomes. One of the consequences has been massive overproduction and related unintended but significant pollution run-off problems (see Chapter 6).

Many environmental goods are also common property and/or open access resources. The combination of weak property right (legal) protection against overuse (or complete open access) together with free or cheap usage of these resources has inevitably led to overexploitation, sometimes to the point of destruction of the stock. Tropical rainforests, marine fisheries and the waste assimilation capacity of seas are all examples of such overexploited resources (see Chapter 15).

Conclusions

To summarize the discussion so far, we have argued that environmental economists have been at pains to emphasize that at least one class of negative externalities — those associated with the disposal of wastes generated by economic systems — are not isolated and rare events but inevitable and commonplace. Further, their economic significance tends to increase as economies develop (industrialize and support larger populations), and the ability of the environment to receive and assimilate them is reduced (increasing scarcity) thereby increasing the value of such natural resource capacities.

From a theoretical viewpoint, it has also been shown that if the capacity of the environment to assimilate wastes is scarce, the market mechanism cannot be free of externality effects (and therefore does not represent an efficient resource allocation mechanism) unless:

(a) the material and energy drawn into an economy via production activities produce no waste (100 per cent recycling efficiency) and all final outputs are eventually totally destroyed by consumption;

(b) property rights cover all relevant environmental goods, placing them in private ownership and allowing them to be exchanged in competitive markets.

Condition (a) contravenes the fundamental physical (thermodynamic) law of conservation of mass/energy and condition (b) is impossible or impracticable given the characteristics of many environmental goods.

Since the essence of environmental issues is that they inevitably involve, among other things, externalities and public-type goods, the market mechanism cannot be relied upon to provide efficient levels of environmental goods and services. But this leaves us with a fundamental question: How can and how should society decide what amount of environmental quality it should purchase? One possible approach which has received most support from economists is to rely on cost-benefit analysis (see Chapter 7).

The big economy

Bibliography

Ends Data Services, HC Written Answers, 22 October 1990, Cols 39-40.

For a recent restatement of the materials balance model see:


Good introductory analysis of market failure and the valuation of environmental goods and services can be found in:


CHAPTER 2

Environment and ethics

Introduction

Many environmentalists feel that modern academic economics is somehow not addressing the ‘real’ problems of the day, and that a ‘new’ or ‘alternative’ economics is required (Daly and Cobb, 1990). This view is not endorsed in this chapter, instead it will be argued that the environmental economics that has been developed since the 1960s has a great deal to offer anyone who wants to understand environmental problems. The principle of opportunity cost, for example, emphasizes that nothing, including environmental resources, is free. Using the environment to produce boating marinas in place of wetlands, for example, means forgoing all the benefits (opportunities) that such natural systems can provide, such as pollution buffering zones, storm protection zones, wildlife habitats, etc.

Nevertheless, the conventional economic approach tends, in practice, to be rather narrow and dominated by the economic efficiency objective (i.e. using scarce resources in such a way as to get maximum benefits net of any costs). By their very nature, environmental issues raise a broad set of scientific, political, ethical and economic questions. Thus, while it is important to investigate ways of using our environmental resources as efficiently as possible, it is also vital, for example, to monitor the fairness of the resulting distribution of benefits and costs (economic equity objective).

Questions concerning ‘fair’ distributions of resources can quickly become complicated and, in the environmental context, will involve fairness not just between individual people alive now but also between them and future generations yet to come. To take just one illustrative example, the exploitation of resources such as fossil fuels and minerals like iron ore and bauxite (non-renewables) today means less of a stock left for future generations. Other resources (renewables) like fisheries and forests may also be over-exploited and not given enough time to regenerate. Again the stocks of such assets for future generations will be reduced. The question can then be posed. Is this fair? Is it ‘right’ that those of us alive now should essentially destroy assets (and the economic opportunities that they yield) gaining benefits in the process, while passing on the costs to people not yet alive and who have had no say in the matter? Now, this argument has been deliberately set up in a simple way in order to provoke the reader into thinking about a number of important and tricky problems that are involved in the use and abuse of our environment.

The position taken in the analysis that follows is that economic efficiency – getting the most ‘welfare’ (benefits net of costs) out of a given collection of resources – is vitally important. But the very nature of environmental issues requires an extension (a ‘greening’) of the conventional economic approach to encompass, among others, distributional equity and environmental quality objectives.

However, there are a variety of green positions on offer and environmentalism (a social and political movement that encompasses how we feel about the natural world, and how we feel we ought to behave towards all living and inanimate objects (O’Riordan, 1991)) manifests itself in various ways especially in the green politics of Europe. In the next section, we will survey the various forms (‘shades’) of greenness with particular reference to their economic dimensions, as well as trying to discern some common features.

Shades of green economics

The different environmental ideologies that make up environmentalism are complex and dynamic phenomena, and it may even be the case that individuals can experience, to a greater or lesser extent, a number of ‘shades’ or levels of greenness. But in terms of the economic dimension there seem to be three common features:

1. A rejection of the idea that economic systems should be deliberately designed to satisfy the unlimited wants of ‘rational economic person’ (homo oeconomicus) – the archetypal selfish (greedy) inhabitant of the unfettered market economy. We need to think more about people’s (collective) needs and less about their individual wants. Human behaviour must be modified to some extent and greed constrained (Pearce, 1992).
2. A green economy is also one that has the capability of replicating itself on a sustainable basis. We will take a detailed look at sustainability and sustainable economic development in Chapter 4. Many definitions of sustainable development have been put forward but for now we will limit ourselves to thinking about this concept simply in terms of economic development that endures over the long run.
3. A green economy must, over time, evolve in such a way as to decouple the growth in economic output (activity) from the environmental impacts of that activity. On the basis of the materials balance principle, decoupling
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will involve technical changes such that our use of resources is made more efficient and our output of pollution becomes less and less damaging. Total decoupling is thermodynamically impossible and some environmentalists argue that decoupling is a necessary but not sufficient condition for a green economy. They would go further and either freeze the scale (i.e., size of economic output, its rate of change and the level and rate of change in population) of the economy, or actually reduce it.

At the risk of oversimplification, we can distinguish two broad ideological camps in environmentalism: technocentrism and ecocentrism (see Box 2.1). Supporters of an extreme technocentrist position would not wish to see constraints placed on individual consumers or on markets. They would support an ‘unfettered free market’ philosophy and combine this with a strong faith in the power of technology to overcome any ‘environmental limits’ problems (extensive decoupling possibilities). We label this position ‘cornucopian technocentrism’ and the resulting system the anti-green economy in Box 2.1.

A less extreme position, ‘accommodating technocentrism’ accepts that free markets have beneficial effects on the environment but only if individuals think and act green. The green consumer, green investor, green citizen and green employee are therefore powerful agents for a green economy. From this perspective, decoupling possibilities will be relevant, but also some environmental limits (e.g., life support system maintenance and waste assimilation capacity maintenance) will become binding and will require some scale changes if the economy is to be sustainable. Some environmental resources (known as ‘critical natural capital’) will have to be strictly conserved (and development activities forgone) to be handed over to future generations undiminished. Other environmental resources (‘other natural capital’) can be exploited because of substitution possibilities – between different categories of natural capital, or between natural capital and physical capital (i.e., man-made, machines, etc.) and human capital (i.e., human skills, knowledge and ingenuity). This ‘constant capital’ rule is an important feature of what we mean by sustainable economic development (see Chapter 4).

In reality, these categories are overlapping and as we pointed out at the start of this chapter several levels of greenness can coexist within one individual depending on the situation and context under study. Thus crossing the ideological divide into ecocentrism we can distinguish a position called ‘communalist ecocentrism’ which supports the idea of a deep green economy. Supporters of this position argue that absolute levels of scale should not decline, but neither should they increase. Limits thinking is now dominant and translates into calls for zero economic growth and zero population growth in order to establish the steady-state economy. Decoupling is supported but must be buttressed by moves to eliminate any increase in the future scale of the economy.

Box 2.1 Environmentalism

<table>
<thead>
<tr>
<th>Technocentric (overlapping categories)</th>
<th>Ecocentric</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Communalist'</td>
<td>'Deep Ecology'</td>
</tr>
<tr>
<td>'Accommodating'</td>
<td>'Communal'</td>
</tr>
<tr>
<td>Resource</td>
<td>Resource</td>
</tr>
<tr>
<td>exploitively, growth-oriented position</td>
<td>conservationist position</td>
</tr>
<tr>
<td>Anti-green economy, unfettered free markets</td>
<td>Green economy,</td>
</tr>
<tr>
<td>by economic incentive instruments (EI) (e.g., pollution charges, etc.)</td>
<td>Green markets guided</td>
</tr>
<tr>
<td>Primary economic policy objective, maximize economic growth (max Gross National Product (GNP))</td>
<td>Modified economic growth (adjusted green accounting to measure GNP)</td>
</tr>
<tr>
<td>Decoupling important but infinite substitution rejected. Sustainability rules: constant capital rule. Therefore some scale changes</td>
<td>Decoupling plus no increase in scale. 'Systems' perspective: 'health' of whole ecosystem very important; Gaia hypothesis and implications</td>
</tr>
<tr>
<td>Scaling imperative; at the extreme for some there is a literal interpretation of Gaia as a personalized agent to which moral obligations are owed</td>
<td></td>
</tr>
<tr>
<td>Support for traditional ethical reasoning: rights and interests of contemporary individual humans; instrumental value (i.e., of recognized value to humans) in nature</td>
<td>Further extension of ethical reasoning: 'caring for others' motive – intergenerational and intergenerational equity (i.e., contemporary poor and future people); instrumental value in nature</td>
</tr>
<tr>
<td>VERY WEAK SUSTAINABILITY</td>
<td>WEAK SUSTAINABILITY</td>
</tr>
</tbody>
</table>
Finally, we come to extreme ecocentrism which we have labelled the 'deep ecology' position supportive of a very deep green economy. Economic systems must as quickly as is feasible, be transformed into 'minimum resource-take' systems (i.e. minimum environmental impacts on sources and sinks). This transformation can only be accomplished by reductions in the absolute level of economy activity, negative change in economic output and reduced population levels (scale reduction). The deep ecology proponents also support a radically different set of ethical/moral principles (bioethics). We now turn to examine a little more closely the ethical arguments that underlie green economics and politics.

We have also fitted different versions of 'sustainability thinking' into the typology in Box 2.1, but we leave a proper discussion of sustainable development to Chapter 4.

Environmental ethics: opening up the 'moral reference class'

Ecological economists would argue that once one adopts the 'systems perspective' then the requirements of the system (the economy and its supporting ecosystems) can take precedence over those of the individual. This argument has important ethical implications for the role and rights of present individual humans compared with the system's survival and therefore the welfare of future generations. The constant capital rule for sustainable economic development requires us to adopt an explicit position on equity (justice) and asset transfers across people and through time. The ethical argument is that future generations have a right to expect an inheritance (in the form of natural capital/physical capital/human capital bequests) sufficient to allow them the capacity to generate for themselves a level of welfare (wellbeing) no less than that enjoyed by the current generation. In more formal language, the requirement is for an intergenerational social contract that guarantees the future the same 'opportunities' that were open to the past ('justice as opportunity' (Page, 1982)).

All this implies that the current generation has obligations to future people. This, in turn, requires that traditional forms of ethical reasoning (which are confined to questions relating to contemporary individual humans) must be broadened, or even abandoned. Philosophers refer to this as an 'extension of the moral reference class'. Green economics supports this extension beyond current individuals to cover the rights and interests of future generations of humans (the intergenerational equity criterion). But deep ecology goes much further and opens up the reference class to cover the interests and rights of non-human nature (animal rights, plants, species and even ecosystem rights). Such radical ethical thinking is necessary, they argue, because non-human nature (conscious and non-conscious) is capable of being inherently valuable (i.e. possesses intrinsic value).

So 'concern for others' is an important ethical issue in the green economics/politics and sustainability debate. To be ethically consistent, sustainable development seems to require us to increase the wellbeing of the least advantaged people in societies today, while at the same time ensuring that the prospects of future generations are not seriously impaired (intragenerational and intergenerational equity objectives). Clearly this is a tall order and will require (among other things) a strong moral commitment. Given that individuals are, to a greater or lesser extent, self-interested and greedy, sustainability analysts are exploring the extent to which such behaviour could be modified and how to achieve the modification. We devote much of Part III and Part IV of this book to an examination of the ways in which such a modification ('greening') could be stimulated. Box 2.2 summarizes very briefly some of the main ethical rules which can guide resource allocation.

Some analysts have argued that a 'stewardship ethic' is sufficient for sustainability, i.e. people should be less greedy because other people (especially the world's poor and future generations) matter and greed imposes costs on these other people. If humans are the stewards of nature, it is in their interests to protect and maintain nature because of the instrumental value that it represents. The protection given brings with it conservation of habitats and other non-human species (which may or may not be morally significant and possess intrinsic value).

Since bioethicists go further and argue that since all living things and even systems matter (i.e. have moral significance) then individual greed must be constrained because greed imposes costs on these elements of non-human nature. This latter position would be stewardship on behalf of the planet itself (known as Gaianism) in various forms up to deep ecology. Gaianism is linked to the scientific Gaia hypothesis (first published in 1972) which seeks to explain the survival of life on Earth for billions of years by treating life and the global environment as two parts of a single system (Lovelock, 1988; Watson, 1991). The system ('Gaia') has developed so that it can regulate and repair itself. Regulation means life actively keeps the global environment comfortable for life to continue. If Gaia is knocked dangerously off balance (by human activity and waste disposal), it can repair itself. But the process of repair only guarantees the system's survival and not the survival of any one (including humans) individual species. Thus Gaianism supports the systems perspective and the need for pre-emptive environmental 'standards' (e.g. covering key species and processes (known as 'keystones') but also conservation zones like national parks, green belts and air, water and solid waste disposal practices, etc.).

The anchor point for most positions that advocate the moral significance of systems and not just individuals is Leopold's 'Land Ethic' (Leopold, 1949). According to Norton (1990, 1992), Leopold's ideas can be viewed as an argument for a two-level criterion of ecosystem health and two-stage policy process. In the first stage, limits inherent in ecological systems (need for
Box 2.2 Ethical rules

**Teleology**

This involves weighing up goods and bads, and aims to maximize what is good. Goods and bads are broadly interpreted. So, for example, maximizing the economist’s notion of wellbeing (‘utility’ or preference satisfaction) would be a particular form of teleology known as **utilitarianism**. The essence of teleology is that it permits a balancing of goods and bads or of one good against another – equality against utility, for example. The cost-benefit approach (see Chapter 7) is teleological, being a form of utilitarianism based on preference satisfaction as a ‘good thing’.

On the teleological approach it would be consistent to adopt a policy that made future generations worse off compared to present generations, if the gains to the present are deemed to be greater than the costs to the future. Thus we may decide not to cut back very drastically on our emissions of CO₂ (carbon dioxide) and other so-called greenhouse gases because of the benefits we derive from the economic activity that is the cause of the emissions and/or because of the costs of abatement. It now seems fairly clear that atmospheric concentrations of the greenhouse gases are rising rapidly due to human activities and this does imply warmer temperatures and possibly other climate changes. But great uncertainty surrounds the scale and extent of climate change and the likely damage costs. So we might reason that the impacts of climate change will be gradual and easily managed by adaptive behaviour (helped by technical progress) in the future. Overall, on this reasoning the cost burden on the future will be positive but not very significant.

But teleology is not consistent, therefore, with the **sustainability** criterion which can be interpreted as ruling out policy programmes that impose substantial risk with regard to future welfare, and mandates above all that we provide for flexibility as future generations adapt to unforeseen and unforeseeable events (Howarth and Monahan, 1992). On this basis we should be cutting back now on greenhouse gas emissions and also making investments to reduce the vulnerability of certain geographical areas (e.g. low-lying coasts at risk from climate-induced sea level rise) and social groups (e.g. poor people in developing countries suffering from food insecurity).

**Theories of justice**

There are several theories of justice, some have been applied to the issue of how to account for the intergenerational distribution of goods and bads.

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**Contractualism**

Contractualists argue that people will come together to determine rules of social behaviour because it is to their mutual advantage to do so. But this doctrine of mutual advantage will arise only in social contexts where the parties to the ‘contract’ are of roughly equal power. But future generations not yet born have no power at all, so the requirement of roughly equal power is not met. Future generations cannot hurt us no matter how much we neglect their interests; they are vulnerable. Despite a large amount of literature trying to link the contractarian approach to the intergenerational equity criterion (based on variations of John Rawls’ work in 1971) none of the efforts are entirely satisfactory. These efforts are also inconsistent with teleology: justice would take precedence over the good.

**Rights**

On this approach, justice implies a duty to behave in a certain way, and confers a right on the person who is the subject of the duty to expect that behaviour. The rights approach is also inconsistent with teleology because what is right takes precedence over what is good. The ‘constant capital’ rule (the capital bequest over time) fits this approach since it is predicated on the view that future generations have a right to at least the same level of wellbeing as current generations.

But a problem arises because of the ‘contingency’ of future people, i.e. the fact that they may not exist at all; from the viewpoint of the present they are only ‘possible’ people, and the number and type of people depend in large measure upon current actions and decisions. It may not now be clear, therefore, who holds the rights. Take a resource allocation policy which has two alternative variants – fast growth and resource depletion over the next 200 years; or low growth and conservation. Depending on which choice was made, two sets of possible people can be envisaged, but only one set will become actual people. Actual people will depend on the chosen policy variant and that policy will be the desirable one since the actual people owe their existence to it, providing that their life is not so miserable as to be not worth living. Our intuition, of course, says conservation policy is desirable because its set of actual people would have been relatively better off. Assuming this ‘person-affecting view’, it is not clear to whom rights will belong in the future – called the ‘non-identity problem’.
**Resourcism**

On this approach each generation should have the same level of resources or productive capacity as each other. Their wellbeing may then differ, depending on what each generation makes of this stock of resources. But their capability to generate wellbeing would be the same. The 'justice as opportunity' argument (Page, 1982) fits into this category, as does the 'Lockean standard' view, i.e. each generation should leave 'enough and as good for others' (Pasek, 1992).

**Strict egalitarianism**

Here the insistence is on equality of some characteristic for each generation. It might be resource endowments (as with resourcism), or wellbeing itself. Or the rigidity may relate to the wellbeing of a target group, say the least advantaged groups or societies (the poor). No change would be permitted if the wellbeing of this poorest group was reduced, regardless of gains to other groups (Rawls called this the 'difference principle'). Again such approaches are inconsistent with the teleological view since none of them allows gains and losses to be weighed up independently of to whom they accrue.

Simplifying the literature a great deal we can group arguments against giving the same consideration to the future as to the present around the following notions:

(a) because of the very temporal location of future individual people - possible vs. actual people, 'circumstances for justice' are not present, and future people are vulnerable not equal to current generation;
(b) ignorance of future individual people's wants and needs;
(c) because of the contingency of future people there is a 'non-identity' problem.

Philosophers who support the intergenerational equity idea put up the following counter-arguments:

1. As long as some people will exist and will be in no relevant way unlike current right-holders, they are worthy of equal consideration.
2. Whatever the uncertainty about the extent of future preferences, it is clear that basic needs will exist and will not be substantially different from contemporary ones. The satisfaction of these basic needs will be a prerequisite of the satisfaction of most of the other desires and interests of future people regardless of their uncertainty.

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3. Obligations need not be tied to actual individuals but can be viewed as 'generalized obligations' from one generation to the next. Obligations on the current generation are to maintain a stable flow of resources into the indefinite future in order to ensure ongoing human life, rather than meeting individual requirements.

4. Generations are not separate but overlap; therefore there is a 'chain of obligation' stretching across time. Since families endure over time, concern about descendants cannot be separated from concern about the welfare of those in the present generation from whom the descendant will inherit. Concern for future generations should reinforce concern for current fairness. Equally, future generations are vulnerable to our actions so we are obligated to provide for the actual children of today, who will in turn be obligated to provide for their children and so forth from generation to generation. A chain of obligation is thus defined, from the present into the indefinite future. If we do not ensure conditions favourable to the welfare of future generations we wrong our existing children in the sense that they will be unable to fulfill their obligation to children while enjoying a favourable way of life themselves (Daly and Cobb, 1990; Howarth, 1992).

**Bioethics**

An ethic of the environment, it requires two conditions: that there are non-human beings which have moral standing; and the class of those beings which have moral standing includes, but is larger than, the class of conscious beings. Moral standing can be given to a being only if society morally ought to consider how it is affected by a given action or policy. Both conditions are satisfied if non-human nature (conscious and non-conscious) is capable of being inherently valuable (i.e. possesses intrinsic value) - see H. Rolston (1988). The debate in this context has been over how far to extend the moral reference class: animal interests and rights, plants and ecosystems as morally considerable beings - Leopold's 'Land Ethic'. Analysts have also argued over a literal and a metaphorical interpretation of Gaian theory which pushes the 'systems' perspective further (Wallace and Norton, 1992).
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derived from economic analysis, but constrained by rules for system maintenance derived from biological science.

The issue of valuation

The focus on the system also serves to highlight questions of valuation. To the economist, economic value arises if someone is made to feel better off in terms of their wants and desires. Positive economic value—a benefit—arises when people feel better off, and negative economic value—cost—arises when they feel worse off. What economic valuation does is to measure human preferences for or against changes in the state of environments. It does not 'value the environment'.

Objections to economic valuation must mean one of the following things:

1. The methods and techniques deployed by economists to measure preferences (e.g. willingness to pay for environmental quality) are unreliable and not valid. We examine these techniques and their limitations in Chapter 8 and conclude that reliable estimates of the value of a wide range of environmental goods and services are possible.

2. The fate of environments should not be determined by human wants at all. This we consider unacceptable on democratic grounds.

3. Human wants matter, but are not the only source of value. There is 'intrinsic' value in nature. The debate between instrumental and intrinsic value in nature is a sterile one. Economists do not deny the possibility of intrinsic value but choose to apply instrumental value via willingness to pay. The debate is sterile because it is not possible to show empirically what intrinsic value in nature is; it has to be accepted or rejected intuitively.

Nevertheless, there is a sense in which economic valuation of the environment will represent only a partial value. This is a criticism long held by scientists. Taking once again a 'systems' perspective, it is possible to argue that healthy ecosystems have to exist prior to the existence of individual functions and services such as watershed protection, storm buffering, waste assimilation, etc. Now total economic value (defined more fully in Chapter 8) relates to these individual functions and services (called secondary values). But total secondary value does not encompass the primary value of the system itself, its life-supporting functions and their 'glue value' that holds everything together and therefore has economic value. We cannot directly estimate primary value, but it serves to remind us that total economic value is an underestimate of the 'true' value of the environment. In terms of the ideological positions we reviewed at the start of this chapter, acceptance of the primary value concept gives further support to strong sustainability thinking.

Environment and ethics

We end this chapter by returning to the level of the individual as a consumer, investor, citizen and employee. Daly and Cobb (1990) are concerned that self-interested behaviour at the core of the market system will lead to corrosion in the system itself. They argue that self-interest corrodes the very moral context of 'community' that is presupposed by the market. The market actually depends on a community that shares such values as honesty, freedom, initiative, thrift and other virtues whose authority is diminished by the unfettered free market philosophy of value. If all value derives only from the satisfaction of individual wants, then there is nothing left over on the basis of which self-interested individualistic want satisfaction can be restrained. It could be argued then, that the market depends on the wider 'system' or 'community' to regenerate its moral capital, just as much as it depends on the ecosystem for its natural capital.

Ecological economists have highlighted the need to view individuals both as consumers (driven by self-interest, which requires modification) and as citizens (driven by ethical motives and moral arguments about what 'ought' to be done). Individuals have needs and not just wants. Needs are not substitutable as wants are, and most higher order needs relate to the wider community and its guiding principles. Sustainability may therefore represent high-order needs and values.

Conclusions

In this chapter we have argued that there are different 'shades of green' thinking within environmental economics and environmentalism in general. Much of the economic debate has centred on the need to constrain human greed, the sustainability of economic systems and the scope for decoupling economic systems from environmental constraints.

The adoption of the 'systems perspective' and the recognition of critical natural capital and the constant capital rule for sustainable economic development have ethical implications. Almost all shades of green economic thinking require support for an intergenerational social contract, i.e. the passing on over time of an adequate capital (all forms) inheritance. The strong sustainability position seeks to pass on a sufficient critical natural capital stock to future generations. Such assets have very high economic value but also in aggregate possess primary value (i.e. value over and above individual functions and services value).

Further reading

A non-technical survey of environmental ethics can be found in:
Economics and the environment


References


Chapter 3

Economic growth, population growth and the environment

Are there limits to growth?

Chapter 1 showed that the economy and the environment are closely linked through the materials balance principle. Economic activity can be viewed as a process of transforming materials and energy. Because we cannot destroy materials and energy in an absolute sense (the ‘first law of thermodynamics’), they will reappear as waste which, eventually, will be discharged to the environment. This suggests that the bigger the economy gets, the more waste will be produced. If we think of the environments that have to handle the wastes – rivers, land dumps, the seas, the atmosphere – as having a limited capability to absorb them, then the real possibility emerges that there is a limit to the expansion of the economy. We tend to measure the expansion of the economy in terms of increase in its national output, or Gross National Product (GNP). GNP is a measure of the level of economic activity in the nation. Increases in GNP are generally known as economic growth (Box 3.1). It follows that there may be a limit to economic growth. As growth increases, so the volume of waste increases relative to the limited capacity of natural environments to absorb that waste. When that capacity is exceeded, severe damage may be done to the environment, so much so that human wellbeing may actually fall. We will call this first ‘limit to growth’ the waste receiving limit to growth.

But this is not the only possible limit to growth. The materials and energy that are transformed by the economic system must come from somewhere. There are basically two sources: renewable resources such as forests and fisheries, and exhaustible resources such as copper, coal and oil. If a renewable resource is used carefully it is possible to ‘cream off’ some of it each year and allow it to grow back again. For every tree that is cut down, for example, another can be grown. Fish can be left to regenerate their stocks naturally, and so on. So, if we use renewable resources sustainably there need be no ‘limit to growth’ from renewable resources. But we cannot say the same
Panel (a) shows the absolute levels of gross national product (GNP) per capita for selected countries of the world, and Panel (b) the rate of growth of GNP per capita. In a few cases, even where GNP grows overall, some countries have population growth rates which are faster than their GNP growth – hence the GNP per capita falls.

<table>
<thead>
<tr>
<th>Country</th>
<th>GNP US$000 million</th>
<th>GNP per capita $</th>
<th>Growth rates in per capita GNP 1965–1989 (% p.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>5156</td>
<td>21 000</td>
<td>1.6</td>
</tr>
<tr>
<td>Japan</td>
<td>2818</td>
<td>24 000</td>
<td>4.3</td>
</tr>
<tr>
<td>Germany</td>
<td>1189</td>
<td>20 000</td>
<td>2.4</td>
</tr>
<tr>
<td>France</td>
<td>956</td>
<td>18 000</td>
<td>2.3</td>
</tr>
<tr>
<td>Italy</td>
<td>865</td>
<td>15 000</td>
<td>3.0</td>
</tr>
<tr>
<td>UK</td>
<td>718</td>
<td>15 000</td>
<td>2.0</td>
</tr>
<tr>
<td>China</td>
<td>418</td>
<td>350</td>
<td>5.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>319</td>
<td>2 500</td>
<td>3.5</td>
</tr>
<tr>
<td>India</td>
<td>235</td>
<td>340</td>
<td>1.8</td>
</tr>
<tr>
<td>S. Korea</td>
<td>212</td>
<td>4 400</td>
<td>7.0</td>
</tr>
<tr>
<td>Mexico</td>
<td>201</td>
<td>2 000</td>
<td>3.0</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>20</td>
<td>180</td>
<td>0.4</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>5</td>
<td>120</td>
<td>-0.1</td>
</tr>
<tr>
<td>Uganda</td>
<td>4</td>
<td>250</td>
<td>-2.8</td>
</tr>
<tr>
<td>Nepal</td>
<td>3</td>
<td>180</td>
<td>0.6</td>
</tr>
<tr>
<td>Mozambique</td>
<td>1</td>
<td>80</td>
<td>n.a.</td>
</tr>
</tbody>
</table>


about exhaustible resources since, by definition, there is only a finite amount of them; and they cannot be regenerated. So, if economic growth means using up more and more oil, for example, perhaps there will be a limit to economic growth set by the available stocks of oil under ground. We will call this the resource availability limit to growth.

We have two possible candidates for limits to economic growth:

- the limited capacity of natural environments to receive the waste generated by economic systems;
- the finite nature of exhaustible resources.
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A somewhat more rigorous definition of economic growth is in terms of increases in per capita GNP, rather than GNP itself. After all, we are unlikely to say that people are ‘better off’ economically if the economy grows but the average level of income falls. This possibility is a real one because in quite a few countries the rate of population growth is so fast that increases in economic growth are more than offset by the increased number of people. The average income falls, or at least does not rise as much as it might have done without population growth. This suggests that population growth is also a source of pressure on natural environments. This pressure takes many forms. The more people there are the more food will be needed. To get more food it becomes necessary to put more land under agriculture, displacing forests and many natural habitats. More people mean more demand for water. We tend to think of water as being plentiful, but in many countries water is a very scarce commodity. More people mean more demand for energy and hence more pollution from energy sources, and, in the developing world, more deforestation as people demand fuelwood (though this is not a major cause of deforestation in most countries). The faster is population growth, then, the quicker we are likely to approach both the waste receiving and resource availability limits to growth.

The interaction between population growth, economic growth, natural resource availability and waste receiving capacity is still regarded by many environmentalists as the reason why growth has to stop. The most celebrated expression of this view was in The Limits to Growth, a book by The Club of Rome published in 1972 (Meadows et al., 1972), but the view also has more current adherents (Daly and Cobb, 1990).

Critics of the limits to growth thesis point to a number of reasons why there may not be limits after all. Some of the reasons are given below:

- Changes in technology enable us to extract more and more economic activity from a given unit of natural resource. Put another way, the ‘productivity of resources’ increases over time and this makes available resources last longer and longer (Box 3.2). This is an important issue. It suggests that we can decouple economic activity and environmental impact by making our use of resources more and more efficient. Total decoupling is not possible: economic activity will always use some resources (by the laws of thermodynamics). But provided the amount used per unit of GNP goes down faster than GNP goes up, the impact on the environment can be reduced each year. One exception to this is cumulative pollutants: pollutants that build up over time because environments cannot break them down into harmless substances.

- We tend to discover more and more resources: the idea of a ‘fixed quantity’ is illusory (Box 3.3).

- We can control the amount of waste entering the environment by recycling materials and taking waste gases out before they leave the economic system.

Box 3.2 The productivity of resources

Energy use

Panel (a) shows that the amount of energy needed to produce one unit of GNP in the countries shown has declined substantially from the early 1970s to the present day. This shows that $1 of GNP is being produced in a more energy efficient way today than it was twenty years ago. Of course, other things besides being more energy efficient account for the decline in energy intensity – the switch from more energy intensive goods to less energy intensive ones, for example. But energy efficiency has played a major role.

For there to be true decoupling, however, we need to see these reductions in energy intensity translated into reductions in the total amount of energy used. This will happen only if GNP does not grow faster than the rate of change in energy intensity. Despite the reduced energy intensity shown in Panel (a), all the countries actually increased their energy use because of growth of GNP. But that decoupling is possible can be shown by the exception of Denmark which had slightly less energy consumption in 1989 than it did in 1970, despite having a 48 per cent increase in GNP in this
Economics and the environment

period. The United Kingdom also consumed only 5 per cent more energy in 1989 than it did in 1970 despite a 55 per cent increase in GNP. Clearly, if there was a bigger effort at energy conservation, decoupling would be possible.

<table>
<thead>
<tr>
<th>Energy intensity</th>
<th>Energy requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>(TOE per 1000 US$)</td>
<td>Change from 1970</td>
</tr>
<tr>
<td>Canada</td>
<td>0.80</td>
</tr>
<tr>
<td>USA</td>
<td>0.60</td>
</tr>
<tr>
<td>Japan</td>
<td>0.38</td>
</tr>
<tr>
<td>Australia</td>
<td>0.54</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.48</td>
</tr>
<tr>
<td>Austria</td>
<td>0.49</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.72</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.49</td>
</tr>
<tr>
<td>Finland</td>
<td>0.58</td>
</tr>
<tr>
<td>France</td>
<td>0.44</td>
</tr>
<tr>
<td>W. Germany</td>
<td>0.53</td>
</tr>
<tr>
<td>Greece</td>
<td>0.43</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.61</td>
</tr>
<tr>
<td>Italy</td>
<td>0.42</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.55</td>
</tr>
<tr>
<td>Norway</td>
<td>0.57</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.55</td>
</tr>
<tr>
<td>Spain</td>
<td>0.39</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.58</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.27</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.49</td>
</tr>
<tr>
<td>UK</td>
<td>0.61</td>
</tr>
<tr>
<td>OECD</td>
<td>0.54</td>
</tr>
<tr>
<td>World</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Note: Primary energy requirements per unit of GDP (at 1985 prices and exchange rates).
Source: OECD (1991)

Box 3.3 Discovering ‘new’ resources

In the physical sense, fossil fuel energy resources are, of course, finite. But new discoveries of what there actually is are made all the time. The ‘proved’ or ‘proven’ reserves therefore tend to increase over time as exploration and recovery technology improves (e.g. the North Sea, Alaska). Panels (a) and (b) show how the proven reserves of oil and gas have changed since 1965. In recent years the increases in oil are accounted for mainly by discoveries in the Middle East. The picture for natural gas also shows increases in proven reserves, although the picture here is one of continuous steady increases in contrast to the growth then stable reserves then growth again picture for oil.

Source: BP (1991)

Proved reserves.
Panel (a) Proved reserves of natural gas. Natural gas reserves have risen steadily for the past 25 years. This growth is particularly marked in the USSR and Middle East.
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Panel (b) Proved reserves of oil. Reserves increased steadily from 1965–1972, mainly in the Middle East. The increase in 1987 occurred in the Middle East and Venezuela, while the 1989 increase was mainly attributable to Saudi Arabia.

![Bar chart showing oil reserves]

- We can change polluting technologies for less polluting ones.
- If resources do get scarce then supply and demand theory tells us that their prices will rise and this will induce people to be more careful in their use (conservation) and to switch into other resources (substitution). This could be true for those resources that have market prices (coal, oil, copper, etc.) but, of course, it does not hold for those resources which are not bought and sold in market-places – the resource of the atmosphere, for example.
- Although the population is growing, in many countries that growth is slowing down as people realize the benefits of having smaller families (Box 3.4).

Economic growth, population growth and the environment

Box 3.4 Growth of the world’s population

There are currently around 5 billion people in the world. By the end of next century there may be twice this number. In only 30 years’ time the population is expected to reach 8 billion, an additional 3 billion people. But rates of growth are declining. Taking the years 1900–2000 and 2000–2100 as two distinct periods, the rates of change are given in Table 2.

<table>
<thead>
<tr>
<th>Table 1 World population (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Africa</td>
</tr>
<tr>
<td>Asia*</td>
</tr>
<tr>
<td>Latin America</td>
</tr>
<tr>
<td>Total: Developing World</td>
</tr>
<tr>
<td>Europe, USSR</td>
</tr>
<tr>
<td>Japan, Oceania</td>
</tr>
<tr>
<td>North America</td>
</tr>
<tr>
<td>Total: Developed World</td>
</tr>
<tr>
<td>Total: World</td>
</tr>
</tbody>
</table>

*Excludes Japan.
Source: T. W. Merrick (1986)

<table>
<thead>
<tr>
<th>Table 2 The rates of change in population growth (% p.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Africa</td>
</tr>
<tr>
<td>Asia</td>
</tr>
<tr>
<td>Latin America</td>
</tr>
<tr>
<td>Europe, USSR, Japan, Oceania</td>
</tr>
<tr>
<td>North America</td>
</tr>
</tbody>
</table>
The North-South divide

All of these things happen but it would be foolish to be complacent. It may be true that the rich countries will be clever enough to invent new technologies, find more resources, recycle more waste and still enjoy the benefits of economic growth. But for the poor world the picture is much less optimistic. A number of parts of the world already have populations that are close to, even in excess of, the carrying capacity of their environments. Carrying capacity is a useful if not altogether very rigorous concept. It refers to the capability of a given system to support a population. For example, suppose the prevailing agricultural system produces X calories and that each person needs a minimum of X/10 calories to survive. Then the carrying capacity of the system is computed as:

\[
\frac{X}{X/10} = \frac{10X}{X} = 10
\]

The carrying capacity of an area is categorically not the desirable level of population: carrying capacity is usually defined as relating to the maximum sustainable population at the minimum standard of living necessary for survival. Maintaining the maximum number of people at a minimum standard of living hardly qualifies as a desirable objective.

The most extensive analysis of the carrying capacity of the world was carried out by the Food and Agriculture Organization (FAO) of the United Nations. The FAO approach involved looking at the potential food production of each of 117 countries. Obviously, potential food production depends on the level of technology applied to agriculture. FAO categorized these as: low level: corresponding to no fertilizers, pesticides or herbicides, with traditional crop varieties and no long-term conservation measures; intermediate level: corresponding to use of basic fertilizers and biocides, use of some improved crop varieties and some basic conservation measures; high level: corresponding to full use of fertilizers and biocides, use of improved crop varieties, conservation measures and the best crop mixes.

On the basis of these different technological scenarios, it was then possible to estimate the potential calorie output. By dividing this by the per capita calorie intakes recommended by FAO and the World Health Organization for each country, a sustainable population can be estimated. These estimates were made for 1975 and the year 2000.

Box 3.5 summarizes the results in a convenient form. It shows the ratio of potential sustainable population in the year 2000 to the expected population in 2000 for various regions of the world, and at the three different levels of technology. For example, for the developing world as a whole, if all cultivable land was devoted to food crops, at the lowest level of technology those lands could support 1.6 times the number of people expected in the year 2000. In southwest Asia the actual expected population will exceed the carrying capacity at both low and intermediate technology levels. As the technological assumptions improve so, dramatically, does the carrying capacity of the regions.

Box 3.5 might appear to suggest a fairly optimistic picture. Certainly, it highlights the role which technological improvement can play in vastly increasing carrying capacity. However, it is important to understand why the picture is far from an optimistic one.

First, carrying capacity relates to the maximum number of people that can be sustained with the given resource, not to the desirable level. Second, the carrying capacity figures relate to a minimum calorie intake, so that even for a single person the approach makes no allowance for increasing nutritional levels. Third, the time horizon of 2000 does not permit much change to take place in levels of applied technology so that at least the high technology input scenario is of limited relevance to what will actually be the case. Fourth, the approach assumes all cultivable land will come under food production or livestock pasture, which is a clear exaggeration of what is feasible. Allowing for non-food crops, the ratio of 1.6 in Box 3.5 becomes 1.07, i.e. at low technology the carrying capacity of the developing countries is only 7 per cent more than the actual population.

In fact the situation may be worse still than is suggested in Box 3.5. The FAO study was concerned with carrying capacity in terms of food. But other resource scarcities may begin to exert an influence before cultivable land. A notable example is the availability of fuelwood. A study of the Sahelian and Sudanian zones of West Africa computed the carrying capacity of various zones according to the limits set by crops, livestock and fuelwood. The results are shown in Box 3.6. It will be observed that the carrying capacity of natural forest cover – the main source of fuelwood – is very much lower than that of...
Economics and the environment

Box 3.6  Carrying capacities in Sahelain/Sudanian zones of West Africa (in people/km²)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Sustainable population</th>
<th>Actual rural population</th>
<th>Sustainable fuelwood</th>
<th>Actual total population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crops</td>
<td>Livestock</td>
<td>Sum</td>
<td></td>
</tr>
<tr>
<td>Saharan</td>
<td>—</td>
<td>0.3</td>
<td>0.3</td>
<td>—</td>
</tr>
<tr>
<td>Sahelbian</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>5</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>7</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>10</td>
<td>35</td>
<td>9</td>
</tr>
</tbody>
</table>


crops using traditional technologies. Moreover, in five of the six regions (underlined) fuelwood carrying capacity is already exceeded, compared to two regions where food and livestock carrying capacity is exceeded. The general picture on world zone carrying capacities may therefore underestimate the problem of resource carrying capacity generally. What matters is which resource scarcity 'bites' first.

Conclusions

While we have shown that a great many of the criticisms of the original Limits to Growth book were justified, it does not follow that there are no limits to economic and population growth. Man's ingenuity has found many ways of making resources last longer, of getting more from less, and of preventing many potential pollutants from reaching the environment. But the benefits of a great many of those achievements have accrued to people who are already relatively wealthy. Breaching the limits in the rich world may well mean more ill health, more nuisance, more inconvenience. In the poor world breaching the limits may well mean starvation.

Even if we are not sure that there are limits to growth it would be prudent to behave as if there were. Provided we make no major sacrifices, this 'precautionary approach' serves to make people about as well off as they would have been without taking anticipatory action, while protecting them against major environmental damage that could seriously affect human wellbeing. As we shall see in later chapters, the world does tend to operate on this basis in respect of some environmental threats - the depletion of the ozone layer, for example. For others, it tends to react rather too slowly, as may be the case with global warming (see Chapter 19), and for still others it reacts hardly at all.

Further reading

The book that did most to advance the idea that economic and population growth would eventually bring about ecological disaster was:
D. Meadows et al., The Limits to Growth, Earth Island, New York, 1972.
A modern statement is:
Modern academic debates tend not to be conducted in terms of 'growth versus the environment'. Major critiques of limits to growth arguments therefore tend to be found in books and articles published in the 1970s. A good example is:

The idea of 'decoupling' the economy from its environmental impact is explored in:
**Sustainable development**

**Definitions**

Many definitions of sustainable development (SD) (often incompatible with each other) have been suggested and debated in the literature. What this suggests is that the debate has exposed a range of approaches which differ because they are linked to alternative environmental ideologies (see Box 2.1). From the eocentric perspective, the extreme deep ecologists seem to come close to rejecting even a policy of ‘modified’ development based on the sustainable use of nature’s assets. For them only a minimalist development strategy is morally sustainable. From the opposite technocentric perspective, other analysts argue that the concept of sustainability contributes little new to conventional economic theory and policy. Given this worldview, the maintenance of a sustainable economic growth strategy over the long run merely depends on the adequacy of investment expenditure. Investment in natural capital is not irrelevant but it is not of overriding importance either. A key assumption of this position is that there will continue to be a very high degree of substitutability between all forms of capital (physical, human and natural capital).

The classification scheme set out in Box 2.1 labelled these two positions as very weak sustainability and very strong sustainability respectively.

The most publicized definition of sustainability is that of the World Commission on Environment and Development (WCED) (the ‘Brundtland Commission’, 1987). The Commission defined SD as: ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ (WCED, 1987, p. 43).

On the basis of this SD definition both intergenerational equity and intragenerational equity concerns must be met before any society can attain the goal of sustainability. Social and economic development must be undertaken in such a way as to minimize the effects of economic activity (on resource sources and waste assimilation sinks – see Chapter 1) whenever the costs are borne by future generations. When currently vital activities impose costs on the future (e.g. mining of non-renewable minerals – see Chapter 16) full compensation must be paid (e.g. performance or assurance bonds yielding financial aid, or new technologies allowing resource switching say from fossil fuels to solar power, etc. – see Chapter 11).

The Commission also highlighted ‘the essential needs of the world’s poor, to which overriding priority should be given’. In other words, SD must allow for an increase in people’s standard of living (broadly defined) with particular emphasis on the wellbeing of poor people, while at the same time avoiding uncompensated and significant costs on future people.

The Commission also took a fairly optimistic view of the possibilities for decoupling economic activity and environmental impact (see Chapter 3) and in terms of our classification system has put itself into the weak sustainability camp. Recall that the strong sustainability supporters, while not dismissing decoupling, argue that modifications to the scale of the economy (the throughput of matter and energy) will also be required. The amount of scale reduction is debated within the strong sustainability camp (which is a fairly broad church’).

SD, it is generally agreed, is therefore economic development that endures over the long run. Economic development can be measured in terms of Gross National Product (i.e. the annual output of goods and services adjusted for exports and imports) per capita, or real consumption of goods and services per capita. In a later section we will argue that, in fact, the traditional GNP measure needs to be modified and extended if it is to measure SD. But for the moment SD is defined as at least non-declining consumption, GNP, or some other agreed welfare indicator.

**The conditions for sustainable development**

A more difficult task is to determine the necessary and sufficient conditions for achieving SD. Fundamentally, how do we compensate the future for damage that our activities today might cause? The answer is through the transfer of capital bequests. What this means is that this generation makes sure that it leaves the next generation a stock of capital no less than this generation has now. Capital provides the capability to generate wellbeing (‘justice as opportunity’ and the ‘Lockean Standard’ notions are relevant in this context – see Chapter 2) through the creation of goods and services upon which human wellbeing depends.

**Weak sustainability (WS)**

Under this interpretation of SD, it is not thought necessary to single out the environment (natural capital) for special treatment, it is simply another form
Economics and the environment

of capital. Therefore, what is required for SD is the transfer of an aggregate capital stock no less than the one that exists now (this then is the weak sustainability constant capital rule). We can pass on less environment so long as we offset this loss by increasing the stock of roads and machinery, or other man-made (physical) capital. Alternatively, we can have fewer roads and factories so long as we compensate by having more wetlands or mixed woodlands or more education. WS is, as we pointed out in Chapter 2, based on a very strong assumption, perfect substitutability between the different forms of capital.

Strong sustainability (SS)

Under this interpretation of SD, perfect substitution between different forms of capital is not a valid assumption to make. Some elements of the natural capital stock cannot be substituted for (except on a very limited basis) by man-made capital. Some of the functions and services of ecosystems are essential to human survival, they are life support services (biogeochemical cycling) and cannot be replaced. Other ecological assets are at least essential to human wellbeing, if not exactly essential for human survival – landscape, space, and relative peace and quiet. These assets are critical natural capital and since they are not easily substitutable, if at all, the SS rule requires that we protect them.

Measuring sustainable development

Another way of looking at the idea that SD means generating human wellbeing now without impairing the wellbeing of future generations is to think about a sustainable flow of income. This is a level of income that the nation can afford to receive without deprecating the overall capital stock of the nation. The danger is that a failure to adequately account for natural capital and the contribution it makes to economic welfare and income will lead to misperceptions about how well an economy is really performing. This danger is real because the current system of national accounts used in many countries fails, in almost all cases, to treat natural capital as assets which play a vital part in providing a flow of output/income over time. Extended national accounts (i.e., not restricted to market-based outputs, incomes and expenditure, as measured in the Gross National Product concept) are required in order to improve policy signals relating to SD.

Two adjustments are required, one for the depreciation of natural capital (changes in quantity) and the other for degradation of the natural capital stock (changes in quality). A framework to reflect the use of natural resources at the national level is in the process of being agreed by the United Nations Statistical Office. However, the theory and practice of making these adjustments is complex and they are not discussed further here (we provide some suggested reading at the end of the chapter). Instead we present a simple test for SD which yields data which is at least indicative of national sustainability. The test is, however, far from a definitive sustainability indicator, but it is based on modified national accounting information.

Simple indicator of sustainable development

One SD rule states that an economy must save at least as much as the sum of the depreciation on the value of man-made and natural capital (Pearce and Atkinson, 1992). An analogy with a business is useful in this context. If our business consistently failed to save enough money to plough back into the business, to replace machinery and buildings as they wear out (depreciate), we might stay afloat for a while but not long term – our business would be unsustainable. The same is true for any economy, its national savings ratio (savings over some measure of income like Gross Domestic Product (GDP)) must be greater than or equal to depreciation in the natural capital and man-made capital stock, if it is to pass our simple sustainability test. Box 4.1 illustrates some sustainability indicators for a selection of countries. Nothing definitive is being claimed since the data available is not always comprehensive and the test itself is ‘static’ and ignores factors such as technological change, population growth and international trade.

Precautionary principle and safe minimum standards

For some analysts supportive of the strong sustainability position, sustainability constraints (such as the critical natural capital protection rule) should be seen as expressions of the so-called precautionary principle and one similar to the notion of safe minimum standard (SMS). The SMS concept is one way of giving shape to the intergenerational social contract idea we discussed in Chapter 2. Somehow we have to trade off using resources to produce economic benefits and conservation of resource stocks and flows to guarantee sustainable benefit flows. The trade-off decisions have to be taken within a context of uncertainty and possible irreversibilities (i.e. decisions once taken result in changes that are physically impossible to reverse or prohibitively expensive to reverse, e.g. loss of tropical forests and complex wetlands). To satisfy the intergenerational social contract (via the constant capital rule and capital bequests), the current generation could rule out in advance, depending on the costs (strictly known as the social opportunity costs, i.e. what society has to give up or forgo), development activities that could result in natural capital depreciation beyond a certain threshold of damage cost and
Box 4.1  Test for weak sustainable development

An economy is sustainable if it saves more than the depreciation on its human-made and natural capital.

<table>
<thead>
<tr>
<th>Country</th>
<th>Gross savings ratio (S/Y)</th>
<th>Depreciation of human-made capital (d_w/Y)</th>
<th>Depreciation of natural capital (d_n/Y)</th>
<th>Sustainability indicator (Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>28</td>
<td>15</td>
<td>2</td>
<td>+11</td>
</tr>
<tr>
<td>Germany</td>
<td>26</td>
<td>12</td>
<td>4</td>
<td>+10</td>
</tr>
<tr>
<td>Japan</td>
<td>33</td>
<td>14</td>
<td>2</td>
<td>+17</td>
</tr>
<tr>
<td>UK</td>
<td>18</td>
<td>12</td>
<td>6†</td>
<td>0†</td>
</tr>
<tr>
<td>USA</td>
<td>18</td>
<td>12</td>
<td>4</td>
<td>+2</td>
</tr>
</tbody>
</table>

Notes and sources:
Y denotes that the values are expressed as a percentage of GDP.
S/Y is taken from World Bank, World Development Reports.
d_w/Y is taken from the UN System of National Accounts (UNSO, 1990).
The test takes the form,

\[ Z = S/Y - d_w/Y - d_n/Y \]

Z must be greater than or equal to zero for sustainability.

irreversibility (i.e. loss of critical natural capital, life support services, keystone species and processes) – see Box 4.2. The compatibility between SMS and strong sustainability is not, however, quite complete. SMS says conserve unless the benefits foregone are very large. SS says that, whatever the benefits foregone, loss of critical natural capital is unacceptable.

Sustainable livelihoods

Any sustainable strategy for the future will have to confront the question of how a much larger total global population can gain at least a basic livelihood in a manner which can be sustained. For the people of the South, many of their livelihoods will have to endure in environments which are fragile, marginal and vulnerable. Sustainable livelihoods can only be promoted via policies which reduce vulnerability – e.g. flood protection to guard against sea-level rise induced by climate change due to global warming (see Chapter 19); measures to improve food security and to offset market and intervention failures such as inappropriate resource pricing and uncoordinated development policies (see Chapters 5, 6 and 23).

Box 4.2  Safe minimum standards approach to sustainability

The line \( S_{de}-S_m \) represents some hypothetical safe minimum standard trade-off decision. Supporters of the weak sustainability (technocentric) position(s) might favour a line such as \( S-5_1 \); while very strong sustainability advocates, such as the deep ecologists, might favour a line such as \( S_{de}-S_{de} \).

Source: Adapted from B. Norton, Georgia Institute of Technology, quoted in Toman (1992).

Sustainable development: operational principles

A number of rules (which fall some way short of a blueprint) for the sustainable utilization of the natural capital stock can now be outlined (roughly ordered to fit the VWS to VSS progression):

1. Market and intervention failures related to resource pricing and property rights should be corrected.
2. Maintenance of the regenerative capacity of renewable natural capital (RNC) – i.e. harvesting rates should not exceed regeneration rates – and avoidance of excessive pollution which could threaten waste assimilation capacities and life support systems.
3. Technological changes should be steered via an indicative planning system such that, switches from non-renewable (NRNC) to RNC are fostered; and
### Box 4.3 Sustainability practice

<table>
<thead>
<tr>
<th>Sustainability mode (overlapping categories)</th>
<th>Management strategy (as applied to projects, policy or course of action)</th>
<th>Policy instruments (most favoured)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VWS</td>
<td>Conventional Cost-Benefit Approach:</td>
<td>e.g. pollution taxes, elimination</td>
</tr>
<tr>
<td></td>
<td>Correction of market and intervention failures via efficiency pricing;</td>
<td>of subsidies, imposition of</td>
</tr>
<tr>
<td></td>
<td>potential Pareto criterion (hypothetical compensation); consumer</td>
<td>property rights</td>
</tr>
<tr>
<td></td>
<td>sovereignty; infinite substitution</td>
<td></td>
</tr>
<tr>
<td>WS</td>
<td>Modified Cost-Benefit Approach:</td>
<td>e.g. pollution taxes, permits,</td>
</tr>
<tr>
<td></td>
<td>Extended application of monetary valuation methods; actual</td>
<td>deposit-refunds; ambient targets</td>
</tr>
<tr>
<td></td>
<td>compensation, shadow projects, etc.; systems approach, weak version</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of safe minimum standard</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Fixed Standards Approach:</td>
<td>e.g. ambient standards;</td>
</tr>
<tr>
<td></td>
<td>Precautionary principle, primary and secondary value of natural capital;</td>
<td>conservation zoning; process</td>
</tr>
<tr>
<td></td>
<td>constant natural capital rule; dual self-conception, social preference</td>
<td>technology-based effluent</td>
</tr>
<tr>
<td></td>
<td>value; ‘strong’ version of safe minimum standard</td>
<td>standards; permits; severance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>taxes; assurance bonds</td>
</tr>
<tr>
<td>VSS</td>
<td>Abandonment of Cost-Benefit Analysis:</td>
<td>standards and regulation; birth</td>
</tr>
<tr>
<td></td>
<td>or severely constrained cost-effectiveness analysis; bioethics</td>
<td>licences</td>
</tr>
</tbody>
</table>

**Source:** R. K. Turner (1993)

**Sustainable development**

- Efficiency-increasing technical progress should dominate throughput-increasing technology.
- RNC should be exploited, but at a rate equal to the creation of RNC substitutes (including recycling).
- The overall scale of economic activity must be limited so that it remains within the carrying capacity of the remaining natural capital. Given the uncertainties present, a precautionary approach should be adopted with a built-in safety margin.

Box 4.3 summarizes some of the measures and enabling policy instruments that would be involved in any application of an SD strategy. Succeeding chapters in this book cover these various elements in greater detail.

### Conclusions

Although it has been defined in many different, and sometimes contradictory, ways the concept of sustainable development does have both relevance and meaning. Weak and strong versions of the concept can be distinguished, and a rudimentary measure of sustainability can be calibrated. How precisely sustainability principles can be translated into operational practice remains more uncertain. But the framework for general sustainability rules has been set out and will require adaptation to specific economic and environmental circumstances.

### Further reading

The basic idea of sustainable development and the constant capital rule are covered in:


and in the context of developing countries by


The strong sustainability position is set out in:


Modified national income accounting is discussed in:


On the safe minimum standard see:


**References**


