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Environmentally Sustainable Development
An Overview

The environment and the economy of a country are inextricably linked. Attempts to maximise economic growth without reference to the environment are doomed to fail. Economic growth and development will not be sustained. Conversely, attempts to solve the problem of environmental degradation without examining the impacts of economic policies on the environment, are unlikely to succeed. Following the 1992 UN Conference on Environment and Development, many countries are in the process of developing and implementing comprehensive national plans for sustainable development. It is vital to integrate economic and environmental policies in the development and implementation of these plans.

This paper highlights the links between the economy and the environment; shows how the causes of environmental degradation can be found in the workings of the wider economy; and identifies the ways in which the economy can be managed, and economic instruments used, in order to make economic development environmentally sustainable.

1.1 The Links Between the Economy and the Environment

The relationship between the economy and the environment is illustrated in Figure 1. The economy can be visualised as a system which processes materials and transforms products. Useful materials are drawn from the natural environment into the economic system (e.g. non-renewable resources such as fossil fuels) and then undergo a series of changes in their energy and usefulness. Unless recycled, all materials eventually return to the environment. This process of inevitably returning materials and energy to the environment is the result of the First Law of Thermodynamics: we cannot create or destroy matter and energy; all we can do is transform it. Coal, for example, becomes heat, ash and particles. We can recycle materials but not energy; hence, by definition, a '100% recycling' society is not feasible. Nor is 100% materials recycling achievable. This is because economic activity tends to be 'entropic'- it uses materials and converts them into diffuse components which are then difficult and expensive to recycle.

Figure 1: **The Links Between the Economy and the Environment**

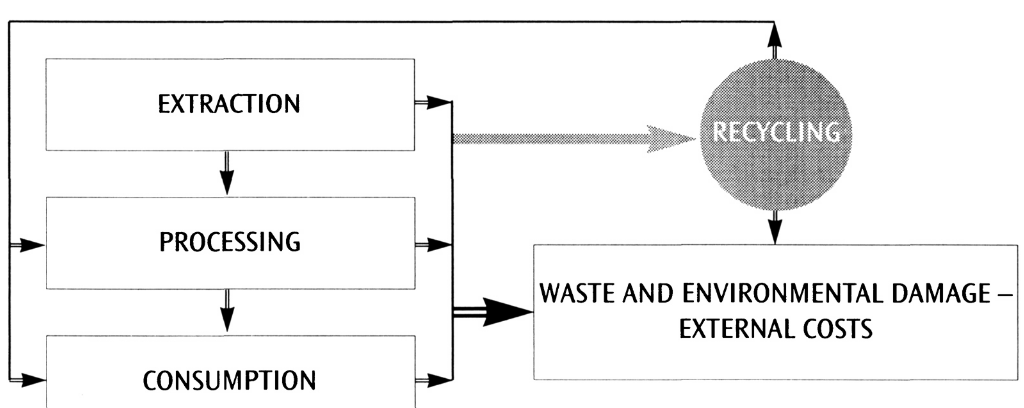


Figure 1 is a very simplified diagram of a 'materials balance' economy. Materials enter the economic system from the natural resources sector, and then exit the economic system to the environment as waste. The diagram immediately illustrates the *natural resource problem*. If the supply of natural resources is finite and we extract them each year for the economic system then, logically, we will one day run out of the resources. This is the 'resource scarcity problem'. Box 1 investigates this issue.

Figure 1 also gives us a clue about the *pollution problem*. Pollution arises as the obverse side of the natural resource problem. The more we take out of the natural resource sector, the more we emit to the environment. Less obviously, the process of transforming natural resources into usable products often changes the *nature* of those resources. Coal, as coal, is inert and non-polluting. Once converted, it produces solid waste and ambient emissions. The sulphur in the coal, for example, becomes sulphur oxides and these can damage health, buildings, and ecosystems. Even then, none of this might matter if the environment could receive the waste and cope with it. We might think of the environment (the seas, the atmosphere, soil, rivers etc) as having an 'assimilative capacity', i.e. a capacity to absorb and degrade wastes. This is true for many wastes, but untrue for some such as mercury and cadmium which do not degrade in the environment. Hence, the environment has varying degrees of assimilative capacity. If those capacities are exceeded then even low- toxicity wastes can cause problems. Essentially, what happens is that the assimilative capacity is itself damaged, making the environment less able to cope with further discharges of waste. If waste emissions continue, eventually the system breaks down or changes. Parts of the Baltic Sea, for example, are 'dead' in the sense that they support virtually no life forms. This is due to pollution. Finally, the diagram also shows that recycling can both reduce the rate of extraction of natural resources, and prevent waste reaching the environment, but, as noted above, this is not true for energy.

Box 1: **Measuring Resource Scarcity**

One way of estimating physical scarcity is through the 'exponential index' of stocks. This measures the number of years before stocks are exhausted, given an estimate of stocks and an estimate of the rate at which consumption grows. The formula for estimating this index, T, which is in years, is

$T = \ln(g.s + 1)/g$

where ln is logarithm, g is the average growth rate of consumption, and s is the static reserve index (current reserves divided by current consumption).

For example, known global reserves of bauxite in 1970 were 1170 x 106 tons (US) and the average growth rate of consumption was 6.4% per annum. Hence,

$T = \ln((0.064 \times 100) + 1)/0.064 = \ln 7.4/0.064 = 2.00/.064 = 31.2$ years.

The index for 1970 and 1994, for other resources, are shown below:

Resource	T_{1970}	T_{1994}	Rate of Discovery
Alum	31	104	+5.2% pa
Copper	21	25	+0.7% pa
Iron	93	115	+0.8% pa
Lead	21	11	-2.3% pa
Mercury	13	20*	+1.8% pa
Silver	13	na	na
Coal	111	139	+0.9% pa
Nat Gas	22	42	+2.7% pa
Oil	20	35	+2.3% pa

(All figures ignore recycling and any efficiency gains.)

* the growth rate of mercury consumption is actually negative but set at zero here so that exponential index = static index.

Note that in all cases other than lead, resources have increased their lifetimes.

One approach to sustainability, then, is to see what conditions have to prevail in order for a society to carry on at least as it is at the moment. From the diagram we can see that continuous extraction of resources is unsustainable if resource supplies are finite. This suggests switching from non-renewable resources to renewable resources where the flow of resource services (e.g. heat) is indefinite, as with solar energy. A second policy would be to maximise the level of recycling, provided it costs no more in terms of materials and energy to recycle materials than are saved by the recycling process. A third policy measure is to ensure that waste is emitted in both quantities and qualities that are consistent with the assimilative capacities of receiving environments. All these policies are consistent with Kenneth Boulding's concept of 'spaceship earth' (Boulding, 1966).

Whatever the relevant policy prescriptions, Figure 1 also reveals the fundamental basis of environmental economics: if we have an environmental problem we should always look at how the economy behaves to see if the cause of the problem lies there. Often we will find it does. If this is true, then the policy dimension is also clear: solving environmental problems will best be done by changing the causal factors at work in the economy. While some commentators still call for ways of 'integrating economics and the environment' the truth is that we have known the basis for doing this for some decades. The issue now is how to make it all work in practice and to gather experience to help us test some of the more detailed relationships involved.

1.2 Environment and Economic Development

Environmental degradation imposes costs on the economy. The most detailed studies of environmental damage and resource depletion costs in developing countries have been carried out for Indonesia (Magrath and Arens, 1989, and Repetto and others, 1989). Their analyses focus on the depreciation of forest assets and the costs of soil erosion. A forest can be viewed as a natural capital asset similar to a human-made capital asset. The asset yields a service over time for which there is a corresponding income. An asset can depreciate for two reasons: changes in value and changes in physical condition. Its value may change independently of any physical change; for example, its price can vary with demand. Obviously, value also changes if physical depreciation occurs. The issue is further complicated because the relevant cost should be that of non-optimal depletion: it cannot be assumed that all depletion is reprehensible. Table 1 shows the results of an exercise to value deforestation and soil erosion in Indonesia. Estimates of the cost of deforestation

Table 1: **Costs of Deforestation and Soil Erosion in Indonesia**

Types and Measure of Loss	(1984 US$ million in current prices)
Deforestation	
total value	3,054
as % of GNP	3.6
Soil erosion	
on-site	315
siltation of irrigation systems	10
harbour dredging	2
reservoir sedimentation	46
total value	373
as % of GNP	0.4

Sources: For forests, Repetto and others, 1989; for soil erosion, Magrath and Arens, 1989.

are obtained by estimating the value of the depreciation. The estimates of soil erosion damage are based on the production function approach which is discussed in Chapter 2.

1.3 Pricing and the Environment

Once the environment-economy link is explored, certain basic features emerge. These are:

a The environment tends to be degraded because it often has no price in the market place: we do not buy and sell clean air, or biological diversity, or nutrient cycling. But environmental conservation invariably has to compete against activities which do have market prices: agriculture, forestry, transportation. The result is that the 'playing field' is uneven. The environment loses because it appears to be worthless, whereas the activities that degrade the environment have economic value. Economists call this 'economic failure': the economic system has failed to take account of the many positive functions of the environment.

b If we create markets for the environment, then we establish *incentives* for people to conserve it. For example, if we tax air pollution we have effectively created a market in clean air. Those who pollute have to pay for the privilege of using up a scarce resource, the environment. This provides them with an incentive not to pollute or at least reduce their pollution. Similarly, if people own natural resources they are far more likely to take care of them than if they shared those resources with a great many others and no rules of access and use are applied. This is why some of the world's oceans are badly polluted: no one owns them. Where territorial rights have been exercised, generally, greater efforts have been made to conserve resources such as fisheries.

c It is fundamental that policies in these areas work towards empowering people. One might wonder whether this is another politically correct phrase. In fact, 'empowering people' has an *economic* rationale, because:

- ❖ intervention has a high risk of failure if the people affected feel excluded from the decision-making which affects their lives;
- ❖ local communities often feel excluded because they have no *incentive* to cooperate with policy (e.g. national parks that bar them from traditional uses of forest resources); and
- ❖ the costs associated with the failure to consult, involve and compensate people are often large and may affect project returns (e.g. resettlement of indigenous people).

Hence, whatever other rationales exist for participation, the economic case is strong.

1.4 Environmental Economics in Action: an Example

To illustrate these principles, consider the case of wildlife conservation in Africa. While a great deal of effort has gone into measuring wildlife benefits, there appears to be less information about the true *opportunity costs* of conservation. Opportunity costs refer to the value of the benefits foregone by conserving land for wildlife, rather than using it for something else. Table 2 shows two estimates for Kenya and South Africa. It is important to determine the correct basis for comparison. Much of the pressure on land in Africa, as in some parts of Asia, is (and will be) for food, both for consumption and trade. Hence, it is legitimate to compare livestock versus wildlife or crops versus wildlife. But there are various 'mixes' that also need to be considered, such as mixed wildlife and cattle systems. In turn, some wildlife utilisation is consistent with consumptive uses of wildlife, while most wildlife is consistent with non-consumptive uses such as eco-tourism. The studies mentioned in Table 2 give very different results. Since land in Kruger

Table 2: **Estimates of Macro Benefits and Opportunity Cost of Wildlife**

Country	Author	GDP from wildlife tourism/ forestry per year (US$million)	Foregone GDP= opportunity cost per annum (US$million)
Kenya	Norton-Griffiths and Southey (1995)	42	203
South Africa (Kruger National Park)	Engelbrecht and van der Walt (1993)	about 110	6
South Africa	Wells (1995)	254-2,174	?

Park is in fact mostly unsuitable for dryland cropping, livestock is, effectively, the only realistic alternative land use. Wildlife would appear to more than pay its way in Kruger Park. In contrast, the Kenya study suggests that Kenya is paying a very high price for its wildlife-based tourism. Despite gross revenues of US$400-450 million per annum, the actual net gain is found to be only US$42 million. This is because of an adjustment of halving the gross revenues on the grounds that wildlife tourism is not the only purpose for the visits, and that the different purposes are largely separable. Well's estimates of the value of the wildlife sector in South Africa cover a wide range for the same reason that it is not easy to allocate revenues to sectors when the revenues have a multi-purpose characteristic. Well's estimates dwarf those for Kenya probably for this reason. Wells' numbers refer to GDP but appear to be gross tourist expenditures, i.e. gross revenues rather than value added. It is clear that considerable research needs to be undertaken to extend and refine the estimates of both the value of the wildlife sector and its opportunity costs.

One conclusion from the Kenya study might be that the country would be better off not conserving its wildlife at all, but converting land to other uses. This appears even more attractive as an option in the face of a rapidly rising population. But this is only part of the story. A number of studies have attempted to estimate the willingness to pay for wildlife conservation in Kenya. Table 3 assembles the estimates, which were obtained using techniques which are discussed in Chapter 2.

First, consider Moran's estimate of economic value of $450 million per annum for Kenya, and compare it to the opportunity costs of conservation as estimated by Norton-Griffiths and Southey in Table 2. It exceeds the opportunity cost by a factor of two, whereas Table 2 suggests that the financial returns to Kenya are less than the opportunity costs. The two assessments are quite consistent: actual financial returns can be less than opportunity cost while economic value can be greater than opportunity cost. While the total willingness to pay to see wildlife in Kenya, and hence conserve it, greatly exceeds the oppor-

Table 3: **Willingness to Pay for African Wildlife**

Study and Approach	Resource	Willingness to Pay
Brown *et al* (1989): contingent valuation, foreign visitors	African elephant in Kenya	US$182-218m per annum
Moran (1994): contingent valuation, foreign visitors	protected areas in Kenya	US$450m per annum
Brown *et al* (1994): contingent valuation and travel cost approach	game parks in Kenya	US$52-86 per visitor day (CVM) US$77-134 per visitor day (TCM)
Navrud and Mungatana (1994): contingent valuation and travel cost approaches	Lake Nakuru, Kenya	US$7.5 m (CVM) US$ 13.7-15.1 m (TCM)

tunity cost of conservation, Kenya's current situation is that the actual financial returns from wildlife are significantly less than the opportunity cost. It follows that Kenya is failing to 'capture' the full economic value of its wildlife.

Second, and allowing for the uncertainty inherent in all these estimates, Kenya should be seeking to exploit this greater economic value by more careful pricing for entry to game parks, as indeed it has been doing recently. The willingness to pay estimates are basically showing us what the demand curve for wildlife conservation is like. This in turn means that it is possible to identify the price at which revenues to Kenya could be maximised. Such a charging policy would need to take account of carrying capacity measures, i.e. the 'optimal' price cannot be one that increases visitor demand, if that demand already threatens wildlife, as has been the case in some Kenyan reserves.

Third, the Brown *et al* (1994) and Navrud and Mungatana (1995) studies also show that revenue maximising prices would actually involve increases in prices and, hence, fewer visitors. Despite this, revenues would rise. The additional benefit would be less stress on animal populations. Pricing can be differentiated between residents, whose demand tends to be more responsive to the price of park entry, and foreigners, whose demand is fairly non-responsive to prices. This has been the policy in Kenyan game parks in recent years.

Fourth, while the studies quoted have not sought to find willingness to pay among foreigners who do *not* visit Africa, there is a strong likelihood that this 'existence' value is high (see Chapter 2 for the concept of existence value). Capturing this 'global value' is now the focus of many innovative schemes, such as debt-for-nature swaps, the Global Environment Facility, transferable development rights and other franchise agreements.

In conclusion, what this example illustrates is the following:

- a when wildlife has a market, it has the potential to compete with other economic uses of land;
- b nonetheless, the prevailing system might not maximise the gains from wildlife conservation;
- c hence, devising the best set of incentives and prices becomes very important so that gains from wildlife can be maximised and realised;
- d incentive systems will range from charging the correct price to 'capturing' economic value through various kinds of schemes; and
- e incentive systems must include those who otherwise suffer the consequences of conservation – communities that suffer from damage caused by wildlife, for example.

1.5 An Overview of Sustainability

When people refer to the factors which render an economy unsustainable, what exactly is meant by the term sustainability? Sustainable development was defined by the 1987 Brundtland Commission as the meeting of "the needs of the present without compromising the ability of future generations to meet their own needs."

An economic interpretation of this definition is that for an economy to be on a sustainable development path, the well-being of the present generation should not be increased at the expense of the welfare of future generations. In other words, society's well-being should not decline over time. Unsustainable development therefore implies that human well-being will decline at some point in the future.

The next generation can produce as much well-being as the present one only if it has the same resource base. This consists of all kinds of capital stocks and technology. Capital stocks, which can be used ever more efficiently through improvements in technology, comprise:

- ❖ Human-made capital (Km), e.g. factories and machinery;
- ❖ Human capital (Kh), e.g. education;

❖ Natural capital (Kn), e.g. forests.

To these some would add:

Social capital (Ks), by which is meant the presence of norms and culture which bind society together rather than divide it.

There are two principles for keeping the capital stock constant over time:

The **Weak Sustainability** principle requires leaving a constant aggregate stock of all forms of capital for the future generation. This provides the opportunity to substitute natural capital for human-made and/or human capital and vice versa. In other words natural capital can be used up provided, as we deplete it, we build up other forms of capital. In other words, K/N = {Km + Kh + Kn + Ks}/N should be constant or rising through time, where K and N denote overall capital stock and population, respectively.

The **Strong Sustainability** principle requires leaving a constant overall capital stock as well as a constant stock of natural capital. It is much more stringent than weak sustainability since it requires that natural capital should not be substituted with any other form of capital.

In other words:

Environmentally strong sustainability means Kn/N should be constant or rising through time and weak sustainability must hold too.

Socially strong sustainability means Ks/N should be constant or rising through time and weak sustainability must hold too.

Strong sustainability in terms of human capital means Kh/N should be constant or rising through time and weak sustainability must hold too.

It is also arguable that we could have a strong sustainability variant in which Km/N is constant or rising as well.

Note the importance of weak sustainability. If any particular form of capital is singled out, weak sustainability must still be honoured, otherwise we could have a constant stock of 'nature' per person, but fail to be sustainable because we let other forms of capital decay.

1.6 Measuring Wealth

The definition of weak sustainability gives us an immediate candidate for an **indicator of sustainability**. This is given by the total stock of capital assets, and the condition is that

K/N = {Km + Kh + Kn + Ks}/N should be constant or rising through time. We can and do measure Km, although it is a complicated process and the estimates are uncertain. Estimating Km requires using the **perpetual inventory method**, whereby each year's investment in Km is added up over time and allowance is made for the rate of decay (i.e. depreciation) of the individual components. The sum of the net annual investment becomes the wealth measure.

Natural capital depreciation is estimated in two ways. For natural resources, the **rents** are calculated as **price minus average cost** (actually this is profit, but price minus marginal cost, the true measure of rent, is difficult to estimate because of data problems). Rents multiplied by quantities extracted or harvested equals depreciation. For pollution, we multiply emissions by the shadow price of pollution (see Chapter 2 on valuation).

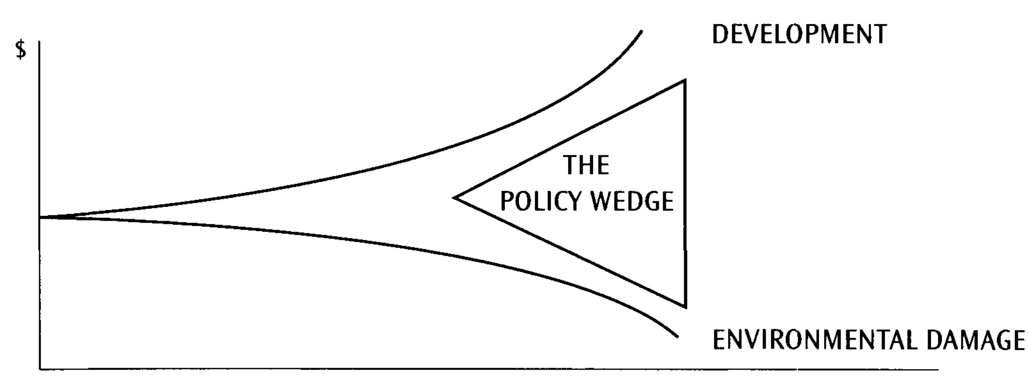
Human capital (Kh) turns out to be the most difficult to estimate. One could take expected lifetime earnings of a person with a given level of education and discount these to get a present value. This could then be compared to the expected lifetime earnings of someone with less education. The 'incremental' return would be the rate of return to education. But the World Bank takes a broader definition to include returns to labour generally (on the basis of the principle that even the most unskilled worker is in reality using skills). They assume that 45% of the agricultural sector's output in any year is due to labour, add this to non-agricultural GDP and subtract from this total the estimates of rents for Kn. The resulting total is then aggregated over the lifetime of an individual aged 1 in the relevant country and discounted. **Social capital** (Ks) is effectively subsumed in Kh in the approach adopted by the World Bank. As yet, no one has devised a way of measuring Ks separately.

1.7 Capital, Substitutes and Complements

Weak sustainability effectively assumes substitutability, whereas in each form of strong sustainability, a certain kind of capital is special in some way and cannot be substituted by other forms of capital. The on-going debate on this issue in the literature perhaps defines one of the differentiating features of ecological as opposed to environmental economics, although many of the claims that these subjects are very different are almost certainly spurious. The kinds of consideration that are relevant are: can we do without the ozone layer? If not, it might be classified as critical natural capital. It does have substitutes for some of its functions: e.g. sunglasses, clothing, sun-tan cream and hats will substitute for the ultra-violet (UV) radiation protection functions of the ozone layer, to some extent. But if UV radiation is implicated in significant reductions in ocean biomass productivity, as some claim, it is difficult to see what the feasible substitute is; and are not Kn and Km complements rather than substitutes? Don't we use timber and tools to build houses (i.e. Kn + Km make further Km)? Are not fishing boats (Km) combined with Kn (fish, oceans) to capture Kn ? The reality is that we do use many types of capital to produce other forms of capital, and we do so because their combination yields a higher rate of return than not combining them (trawlers are more productive than fishing lines, for example). But these combinations do also destroy Kn, e.g. Km, Kh and Kn combine in fishing to destroy fisheries; Kn, Km and Kh combine to build roads which may also destroy Kn. Hence, it seems that talking in terms of substitutes and complements is not necessarily very helpful.

In practice, finding the level of strong sustainability is difficult. If, for instance, ecologists could define the minimum critical amount of natural capital that must be preserved to ensure continued eco-system survival, the weak sustainability principle can be applied until that critical threshold. Thereafter, the strong sustainability principle would be implemented. A great deal of uncertainty remains over defining a critical minimum stock of natural capital and the extent to which science will reduce uncertainty over time is a contentious point. Given the weak and strong sustainability options, is it possible to promote economic development and conserve the environment at the same time? Figure 2 depicts how this may be possible.

Figure 2: **The Policy Wedge**



The 'policy wedge', which helps achieve the dual aims of reducing environmental damage and increasing economic development consists of the following measures:

- Creating new or enforcing existing property rights
- Creating countervailing power (empowerment, participation, consultation)
- Creating markets (both on a local and global scale)
- Changing intervention policies
- Addressing the issues of scale (population, the decoupling of economic growth and resource use)

The importance of these measures will become clearer in the latter Chapters.

1.8 Bringing Sustainable Development Down to Earth

Many of the implications of sustainable development are familiar messages about ensuring that environmental effects are fully accounted for in pricing and investment decisions, policy appraisal and macroeconomic work, including green national income accounts. But some differences of emphasis and newer directions are also called for with regard to the use of discount rates, land-use planning/zoning, and designing projects in harmony with nature. Special attention needs to be given to inter-generational concerns: the imposition of costs on future generations because of actions taken today (see Chapter 2 for a discussion on different perspectives on the use of discount rates).