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## AGRICULTURAL SUSTAINABILITY

### Definition and Implications for Agricultural and Trade Policy

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WP 91/01

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## 1.1 Introduction and overview

The notion of sustainability has been developing for some time in both the economics and ecology literature. Much of the economics of renewable resources has been concerned with sustainable yields (both maximum and economic optimum), and so the idea of the integration of economic and environmental issues is not new. What is novel however, is the extension of the area of concern from individual specie or ecological habitat to the sustainability of man's current demand upon the environmental system as a whole, and the possibility that those demands will be overbearing. The evolution of the concept has been reviewed elsewhere (Adams, 1990) and will not be pursued here.

Despite its long gestation, there is little convergence between the different notions of sustainable development. Given that its definition involves economic, social, political and ecological factors, perhaps this is not surprising. An important distinction can be made between the definitions of sustainable development and the conditions for achieving sustainability. We concentrate here on the definitions that have a significant economic or natural resource content, and investigate the criteria that may be used to achieve these, although this is not to deny the significance of the other, alternative views.

### 1.1.1 Definitions of Sustainability

There are a large number of alternative definitions, with the annex in Pearce, Markandya and Barbier (1989) identifying at least 24. The most quoted form, and the one that we propose to adopt, is from the Brundtland Commission:

'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987)

This has the advantage of being brief, and highlights the central concern within the sustainability literature, which is one of maintaining the welfare over time. Other definitions can be viewed as complementary, in that they become more specific, and address different aspects of this general statement, such as the nature of 'development', 'needs' or the time scale involved.

Pearce, Barbier and Markandya (1988a) take development to be a 'vector of desirable social objectives' (p3), with this vector comprising elements such as increases in real income per capita, access to resources, and a 'fairer' distribution of resources. Barbier (1987, p103) goes further, to suggest that '..[sustainable development] is indistinguishable from the total development of society...' and the analysis of it cannot take place independently of an analysis of the interactions between economic change and social, cultural and ecological change. The notion of needs can extend from the very general, to the specific, such as that given by Pezzey (1989): 'Our standard definition of sustainable development will be non-declining per capita utility...' (cited in Pearce et al. (1989)). The period over which this should be sustained is often not explicitly stated, but as Markandya and Pearce state: 'Unless there are good reasons to the contrary, the time horizon in question is an infinite one.' (1987,p19)

### 1.1.2 The Role of the Environment

The fundamental concept, then, is one of ensuring mankind's survival as a species, and maintaining the welfare of that species at as high a level as possible. It might be thought that this objective could be pursued independently of any environmental concern (and indeed much of the economic theory of growth has not included any reference to the environment) but this is not the case.

The environment can be viewed as providing four types of service.

1) Material inputs into the production process: either from renewable sources, such as wood, or exhaustible sources such as fossil fuels. These inputs can either be consumed directly (as in the case of food) or transformed before consumption. The form of the input can also be extended to those that involve 'non-use' of the resource, such as tourism.

2) As an assimilative waste sink for the by-products of production and consumption. Natural environments have a limited ability to process these by-products into forms that are not harmful to man or to productivity levels (e.g. rivers and seas can process a limited amount of pollutants).

3) By its complex nature and many interrelated factors, the environment can provide essential life support services, such as resilience to change. Reducing that diversity, or changing the interlinkages, may not affect the resources that are used directly, but may still have important impacts on human welfare.

4) The environment may provide 'existence values' directly, unrelated to any economic valuation of it. The source of this value may be traced to altruism, or a notion of 'stewardship' for the environment (see Pearce, 1987a).

The role of the environment in both enabling development, and ensuring its sustainability is now being explicitly recognised. Thus:

> 'Conservation of living resources - plants, animals, and micro-organisms, and the non-living elements of the environment on which they depend - is crucial for development.' (WCED, 1987, p147)

The usefulness of the slogan "sustainable development" is its suggestion that natural resources must be understood as productive capital, not just when they are mined or harvested as a flow of commodities, but as a working stock that contributes critically to production as it stands (Repetto, 1987)

### 1.1.3 LDCs' Interest in Sustainable Agriculture

The relevance of the sustainable development debate is not restricted to particular geographical regions, nor to countries in particular stages of development. What may differ is the transparency of the relationship between unsustainable economic activity and economic welfare. In developed countries there is a significant degree of 'roundaboutness' in economic activity: few of the population directly derive their livelihoods from utilizing the natural resource base. However, there is an emerging awareness that the pattern of development may be having long term effects in areas that had not explicitly been viewed as resources (such as pollution on assimilative capacity, or CFCs on the ozone layer, or consumption of fossil fuels on global warming) and that if a long term view is taken '..'sustainable development' becomes a goal not just for the 'developing' countries but for industrial ones as well.' (WCED, 1987,p4). It could be argued that this concern for environmental quality is a reflection of the higher incomes in developed countries: that essentially it is an income elastic good. This would imply that LDCs cannot afford to be concerned with the environment, as they have more pressing needs for consumption and growth, and hence less concern for conservation for future generations.

In fact, LDCs probably have a more direct and immediate interest in the concept, as many households are directly dependent on natural resources for welfare (Pearce, 1987b). In LDC's environmental degradation is not merely one of variations in the quality of life but one of the maintenance of life itself. Resource degradation may result in the transgression of the so-called 'inner limits' (minimum material needs for human survival) (James, 1978). The causes of this are

1. LDCs are comparatively more dependent on environment-based production -namely agriculture, forestry and fisheries -and its extensive sensitivity to ecosystem shocks and stresses, such as droughts, wars and floods. Wood and crop residues for fuel, direct abstraction of water, and use of marginal lands for subsistence crops are important examples of this dependence.

2. Capital and labour are relatively immobile (partly because of low reserves to search for employment, and relatively poor communication systems). With the collapse of production system in a local area or region, the individuals affected cannot easily find alternative employment.

3. Population growth in response to increased income may be faster in LDCs than DCs. If income cannot be maintained, considerable welfare problems will be encountered in the long term, as population cannot easily be reduced.[1]

4. Many LDCs have few reserves or the safety net of a social security system for taking risks on non-sustainability. Failure may have dire consequences.

5. Greater uncertainty in LDCs with respect to the probable effects of new technology. So there is an incentive to preserve existing systems (at least to a reversible level) until more knowledge is forthcoming.

[1] Tisdell and Fairbairn (1984) illustrate, for small subsistence economies such as the island economies of the Pacific, the adjustments required when exports of a non-renewable resource are halted as the resource is exhausted. In an alternative model he shows how international trade is not sustainable in the long run in this type of subsistence economy.

Table 1.1 gives a classification of different environmental concerns, from the differing perspectives of developing and developed countries, with emphasis given to the more significant elements in each. A point that is perhaps not sufficiently drawn out from this table is that the concern need not be restricted to the geographical region where the impact is occurring: thus the environmental impacts of deforestation include an impact on global warming, which is also important for industrialized countries. What does emerge, however, is the more immediate nature of the problems caused by environmental degradation in a developing country context in that it impinges directly and critically on human welfare.

**Table 1.1: Environmental concerns of developing and industrialized countries**

| Enivronmental concerns | Developing countries | Industrializing countries |
|---|---|---|
| **I Natural environment** | | |
| A Air | Air pollution in major cities | AIR POLLUTION |
| B Land, soil, mineral resources (incl. energy) | SOIL EROSION AND DEGRADATION, DESERTIFICATION | Soil loss and deterioration; dumping of waste; risk of radioactive contamination from nuclear-power production |
| C Water | FRESHWATER SHORTAGE; freshwater pollution (sewage,pesticides); pollution of coastal waters | Freshwater shortage; INLAND AND MARINE WATER POLLUTION |
| D Fauna and flora | DEFORESTATION (especially of tropical forests); loss of genetic resources; endangered species | Loss of genetic resources; endangered species |
| E Ecosystems | Pollution of coastal ecosystems (decreasing fish catch) | Disruption of mountain, wetland, fresh-water (especially from acid rains and eutrophication) and coastal ecosystems |
| F Natural disasters | FLOODS; DROUGHTS; STORMS; earthquakes, volcanic eruptions | Floods; earthquakes |
| **II Man-made environment & living conditions** | | |
| A Bioproductive systems | LOSS AND DEGRADATION OF ARABLE LAND; pests and pest resistance; water shortage; pressures on fish population (overfishing pollution); IMPACTS OF FUELWOOD CONSUMPTION, food contamination, post-harvest losses | Loss of croplands to urban sprawl; pests and pest resistance; contamination of crops and fish; over-exploitation of fishing grounds |
| B Human settlements | MARGINAL SETTLEMENTS (RURAL-URBAN MIGRATION, URBAN GROWTH) | URBAN SPRAWL; NOISE |
| C Health | MAL- AND UNDERNUTRITION; INFECTIOUS AND PARASITIC DISEASES | CANCER; cardiovascular diseases; genetic and long-term effects of POTENTIALLY TOXIC CHEMICALS |

Source: Bartelmus, P. (1986).

### 1.1.4 The Environment and Economic Growth: Trade-off or Complementarity

The problem still remains, however, as to whether there is an inherent contradiction between development and maintaining the environment. If development is viewed as resulting in increased economic activity, and greater transformation of products prior to consumption (a view that will be discussed later), then this may be seen as conflicting with maintenance of the environment. Exhaustible resources will be depleted, eco-systems transformed (i.e. by agriculture) and possibly the assimilative capacities overwhelmed. This need not be the only result, however. By their nature, renewable resources can be sustainably exploited, and their productivity enhanced by management and investment, as can the 'waste sink' role of the environment. It is possible that there is a complementarity between growth and the natural resource base. This possibility is shown in Figure 1.1 below, which is derived from Pearce and Turner (1990).

On the vertical axis is measured the standard of living (SOL) (or in some representations, the level of man-made capital), on the horizontal axis an aggregate measure of the environmental stock. If there is a conflict between growth and the environment, then society has to choose some point on the line A-B: higher levels of income can only be achieved by reducing the environmental stock. If there is complementarity between growth and the environment, then a point has to be chosen on the line C-D. The development process may be viewed as being a combination of both complementarity and trade-off. Thus in the early stages of development, growth in SOL occurs as the environmental capital is developed and expanded. However, at some point a limit is reached (i.e. E) where there then has to be a choice: if SOL is to be increased further, the environmental capital has to be reduced (or alternatively SOL falls if $K_n$ is to increase). Reaching a point such as E has implications for sustainable growth, in that there is a limit to the trade off (such as $K_{min}$) where the environmental capital cannot be further reduced. Getting access to the shaded area (denoted as the "sustainability paradigms") requires some additional mechanisms, such as technical change.

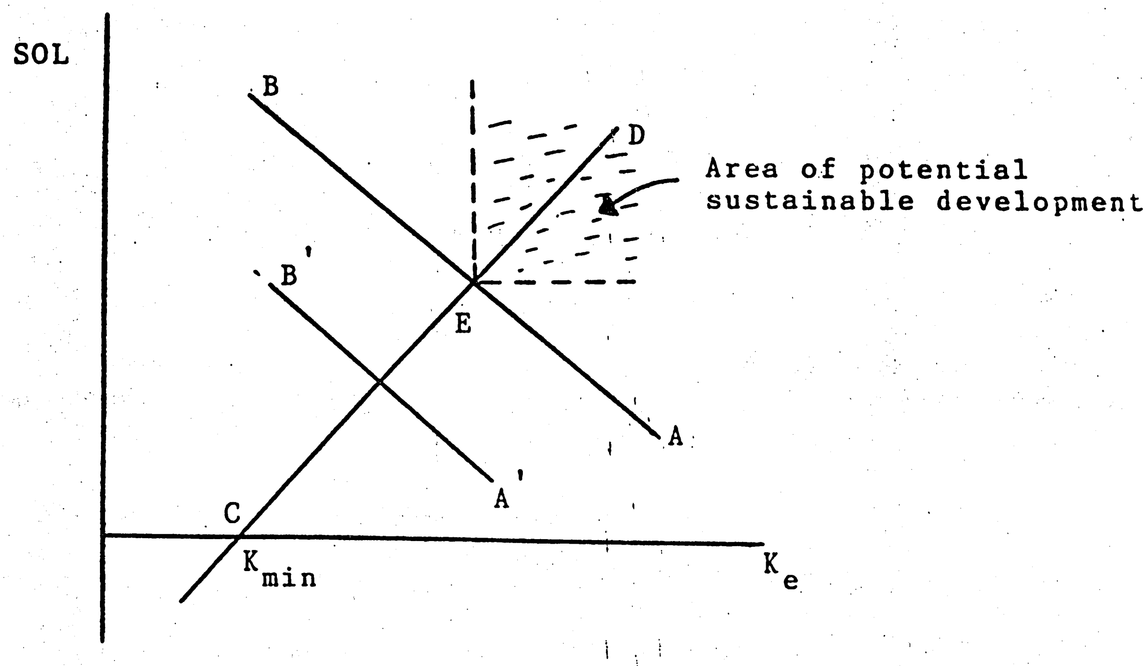


FIGURE 1.1 : Complementarity and Tradeoffs Between the Environment and Growth

It is more usual to suggest that there is a trade-off between environmental capital and economic activity (see, for example, the more complex representation by Siebert in Appendix 1), and the possibility that there is a complementarity relationship would mean that a country is on the inside of the production frontier. However, what a representation such as Siebert's does not accommodate is the dynamic of the development process. Thus development may be represented as an outward shift in the frontier over time, or a movement along a trade off function.

In Figure 1.1 this situation is represented by the line A'-B'. It is possible to achieve increases in SOL by moving up this line, but thereby eroding the environmental capital. However, complementarity would suggest that the whole frontier can be moved out towards A-B, increasing both SOL and the natural resource base. It would appear that this analysis implies that there is a fundamental difference in the notions of trade-off and complementarity. Trade-offs imply that the economic growth is being achieved (in some sense) by the consumption of the natural resource base. Complementarity does not imply that economic growth <u>creates</u> the natural resource base, but that the enhancement of the natural resource base is a pre-requisite for the economic growth to occur.

The notion of complementarity is attractive, in that it holds out the possibility of resolving both the poverty and environmental problems of LDCs (James, 1978). It should be noted however, that this complementarity is not limitless. It may also not occur over <u>all</u> aspects of the resource base. The provision of roads and other infrastructure is bound to reduce some aspects of the environment (through the physical destruction of the land, or loss of existence value). However, one could view complementarity between growth and an aggregate measure of natural resource, so that some resources may be degraded, but others are enhanced (e.g. the removal of forests may be replaced by more productive (sustainable) agriculture, or fisheries may be enhanced by management).

One could argue that the degradation of the resource base that some have identified in developing countries is due to movements along trade-off frontiers. If institutional and policy frameworks remain unchanged then the resource base can only be enhanced by moving back down the trade-off frontier, an option which is not desirable given the existing poverty of many of those countries. The challenge of sustainable development is to identify the mechanisms that can shift the frontier outwards: the policies and institutions that can ensure that the resource degradation is halted and reversed, and that economic growth can be made compatible with this. The important factors are the interactions between the specific environment and the type of development that is being undertaken.

The organization of the rest of this chapter is as follows. Differing perspectives of the criteria for sustainable development will be presented, from the agro-ecosystem level, through a more general, economy wide level, to a global perspective that raises fundamental issues in the relationship between man and the global environment. Some of the reasons why unsustainable development has occurred in the past will be reviewed, and some of the mechanisms that have been advocated for achieving sustainable development will be outlined. It is not the intention of this section to pre-empt the discussion of the role of trade, nor any recommendations that may be made on trade policy and the environment. Rather, it is provided to allow that analysis to be placed within the broader context of sustainable development and the environment.

## 1.2 Alternative Views of the Criteria for Sustainability.

### 1.2.1 Agro-ecosystem Level

At the farm or systems level, the emphasis within the sustainability literature changes from one of preserving overall capital stocks, to the problem of the degradation of individual resources or eco-systems. At this level the definition of sustainability most commonly adopted is that advocated by Conway (1987), of resilience.

Resilience is the ability of a system to maintain its structure in the face of external changes. These changes may be environmental or economic, and be of two types, stress or shock. Stress refers to small, incremental but persistent effects, the cumulative impact of which can be large. Examples could be erosion, salination or declining market demand for the product. Shock is a substantial but transitory factor, such as drought, or significant changes in input prices, e.g. due to an oil crisis. If an agro-ecosystem is resilient, then it can maintain its productivity in the face of such shocks or stresses. Human inputs and management can counter stress or shock, such as countering soil erosion by increasing fertilizer inputs, but such action may lead to further stress.

The development of agro-ecosystems is seen as a trade-off between the four properties of productivity, stability, sustainability and equatability. These four characteristics are illustrated in Figure 1.2, taken from Conway (1987).

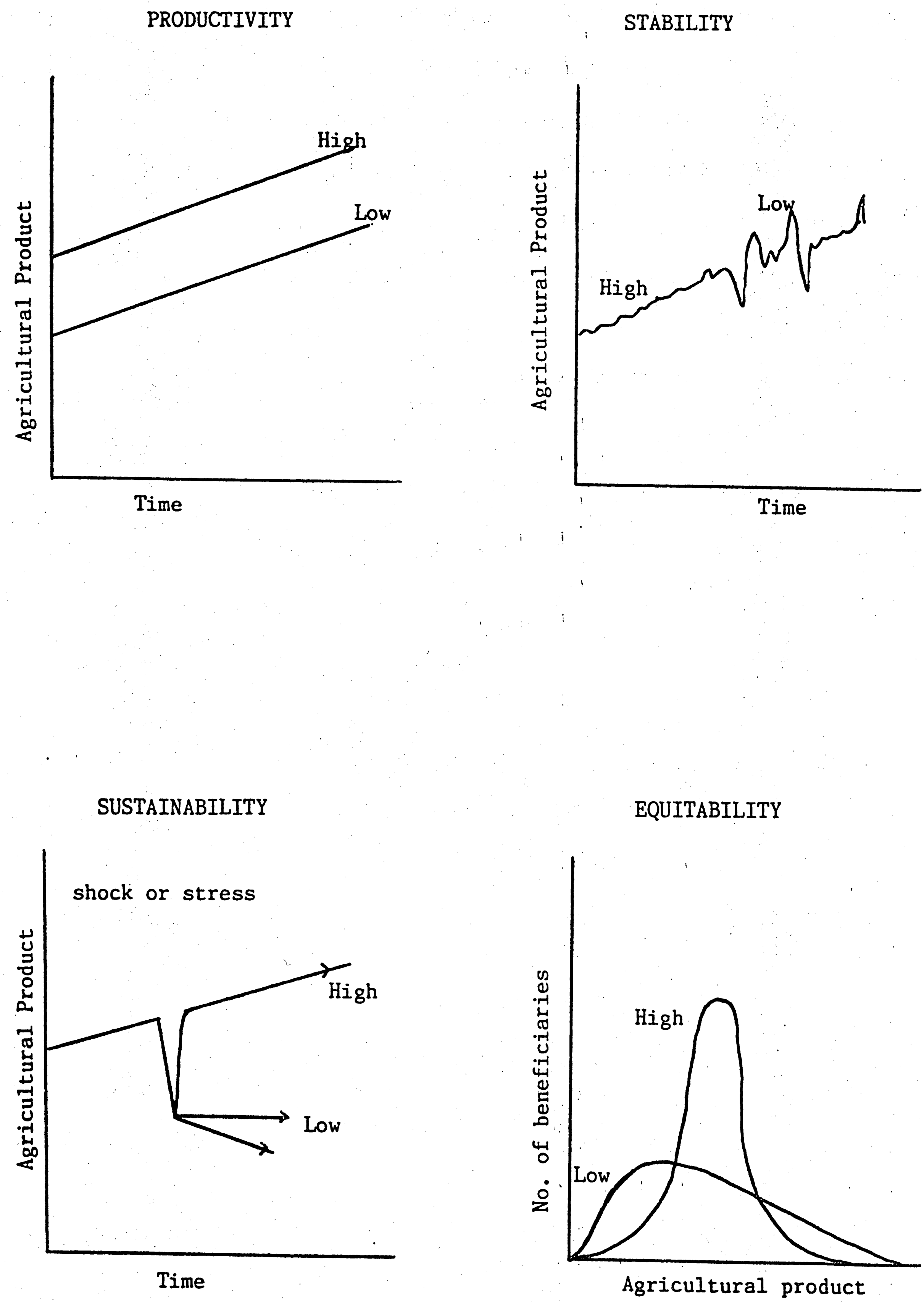


FIGURE 1.2: Indicators of Agricultural Performance

Source: Gordon R. Conway, Helping Poor Farmers - a Review of Foundation Activities in Farming Systems and Agroecosystems Research and Development (New York: Ford Foundation 1987).

Typically, increasing productivity (for example) by moving to monoculture systems, mechanization and the use of other inputs is seen as being at the expense of the sustainability of the system. The objective of agro-ecosystem research is to explicitly account for these trade-offs, in an attempt to identify systems that maintain or improve productivity without losing sustainability. Such systems are identified as including integrated pest control systems, multiple cropping, crop-livestock polyculture, communal resource use, etc. Of critical importance is the identification of the interaction of the farm management practices and the environment, where this is taken to cover all effects and not just those that affect the immediate production system. Thus the impacts of soil erosion or pesticide run-off extend beyond the farm on which it occurs and should be accounted for in any programme of sustainable development. Table 1.2 gives examples of agricultural systems that are likely to have a high potential for sustainability.

**Table 1.2 : EXAMPLES OF AGRICULTURAL TECHNOLOGIES THAT HAVE A HIGH POTENTIAL SUSTAINABILITY**

**Intercropping** - the growing of two or more crops simultaneously on the same piece of land. Benefits arise because crops exploit different resources, or mutually interact with one another. If one crop is a legume it may provide nutrients for the other. The interactions may also serve to control pests and weeds.

**Rotations** - the growing of two or more crops in sequence on the same piece of land. Benefits are similar to those arising from intercropping.

**Agroforestry** - a form of intercropping in which annual herbaceous crops are grown interspersed with perennial trees or shrubs. The deeper-rooted trees can often exploit water and nutrients not available to the herbs. The trees may also provide shade and mulch, while the ground cover of herbs reduces weeds and prevents erosion.

**Silvo-pasture** - similar to agroforestry, but combining trees with grassland and other fodder species on which livestock graze. The mixture of browse, grass and herbs often supports mixed livestock.

**Green manuring** - the growing of legumes and other plants in order to fix nitrogen and then incorporating them in the soil for the following crop. Commonly used green manures are Sesbania, and the fern Azolla which contains nitrogen-fixing blue-green algae

**Conservation tillage** - systems of minimum tillage or no tillage, in which the seed is placed directly in the soil with little or no preparatory cultivation. This reduces the amount of soil disturbance and so lessens run-off and loss of sediments and nutrients.

**Biological control** - the use of natural enemies, parasites or predators, to control pests. If the pest is exotic these enemies may be imported from the country of origin of the pest; if indigenous, various techniques are used to augment the numbers of the existing natural enemies.

**Integrated pest management** - the use of all appropriate techniques of controlling pests in an integrated manner that enhances rather than destroys natural controls. If pesticides are part of the programme, they are used sparingly and selectively so as not to interfere with natural enemies.

Source:- Conway (1987).

The dichotomy of 'internal' and 'external' resources has been suggested as being important for identifying those practices that will lead to sustainable agriculture. Thus Francis (1988) states:

> 'Sustainable agriculture builds its foundation on the resources which are renewable within the farm and its immediate area.'

Table 1.3 below summarizes internal and external resources. It will be noted that most categories of inputs can come from either internal or external sources, and that the use of external inputs is associated in part with the depletion of exhaustible resources. However, in the discussion that follows in that paper there is a modification of the general principle proposed earlier that internal are to be preferred, in that the introduction of hybrids and new varieties is advocated as being an important way of improving the use of the 'internal' resources. In fact, there is no rationale for trying to exclude these new crops if they can be integrated into sustainable systems, and to deny their value simply because they have to be purchased annually ignores the opportunity costs involved in farm-saved seed, both in terms of direct costs and potential yield losses.

**Table 1.3 : Agricultural Production Resources Which are Derived from Internal and External Sources**

| Internal Resources | External Resources |
|---|---|
| **Sun** - source of energy for plant photosynthesis | **Artificial lights** - used in greenhouse food production |
| **Water** - rain and/or small, local irrigation schemes | **Water** - large dams, centralised distribution, deep wells |
| **Nitrogen** - fixed from air, recycled in soil organic matter | **Nitrogen** - primarily from applied synthetic fertiliser |
| **Other nutrients** - from soil reserves recycled in cropping system | **Other nutrients** - mined, processed and imported |
| **Weed and pest control** - biological cultural and mechanical | **Weed and pest control** - chemical herbicides and insecticides |
| **Seed** - varieties produced on-farm | **Seed** - hybrids or certified varieties purchased annually |
| **Machinery** - built and maintained on farm or in community | **Machinery** - purchased and replaced frequently |
| **Labour** - most work done by the family living on the farm | **Labour** - most work done by hired labour |
| **Capital** - source is family and community reinvested locally | **Capital** - external indebted -ness, benefits leave community |
| **Management** - information from farmers and local community | **Management** - from input suppliers, crop consultants. |

Source:- Francis and King, 1988 p68.

In general, a point of concern in this categorization, is the apparent basis of the classification on geographical closeness. There is no *a priori* reason why purchased machinery should be less acceptable than that produced on the farm (nor why it should be replaced frequently). The classification advocated here could be interpreted as tending towards an autarkic state, where trade *per se* is undesirable. This stance would appear to deny the possibility of advantages to specialization and comparative advantage, and has not been universally accepted, even by those critical of current development practice, and who advocate the need for change. As Barbier (1987, p105) states:-

> '.. many agro-ecosystems are not 'closed' with respect to material cycling but are interdependent on one another and on other natural ecosystems for a continuous inflow of organic material and nutrients to maintain soil quality... If maintaining the nutrient levels and organic material of soil is a necessary condition for agricultural sustainability there should be no fundamental problem in maintaining an agro-ecosystem by some increase of external inputs provided those inputs are ecologically benign or even beneficial.'

Weeks (1987) views sustainable agriculture as primarily an issue of marginal lands. Sustainable agriculture is taken to mean systems which maintain environmental integrity <u>and</u> provide for sustained increase in household income. Production on the intensive margin is seen as sustainable and is amenable to mono-culture and mechanisation as methods of increasing productivity. However at the extensive margin, these practices result in lower crop yields, environmental degradation and furthermore, this environmental degradation provides cumulative changes which prejudice the broader environment.

Lynam and Herdt (1989) suggest that the issue of sustainable agricultural technologies can only be addressed if the system that is using the technology is well specified, which means that the criterion cannot be empirically applied above the farming system level.

### 1.2.2 Maintaining the Capital Stock

In trying to incorporate the notion of sustainability into the macro-economic models, a central theme which is emerging is that the capital stock should be maintained, where that capital stock is in some sense defined over both man-made and environmental resources. Apart from its intuitive appeal, the basis of which will be discussed later, the theoretical underpinning for this proposition appears to be the seminal work of Hartwick (1978) and Solow (1986). In Hartwick's original model, an economy is assumed to produce current output with the use of a stock of capital previously accumulated, and an exhaustible resource, with production being governed by constant returns to scale. If society adopts the classic Hotelling's rule for exploitation of the exhaustible resource, then it will be utilized so that the price of the resource increases at the rate of interest. Assuming constant costs of production (or zero costs in Solow's case) this implies that the resource rent (the difference between the value and costs per unit of extraction must rise. It is the destination of these resource rents that is important. If they are re-invested in the reproducible capital, then

> '... this society will find that it is just able to maintain a constant stream of consumption. The accumulation of reproducible capital exactly offsets the inevitable and efficient decline in the flow of resource inputs.'(Solow, 1986, pp144-145).

Solow goes on to show that this 'neat' result can be interpreted as maintaining a capital stock, such that net investment over all forms of capital is zero. This result appears to have achieved wide currency (Pearce and Turner, 1990, Pearce et al., 1989, pp49-50, Barbier, 1989b, p65, Barbier and Markandya, 1989) but there are two problems with it if it is to be practically implemented. The first is the requirement that there is an elasticity of substitution between the natural and reproducible resource of unity. Without this, the condition fails (Maler, 1986). There are good reasons why it may be expected that the substitutability between the two is not unitary, as there are some services from the natural resources that man-made capital cannot provide. The second, deeper problem is that the models based on this approach appear to ignore the biophysical limits that are emphasised by Daly (see section 1.2.3), and in particular the first law of thermo-dynamics. In simple terms this implies that the amount of 'waste' produced by a system must equal the amount of resource used up, where here 'waste' includes the product of capital depreciation (Pearce and Turner, 1990, p37). Within the Solow/Hartwick formulation, the constraint on net investment is a financial one, whereas there should also be a physical one, in that, depreciation of the physical stock has to be compensated for by extraction of the exhaustible resource. Over time, the model suggests growing capital stocks, implying higher depreciation to be met from the declining physical stocks of exhaustible resource. The system is not sustainable in a biophysical sense, even if it appears to be so in an economic sense.

> 'To apply conclusions derived from a model of circular flow of money to issues dominated by the linear throughput of matter-energy is a classic case of the fallacy of misplaced concreteness... Biophysical limits are real.' (Daly, 1987, p32.)

This may seem to be an abstract point of little relevance to practical policy implementation, but if the notion of maintaining a constant physical stock is to become central to the implementation of sustainability, then the definition of what resources should be incorporated into that definition of stock is important.

Two alternatives have been suggested,

(i) all stocks, both man-made, renewable and exhaustible resources (Pearce et al., 1989, p35) or

(ii) the natural resources only.

The reason for excluding the man-made capital is on the basis of the imperfect substitutability between man-made and natural resource functions, so that even if the aggregate of natural and man-made resources does not decline, if there is a loss of vital environmental services, then the accumulation of man-made capital cannot compensate for it (e.g. the depletion of the ozone layer), and the system is unsustainable.. The natural resource base assumption is implicit in the Brundtland report. Thus

> 'If needs are to be met on a sustainable basis the Earth's natural capital stock must be conserved and enhanced.' (WCED, 1987, p57.)

and this idea seems to be coming more widely accepted. This does not necessarily require that all natural resources are maintained, ('Every ecosystem everywhere cannot be maintained intact' WCED, 1987) but that there can be changes in the mix of natural resources, subject again to any non-substitution properties <u>within</u> natural resources. Thus Pearce et al. (1988a) restrict themselves to natural resources, and Barbier et al. (1990) restrict their concern to environmental assets only (soil, minerals, biomass, etc.), arguing that if one is concerned specifically with agricultural systems in less-developed countries then the dependence on essential environmental resources and ecological functions is critical (there may also be an inference that exhaustible resources should be excluded as '..dependence on exhaustible resource inputs is typically low' but this is not made clear).

The appropriate techniques for maintaining the natural capital stock are clear-cut for renewable resources or those that provide service flows. <u>Renewable resources should not be harvested at rates that exceed the regeneration rate, so that the resource stock can be maintained, and pollution levels should not exceed the capacity of the natural environment to assimilate them.</u> Substitution between resources would allow, for example, deforestation that is replaced with <u>sustainable</u> agriculture producing output of a similar value. Exhaustible resources pose more of a problem in that any consumption level is going to reduce stocks and future availability.

'It makes no sense to talk about sustainable use of non-renewable resources (even with substantial recycling effort and re-use rates). Any positive rate of exploitation will eventually lead to exhaustion of the finite stock.' (Turner, 1988, p13.)

Pearce and Turner (1990) suggests that the 'sustainablists' therefore resort to substitution possibilities between the exhaustible and other resources. However, as we have seen from the critique of the Solow model, the notion of substitutability in production does not lead to sustainability. Transforming non-renewable resources into depreciating capital may result in a significant increase in the productivity of the resource, but it ultimately consists of delayed consumption.

The best use of the exhaustible resource is to enhance the productivity in the renewable resources (Pearce, 1989, p45).

Again, care needs to be taken in the method by which this enhancement occurs. Raising the productivity of land by depleting mineral reserves and using them as fertilizer would achieve a short run substitution between the two resources, but this is merely a form of delayed consumption. What is required is that as each unit of a non-renewable resources is consumed, this resource is used to achieve a long run increase in the sustainable yield of the renewable resources. In this manner, the exhaustible resource can generate a continuous stream of social returns (Mikesell, 1989). This process can be envisaged either as enhancement of existing biological resources, establishment of new ones, or the development of alternative technologies (such as solar or wind power). If such sustainable enhancements in renewable resources are not possible then a case could be made for excluding them from the stock of capital that is to be maintained, as essentially they can not. The role of these resources in the development process then becomes more problematic. They should become an enabling resource, implying

'..depleting non-renewable resources at a slow enough rate so as to ensure the high probability of an orderly societal transition to renewable energy sources..' (Goodland and Ledoc, 1987).

This corresponds to the view put forward by Norgaard (1984a, p531) that the stock resources could be used '..as an input to affect coevolutionary development' (see the following section for a more detailed discussion).

Whatever the scope of the definition of the resource base, an additional problem exists in its measurement. Pearce et al. (1988a, 1990) suggest three alternatives.

(1) The maintenance of a constant physical stock is attractive, in that it is a direct measure of the resource base. However, given that it is the aggregate that is to be maintained, and that there are to be changes in the mix of resources (especially if exhaustible resources are included) then some form of aggregation mechanism is required.

(2) One option is that the economic value of the stock should be maintained. This allows both an aggregation mechanism and the possibility that physical stocks can fall if prices rise. The latter would be important if technological advances meant that the service flow could be increased from a given stock. In that case, a reduced stock would be compatible with sustainability, and would be feasible within the decision rule as the valuation of the resource would increase (as it is now more productive) hence the value of the stock remain constant. The difficulty with the approach is that the definition of the price of the resource is fraught with problems, in that all values of the resource have to be accounted for (and in particular, values that are not reflected in market prices). It also raises the possibility that a constant economic value may be achieved even if all natural resources are declining and there is no technological advance. As resources become scarce, their marginal value increases. If the price of the resource rises proportionally faster than the rate of depletion, then the value of the resource stock rises as it is depleted, despite the fact that the

physical resource base may be declining unsustainably.

(3) The third definition of constant capital stock uses the view that rising prices are an indication of scarcity, which in turn implies a variant on the constant economic value, namely that the price of the resource should remain constant. The point is made that for renewable resources current prices may not reflect future scarcity, but are simply functions of the flow of resource, with the example given of fuel wood prices remaining constant in real terms despite stock reductions as the quantity of wood supplied per period is held constant. Prices would then only rise at the end of the period. This appears to be an invalid argument, in that if wood is being exploited at an unsustainable rate, then it is being 'mined' as an exhaustible resource and the market should accommodate this. If it does not (as may be the case in practice) then there is market failure, which merely emphasises the point made earlier that the price used should reflect all economic values, and the valuation problem is now extended even to observed market prices.

A further point to be made is that the relevant price is an aggregate price (or price index) in that it is the aggregate stock that is to be maintained. Individual prices are to expected to vary as the composition of the aggregate changes.

There is not yet any concensus on what is the correct definition of the natural resource stock that is to be maintained. The one which appears to have the greatest theoretical content is the 'constant resource price' (which accommodates aggregation) but with the additional requirement that 'safe minimum standards' (Bishop, 1978) be identified and maintained. This would be the case for natural resources that are vital for sustainability and have no or low substitution possibilities with other resources. However, in general '.. the issues have yet to be resolved' (Pearce et al., 1988a, p11)

### 1.2.3 The Implications of Entropy and Coevolutionary Development

At this level, much of the debate is about the nature of what is being sustained. For Daly this hinges on the difference between growth and development, the bio-physical limits imposed by the first and second laws of thermodynamics, and the finite nature of many of the worlds natural resources. 'Growth' is here defined as

> '... quantitative increase in the scale of the physical dimensions of the economy: i.e. the rate of flow of matter and energy through the economy..' while development is '... the qualitative improvement in the structure, design, and composition of physical stocks and flows, that result from greater knowledge, both of technique and of purpose .... development is qualitative improvement in non-physical characteristics' (Daly, 1987, p323.)

For Daly, 'growth' as conventionally defined should be viewed as something to be avoided, in that it implies a higher level of throughput of the economic system, and given that the path of the throughput is linear in an entropy sense[2], this simply hastens the point where the bio-physical limits to 'draw-down[3]' are met. Thus the standard measures of economic welfare, such as GNP, in fact measure the throughput of the economic system, and should be minimised rather than maximised (Daly 1988 p53). Although this view may appear bleak, at a fundamental level it is difficult to refute: the 'impossibility theorem' that the goal of US levels of consumption/GNP for the world population would require global levels of exhaustible resource extraction at approximately seven times current levels, with the marginal environmental impact on

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[2] 'There is a one way, linear entropic flow (throughput) from the environment (depletion) through the economy (production and depreciation), and back to the environment (pollution).'(Daly,1987, p327). Entropy is a measure of the degradation of the universe. Any process results in the transformation of low entropy material (which can be utilized for work) into high entropy material (which cannot). Of particular significance is the transformation from low- to high- entropy status of terrestrial material.

[3] Draw-down is the process by which temporary economic expansion can be achieved by utilizing mineral stocks.

renewable resources and eco-systems substantially greater, leads to the notion of 'over' development as a counterpart to 'under' development (Daly, 1988). What in fact should be maximised is the flow of services from accumulated stocks (both man-made and natural). Thus development is seen as the process by which the flow of services can be enhanced without causing increases in throughput.

The notion of 'entropy' as a physical constraint on economic processes, and the importance that this places on the role of exhaustible resources and maintaining the flow of service from renewable resources is something which re-emerges throughout this introduction.

For Norgaard (1984a, 1984b, 1985), the problem is not merely the limits that the environment places on human actions, but the evolving nature of the relationship between man and the environment. Sustainability cannot simply be viewed as the optimal manipulation of a compliant environment to achieve a pre-determined set of objectives, as the environment itself will evolve in response to that manipulation. This view leads to two important implications. The first is that a naive application of the entropy concept to human development is misplaced. From the standpoint of mankind, there has not been a continuous process of wind-down in the status of the environment:

> 'Man could not have existed 4.5 billion years ago, before life began to evolve an order - through the use of solar energy - that had low entropy for man.... From the perspective limited to man and the earth, the evolution of life has been a negentropic process.' (1984a p531.)[4]

[4] That is, from man's perspective there has been an increase in the available low entropy material over an evolutionary time frame, but there is by necessity a limit to this.

This would accord with Daly's idea of development still being possible within the limits of minimised throughput, in that development is a change in structure. There are however caveats to this, the most important of which is that it is possible that the technologies being generated by development may simply be utilizing low-entropy stocks (e.g. the exhaustible resources) faster, or that the response of the natural environment to man's actions need not be fast enough nor sufficient to maintain the system. Thus 'coevolution' merely refers to the reciprocal process of change, with no guarantee that this is will be coevolutionary <u>development</u>, i.e. change that is to the (long run) benefit of man.

Although apparently abstract and operating at a level of generality and time scale beyond the norm used in economic policy analysis, the theory generates ideas that are echoed in the more pragmatic approaches to sustainability that were discussed in the previous sections. Thus the following quotation reflects many of the concerns about the optimal exploitation of exhaustible resources:-

> 'Coevolutionary agricultural development can be envisioned as a sequential process in which a surplus of energy and human capital ... is directed to establish a new interaction between the [socio- and eco-] systems. If this new interaction is favourable to man ... coevolutionary development is under way.... Stock resources, or the low entropy of the existing order of the world, can be used for consumption or as an input to affect coevolutionary development. This latter opportunity significantly alters how we should view the optimal exploitation of stock resources or, more precisely, their optimal exploitation in conjunction with flow resources.' (Norgaard, 1984a, p531.)

At the systems level, the point is made that Western agriculture, which does involve coevolution (the relationship between pesticide use and the evolution of resistance to them is an example) may not fit the coevolutionary development mould (1984a, p532). If the advances are merely the result of a temporary exploitation of exhaustible resources, the system will have to alter when those resources are depleted. It could be argued that meeting this limit will simply provide the impetus for a subsequent period of change (e.g. the development of nitrogen fixing plants, the application of bio-technology to food production), in the same way that it has been argued that the initial agricultural development was stimulated by environmental constraints (Boserup, 1965). However, the current form of agricultural development may well be limiting the possibilities for future beneficial coevolution in that it is reducing future options by reducing genetic diversity and degrading renewable resources or the flow of service that those resources provide.

The second important implication of this view of development is the appropriate framework for analyzing changes in the economic system, and for providing policy guidance in the task of influencing coevolution to our advantage. The view that the 'Atomistic-Mechanistic' approach is suitable, as exemplified by neo-classical economics, is rejected by the coevolutionary school. In the development of the A-M world view, the environment and natural resources played little part, with an emphasis on the interactions between labour and capital, the 'circular flow' of value through the economic system, stable equilibria and the reversibility of system changes (Norgaard, 1985, p383). The emergence of concern about the environment and the economic process has resulted in simple extensions to this theory, treating many of the environmental problems as 'externalities' to the system under consideration, to be dealt with by internalising them through changes in property rights or the assignment of shadow prices and regulation. By doing so, the economic analysis is ignoring many of the fundamental properties of the environmental system, and as a result at best can only achieve temporary success in dealing with existing problems (e.g. pesticide policy), while being particularly cumbersome in trying to identify time paths to avoid future problems (such as sustainability). This does not imply that the neo-classical paradigm is to be discarded for all purposes, and the coevolutionary world view substituted for it, but rather that the value of different models for different situations be recognised and that where one is on the boundary between different disciplines (as environmental economics is), there is a case for pluralism if errors of interpretation and prescription are to be avoided. Despite this concern, the majority of the abstract thought on the notion of sustainability within the economics literature is based on extensions and developments of the standard neo-classical model.

### 1.3 Examples of Unsustainable Agricultural Practices

There are problems in assessing the condition of world resources due to the sparseness, inexactitude, and non-comparability of available data. However concern is centred on five main aspects, desertification, soil erosion, loss of water quality, deforestation and loss of genetic diversity. These are not independent of each other, and a specific change in management practice may result in degradation in all or a number of these areas. Thus removal of tree cover may cause shortages of fuel provision and loss of the natural ecosystems, but then also lead to loss of soil structure, leading to desertification, soil erosion and hence also silting up of waterways. It is this multiplicity of impacts that makes the management of the resource base so complex.

#### 1.3.1 Desertification of Rangelands and Semi-arid Areas

In semi-arid areas, this involves impoverishment and depletion of vegetative cover, exposure of soil surface to accelerated wind and water erosion, reduction of soil's organic and nutrient content, and deterioration of its structure and water-retention capacity. In rangelands it results from overstocking and removal of plant cover. Warren and Agnew (1988) identify overcultivation as a much greater menace than overgrazing, as the exposure of the surface of the soil by cultivation encourages the loss of fertile topsoil. Mechanization in itself can create problems, and this has been attributed as the cause of the US dust bowl of the 1930's, as well as current degradation in developing countries.

### 1.3.2 Soil Erosion in Watershed and Upland Areas

Across all LDCs, FAO estimated that unless effectively checked, erosion would cost 20% of potential agricultural production by the end of the century (Repetto, 1987). Apart from the direct loss of agricultural productivity as a result of losing the soil, there are also substantial off-farm impacts where that soil then finds its way into watercourses, causing the silting up of waterways and reservoirs. Conway and Barbier (1990) report estimates of between $25m and $91m dollars for the offsite costs of soil erosion in Java.

### 1.3.3 Waterlogging and Salinization of Irrigated Lands

In large tracts of land that have already been irrigated, productivity is declining through salination and waterlogging, as the level of the watertable is raised, and insufficient attention is given to adequate drainage. The costs of bringing additional areas under irrigation has also risen markedly.

### 1.3.4 Depletion of Tropical Forests and Biological Diversity

The environmental impacts of the depletion of tropical forests have many facets. There is straightforward loss of the sustainable system of wood production, which may be followed by soil erosion if the loss of tree cover is not replaced by a sustainable land management system. If the trees are removed by burning, then this will add to the emission of $CO_2$ gas, which in turn may have an effect on global warming. The loss of the forest will also entail the loss of the other species (both animal and plant) that are dependent upon it, and this will represent an irreversible loss. Poore (1989) suggests that less than 1m ha. of tropical forest is managed sustainably, out of a total of 828m ha. One of the main reasons advocated for this failure is lack of tenure, or the certainty that the forest will be allowed to remain as a productive system. Without this, there is little incentive <u>not</u> to mine the forest unsustainably, nor to conduct the correct silviculture management practices.

### 1.4 Causes of Unsustainable Resource Management

This section is intended to give a brief review of some of the reasons advocated for unsustainable resource management, with examples of where they may appear to have caused problems.

#### 1.4.1 Population Growth

It is normally taken to be the case that increased population levels increase the likelihood of unsustainable natural resource use. They will cause additional demands for subsistence goods which will put pressure on renewable resource stocks, as well as intensifying the demands made on exhaustible resources. There will not only be additional pressure on currently sustainable agricultural land, but production may also expand onto previously un-exploited, marginal land that can not support the new forms of production needed. We do not explore the implications of this population pressure further, but note the point made by Repetto and Holmes (1983) that the extent of resource degradation is much greater than can be justified by appealing to population growth, and that there are other important causes as well. Furthermore, they argue that there is a synergy between population growth and these factors which result in the degradation being much worse than that due to population growth alone.

### 1.4.2 Property Rights

Possibly the most influential single idea in the management of natural resources is that of 'the tragedy of the commons'. As propounded by Hardin (1968), the existence of common property resources will lead to over-exploitation, as each person with access to the resource will increase exploitation for personal gain, even though the aggregate action of all means that the productivity of the commons falls. In fact, an important distinction has to be made between common property and open access resources. In open access resources, exploitation of the resource is truly open to anybody, but for common property resources, there is an identifiable body of users who have exclusive rights. Furthermore, there are usually very strong systems of control (e.g. social, or political or straightforwardly coercive, see Berkes, 1989) which have emerged to ensure that the resource is not over-exploited by the 'commoners'. It would be surprising for this not to occur, given the fragility of such systems (if mechanisms had not emerged, the resource would have long before been depleted). Hardin ignores such mechanisms, but ascribes the survival of commons to

> 'tribal wars, poaching and disease, which keep both man and beasts below the carrying capacity of the land.' (p162)

and their eventual decline to the emergence of 'social stability'.

In fact, the cause of the tragedy of the commons is more probably the reverse, with the breakdown of 'social stability' either through political, economic or military forces, resulting in a breakdown in the existing control mechanisms and the conversion of common property resources into open access resources, where the problem of over-exploitation is real.

The issue of property rights is not restricted to their existence, but also their allocation. If a large proportion of the population do not have access to, or are excluded from, the resource base, they will be forced to move onto the marginal lands to generate subsistence incomes, where these areas may not be capable of supporting this form of exploitation. The cause of this movement to the margin may be due to an increase in population, but also may be due to the re-structuring of property rights as a result of government policy. If particular commodity programmes are seen to be advanced by the encouragement of exclusive property rights to land, and the amalgamation of land holdings, then those who lose their property rights (or are encouraged to give them up through other policies) will move to the extensive margin (Southgate, 1990; Warren and Agnew, 1988; Twose, 1984).

The consequence of the absence of property rights is two fold. Firstly, the movement to the margin may result in the transformation of the environment, such as the conversion of forest to farm land, which results in the loss of the original resource and which may also not generate a sustainable alternative. The second consequence is the lack of any incentive to invest in land conservation, even where such systems could be sustainable. There is both theoretical and empirical evidence to suggest that the lack of property rights results in avoidable resource degradation (Southgate, 1990; Conway and Barbier, 1990).

The conclusions of this section are subtle: property rights appear to be a fundamental aspect of the sustainable use of resources, and open access resources will be overexploited. Although in some cases the establishment of sole ownership property rights may improve resource management, this is not necessarily the case, especially if this results in the removal of traditional common property management systems, and for some eco-systems this may actually result in degradation. Furthermore, it is not just the existence of property rights that is important, but the allocation of property rights, both on the extensive and intensive margins.

### 1.4.3 Poverty

The claim is often made that it is the resource poor who are responsible for the majority of the resource degradation that occurs. This is in part attributable to their lack of property rights, as discussed in section 1.2.3 above. Although poverty may be associated with lack of property rights, it has an additional impact on resource degradation, which may occur even if property rights are well defined. The ultimate constraint faced by the poor is one of survival, so even if they have sole access to a resource, they may still degrade it unsustainably if that is the only way in which they can survive, irrespective of the future costs that will be incurred as a result of that degradation. It has been suggested that this behaviour is attributable to 'high' discount rates on the part of the resource poor (Pearce 1988b, Weeks 1987, Barbier 1987). From an analytical viewpoint it would seem more reasonable to simply describe it as survival constrained behaviour, but either way it has significant impacts on resource use (see section 1.5.2 for a more detailed critique of the 'high interest rate' rationalization). A further consequence of poverty is not just resource degradation, but also a lack of resource re-generation. Capital is needed to restore (and hence to increase the sustainable productivity of) degraded land, and the poor do not have access to it (Warren and Agnew, 1988).

### 1.4.4 Prices and Government Policy

The role of prices in resource degradation is not clear-cut and a source of some conflict in the literature. One proposition is that it is the lack of prices for non-market goods that cause them to become over-exploited. This is common view on pollution etc, and leads to policies that suggest tradeable licenses, essentially creating a market and a price for the good. Alternatively a tax or subsidy should be placed on inputs that damage/enhance the environment in ways that are not already reflected in their market price (see section 4.1.1). The effects of commodity prices on resource use is in fact more difficult to identify for agriculture. Higher agricultural prices give higher incentives to increase input use, and may make mechanization viable, both of which may cause environmental degradation. They may also encourage the conversion of resources to agriculture that otherwise would not be converted (such as virgin forest and rangelands) as the value in agriculture is now higher. However, they may also encourage more conservation work on existing agricultural land, as the resource is now more valuable, and losses in productivity (such as from soil erosion) now exceed the costs of avoidance (Southgate, 1990). Also, increased prices may reduce the level of poverty (of net producers), so that the higher prices enable the resource poor to achieve subsistence levels of consumption without unsustainably depleting their resource base. Again it is the interaction of several elements that is important. The existence of property rights may encourage conservation of the resource, but may lead to new techniques or new crop mixes that are not favourable to the environment. Whether that has adverse impacts depends on the relative technologies used (Barbier, 1989c). Where there are no property rights increased commodity prices may lead to further degradation of the resource base.

Government input subsidies, land taxation policies or government directives have similar, ambiguous effects. Again there is a synergy between these elements and those of poverty and property rights.

In Chapter 3 some of these issues are further explored, with particular reference to changes in prices that may be induced as a result of agricultural policy reform.

## 1.5 Criteria for Sustainable Development

This section is not intended to pre-empt the later discussion on the required modifications to policy that the discussion of trade and the environment will generate. Rather, it is intended as an overview of the general criteria that have been advocated for achieving sustainable development.

Given the concern with maintaining a constant capital stock as the criteria for sustainability, it is not surprising that there are several approaches that have been developed that attempt to formalize this.

### 1.5.1 Natural Resource Accounting

In the definitions of Gross National Product that are used, environmental capital is in an anomalous position with respect to other forms of capital. If man-made capital is depreciated, then that depreciation appears as a cost in the accounts, but if natural resources are depreciated then they are not. This means that apparent increases in GNP can be achieved by consuming the natural resource capital, which is obviously not sustainable. Natural Resource Accounting advocates the valuation of all natural resource depreciation, and deducting this as a cost from GNP (Pearce et al., 1989 Ch.4, Levin, 1990). The resources to be treated in this manner are the exhaustible resources, but also any reductions in the stock of renewable resources, and declines in the stock of environmental resources that provide flows of services, such as the soil or air quality. In this way, reductions in capital stock are explicitly expressed. This does not mean that the natural resource base will be explicitly maintained, but that degradations in it will be accounted for.

### 1.5.2 Cost Benefit Analysis.

Pearce et al. (1988a) suggest a modification to the standard cost benefit (CB) methodology to ensure that the natural resource base is preserved. Thus the standard criteria for accepting a project is that the net benefit be positive, where that net benefit is usually defined as a discounted sum over some (possibly infinite) time horizon.

The modification that is introduced suggests that the project should be undertaken if the net benefit is positive, and the natural resource base is not degraded.

To apply this to each individual project would probably be infeasible, as it is unlikely that individual projects could ensure that there is no degradation, but given that it is the aggregate resource base that has to remain constant, one does not require all resource stocks to be maintained, just that any degradation in one is compensated for by enhancements elsewhere. Thus the criteria is introduced at the programme level, so that the net environmental damage is non-positive. This requires a series of 'shadow' projects in any programme, the intention of which is to compensate for any reduction in capital stock implied by the main projects. There are then two alternative forms of sustainability:

Weak Sustainability requires that the sum of the discounted net present value of the damage costs across all projects is non-negative[5], whereas

Strong Sustainability requires that the value of the damage costs be non-negative in each period.

It would appear that the strong form is to be preferred; otherwise a substantial reduction in the resource base at a distant point in time can be 'compensated' for by a small increase in the resource base now. This is the standard form of the result from CB analysis, given the use of a positive discount rate, but in that case it relies upon the possibility that the current investment can accumulate at the compound interest rate, and thereby compensate the later loss. Given the nature of the environmental resource base

[5] Note that within the CB framework conventional environmental damage would take a negative value; environmental enhancement would have a positive value.

that is being maintained, this accumulation is unlikely to be feasible. For example a project with a positive net benefit, but which results in 100 units of soil degradation in 50 years time can proceed if a shadow project is established that regenerates 1 unit of soil in the first period, assuming a 10% discount rate, and that the 'valuation' is constant over time. Clearly, the resource base is degraded.

Although computationally difficult, the advantage of the method is that it requires an explicit recognition of possible resource degradation as a result of projects, and requires some action to meet this.

<u>A Digression on Discount Rates</u>

As an incidental point, this methodology raises the question of the appropriate rate of interest to apply. Discounting in this context is contentious because it shifts environmental costs forward to future generations, and, it has been argued, is detrimental to the conservation of resource stocks, both exhaustible and renewable. However, simply reducing the rate does not unambiguously improve the position of natural resources. If the discount rate is reduced, then more projects will meet the criteria for acceptance, implying a greater demand pressure on the natural resource base. High rates discourage projects that would otherwise compete for environmentally benign uses of the resources, such as leaving them undeveloped. Arbitrarily altering the interest rate seems too imprecise a mechanism, with impacts extending far beyond the concern of preserving the natural resource base (see Pearce and Turner, 1990; Markandya and Pearce, 1987).

The introduction of the explicit 'sustainability criteria' into the CB analysis is due to the idea that conventional economic criteria alone are no guarantee of sustainability of an economic system. Barbier and Markandya (1989) present a model which has a detailed representation of the natural resource base, allowing for increases in pollution above assimilative capacity, degradation of renewable resources and substitution of exhaustible for renewable resources. Optimisation of a welfare function (defined as the discounted net present value of utility, which in turn is defined over consumption and the stock of resources) generates conditions for the optimal evolution of the economy over time, and in particular, the conditions for sustainable growth. Sustainable growth is feasible, but the most intriguing feature of the results from this model is that it is possible for there to be an optimal growth path that leads to total environmental degradation and hence collapse of the economic system. The rationale for this is given as:

> 'Since the benefits of increased consumption occur in the present whereas environmental degradation and collapse is a future problem, this strategy is made optimal by a high rate of discount on future utility.' (Barbier and Markandya, 1989, p16.)

This view that the system could justifiably be sent to extinction on the basis of standard economic criteria, appears elsewhere too (Pearce, 1987a), and implies the need for 'sustainability' criteria to be included in economic analysis. It is also justified by appeal to technical literature on the optimality of extinction of specific species due to their low rate of return relative to the discount rate (e.g. Clark, 1976) and to the behaviour of resource poor farmers who may unsustainable 'mine' their natural resource base, on the basis that their circumstances mean that they have high discount rates. However, it would appear that this argument is fallacious. There is no basis for extrapolating from the economic management of a single species, such as whales, where extinction may be deemed optimal, to then say that adopting a development path that implies extinction of the entire economic system is optimal. Extinction of a species is (or may be) marginal to the operation of the entire system, extinction of the system could be classified as a 'catastrophic event'. Such an event can be allowed for by attaching a sufficiently high dis-utility to it, so that one avoids it if at all possible (Collard, 1988). The example of poor farmers mining resources, and attributing this to high discount rates appears to be an attempt to restrict the explanation of their behaviour to an interior solution of a standard neo-classical maximisation problem, whereas it would be more simply described as a 'corner' solution i.e. they are not 'rationally' consuming the resource base as a result of discounting the future at high rates of interest, but consuming the resource base because they face an 'existence' constraint, in that they have to consume to reach the next period at all. Societies that have such an eroded resource base are not optimising, in the conventional sense of equating marginal utilities over time, but merely surviving. Models that suggest that it is optimal to drive the entire system to extinction when not forced to by an existence constraint would appear to suffer from a miss-specified social objective function.

### 1.5.3 Getting the Right Prices Right

As we noted in section 1.4.4, the role of prices is important, and the linkages are not fully understood, but some general principles can be outlined.

1) Commodities that are used in production, but which are essentially 'free', will be overexploited. It may not be feasible to allocate property rights to these resources, but it may be possible to incorporate them as a cost to the producer by attaching suitable prices to their use. This is a standard policy prescription in the literature on pollution, where appropriate charges are set.

2) Where there are institutionally set prices for commodities or inputs, these prices should be set to reflect the full social cost of their use, including the cost of environmental degradation that may occur as a result of increased production. In order to avoid resource mis-allocation the 'right' prices have to be targeted: if excess input use causes pollution through run-off, then input subsidies should be reduced, or possibly converted to taxes. If the production of particular crops generates unsustainable resource degradation, then crop prices should be adjusted, either in absolute level with respect to the input prices, or relative to other crop prices so that the correct crop mix is produced.

3) If necessary, 'sustainability' premia should be included in prices. This is an idea developed in Pearce (1988a), and which suggests that 'sustainabilty' itself should be given an economic value, in the same way that other externalities are valued. The idea is outlined in Figure 1.3 below, for the case of some waste assimilation system (although one could extend the idea to other examples such as soil erosion). The vertical axis measures the conventional average/marginal costs and benefits of economic activity, and the horizontal axis is the level of production (q). Associated with production is an externality. The assumption is that at levels of output below $q_e$ the system can absorb this externality, but at levels above this there is resource degradation. Line e'(q) represents the social costs of the externality, in terms of reduced productivity, while c'(q) represents the private costs of production. If r(q) and r'(q) represent the average and marginal revenue curves, then one can easily derive the sustainability premium. If the external costs are ignored, private marginal costs and benefits are equated, resulting in output an output level of $q_\pi$ and a price of $p_\pi$. If the external costs are included then marginal benefit is equated with the aggregate of private and social costs (c'(q)+e'(q)), giving a price of $p_s$ and output level $q_s$. However, this is an output level above that which can be sustained i.e. $q_e$. a surcharge of $p_e$-$p_s$ has to be made if the sustainable level of output is to be achieved. This value can be taken as the economic value of sustainability.

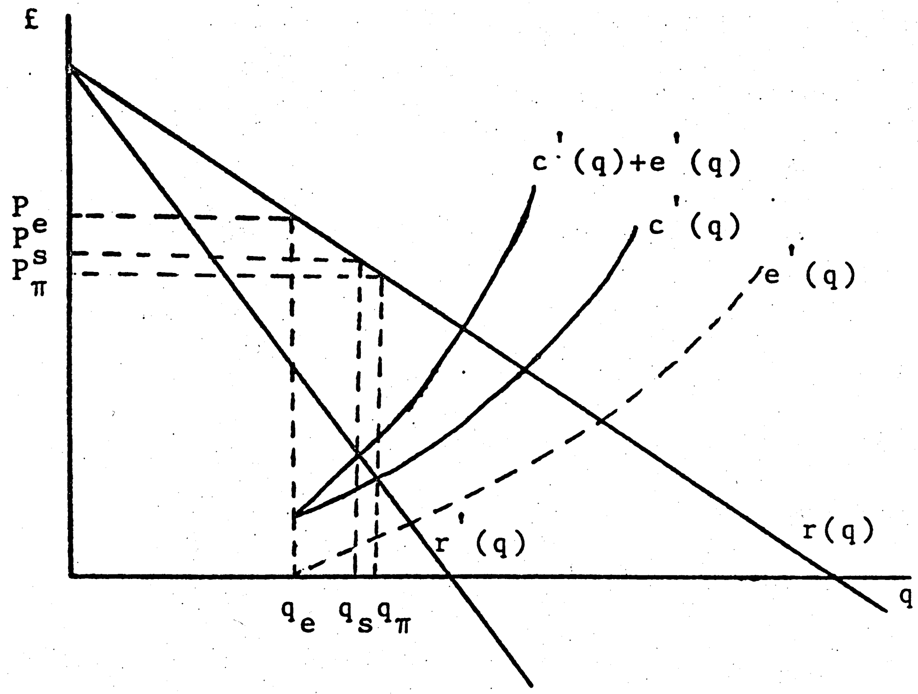


FIGURE 1.3 : Optimal Prices for Sustainable Development

Source: Pearce(1988a)

### 1.5.4 Agro-ecosystem Analysis

At the agro-ecosystem level, it is less easy to identify general criteria for sustainability. There is a danger that if a single resource approach is taken there may be transgressions from one resource to another, but if one adopts a holistic interpretation it will almost certainly prove impossible to define a single measure of sustainability at a general level (Cocklin, 1989). However, some factors have emerged. The first is the issue of participation of the farmer in decision making, both in general terms of development and conservation projects, and more specifically in terms of property rights. As indicated in the section on the causes of unsustainable practices, property rights are viewed as vitally important in maintaining the resource base and encouraging conservation. This need not be exclusive rights to the resource, but may involve the evolution of common property systems, where there is a sufficiently strong institutional structure to prevent over-exploitation.

An additional area of importance is the role of the research institutions in generating the form of technologies required for sustainable development. There is a need to incorporate the sustainability criterion into the research process at three levels

(a) as an evaluation criterion in technology testing
(b) as a design criterion in the creation of crop/livestock technologies
(c) as a set of concerns around which to organize research.

Lynam and Herdt (1989) identify two issues that are likely to prove difficult in adapting the international agricultural research effort: how to organize research that is location specific, and how to organize research that is at the system level, as opposed to crop level.

## 1.6 Concluding Remarks

This initial chapter has had two primary objectives:

i) to review the basic concept of sustainable development and sustainable agriculture, and identify the relationship between the environment and economic growth,

ii) to identify the reasons for unsustainable resource management and the criteria that have been suggested for achieving sustainability.

The key conclusions from this chapter are that the maintenance of the environment is vital if sustainable development is to occur, and that this applies to both developing and developed countries alike, although the specific concerns of each are likely to differ. The criterion that has emerged for achieving this is one of not allowing the environmental capital base to decline. Two important reasons for the decline in the past have been identified, and these are inappropriate property right allocations, and inappropriate price levels. The impacts of changes in either of these in specific cases are not easily identified, making it difficult to identify 'the easy fix': the interaction of the social, environmental and economic components of the system make that inappropriate. Our attention now turns to a specific aspect of that interaction, the environment and international trade.

# CHAPTER 2 SUSTAINABLE AGRICULTURAL DEVELOPMENT AND INTERNATIONAL TRADE

## 2.1 Environment as a Determinant of Comparative Advantage

Comparative advantage, which determines location and the trade product mix, is governed by a country's endowment of labour and capital, technical knowledge, tastes, government policy and environmental scarcity. Natural resources and the environment must be seen as productive capital, and hence a production factor determining comparative advantage.

In establishing the country's resource base, account must be taken of

a) the endowment of public consumption goods (e.g. landscape amenity, wildlife). Any restrictions imposed on these will influence its foreign trade position, notably of the service sector (tourism).

b) the assimilative capacity of the country, which in turn depends on

i) the capacity of environmental systems to reduce environmental damage by natural processes

ii) the tolerable level of environmental damage beyond this- which depends on society's preferences, income, population density, etc.)

iii) the amount of environmental damage in the form of pollution emissions, soil erosion, deforestation, etc.

iv) investments to increase assimilative capacity or reduce demand for assimilative services.(Siebert, 1981)

Many LDCs are considered to have a comparative advantage with respect to environmental endowment and some have high assimilative capacity, due to a relatively low demand for assimilative services (given a relatively low level of industrialisation), and a different valuation of environmental quality.

## 2.2 Gains from Trade when Environmental Damage is taken into Account

A standard proposition which emerges from orthodox economic theory is that countries benefit from trade. A question which arises in the present context is: does this proposition still hold if environmental effects are taken into account?

Consider a country with a comparative advantage in an agricultural export crop, the production of which generates some environmental damage, say soil erosion. Consequently, as production increases, environmental quality declines. As Siebert (1977) demonstrates (see Appendix 1), there will be a trade-off between welfare gains from trade and environmental quality. To put this in the context of the earlier discussion of trade-offs and complementarities (section 1.1.4), it is being assumed that the country is operating on a production possibilities frontier, such as A-B in Figure 1.1. The scope for complementarity has been exhausted or is unobtainable in the short run.

To assess whether a country will gain from trade, the net benefit position must be examined. Trade only pays when net welfare rises, i.e. when traditional gains from trade outweigh deterioration of environmental quality. *A priori* it is conceivable that in the case of a strong preference for environmental quality and of a high marginal physical damage due to the side-effects of production, the welfare loss associated with deterioration of environmental quality may outweigh conventional gains from trade. In this extreme case, the country would be better off by not engaging in trade in the environment-damaging product.

If an appropriate corrective environmental policy (discussed in Ch. 4) is introduced, the social costs of export production will be taken into account by producers. But as production costs rise, the country's comparative advantage in that product is reduced and the correct benefits from trade would be established. In the limiting case it is possible that production costs could increase to such a degree that the country prices itself out of the market, losing its comparative advantage entirely.

Where there are external costs to production, comparative advantage is distorted in the absence of environmental policy. In effect, the sector generating the external costs is receiving a hidden subsidy. Too many resources are used in that sector and there is an excessive degree of environmental damage.

## 2.3 Effects of Environmental Regulation On Comparative Advantage

### 2.3.1 The Nature of Environmental Regulation

To reach a desired level of environmental quality, "the role of government ... is to redefine the conditions of individual activity in such a way that private costs do not differ substantially from the social costs of individual activities." (Siebert, 1981, p.113). The orthodox supply schedule incorporates private marginal costs of production only. Where production has spill-over effects in the form of pollution, soil erosion, deforestation, etc., then these social costs should be taken into account. In Figure 2.1 $S_P$ denotes the orthodox supply curve and $S_{SC}$ the supply schedule incorporating marginal social costs of production. The figure depicts the "textbook" case in which social costs are incurred at all levels of production. In some instances this would not be an appropriate characterisation of agricultural production; as in Fig. 1.3 there may be some range of output over which the environment may be able to assimilate fully the externality. With this proviso duly noted, it is concluded that for a given price $P_e$, society would prefer a lower output ($Q_S$) to that provided in an unfettered private market. The task of environmental policy would be to encourage a re-allocation of resources in that direction.

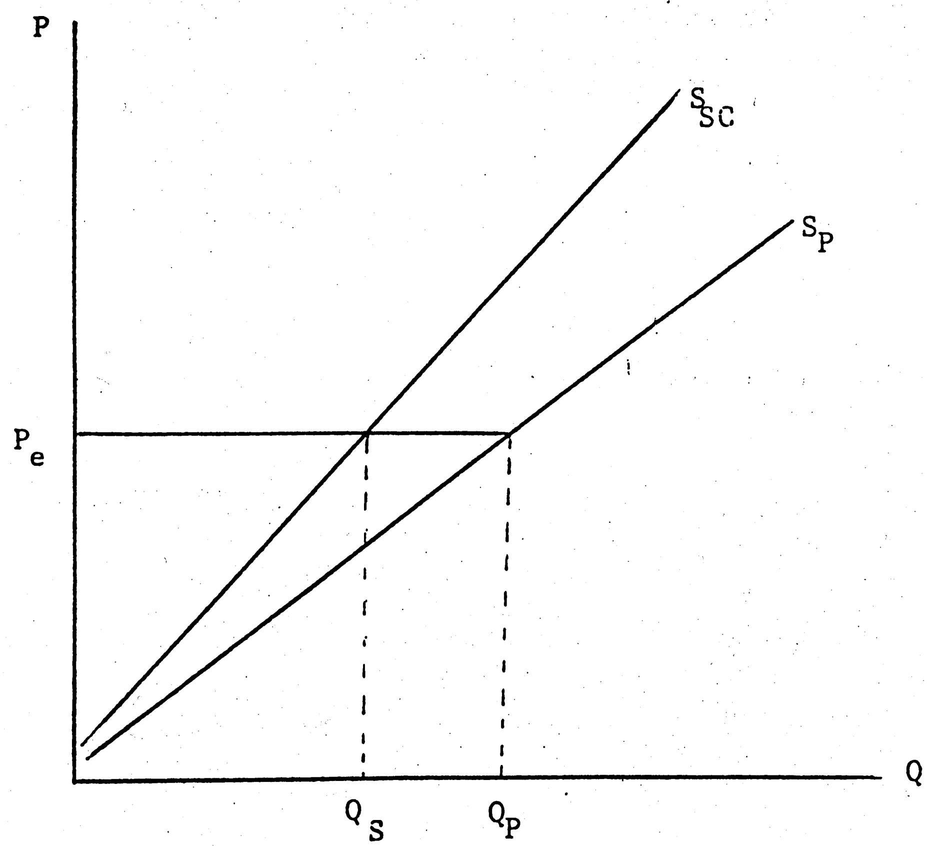


FIGURE 2.1: Private and Social Marginal Costs

A number of policy instruments can be utilised for this purpose, including moral suasion, subsidies, taxes, regulation, and licences. Detailed discussion of these is deferred until Chapter 4. At this juncture we wish to consider only the impact of typical policy interventions on production costs and output.

The effects of environmental and natural resource policies on the production costs can be assessed by examining how the marginal cost of production changes as a result of policy intervention. The impact may be neutral if producers can readily switch to alternative production systems but as a general rule, production costs would be expected to rise with the imposition of a tax or direct prohibition, and to fall if a subsidy is put in place.

Subsidies or more general resource development programmes are used to encourage specific production practices. For example, there has been much interest in several developed countries recently in the use of subsidies to promote the conservation of landscape amenity. This type of intervention could equally well apply in a developing country context- to preserve wildlife habitats, for example. However, an important policy of this type which has been initiated in a number of developing countries (notably Brazil) is the land expansion programme, which far from improving environmental quality, encourages unsustainable agricultural development.

Figure 2.2 illustrates the effects of a land expansion programme[4], for the case of a "large country" which can influence world market prices by its actions. As the supply of land increases (to $S_L$'), the demand for complementary inputs expands (to $D_I$'). The demand for the product ($D_P$), depicted in panel c, combines the demand of domestic consumers and the excess demand of the rest of the world. As the supply

[4] This analytical approach follows McCalla and Josling (1985).

of the product increases (to S'), the world price falls and marketed output (home supply and exports) rises. [Schwartz and Rossmiller (1988) note that the land expansion policies in Brazil were partly responsible for its increased share of the beef and soybeans markets.] Input suppliers and domestic consumers benefit directly from the policy; exporters' foreign exchange receipts will increase if the demand for exports is elastic; landowners may or may not benefit, depending on the elasticity of demand for land. However, what this type of analysis omits is the social or external costs (from deforestation primarily) which the land expansion would generate. If these costs were taken into account[5], domestic production and exports would be reduced.

The imposition of a tax or prohibition on specific agricultural inputs or practices offers a more certain means of improving environmental quality. Figure 2.3 illustrates the effects of imposing a tax on input use, say on fertiliser. The tax shifts fertiliser supply to $S_I$', domestic product supply to $S_P$' and demand for land to $D_L$'. The reduced output causes the world price to rise and exports to decrease. (This is explored in more detail in section 2.3.2.) Overall welfare will be increasing from environmental policy as long as marginal social costs of producing the good (including environmental costs) are higher than the marginal value of the good in consumption or as long as the tax is lower than the marginal environmental damage.

The foregoing assumes that environmental regulation is undertaken in unfettered competitive markets. This is an oversimplification; in many developed countries, governments intervene to ensure producer prices above free market levels, whilst government intervention in many LDCs establishes producer incentives below free market levels. However, the analysis can easily be modified to take account of specific agricultural policy regimes. In all cases the imposition of an environmental tax on input use would reduce the level of agricultural production but the impact on producer and consumer prices would depend on the specific agricultural policy instrument in place. For example, under rather general conditions, with an

[5] Furthermore, if the land expansion programme relies on the provision of subsidies, the cost to the exchequer must also be taken into account.

intervention buying scheme (as in the E.C.), prices would be unaffected, whereas under a deficiency payment scheme , the consumer price would rise but the farmer would continue to receive the guaranteed price. In the case of producers selling their output to a single (monopsonistic) marketing board (several export marketing boards in the LDCs would serve as examples), the price paid by the board would rise but the effective price to producers would fall, as a result of the input tax.

A major consequence of environmental regulation is a shift in property rights. Both regulatory and taxation approaches disadvantage some sub-set of farmers. Paradoxically, regulations which increase costs of production can increase aggregate farm income (if demand is relatively unresponsive to price)[6]. Net revenue changes will be greater for some producers than others; those heavily dependent on use of regulated input or productive practice will be worse off. As Reichelderfer (1989) notes, according to "polluter pays" principle, this is as it should be. But it can give rise to particular concern if it is the small farmer who suffers most.

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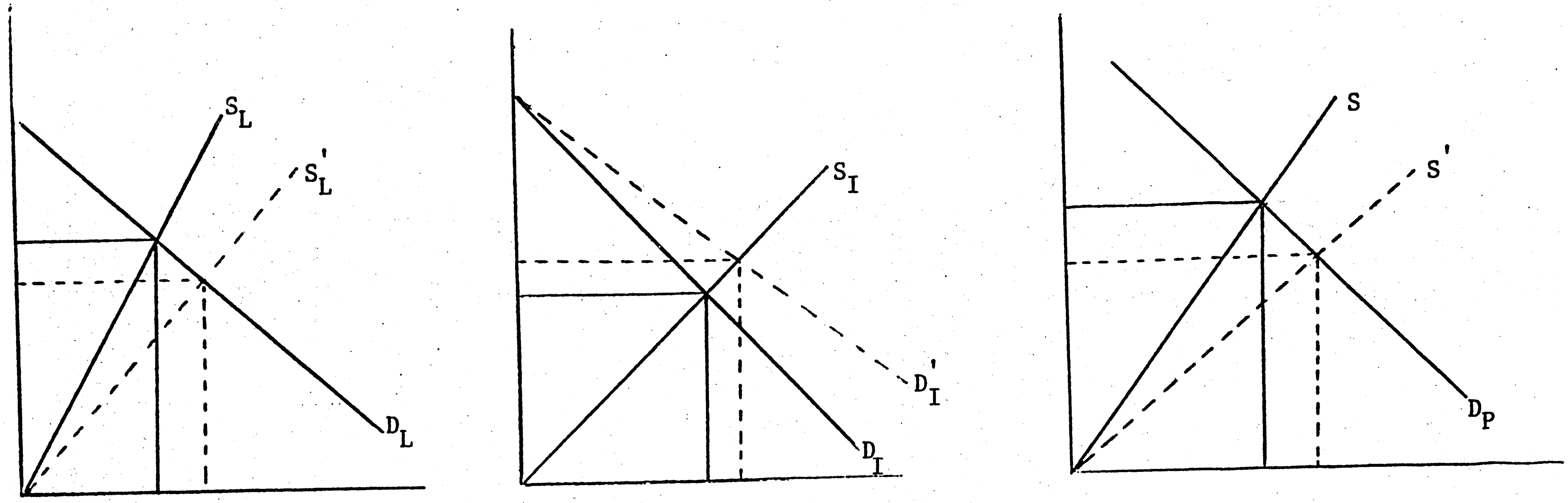
[6] However, increasing aggregate farm income is not synonymous with increasing aggregate farm welfare measured in terms of producer surplus. Miller et al. (1988) demonstrate that the result depends on the form of the supply curve, the type of supply curve shift and the relative slopes of the demand and supply curves in the relevant neighbourhood.

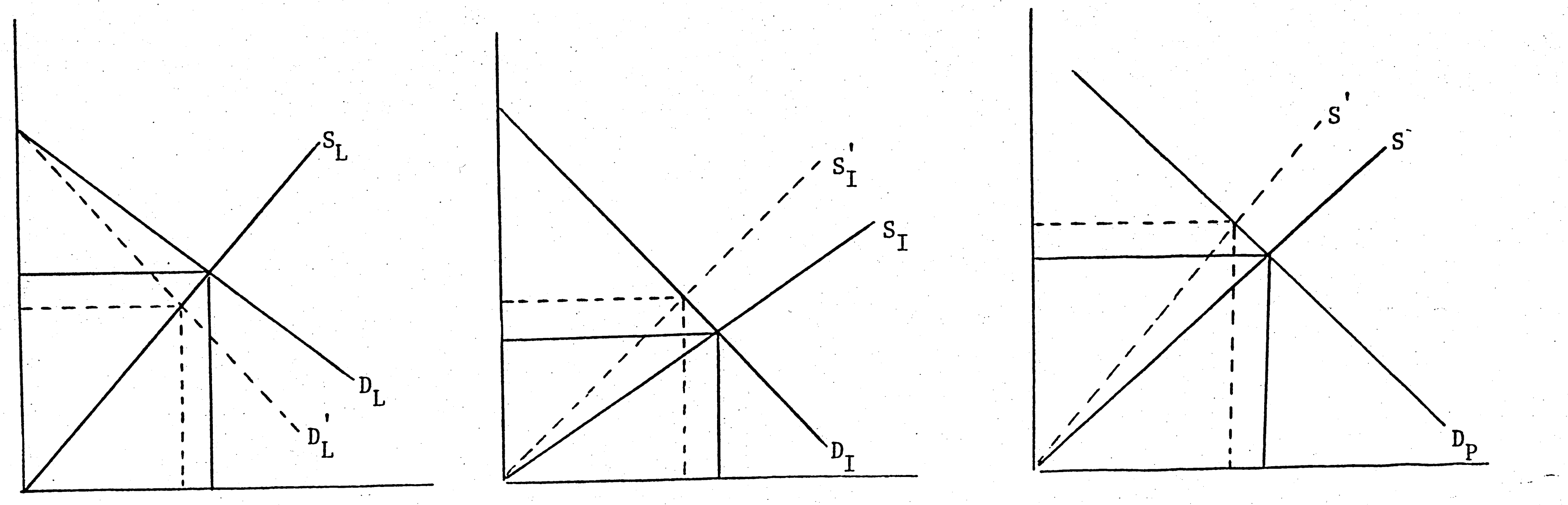



a: Land Market

b: Input Market

c: Domestic Product Market

FIGURE 2.2: Land Expansion Policy




a: Land Market

b: Input Market

c: Domestic Product Market

FIGURE 2.3: Environmental Tax

### 2.3.2 **Short Run Effects of Environmental Regulation on Trade**

Some Generalisations

For the small country which must take world prices as given, the introduction of environmental policy will reduce the country's comparative advantage in the environmentally damaging good. As the costs of environmental protection rise progressively, comparative advantage deteriorates progressively with environmental policy. Moreover, the policy will

a) reduce resource use in unsustainable practices and the output of these activities,

b) reduce exports and foreign exchange earnings,

c) increase resource use in abatement and environmental protection,

d) reduce national income.

It is to be expected that capital will move from countries with environmental regulation in place to those which are relatively regulation-free.

A large country which is a net exporter will enjoy an increase in its terms of trade, as world price rises, and can increase its foreign exchange receipts.

Analytical Approaches

The effects of environmental regulation on trade can be analyzed in a number of ways. Here we present two relatively simple approaches.[7]

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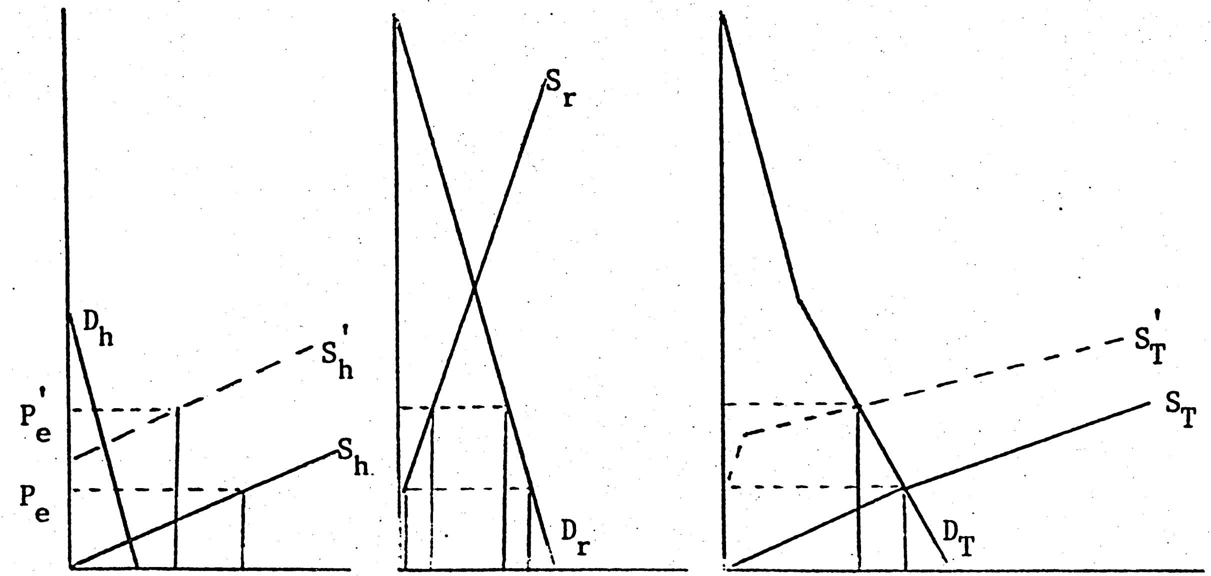
[7] Alternative approaches, emphasising the dynamics of natural resource use and trade, are considered in Sutton (ed) (1988).

A. <u>A Spatial Equilibrium Model</u>

Baumol and Oates (1988) present a simple spatial model of a competitive world market for a single product (the analysis is very similar to that presented in 2.3.1). The commodity is produced and consumed both in the home country and in the rest of the world. The production of the good, however, generates some social costs through environmental damage. The home country considers unilaterally introducing environmental regulation.

Figure 2.4 illustrates this type of market. The figure is divided in 3 parts: the home country with demand and supply ($D_h$ and $S_h$), the rest of the world ($D_r$ and $S_r$), and the total world market ($D_t$ and $S_t$). Transport costs and trade barriers are ignored. Imposing a tax or a ban on the agricultural practice which causes the environmental damage has the effect of increasing the domestic costs of production (the supply curve shifts to $S_h$'). The result will be a higher world price ($P_{\bullet}$') and a reduced world demand for the product. The home country produces less and its exports fall. However, foreign exchange receipts may increase if the rest of the world's demand for imports is inelastic (in which case the rise in price more than compensates for the reduced sales).




a: Home Market b: Rest of World c: Total Market

FIGURE 2.4: Environmental Policy in a Spatial Model

Two further points may be noted. In the classical small country case (where the demand for exports is perfectly elastic), foreign exchange receipts will fall as a consequence of environmental regulation. Secondly, if the (small) home country is a net importer, its balance of trade will be worsened by adopting an environmental policy (as unit costs and the price of its imports rise).

Little empirical evidence can be brought to bear on this analysis. Baumol and Oates cite some work by d'Arge reported in Kneese et al. (1971). Assuming a country were to impose environmental protection measures unilaterally and these charges were passed to consumers in the form of higher domestic and export prices, the effect on gross domestic product was estimated to be as follows: losses of 1.3 - 2.6 % in the U.S., 19.2 - 38.4% in Japan, and 2.7 - 5.4% in W. Germany, but gains of 1.5 -7.4% in the U.K. and 6.2 - 12.5% in France. However, with the exception of Japan, the trade balance improved. Nevertheless the imprecise nature of these calculations must be stressed; in particular governmental counteractions are not considered and several of the estimates of elasticities and propensities used in the analysis are extremely unreliable.

B. A Model of a Small, 2-sector Economy

Siebert (1981) and Siebert et al. (1980) explore the effects of environmental regulation in a small, 2-sector economy. Of the two commodities which can be produced, one is intensive in terms of damage inflicted on the environment. In the model, external costs are due to the emission of pollutants but, with respect to short run impacts, the analysis holds equally for other externalities (soil erosion, salination, health and safety risks, etc.). The country exports the "damage-intensive" commodity (good 1) and imports the other commodity (good 2). As a small country it must take the relative price of the two goods as given exogenously on the world market.

It is then supposed that the country introduces an environmental policy, such as a tax, so that production costs fully reflect the external social costs which are incurred. The following conclusions are drawn (the technical details are relegated to Appendix 1):

i) resource use in environmental protection (abatement) activities will rise, whereas resource use in the damage-intensive sector (good 1), and also in both production activities taken together, will fall. Resource use in the less damage-intensive sector (good 2) may increase or decrease. Once the (given) relative commodity price and environmental regulation (tax) are fixed, the production point is completely determined. The price of the resource used in production adjusts until the resource market is in equilibrium.

ii) national income will fall. This is the cost of increasing environmental quality. It occurs because less is produced, as resources are withdrawn, whereas the relative commodity price remains fixed.

iii) the level of excess demand is determined by consumer demand, i.e. consumers decide the level of home consumption and hence the level of exports. By assumption the balance of payments is held in equilibrium and this condition, given the relative commodity price, determines the level of imports. If the demand for good 1, the damage-intensive product, is less income elastic than that of good 2, then exports will fall. Since home demand does not fall too strongly (in response to the drop in national income) but production is reduced, exports must be lower. Home demand for good 2 falls if its income elasticity is positive.

Before proceeding it should be stressed that the analysis presented in this section, although following the orthodox approach, focuses on the short run, comparative statics of environmental protection and on the short run costs of improving environmental quality. There are, however, dynamic effects of natural resource management which will be expected to influence long run costs and benefits. An example of this more complex analysis is provided by Chambers and Reichelderfer (1988).

2.3.3 International Repercussions and Long Run Consequences:

When a country takes unilateral action to improve the quality of its environment, comparative advantage in the production of the damage-intensive good moves in favour of its competitors (with a resultant resource degradation in the latter).

Siebert terms this relocation of productive activity a case of "pollute-thy-neighbour-via-trade". He does suggest, however, that there are some factors which mitigate the process. In particular, the home country, if unwilling to incur the full costs, may fall short of adopting the optimal level of environmental regulation; as the costs of environmental protection rise progressively, severe limitations are placed on environmental policy; and competitors can restore the original trade position by undertaking their own environmental policy programme.

Nevertheless there are cases of resources shifting from regulated to unregulated countries. Often the flow is from developed countries to low income developing countries which are lax with regard to environmental regulation and which subsequently become the home of the world's "dirty" industries and a ready market for restricted agricultural and industrial chemicals[8]. As Runge (1989) notes, "a kind of 'environmental arbitrage' results, in which profits are gained by exploiting the differential in regulations."

[8] Examples include Italy's shipment of hazardous wastes to Nigeria in 1988 and Switzerland's (as well as others') exports to LDCs of agricultural chemicals the use of which would not be permitted at home.

In the longer term this can create problems in the recipient country, as social damage rises with population growth, the extent of environmental damage itself increases, and per caput income rises (and society's valuation of environmental quality changes). In other words, in the long run the country may wish to have a very different product mix.

Moreover, where particular agricultural practices (e.g. the use of agricultural chemicals) pose health or safety risks, products carrying these risks from unregulated countries may face non-tariff trade barriers in the regulated countries. Having lost competitive advantage through environmental regulation, producers have an added incentive to resist imports by initiating further environmental or health restrictions on trade from the unregulated markets. In this case environmental regulation can mask protectionism[9].

Finally, it should be noted that, although trade opportunities are reduced in the short run when environmental policy is adopted, future competitiveness of the country undertaking environmental policy measures should be enhanced. In the longer term those countries which do not protect their environment and continue to degrade their resources must ultimately face falling agricultural productivity. On the other hand, a country which chooses to adopt sustainable agricultural practices must benefit in the long run.

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[9] Runge cites as an example fruit and vegetable production in the Caribbean. "While Caribbean farmers are encouraged to use pesticides, herbicides, and fertilisers, regulation against some of these products in North America are rapidly becoming barriers to market access."(p.13)

## 2.4 Concluding Remarks

Just as a firm may be reluctant to take unilateral action to protect the environment from fear of losing a competitive price advantage in the marketplace so a government may feel it cannot introduce significant environmental policy because of the impact of its trading position.

However, against the short run losses in terms of output and national income, which environmental policy inflicts, should be set the long run gains in the form of higher agricultural productivity than otherwise would have been achieved. In the long run comparative advantage may be re-gained as competitors who fail to adopt sustainable practices must grapple with declining productivity on a degraded resource base. Nevertheless, in making the adjustment to a more sustainable agriculture, there may be short term hardships and particular groups of farmers may be severely disadvantaged under the new production regimes.

The willingness to adopt sustainable agricultural practices may also be muted where significant benefits accrue to non-residents -for example, a reduction in the rate of deforestation in Amazonia would yield global benefits in terms of climatic stability, preservation of species, etc. This suggests that some environmental problems cannot be solved by unilateral action alone. International co-operation, possibly fostered by side-payments or compensation for profits foregone, will be required. This will be considered more fully in Ch. 4.

## CHAPTER 3 AGRICULTURAL POLICY REFORM AND ENVIRONMENTAL QUALITY

The pattern of agricultural development and its impact on the environment is greatly influenced by government agricultural policy. This chapter indicates the nature of these policy effects and examines how agricultural policy reform, at both the national and international levels, might affect environmental quality. The discussion is set in the context of developing countries' interest in recent policy debates on structural adjustment programmes and trade liberalisation. At the outset it should be stressed that in these debates on policy reforms the effects on the environment are rarely considered in detail. Indeed the issue is a complicated one, with very little rigorous research on which to draw.

### 3.1 Short Run Effects of Agricultural Policy Reforms on Environmental Quality

With regard to the agricultural sector, the main thrust of structural adjustment programmes acts through the removal of trade distortions, exchange rate re-alignment, removal of subsidies, privatization and the re-structuring of public agencies. However, not all reforms affect agricultural production, the main concern here, in the same direction. Specifically, devaluation encourages the production of tradeables (exports and import substitutes) by raising their relative price, but also raises the price of imported inputs. The removal of export taxes and levies also boosts production for export, but the removal of credit and other input subsidies raises production costs and discourages output. Nevertheless, it is expected that the net effect would be an increase in the production of agricultural tradeables and a relative decline in non-tradeables. Some of these impacts are discussed in more detail below.

Increasing agricultural commodity prices

Agriculture in developing countries is often characterised as an undervalued sector in which price incentives to producers are below optimal levels (see, for example, Schultz,1978 ). Increasing commodity prices, by removing domestic price distortions, would induce farmers to produce more (and to change the product mix), to use more inputs, and ultimately to increase productivity through adoption of new technology. The extent of the short run response depends on the elasticity of supply[10].

The additional use of inputs (in the form of chemical fertilisers and pesticides) can increase the spill-over effects of agricultural production on waterways and land quality. But environmental damage may come from another source. As Pearce and Turner (1990) argue, the positive supply response may be through an extension of agricultural margins rather than an intensification through the application of fertilisers, technology, etc. This would likely be the case where farmers have limited access to input markets or to technology. Extended margins may involve forest clearance or expansion into marginal arid areas , resulting in increased desertification, and lower yields in the longer term.

These negative environmental effects would be mitigated to the extent that the increased prosperity which higher prices bring allows resources to be re-invested in resource conservation. This may be particularly important for the subsistence farmer since, as the threat to survival is reduced and the constraints on resources eased, a switch to more sustainable agricultural practices may be possible.

An additional complication is introduced when changes in the product mix are considered. As price incentives alter, so too will the mix of agricultural commodities produced. However, the amount of

[10] It is generally accepted that the elasticity of supply in LDCs is positive, but low in the aggregate and for some individual agricultural commodities. See, for example, Chibber (1988).

environmental damage varies markedly by type of crop -for example, bush and tree crops are less erosive of the soil than many root crops such as cassava, maize, millet and sorghum. So in assessing the overall environmental impact, account must be taken of the products which are being encouraged by policy reform and those which are discouraged. This point is taken up in more detail below.

Reducing risk

An important objective of government intervention in agricultural markets is to reduce the riskiness which the vagaries of the weather, depredations of pests and outbreaks of disease inflict on agricultural enterprises. As Reicheldelfer (1988) notes, when in the form of disaster payments, subsidised farm credit or, more rarely, subsidised crop insurance, such intervention allows the farmer to invest in soil conservation and experiment with alternative pest management, thus permitting improvements in environmental quality. However, when in the form of price guarantees, it may encourage production[11], possibly in areas ill-suited for some supported crops. Moreover, where the source of risk is highly variable rainfall or high pest threat, programmes which underwrite risk encourage greater use of agricultural chemicals. Such stabilization schemes need not be undesirable: "where risks are high, farmers are risk averse, and administrative costs are low, some schemes may provide a net social gain" (Hazell, 1987, p.362). But it is important to include in the net welfare calculation the costs in terms of changes in environmental quality. That is to say, the external costs associated with particular crop mixes (with and without government intervention) must also be fully taken into account.

[11] Note, however, that stabilising price does not stabilise producer revenue if the source of instability is fluctuating yields. Moreover, price guarantees on specific cash crops may not induce more output if farmers perceive a high risk of payment delays or default by the government agency. This misgiving may be well placed in many countries where the supply of finance from the banking system to the agricultural production and marketing sectors has been curtailed as part of an attempt to restrict the growth of domestic credit creation.

When farmers' perception of the riskiness of agricultural enterprises is influenced by policy intervention, the crop pattern will alter. Without risk-reducing measures production would be distributed by natural comparative advantage, possibly with lower production costs and lower rates of fertiliser, pesticide and soil erosion.

Subsidies

Input subsidies are a common feature of agricultural support programmes in LDCs. Chemical fertiliser subsidies of 50-70 % of delivered cost are widespread (WRI, 1987). In addition to explicit price subsidies, imported agricultural chemicals, including pesticides and fertilisers, are subsidised by overvalued exchange rates, as is the use of imported farm machinery. The latter is often also subject to preferential foreign exchange allocations and exemptions from import controls. In many low income countries public funds are directed to expanding irrigation, improving drainage and flood control. Typically user fees do not cover operating costs (Sutton, 1989).

Government intervention of this kind promotes a particular form of intensive farming and encourages the overuse of inputs, in terms of social costs, as natural resources are depleted and the unwanted residues and waste by-products are deposited.

The removal of subsidies, often a feature of structural adjustment programmes, raises the cost of production, thereby discouraging input use and reducing output (the supply curve shifts to the left, in the same way as depicted in Figure 2.3 in Ch. 2, where a tax is imposed on input use.), with a resultant gain in environmental quality.

Property Rights

As noted in Chapter 1, the risk of over-exploitation of natural resources is particularly high where clear property rights are not established. Berkes and Farvar (1989) distinguish four types of property-rights regime:

1. open access- the resource is owned by no-one; it is free-for-all.

2. state property- state or crown ownership and management control.

3. communal property- common property with use rights controlled by an identifiable group.

4. private property- ownership and management by private individuals.

Open-access gives rise to particular concern, since it is under this regime that the so-called "tragedy of the commons" (where there is a high risk of extinction from over-exploitation) occurs. But in fact relatively few resources used in agricultural production are purely open access. Most are a mixture of these idealised types of property rights regimes.

It is worth repeating that open-access must not be confused with communal property. Common ownership frequently involves a high degree of control over the use of the resource, with sanctions by the group on deviant behaviour. Communal property regimes have often evolved in such a way as to assure survival of the community; they are inherently "sustainable."

However, property rights regimes are not static but rather adapt to changing circumstances. In particular, privatization can occur as land starvation becomes apparent or when the opportunity costs of over-exploitation of the resource are evident. More worrisome is the shift from communal property to open access, with all the accompanying risks of resource depletion, which may occur in pastoral societies in response to pressures of rapid population growth, increased commercialisation, loss of social cohesion, etc.

Institutional reforms in the politically contentious spheres of land ownership and tenure require a very detailed and complete knowledge of the legal, political and social framework of the country. But where such reforms succeed in clarifying the rights of ownership and management of natural resources, they establish the basis for improvements in environmental quality.

### 3.1.1 Some Particular Concerns

#### Agricultural Export Promotion and Resource Depletion

Agricultural strategies which are seen to promote exports have been a particular source of controversy. In the present context, the concern is that every extra unit of an export crop involves more use of resources and this can result in additional resource depletion, principally in the form of soil erosion. This is not solely a concern for developing countries undertaking structural adjustment programmes or trying to maximise export revenue to meet debt service obligations. For the USA the export boom of the 1970s was seen as a mixed blessing, with some arguing that the country was "exporting its soil" (Gardner, 1988).

Gardner demonstrates how an expansion of exports accompanied by increased external costs inflicts a net welfare loss on the home country, while the major benefits may be enjoyed by importing nations.

Figure 3.1 illustrates the argument. Here the demand for the home country's exports is less than perfectly elastic. In other words, it is assumed that the home country has some market power and its own actions can influence the world price. Domestic demand is represented by the schedule $D_d$; the total demand for the domestic product, including overseas demand, is given by $D_T$. The domestic supply curve, based on marginal private costs is given by S. As noted in Chapter 2, the notion that production incurs external costs such as soil erosion can be expressed by incorporating marginal social costs into the supply relation, giving $S_{sc}$.

The appropriate level of output when external costs are taken into account is then $Q^*$ with a market price of $P^*$. If the external costs of production are ignored, output would be expanded to $Q_e$ with a market equilibrium price of $P_e$.

In moving from $Q^*$ to $Q_e$, there is a gain to domestic consumers purchasing more of the product at a lower price (the gain in consumer surplus is represented by area a in the figure). Foreign consumers also benefit from access to lower priced exports (their gain in consumer surplus is given by area b+c+d). There is, however, a loss in producer surplus in the home country (area a+b+c-e) and additional external costs of production to be borne (area g+d+e). Summing these costs and benefits, the increase in exports produces a net welfare loss (area g). Furthermore, the welfare loss to the home country alone is greater (area g+b+c+d) -the gains to domestic consumers are outweighed by producer losses and the additional costs in terms of environmental damage. The home country bears the welfare loss of an export expansion which primarily benefits the importers.

For completeness, Figure 3.2 depicts the case of the small country which takes the world price of the product as exogenously determined (the demand for its exports is perfectly elastic). In this case, there are no consumer gains from the expansion in production but there is a producer surplus gain (area e) to be set against the additional external costs of production (area g+e). Again there is a net welfare loss to the domestic economy (area g).

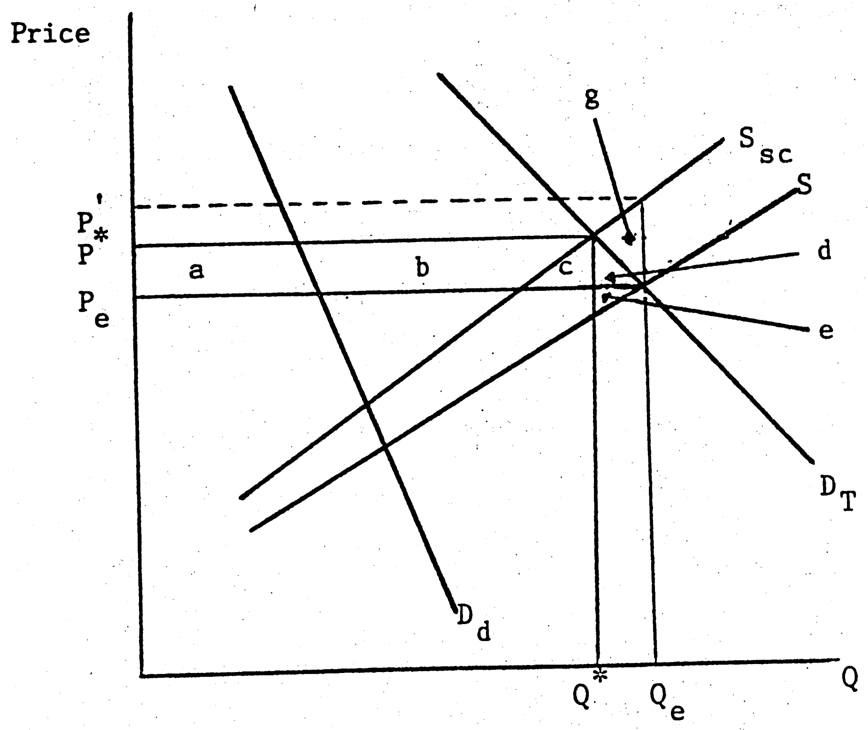


FIGURE 3.1: "Exporting the Soil"; large country

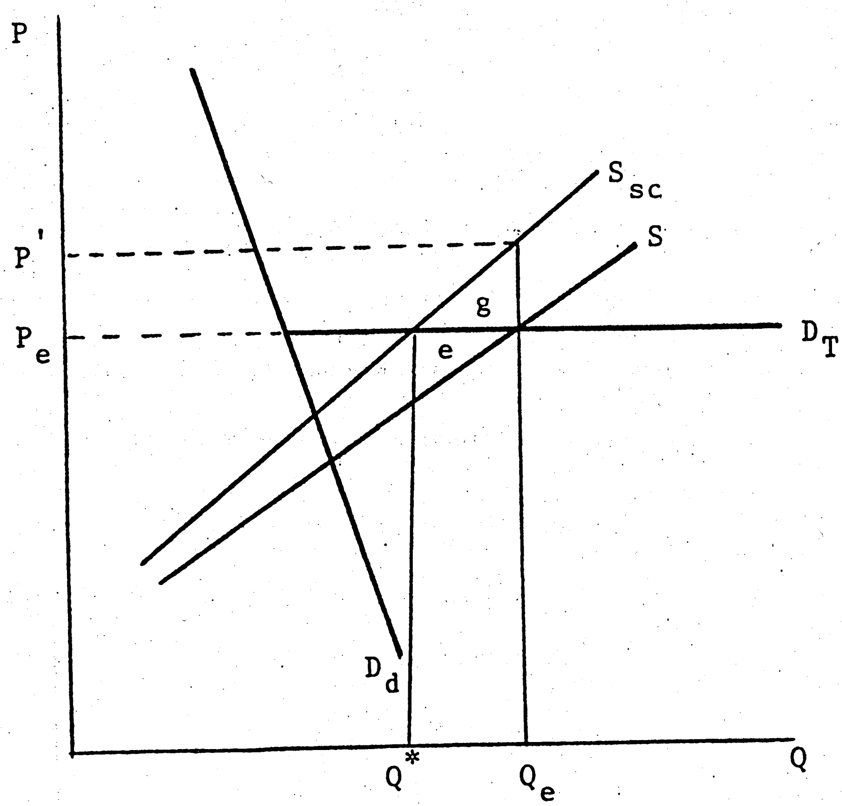


FIGURE 3.2 : "Exporting the Soil"; small country

This is clearly a short run analysis in that erosion will ultimately cause production costs to rise and so the supply curve S will shift towards $S_{sc}$.[12] However, it does beg the question: why would producers be so myopic? A number of reasons have been suggested including producers' ignorance of underlying technical and economic relationships, the short time horizon of rental agreements, and the belief that technical change, capital accumulation, or participation in a soil conservation programme will allow productivity to be maintained in the longer term. Nevertheless, it should be noted that if water pollution is ignored, and if financial and real asset markets are efficient and if private and social discount rates are the same, then the farmer "will mimic the intertemporal path of soil use chosen by a wise social planner" (McConnell, 1983). In these circumstances there is no need for policy action[13].

The simple analysis does, however, serve to illustrate the need to address adequately the problems of natural resource management in the formulation of agricultural development strategy. This point is reinforced when changes in the product mix which policy encourages, are considered.

Export Crops vs. Food Crops

Barbier and Conway question the assumption that policies to attain food self-sufficiency promote an inherently more sustainable pattern of agricultural development than promotion of exports (Barbier(1989), Conway and Barbier (1990)).

First, it should be stressed that the distinction between "export crops", "cash crops" and "food crops" is not clear. Often the terms "export crops" and "cash crops" are used interchangeably. Strictly, however, a cash crop is one which is marketed at home or abroad, and may be a food or non-food product. An export crop is a cash crop which is produced for the overseas market. A "food crop" usually denotes a basic

[12] The two curves will not converge if there is a pure externality, such as water pollution.

[13] Moreover, some amount of soil loss may be optimal.

staple -cereals, pulses, roots and tubers. But although they are the main subsistence products, nevertheless they are often marketed. For example rice is a basic staple in Asia but is a major export of China, Burma, Pakistan and Thailand[14].

At the aggregate level expansion of exports is not at the expense of staple food production in most LDCs. As FAO data clearly shows (Barbier, 1989), the amount of land growing both exports and food crops has increased, as previously uncultivated land (forest or marginal land) is brought into production. But in some cases export production has shifted onto fertile land which once grew food, while the latter is moved to less fertile land[15].

As far as the environmental impacts are concerned, it is not a matter of whether exports or food products are promoted, but whether the natural resource management problems are being properly addressed. Specifically, agricultural policies that do not take into account the possible environmental impacts and displacement effects may lead to a sub-optimal allocation of resources. The critical parameters include:

1. <u>Input requirements of different crops</u>: About 25% of the world's pesticide usage is in LDCs, and is used mainly on cash crops. As already noted, pesticide and fertiliser imports for cash crops are often heavily subsidised. An additional factor is that as developed countries, for health and safety reasons, increase the restrictions on the use of agricultural chemicals, manufacturers seek out unregulated markets, often to be found in the Third World, to take their exports. Although the use of these inputs in the production of basic

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[14] There may be however be significant quality differences between the export product and that eaten by the low income domestic consumer.

[15] This shift is also noted by Twose (1984), who argues that heavy concentration on cash crops in the Sahel has forced the poor food-producers onto marginal land.

food staples tends to lag behind, there are environmental hazards associated with the production of certain food crops (e.g. pesticide use is quite extensive in rice production in some areas).

2. Impact on erodible soils As Table 3.1 illustrates, the rate of soil erosion varies markedly by type of crop. Some cash crops (cotton, tobacco and groundnuts) do leave land susceptible to soil erosion, but others (oil palms,coffee and cocoa, with grasslands as cover) have rates of soil erosion 2-3 times less than erosion rates for staple root crops (e.g. cassava and yams) or row crops (e.g. maize, sorghum and millet). Hence it is not simply the case that food crops generate less environmental damage than export crops.

3. The importance of management techniques and agricultural practices As a generalisation, risks of environmental damage are much greater in mono-cropping, either export crops or food crops, than in multi-cropping. Intercropping techniques and agroforestry can reduce undesirable environmental impacts. The influence of agricultural policy should again be noted. In many countries, past patterns of commodity specialization is influenced by governments, as initial natural advantage has been reinforced by development of downstream agroprocessing and marketing channels, by public investments in irrigation, and by research focused on these crops by national and international research organisations. As Hazell (1987) claims, this has often led to excessive specialization at the farm level, as less favoured alternative commodities have been pushed out.

**TABLE 3.1: RATE OF EROSION UNDER DIFFERENT CROPPING PATTERNS AND COVER, RELATIVE TO BARE SOIL***

| | |
|---|---|
| Bare Soil | 1.0 |
| Dense Forest | 0.001 |
| Savannah and grassland, ungrazed | 0.01 |
| Forage and cover crops | 0.1 - 0.8 |
| Maize, sorghum, millet | 0.3 - 0.9 |
| Rice (intensive cultivation) | 0.1 - 0.2 |
| Cotton, tobacco | 0.5 |
| Groundnuts | 0.4 - 0.8 |
| Cassava (lst year) and yams | 0.2 - 0.8 |
| Palms, coffee, cocoa, with cover crops | 0.1 - 0.3 |

* In general, the better the protection of the soil surface, the lower is the rate of erosion indicated.

Source: Adapted from Repetto (1986), as cited in Conway and Barbier (1990).

More diverse cropping patterns, particularly if integrated with livestock, may have the advantage of providing more sustainable farming systems in terms of their impact on soils and environment. By increasing the importance of crop rotation and livestock in maintaining yields, farmers may also use less fertilisers and pesticides.

The conclusion to be drawn is that it is not the choice of crop *per se* that should give rise to concern but the failure of agricultural policymakers to consider the implications of policy signals for resource use. Moreover, the orthodox crop-by-crop approach is unlikely to adequately address the pressing problems of resource depletion. The focus of attention should shift to the farming system viewed as a whole and to assisting choice of production practices and product mix which are more consistent with ecological conditions as well as the needs of farming households.

## 3.2 Trade Liberalisation

The Uruguay Round negotiations, with agricultural protectionism as a key issue, have provided the impetus for analytical work on the effects of trade liberalisation. However, attention has focused, almost exclusively, on the implications for trade flows and national welfare. Very little regard has been given to the likely environmental impact of the removal of trade barriers.

### 3.2.1 Effects of Trade Liberalisation on Agricultural Production and Trade

Anderson and Tyers (1990) present a standard economic analysis of the effects of liberalisation of markets for temperate food products. The conventional view is that if the industrial market economies alone liberalised, food prices in international markets would be higher.

Assuming no distortions in the developing countries which would reduce the degree of price transmission, their domestic producers gain from receiving a higher price for their product, while consumers lose. Net importers will suffer a net welfare loss (unless price should rise to such an extent that the country becomes a net exporter). An undistorted net food exporter gains unequivocally. Figure 3.3 illustrates this point. The country suffers a net loss if the world price were to rise from $P_0$ to $P_1$, but would enjoy a net welfare gain if the final price were P'.

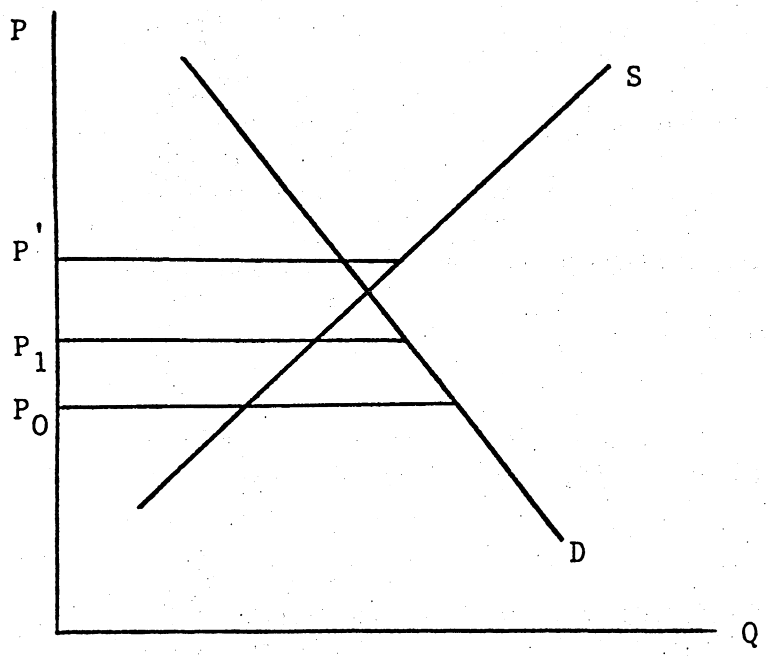


FIGURE 3.3 : Trade Liberalisation and the Net Importer

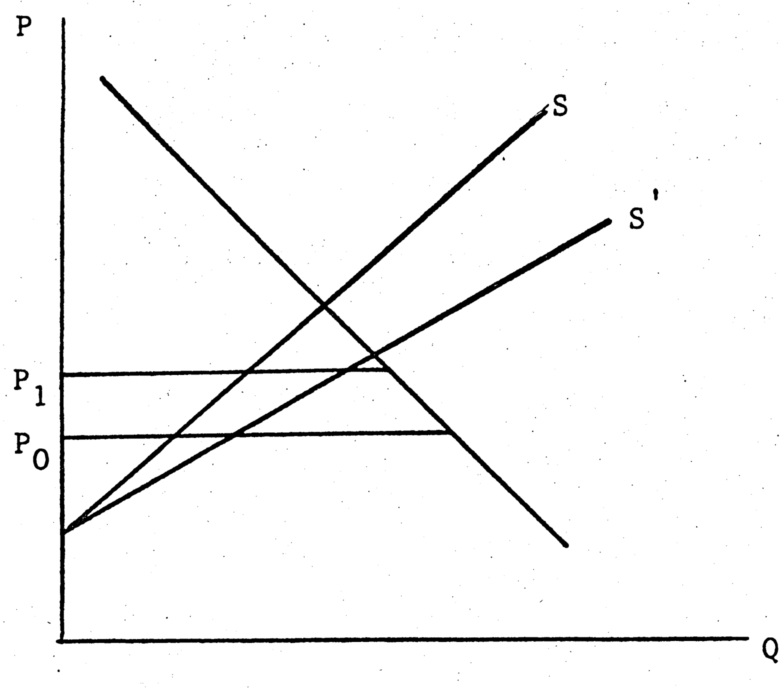


FIGURE 3.4 : Dynamic Effects

Other considerations can be brought in:

i) reduction in food price instability.

Because many countries insulate their domestic market from international price fluctuations in the short run and export some of their own domestic market fluctuations, it is often argued[16] that liberalisation will reduce price fluctuations on world markets. The welfare of developing countries will be enhanced thereby, insofar as they transmit these price movements to their domestic markets and their food producers and consumers are averse to risk.

ii) dynamic effects through induced innovations.

A permanent reduction in protectionism would lower domestic food prices in the developed countries and increase food prices and their stability in developing countries. These changing market signals are likely to boost agricultural productivity growth in the developing countries while slowing it in developed countries. Figure 3.4 illustrates how the latter's supply schedule might shift (from S to S'), thereby reducing the extent of consumer losses and further adding to producer gains.

iii) liberalisation in developing countries' markets

If, as is generally the case, developing countries distort their own food markets, there is scope for further economic gains if they join with the industrialised countries in liberalisation. This will be muted, however, if price distortions in non-agricultural sectors remain in place[17].

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[16] See, for example, Anderson and Tyers (1990, p. 54). As noted later in this chapter, the proposition has yet to be empirically well established.

[17] Krueger et al.(1988) have emphasised the importance of protection of manufacturing and overvalued official exchange rates as indirect means of taxing agricultural production in LDCs. One implication is that there can be conditions in which anti-agricultural biases can be aggravated if industry is not liberalised at the same time.

iv) liberalised trade in tropical products

If industrial market economies liberalised import restrictions on tropical agricultural and forestry products, there would be an unambiguous welfare gain to net exporters of these commodities.

## Empirical Results

The contributions to a recent OECD/World Bank symposium on agricultural trade liberalisation and its implications for developing countries (Golden and Knudsen, 1990) represent the "state of the art" of analytical work in this area.

Golden and Knudsen in their summary of this work take price changes as a rough indicator of trade and welfare effects of liberalisation. Table 3.2 presents the price changes predicted by some of the main models for the scenario in which OECD countries alone liberalise their agricultural trade. In all but one model, increases in meat, dairy, and sugar prices are anticipated. For feed grains the results are more ambiguous; the Valdes/Zeitz model and OECD's MTM model suggest that this price would fall.

Although there is broad agreement on the direction of price changes, there is some variation in their magnitude, especially for livestock products and sugar. Some of the difference can be accounted for by choice of base year and the assumed level of support.

Since the developing countries in the aggregate are net importers of the temperate zone products considered (mainly grains, livestock and sugar), they lose more as consumers than they gain as producers.

<u>**TABLE 3.2: PRICE EFFECTS OF LIBERALIZATION BY OECD COUNTRIES**</u>

(Percentage change)

| Model | Wheat[1] | Coarse Grains | Meat | Dairy | Sugar |
|---|---|---|---|---|---|
| Partial equilibrium Model | | | | | |
| Anderson-Tyers[2]: (projected 1995) | | | | | |
| a. Price-independent productivity growth | 25 | 3 | 43 | 95 | 22 |
| b. Price-dependent productivity growth | 19 | 2 | 39 | 90 | 27 |
| Zietz and Valdes: (OECD countries liberalize) | 3 | -3 | 10 | - | 15 |
| OECD/MTM: (OECD countries liberalize) | -5 | -10 | 5 | 31 | 9 |
| USDA/SWOPSIM: (1986 base) | 27 | 16-22 | 16 | 84 | 29 |
| General equilibrium models | | | | | |
| IIASA (projected 2000) | 18 | 11 | 17 | 31 | - |
| RUNS | 15 | 8 | 18 | - | 57 |
| WALRAS | 17 | - | 10 | 14 | - |

1. For some models includes other grains.
2. Meat is ruminant meat.

Source: Goldin and Knudsen (1990), Chapter 17.

Table 3.3 presents the predicted price changes for the case in which developing countries also liberalise their trade. The participation of the LDCs allows international price signals to be more fully transmitted to their farmers, with result of greater production response. As the tabulated results indicate, the price changes would be considerably muted.

In most of the empirical work to date whether there are dynamic effects from induced technical change remains an open question. If it is assumed that more rapid technical change is encouraged, real food prices are likely to be lower than would otherwise be the case.

The effect of liberalisation on price instability must also be the subject of further research. Although, as noted above, Anderson and Tyers suggest that instability will be reduced, others would argue that too little is known about the true causes of instability in agricultural markets to be so confident of the outcome.

Finally, it must be admitted that in the design of many of these models, the interests of the LDCs has been of secondary importance. They were built primarily to analyze the effects of agricultural policy reform in industrial market economies. There is little disaggregation of "developing countries", tropical product markets are neglected and "minor" commodities are ignored, unless they are significant substitutes in consumption (e.g. fats and oils or manioc). Consequently, many commodities of interest to LDCs exporters receive cursory attention.

**TABLE 3.3: PRICE EFFECTS OF OECD AND DEVELOPING COUNTRY LIBERALIZATION**
(Percentage change)

| Model | Wheat[1] | Coarse Grains | Meat | Dairy | Sugar |
|---|---|---|---|---|---|
| Partial equilibrium Models | | | | | |
| Anderson-Tyers[2]: (projected 1995) | | | | | |
| a. Price-independent productivity growth | 1 | -88 | 60 | -12 | - |
| b. Price-dependent productivity growth | 1 | -7 | -2 | 56 | -19 |
| Zietz and Valdes: (OECD countries liberalize) | -12 | -24 | 13 | - | 1 |
| OECD/MTM: (OECD countries liberalize) | -7 | -12 | -4 | 29 | 7 |
| USDA/SWOPSIM (1986 base) | 23 | 8-19 | 7 | 79 | 7 |
| General equilibrium models | | | | | |
| IIASA (projected 2000) | 23 | 13 | 11 | 34 | - |

1. For some models includes other grains.
2. Meat is ruminant meat.
3. Meat projection is only for beef.

Source: as Table 3.2.

### 3.2.2 Effect of Trade Liberalisation on Environmental Quality

It should be clear from the foregoing that the effects of trade liberalisation will depend critically on the changes in producer price which are induced. In turn, whether farmers in the LDCs receive a higher price for their product will hinge on the extent of liberalisation in the LDCs themselves and in the type of product which is included in the reform programme.

Even in those cases in which the direction and magnitude of price changes can be accurately predicted, the impact on the use of resources and on environmental quality is difficult to assess. The arguments introduced in section 3.1.1 again come into play. A price rise could induce an increase in the intensity of resource use (a negative environmental impact), an expansion of the extensive margin (again a negative impact) or, by easing the income constraint, encourage conservation measures (a positive impact).

The environmental impact becomes more uncertain because relatively little is known about (i) what the dynamic effects of liberalisation would be, and (ii) what the effect on price instability in world markets would be. Trade liberalisation might induce a more rapid rate in technical change in the agricultural sector. This growth in agricultural productivity might in turn promote, through a multiplier effect, an increase in general economic activity, both of which may be environmentally damaging. On the other hand, if a greater degree of price stability were generated, more investment in conservation may be undertaken. But it must be admitted that the link between liberalisation and environmental quality has yet to be firmly established.

## CHAPTER 4 APPROPRIATE POLICIES FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT

It would be foolhardy to suggest that there is a single prescription which would guarantee the attainment of sustainable agricultural development. The burgeoning, if not bludgeoning, rate at which the literature on this topic is appearing serves to emphasise the urgent need for a greater recognition of the interdependence between agriculture and the environment. But the lack of theoretical and empirical research[18] and the complexity of the subject precludes any easy answers. The appropriate policy intervention must be determined on a case by case basis (for examples, see Boxes 1 to 4). In this chapter some of the considerations which come into play are presented.

### 4.1 National Responses

#### 4.1.1 Integrating Agricultural and Environmental Policies

The task is to change the frame of reference so that social costs in terms of environmental damage and resource degradation are fully considered in the formulation of agricultural policy and are internalised in private economic decisions[19]. It may be tackled on three fronts:

[18] One reason has been the lack of collaboration between agricultural economists and environmental economists. Until recently the two disciplines have kept a discreet distance. See Sutton (1988).

[19] OECD (1990) provides a detailed account of many of the options considered below, albeit from a standpoint of the developed countries in the main.

**A. Advisory approaches:**

By moral suasion, the use of education and advisory services, an attempt can be made to change the orientation of farmers and rural households. It is hoped that, by making them aware of the social consequences of their actions, their behaviour, particularly their use of inputs and adoption of agricultural practices, can be modified.

Agricultural research priorities will need to change from the crop-by-crop approach to one in which the focus of attention is the farm system. This entails developing new technologies and product mixes which meet the needs of agricultural households, particularly the poor, small scale farmer, and which are ecologically sound in terms of their sustainability. In line with these changes, the extension service must be re-oriented, with consistent advice on environmental management practice to be given along with technical advice on production methods.

It is likely that a farm system approach to research and extension services would promote a shift from mono-cropping to a more diversified product mix. The government can further assist in the diversification process by helping new markets develop for alternative crops -providing market information, storage facilities, grading systems, quality control, etc.

However, in a free market system and where poverty significantly constrains behaviour, persuasion and encouragement to modify agricultural practices may be insufficient to achieve the goal of sustainable agricultural development. There may have to be recourse to regulation as well.

**B. Economic Incentives and Regulation:**

The aim here is to alter market signals in such a way as to make all economic agents fully aware of the social costs of their actions. The main policy instruments are subsidies, input taxes, direct regulation in the form of standards or prohibitions, and licensing[20].

As well as the nature of the environmental issues to be addressed, and the country's institutional and political setting, the choice of regulatory measure will depend mainly on its ecological incidence (i.e. the improvement in environmental quality to be expected), the information requirements, administrative and management costs, and its degree of economic efficiency (since a given quality target should be achieved at minimum costs). In theory, the policy instrument which maximises net benefit of intervention, given the ecological, institutional and political constraints should be chosen. In practice, given the multidimensional nature of the problem, and the trade-offs between the various criteria, the appropriate choice may not be readily determined.

-<u>subsidies</u>

In areas where landscape amenity, wildlife habitat and species diversity is considered important, the provision and re-direction of specific financial assistance, in the form of <u>direct payments</u>, to encourage sustainable agricultural practices may be necessary. (As noted below, direct payments may also have a role where environmental protection must have an international orientation.) The provision of direct payments for conservation does, however, introduce a moral hazard. Farmers are given an incentive to threaten damage to the environment in order to obtain a payment for preserving it.

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[20] Siebert (1981) discusses these in considerable detail. For a discussion of other measures, such as set-aside schemes and cross-compliance, which are of topical interest in the DCs, see OECD (1990).

The removal of subsidies on input use (e.g. fertilisers, pesticides) can also promote a better allocation of resources, reduce environmental and health risks and discourage waste. For example, an increase in water users' fees may result in the adoption of cost-saving methods (e.g. drip irrigation) in the long run (Schwartz and Rossmiller,1988). However, the removal of subsidies to farmers near the subsistence level is likely to exacerbate their situation and put greater, not less, pressure on the environment. In such cases, direct assistance, in the form of direct income payments, food aid etc., could be provided to compensate for the loss of subsidy.

-regulation

Direct regulation can be used to restrict the availability of environmentally hazardous agricultural inputs (e.g. DDT), to prohibit the use of environmentally damaging production practices[21] (e.g. restrictions on logging), or to set a maximum quantity of pollution emissions. If the quality target is properly set and there are no violations of the law, this form of intervention has the advantage of ecological incidence and flexibility in that it can be applied to all farmers or a sub-set in a particularly sensitive regions of production.

Its principal shortcomings are its relative inefficiency (since no account is taken of individual farmer's costs of conservation), the administrative costs of implementation and policing, and its static nature (often regulations are linked to specific technologies). Nevertheless, it has been widely used as a means of controlling the use of agro-chemicals, as well as water and air quality in the DCs.

-taxes, user fees, or effluent charge.

The imposition of a tax on input use (e.g. on the use of nitrates) can improve environmental quality

[21] For example, there is a detailed sequence of planning and controls in the logging of rain forests in Queensland, Australia, including a total allowable cut, scheduling of areas from logging history records, a required 50% canopy cover after removal, etc. (Poore,1989). In the Sudan, leasing conditions on agricultural land stipulate that 15% of the land be left for shelter belts (Pearce et al.,1990).

by encouraging a substitution of less damage-intensive inputs, a change in the product mix away from those commodities which use the taxed input most intensively, and the introduction of alternative technologies.

Taxes and user fees are often proposed as the appropriate policy instrument, and from a theoretical, efficiency standpoint, they are preferred to direct regulation. In reality, however, there are a number of problems to their implementation in the agricultural sector. In particular, it is difficult to determine the optimum tax rate or fee schedule for agricultural pollutants (given nonpoint source pollution, variability of agricultural output,etc.) But the problem of measurement of environmental damage also arises with the regulatory approach. Self-reporting, backed up by occasional monitoring and by measurement of ambient environmental quality might offer a practical way of proceeding (Siebert, 1981).

Another difficulty, shared with regulation and licences, concerns the interactions of pollutants. When pollutants are diffused or when a synergy of several pollutants occurs, the link between emissions and environmental quality may be destroyed.

**BOX 1 SUSTAINABLE AGRICULTURAL DEVELOPMENT IN JAVA**[22]

Currently there are high rates of protection on vegetables, fruit and dairy products, which are not traded internationally. They also exist for sugar, rice, and cassava, which are traded. For cassava, the domestic price has at times been 200% higher than world price, with a procurement policy which is intended to ensure that the EC import quota is fulfilled. There is little support for non-traded food crops, the prices of which are also depressed by the high levels of rice production (which are supported through input subsidies rather than the producer price).

The effect of these polices is to change the geographical allocation of crops, crop mix and production techniques, most of which have deleterious effects on the environment. Production in the uplands moves away from basics to the higher value crops. This increase in value may well increase the incentive to undertake soil conservation techniques, (as suggested by Southgate (1990)) but it also encourages a shift in the spatial allocation of production, so that vegetables and cassava are being grown on the higher grounds, where erosion is increased.

Fertilizer subsidies are not only wasteful in the sense of misallocated resources, but have adverse effects on water quality due to run-off and may also result in switching of production techniques, away from expensive systems that maintain productivity towards those that simply replace lost resources with purchased fossil fuel based inputs. Pesticide subsidies have similar effects, causing switches of technique away from traditional systems, and yet the new may not be sustainable (i.e. increases in 'brownhopper' infestations tend to follow extensive pesticide treatment as a result of destroying the natural predators).

Five policy changes are advocated:

1) Eliminate the high protective rates for vegetables and sugar.
2) End the procurement polices for cassava that artificially increase its relative price. This implies that the trade policy of maximising exports and fulfilling the export quotas should not be followed independently of the environmental damage that it causes.
3) Remove monopolistic trading and marketing practices to allow the benefits of improved terms of trade of commercial tree crops to reach the upland smallholders. If a greater proportion of the economic rent accrues to the farmer as opposed to other agents in the food chain, then there will be reduced pressure on the environment as a result of poverty, and increased incentives to invest in soil protection.
4) Ensure there is affordable credit.
5) Overcome bottlenecks in the production and dissemination of seeds of HYVs crucial to improve diverse farming systems for variable upland conditions.

This policy package is intended to change the system of incentives such that they fully reflect the costs of agricultural production. It is suggested that the savings in the fertilizer subsidies and extension services that are currently directed at the low level rice production should be diverted to developing sustainable, high productivity agriculture in the highlands.

[22]The discussion in this section is largely based on Pearce et al. (1990), Chapter 4, and Barbier (1988).

-<u>emission rights/licenses</u>

This measure is most suitable where the environmental damage takes the form of agricultural pollutants. Having set a quality target, licenses or emission rights up to that level can be assigned to producers. By specifying the total quantity of tolerable emissions, environmental quality is clearly defined. In addition, a price is charged for using the environment as a waste receptor, thus defining its scarcity value. However, this form of intervention has significant information requirements for setting targets and monitoring emissions. Given the nonpoint, variable nature of some agricultural pollution the difficulties are particularly great and so this type of regulation may be infeasible, at least in some countries.

Economic efficiency arguments would require that licenses were transferable but this can induce a spatial structure which is undesirable on non-economic criteria. An additional problem is the delineation of regions, since the total quantity of rights must be defined for a specific area.

**C. Institutional strengthening**

The absence of property rights, insecure or ambiguous tenurial arrangements are common in many renewable resources (ground and surface water, wild species, woodlands, pasture). As already noted, they undermine private incentives to improve or preserve these resources for future use. Communal ownership provides effective resource management but can be put under stress by rapid population growth, increased commercialisation, and cultural and political pressures from within or outside the group. Widespread poverty or a skewed distribution of wealth creates additional pressures with some holdings being underexploited, while on others short term survival strategies take precedence over conservation plans.

A significant improvement in environmental quality could be achieved where the rights of ownership and management are clarified. The creation of secure rights of individual ownership (e.g. of forest plots) can encourage conservation efforts and the adoption of sustainable agricultural practices. But there are also examples of privatisation which has exacerbated inequalities without appreciable gains in environmental quality. (Repetto, 1987). Moreover, it is not sufficient to allocate land rights, if the recipients are still left so poor that resource degradation continues; the resources allocated must allow sustainable agriculture and provide a reasonable standard of living.

In many cases (notably fishing and pastoral societies) it will be more effective to build upon local traditions of communal property and resource management. A more modest, but potentially fruitful, intervention here would be to facilitate the formation of associations which set the environmental quality target themselves or implement a quality target specified by the policymaker. The government's role would be to provide information, technical assistance, and legal recognition. Associations have been found to be effective in the management of water resources but could have wider appeal. For example, Thebaud (1988) suggests that, given the failure of all major approaches to pastoral development in Niger, a new start could be made if associations were formed on the basis of the cultural and ecological specificities of the area[23].

Finally, in many developing countries there is a proliferation of agencies with responsibilities for agricultural activities and resource management. Effective integration of environmental and agricultural policies will require much improved communication and collaboration between these agencies and a greater recognition of their interdependence. Undoubtedly, in some cases there is scope for rationalisation and amalgamation of ministries and parastatals. But at the least, administrative procedures such as mandatory referral of policy proposals to other departments must be set up to ensure that one sector's policy interventions are assessed on the basis of their likely impacts on all related sectors.

[23] She suggests that once formed the associations could manage a range of activities in addition to the regulation of grazing space. These include the management of wells, savings and credit, distribution of cereals, etc.

**BOX 2 SUSTAINABLE FORESTRY PRODUCTION**[24]

As has been noted earlier, very little of the world's tropical forest is managed sustainably (possibly less than 0.2%). An area which historically has achieved a sustainable system is in Queensland, Australia. The majority of the forest is owned by the State, managed by the Forestry Department, with the central aim of forestry policy being the maintenance of the area for wood production in perpetuity. Logging is carried out by license, with strict guidelines on the number of trees that are to be removed, the trees that are to be left for regeneration, the siting of roads and other works, and the period in which the operations can take place. If these guidelines are not met then the logging companies can be penalised. Even with these tight environmental restrictions the logging activity is profitable for the logging companies.

The status of these forests is clearly unusual as compared with the bulk found in Africa or Latin America. The ownership rights are clearly identified, and enforced by the state, with no pressure for encroachment by agriculture. Possible over-exploitation by the logging companies is limited by the licensing system, and there are no financial pressures or requirements for foreign export earnings that may induce government agencies to over-exploit the resource. There is a substantial body of research which can guide the planning of the management process. Sustainable management of such a resource is possible, if the institutional conditions are right.

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[24] The discussion in this section is largely drawn from Poore, (1989).

**BOX 3 SUSTAINABLE AGRICULTURE IN SUDAN**[25]

The major environmental obstacle to sustainable agriculture in Sudan is the fragile soil structure, which is highly prone to erosion and loss of fertility if subjected to monocropping and mechanised agriculture. An important mechanism for preventing soil erosion is the gum arabic tree, which provides a cash crop but more importantly has numerous ecological advantages, such as stabilizing the soil, encouraging grass growth in the immediate vicinity and providing forage and firewood.

One of the important policy features which impairs natural resource quality is the form of land tenure that is used. The ownership of the land is with the state, but the rights to use the land are allocated to cultivators. Tenure is ensured if cultivation is maintained, but if there is sufficient pressure for land, fallow land can be lost. More importantly, the rights to marginal land can be acquired by cultivation. This encourages movement onto the extensive margin of the cultivable area. The pricing policy may also encourage this action. Producer prices are substantially above the world price, and the impacts of this are likely to cause further extensification of production rather than yield increases. Mechanisation of agriculture causes environmental degradation, and in 'undemarcated' mechanization areas the problems are particularly severe as there are no controls on their actions. Even in demarcated areas the leasing conditions that demand environmental protection are ignored, and recommended cropping patterns not followed. When the resource degradation that results becomes overwhelming the operators abandon the farms and move to other areas.

The policy recommendations put forward to overcome this centre on the issue of tenure. If socially optimal behaviour is to be achieved then individuals have to have a stake in their natural environment, and recognise that there future wellbeing depends upon the maintenance of that environment. In itself, this will not be sufficient, in that private responses to market signals may still result in degradation. Corrections to the tenure agreements can only be of value when combined with price and social policies that provide the incentives to sustain the resource base.

### 4.1.2 The Role of Trade Policies in Environmental Management

#### Trade Liberalisation

It is by no means clear that trade liberalisation, and the changes in producer prices that it would entail, would reduce the rate of resource degradation. The price regime which results from free trade reflects the underlying private costs and benefits; no account is taken of domestic externalities such as soil erosion. To achieve a socially optimum level of production and trade, these social costs must be

[25] The discussion in this section is drawn from Pearce et al. (1990), Chapter 6.

"internalised", by means of one or more of the measures discussed in the previous section. Even this may be insufficient, if some aspects of resource degradation has repercussions in other countries (e.g. the impact of deforestation on global warming). These international dimensions are considered in section 4.2 below.

For developed countries in which agriculture is overvalued as a result of government intervention, liberalisation would reduce the price received by farmers. Figure 4.1 illustrates this case. It is assumed that the external costs increase with production: the orthodox supply schedule incorporating private costs of production is denoted $S_P$, the supply curve including all social costs is given by $S_{SC}$. The fall in producer price induces a reduction in output (from $Q_0$ to $Q_1$). Hence liberalisation brings with it the benefit of a reduction in social costs (**a** + **b**). However, at the new price level the socially optimal level of production is $Q_e$. Liberalisation prompts a shift of resources in the right direction but a further reduction in output is necessary.

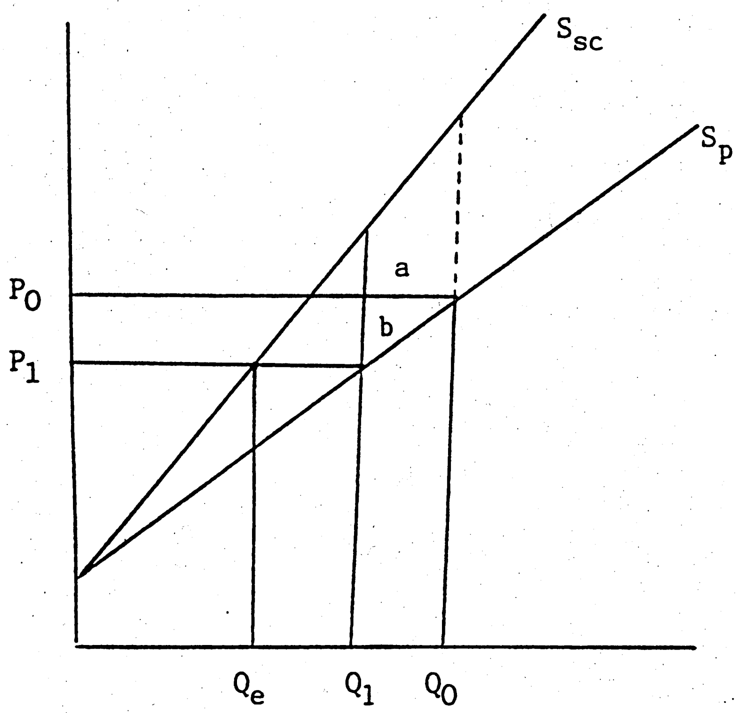


FIGURE 4.1 : Effects of Lower World Price

Turning to the LDCs, liberalisation would be expected to increase the price received by domestic producers. It has already been noted that the link between market stimuli and environmental quality is not well established but we proceed by assuming that as farmers respond by producing more, environmental damage is increased. Figure 4.2 depicts two possible outcomes. In panel (a), when social costs are taken into account, output would expand but only to $Q_e$, not as far as $Q_1$, the output level under trade liberalisation. In panel (b), where external costs are particularly significant, liberalisation again induces an increase in production but the socially optimal level of output ($Q_e$) is less than the pre-liberalisation level. In this case, liberalisation signals a re-allocation of resources in the wrong direction.

Thus, trade liberalisation cannot be relied upon to improve environmental quality. From the standpoint of economic efficiency, trade liberalisation is the optimal course provided private costs do not differ significantly from social costs or, by environmental policy, the cost structures of private agents reflect the social costs of their actions. The existence of an externality implies a divergence between private and social comparative advantage and market-determined trade patterns are no longer optimal.(Segerson, 1988).

An additional complication arises where there are international externalities, i.e. some portion of the social costs of agricultural production is borne by non-residents. For example, deforestation in Amazonia not only generates domestic social costs in the form of soil erosion etc. but also has international repercussions through the loss of animal and plant species and through increased global warming. In this case, national endeavours to internalise the costs of environmental damage will not produce the optimal allocation of resources. Some form of international action is required.

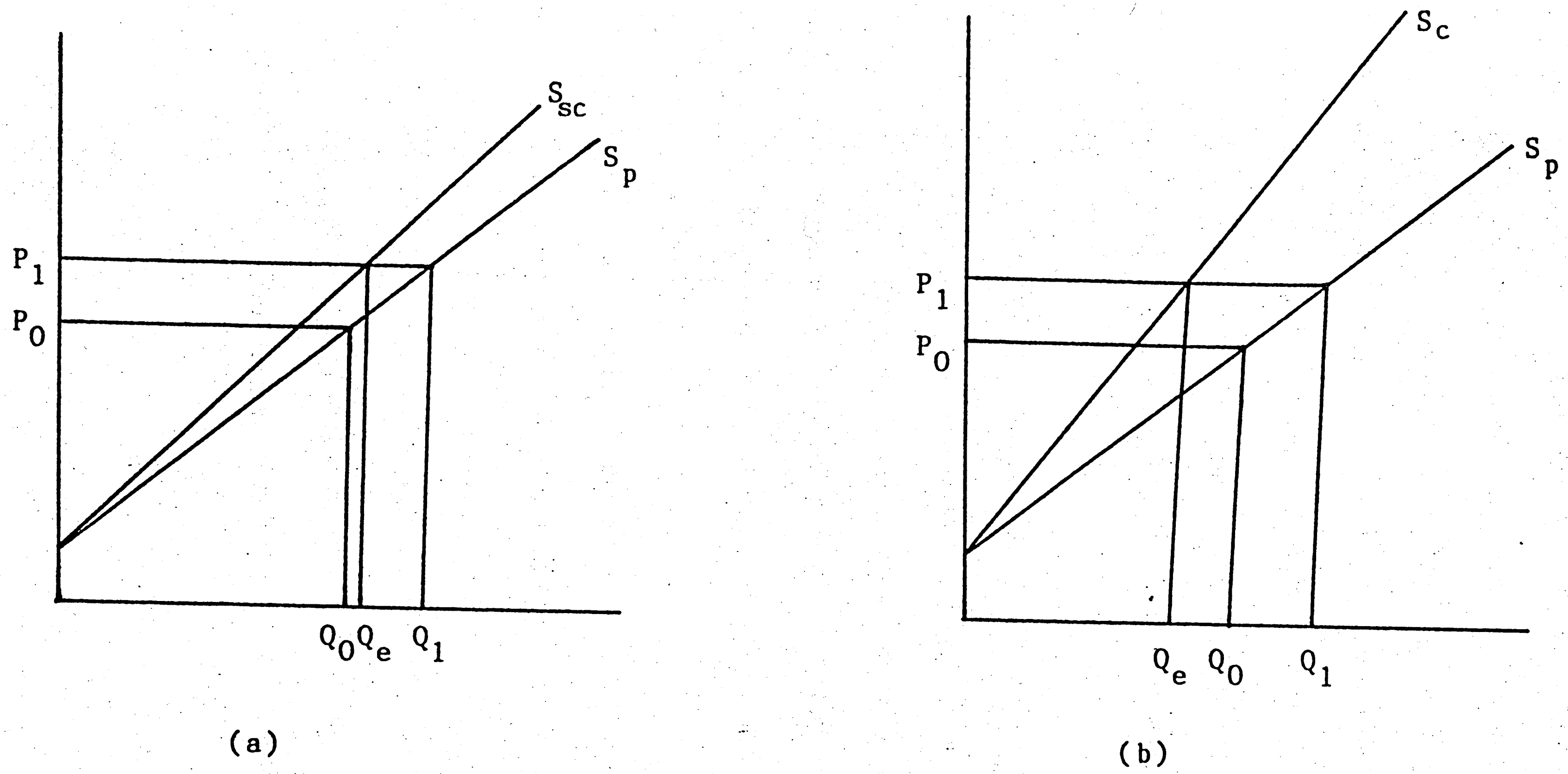


FIGURE 4.2 : Effects of Higher World Price

Non-tariff Barriers

An important aspect of non-tariff trade barriers is the imposition of bans on trade in certain species or products, either because of their intrinsic worth, or because the production system from which they have been generated is thought to be unsustainable. It is important to note that these bans do not spring from the same concerns as the 'health and safety' restrictions (referred to in section 2.3.3), where the cause of the ban is (may be) due to the explicit impact of the characteristics of the product on consumption. Rather, the ban is based, not on concern for the qualities of the consumption good itself, but for consumption *per se*. Examples would include the ban on the trade in ivory, and other wildlife products such as fur, and the concern about the source of tropical hardwoods, requiring that it should be produced 'sustainably'. By its actions, the consuming nation (usually a developed country) is trying to express its 'existence' valuation of the resource, even though in an individual country consumption may be negligible. The reason for focusing on trade in the species is that it is only at this point in the marketing system that such countries can have any impact on the exploitation of the product, give that its source is within another country, and it may even be exploited illegally.

The question arises as to the efficiency of such bans on achieving the desired objective of resource base management. This issue is discussed, for the case of ivory, in Box 4. One of the conclusions that comes from that discussion, and which emerges from consideration of other proposed bans on particular species or products, is that banning trade may not enhance the survival of the species. By reducing the economic value of the species, the direct incentives for exploitation may be reduced, but the probability will increase that the resource will be displaced by other economic activity which now generates a higher value.

A standard result from the environmental economics literature is that resources will be mismanaged when their value is not manifest, and the banning of trade is suppressing the expression of one element of the resources value. In many cases the cause of the inefficient management of the resource is the lack of property rights, but to try to correct for the effects of this by undertaking policy action at a different point in the system will (at a theoretical level) be inefficient, and may also lead to perverse results.

It is important to emphasis that it is not trade *per se* that is endangering species, in the same way that it is not trade that causes soil erosion, but inappropriate management of those species at source. The first best response is to improve that management, either by strengthening property rights and the institutions that should enforce them, or if it is needed, by further developing an understanding of how those resources are best exploited within the context of the economic/ecological systems. Where this is seen to be impossible, then the development of a trade based policy should be viewed as a 'second best' option. Its advantages are that the consuming countries are likely to be a source of sufficient public opinion to ensure that any regulation is enforced. If appropriate mechanisms are devised, such as a consumer cartel that can appropriate the resource rents at the final demand level, then these rents can be channelled back to the producer states to enhance management (ITRG, 1989). The problem with such a mechanism is that it requires domestic implementation, and if the will exists to undertake this then the consumer cartel should be unnecessary. A ban on trade should be seen as a short term response that is required if there are no alternatives to prevent an irreversible decline in the species, but given the level of resources that are likely to be needed to police such a ban, the question has to be raised as to whether those resources would be better utilized in attacking the root cause of the problem, which is one of inappropriate domestic management.

An alternative to a total ban on trade is to limit trade to those commodities that are produced in a sustainable manner. This would require some form of labelling system. This has been proposed for tropical timber products, but has been rejected by the producing countries as a form of hidden protectionism for the developed countries' timber industries. The advantage of the system is that it does not reduce the value of the resource to zero, but only that component that is produced in an unsustainable manner. The incentive mechanism then operates in such a way that there is an advantage in converting to sustainable production techniques. The drawback of the scheme is that the identification system is likely to be complex. It also does not preserve forests that are being destroyed for conversion to other uses (such as agriculture) where the wood is seen as a by-product of that process, or where the wood is consumed domestically rather than being traded. It is interesting to note that a similar selective trade ban has been suggested for ivory, with some countries being allowed to re-classify their elephants from Annex 1 to Annex 2[28] if they can show that certain management and conservation criteria are being met (Ivory Trade Review Group (ITRG), 1989).

[28] An Annex 2 classification implies that a species could become threatened if trade is not regulated, an Annex 1 classification implies a ban on trade.

**BOX 4** **TRADE AND THE SUSTAINABLE DEVELOPMENT OF THE ELEPHANT**

An example of this position is the African elephant, and the ban on the trade in ivory. The source of that ban is due solely to the adverse effects that the ivory trade is assumed to have on the elephant population. The true extent of that effect is not clear-cut (see ITRG, 1989) and the question has to raised as to whether trade is the cause of the population decline, or a symptom of other problems in the institutional arrangements surrounding the elephant, a point that will be returned to.

The management of a resource such as the elephant within an international context is unusual in that, notionally, it is a national resource, with national facilities for its control. The reason for implementing an international mechanism is that trade is seen as a significant cause of the resource over-exploitation, and national governments are seen as unable to effectively manage the resource. In fact, the problem is one of separation of ownership and control. Here, control has (largely) been passed to the illegal poacher, and then to the traders and dealers who process the ivory. Given that these parties do not have exclusive rights to the resource they have no incentive to invest in the resource, and hence it is over-exploited. This could be taken as a clear example of a *de facto* open access resource.

Furthermore, given that the state does not control the resource, the incentives to invest in the species are also reduced. The data below from Swanson (1989) are examples of the revenues flowing to harvesters in Africa, and the price of raw ivory in Japan (a major consumer).

| Chad | CAR | Cameroon | Zaire | Zimbabwe | Japan |
|---|---|---|---|---|---|
| $7/kg | $6-8/kg | $15/kg | $7/kg | $63-76/kg | $85-99/kg |

It is clear that, apart from Zimbabwe, the majority of the resource rent is being appropriated by people other than the harvester, which means that the resources are not available for further investment. The Zimbabwe case is interesting in that it could be argued that the resource is being controlled by the state, illegal exploitation minimised, and the resource rent is being fully appropriated by the owner and controller of the resource (Martin et al., 1989).

By making trade in ivory illegal, it is intended that the incentive to exploit the resource is stopped, effectively by increasing the costs of exploitation (through avoidance costs, fines etc.). However, given the size of the apparent resource rents that can be earned by exploiting the resource, it would appear unlikely that the trade ban would prevent the continued exploitation (although the risk premium would be transferred from poacher to trader, and hence may be higher).

A further complication is that the ban itself may cause the incentive mechanisms to work in the opposite way to that required. The price of illegally traded ivory will be raised by the restriction, increasing resource rents, while the economic value of the species to the range states will be reduced, as they cannot legitimately trade. If resources are scarce, then ultimately all resources must justify their current form, if they are to avoid conversion to other uses (or in this case, the conversion of the habitat). That does not mean that there has to be a depleting use of the resource, if non-use values can be identified (such as tourism), but banning trade does reduce one component of the total valuation of the resource in its unconverted state. Thus as Swanson states:-

'...high level demand for a species or its products is not a contributing element to resource exhaustion in this light. Demand in the first instance, creates value which is available for use to conserve and sustain the species...Institutions which fail to channel high level demand into resource management cause species extinction...the role of international cooperation in this scenario is the preservation of demand in combination with the reform of institutions so as to constructively channel its force.' 1989, p5 emphasis in original

A proposed mechanism put forward by Swanson is an 'ivory currency unit', denominated in kilos, and allocated to producer states by the CITES Secretariat. These units are then sold to final demand centres, and imports of ivory only permitted if accompanied by such a unit. The resource rent is then captured by the producer through the value of the currency unit, and exploitation can be restricted by limiting the total allocation of units. Presumably trade in units between producers would enable any comparative advantage in production to be expressed. The mechanism can only work effectively if poaching is eliminated, but the appropriation of the resource rent by producer countries (as opposed to traders or the consumers) would enhance this.

A total trade ban is rejected as a long run mechanism for preserving elephants, in that it is attempting to reduce the exploitation by reducing the value to zero. While this may be the only viable short run option, it is also risky, in that reduced valuation will increase the chances of depletion by competition. It would also be viewed as economically inefficient in that it is not addressing the central problem of the resource which is one of un-enforced property rights. If countries wish to express their existence values for the species it may be more efficient for them to direct aid towards ensuring that the illegal exploitation is prevented directly.

## 4.2 International Responses

Some environmental problems have an obvious international dimension. The atmosphere, the stratosphere and the oceans beyond exclusion zones are open access resources, which are in danger of over-exploitation if national self-interest is left unchecked. To prevent the "tragedy of the commons" international agreements are needed which in effect alter property rights from open access to common property[27], i.e. the management of the resource is undertaken by a well-defined group governed by an agreed set of rules.

[27] An alternative would be nationalisation of the resource. The creation of national property rights, as in the case of the 200-mile exclusion zone of the ocean along coastline, is an example of such an approach.

As Helm and Pearce (1990) point out, there is still a risk of breakdown in these agreements, where maximisation of national welfare is in conflict with maximisation of the collective good[28]. To make the agreement binding, some form of side-payment (an in-kind transfer, cash payment, or transfer of technology) may be required. In essence such side-payments conform to a "victim pays principle"[29]. The victim may have little alternative to offering side-payments, if it does not import the product whose production creates the spillover (and so cannot retaliate with barriers to that trade).

Incentives to co-operate in the management of international externalities may also be necessary in cases where countries are differentially affected, or place a different valuation on the environmental damage, or have different capacities to contribute to the management of the common resource. The latter is of particular topical interest, since many developing countries, beset by international debt problems, cannot meet the costs of improving environmental quality. As in a national setting, a moral hazard is introduced, whereby, in order to elicit payments, the country may threaten to degrade its resources, falsify information on the rate of degradation, etc.

Some environmental problems appear as purely national concerns but take on an international character when international trade effects are considered. As noted above, differential environmental regulation can encourage the international transmission of environmental risks -"pollute-thy-neighbour-via-trade". This in turn often leads to barriers to this trade being introduced, both as a means of maintaining national health and safety standards and as a form of protectionism. However, little attention has been given to this issue. As Runge (1989) notes, one of the few international responses has been FAO's work in

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[28] The problem may be characterised as the "Prisoner's Dilemma". Each participant stands to gain by not co-operating with the others, but all participants would be better off if they all co-operated.

[29] As examples of this principle at work, Helm and Pearce cite Sweden's technical assistance to reduce acid emissions from Poland and the currently negotiated technology transfers to China and India with respect to CFCs.

developing the "Codex Alimentaris" as a set of rules governing food and agricultural health and safety.

Obtaining agreement on binding environmental and health standards is of course fraught with difficulties, not least in determining the level at which the standards should be set. Differences in national priorities and level of economic development must be allowed for; standards need not be the same for all countries. James (1982, p.260) advocates "intermediate standards" for LDCs. That is to say, whereas there is a need to improve health and environmental regulations in the LDCs, "it does not follow from this that countries of the Third World should adopt either the same number or the same level of standards as developed countries."[30] In this regard a case could be made for "Special and Differential Treatment" for LDCs under GATT rules. The terms under which it is granted may reduce present regulatory differentials by upgrading LDC norms (Runge, 1989).

Clearly there is a role for the multinational agencies (WHO, FAO, UN Environment Programme, as well as GATT, the World Bank and IMF) in coordinating international efforts towards a cooperative solution. As a beginning, current discussions on trade, aid and development could be extended to a consideration of environmental and health regulation and its use as a barrier to trade. In addition, one could follow Runge's suggestion of an international accord "to call for the rights, duties, and liabilities that define national regulations." The recent Montreal Protocol on emissions reduction, agreed by 40 nations, suggests that some progress in this direction is possible.

### 4.2.1 External Assistance

Although not strictly related to trade policy, a variety of forms of external assistance exist which may be of significance in improving the sustainability of agricultural systems. Debt relief will be of importance

[30] Cited in Runge (1989).

if unsustainable practices are being encouraged in order that agricultural exports can generate foreign exchange earnings (for example, the case of 'exporting the soil' developed in section 3.1.1). Writing off debt removes this particular pressure, but there is no guarantee that this in itself will result in a reversal of the adverse agricultural policies. Other sources of export earnings may be reduced or foreign exchange may still be demanded for other purposes. 'Debt-for-nature swaps' are more focused, in that there is a commitment to maintain a specific level of environmental quality in return for writing off some debt (Hansen (1988) reports on two schemes implemented in Bolivia and Costa Rica). Where that environment is under threat from exchange-earning activities, the national government can easily identify the net benefit from entering into the arrangement, although loss of sovereignty over the utilization of the resource may have to be borne.

Where the reason for intervention is to prevent a negative externality (such as increased $CO_2$ levels due to clearing rain forests), debt-for-nature swaps would appear to be implementing a victim-pays principle. In such cases of international externalities this may be the only feasible solution. On the other hand, intervention may be a means for expressing an existence value for the resource, and therefore the side payment is appropriate. Formally, there is no reason why this payment should be linked to debt. Control of threatened resources can be passed to other agencies for conservation purposes. Such a scheme is currently being developed in Belize, where a charity, Programme for Belize, has purchased 110,000 acres of forest which otherwise would have been unsustainably exploited, with the purchase price being raised by public appeal, mainly in the UK, US and Canada. (Programme for Belize, 1990).

Other forms of assistance may also be of importance. For example, food aid in the time of drought clearly has a fundamental humanitarian objective, but it could also be important in preventing resource degradation by people facing an absolute existence constraint. Furthermore, given the possibility of irreversibilities in natural systems, such aid should be preemptive, being provided before significant resource degradation occurs. This need has to be balanced against disruption to the domestic production and marketing system.

Project aid clearly has the potential for generating significant improvements in sustainability, either through the assessment of the environmental impacts of all aid-based projects, or more directly through projects aimed at improving specific environments. The latter could include changing agricultural practices by education and dissemination, implementing direct projects such as erosion control, waste disposal, tree planting etc. Although projects may increase sustainability in this way, their success will be constrained by national agricultural policies which determine the general economic conditions, and so programme aid has a role in facilitating the sorts of domestic policy developments that have been outlined in this report.

Once again, there is a clear role for the multinational agencies in coordinating international efforts towards a cooperative solution.

## 4.3 Concluding Remarks

The main obstacle to sustainable agricultural development is the failure of economic policy to address adequately the problems of natural resource management. Where there are external, social costs associated with production, agricultural policy, including trade policy, cannot be formulated in isolation. If excessive environmental and resource degradation is to be avoided, there must be explicit integration of agricultural and natural resource management concerns in economic policy design and implementation.

The process of integration can be based on moral suasion and education, on regulation and on institutional reform. But given the multi-use nature of the resource base, the complexity of the interactions between market stimuli, economic activity and environmental quality, and the differential constraints and valuations placed on its management, the form of the integrated package of policy instruments will depend on the specificities of the problem in hand.

The interaction between international trade and resource degradation is particularly important, since the pattern of trade has implications for resource use and environmental policy affects comparative advantage. But again the precise linkages are often difficult to establish. What does emerge is that i) where externalities exist the market-determined trade pattern is not socially optimum, ii) trade liberalisation cannot be relied upon to improve environmental quality, especially in the developing countries, and iii) non-tariff barriers on trade may not protect the resource base as intended, if the economic signals created are inappropriate. A central point is that where there are non-market, social costs to production, these must be fully incorporated in economic signals: it is a question of getting the right prices right.

Finally, national responses to problems of environmental and natural resource management will inevitably prove inadequate where there are "international externalities", i.e. resource degradation has spillover effects on non-residents. In this case there must be international co-operation, with the multinational agencies taking the lead, to ensure that vital environmental resources are protected from the risks associated with myopic national self-interest.

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## APPENDIX 1

### The Trade-Off Between Environmental Quality and Production

With a given technology and full employment of resources, an improvement in environmental quality is possible only if more resources are used in abatement of the external costs of production and hence the production of commodities is reduced. Alternatively, commodity production can be expanded at the cost of reduced environmental quality, if resources are withdrawn from abatement and the external costs rise with output. Figure A1.1 illustrates this point: JK represents the economy's production possibilities of the two goods with a high environmental quality; DE depicts the frontier if environmental quality is reduced.

The trade-off between environmental quality might be better illustrated by the three-dimensional Figure A1.2. The economy would be in "ecological paradise", to use Siebert's phrase,[1] at point A, with maximum environmental quality and no output of either product. Initiating production of good 1 alone generates environmental damage, say in the form of pollution, but up to a certain point (B) all emissions can be reduced by using resources in abatement. Similarly, production of good 2 could be undertaken, in the absence of good l, and the economy could reach point (C), maintaining the initial level of environmental quality. If production is increased beyond B or C, environmental quality declines, since the quantity of pollutants rises and resources are withdrawn from abatement activities. If no resources are used in abatement in sector l, the economy could reach a production maximum depicted at point D. Similarly if no resources were used in abatement in sector 2, point E could be reached: DE or equivalently D'E' is the orthodox production possibilities curve for the two goods.[2]

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[1] Siebert (1977), p.665.

[2] Note $DD' > EE'$, indicating that good l is the product generating relatively more environmental damage.

### Introducing Trade

Siebert (1981) and Siebert et al. (1980) explore the effects of environmental policy on a small, two sector, open economy in which pollutants are generated as joint products of output and, when emitted into the environment, reduce environmental quality. Under the "small country assumption" relative commodity prices are exogenously determined in the world market.

### Production Technology

Production of commodity i (i=1,2) is derived from a simple production function with decreasing marginal returns:

$$Q_i = F_i(R_i) \qquad \text{(A1.1)}$$

where $Q_i$ is the quantity produced and $R_i$ denotes the resources used in production.

As a joint product, pollutants $S^p$ are generated:

$$S_i^p = H_i(Q_i) = H_i(F_i(R_i)) = Z_i(R_i) \qquad \text{(A1.2)}$$

with $Z_i' > 0$, $Z_i'' > 0$.

By using resources in abatement ($R_i^r$), pollutants can be reduced, at a rate specified in an abatement function:

$$S_i^r = F_i^r(R_i^r) \qquad \text{(A1.3)}$$

with $F_i^{r\prime} > 0$, $F_i^{r\prime\prime} < 0$

The total emissions and pollutants ambient in the environment are then simply given by:

$$S = \Sigma S_i^p - \Sigma S_i^r \qquad \text{(A1.4)}$$

Production and abatement activities are restricted by an overall constraint on resource availability:

$$\Sigma R_i + \Sigma R_i^r = R \qquad \text{(A1.5)}$$

assuming resources are fully employed.

Finally, the public good, environmental quality, (U) is determined by the pollutants ambient in the environment:

$$U = G(S),$$

with $G' < 0$, $G'' < 0$.

The production possibilities of the economy can also be depicted graphically. Figure A1.1 represents a transformation frontier, indicating the maximum production possibilities of the 2 commodities and of the public good, environmental quality.

**<u>Consumption and Resource Demand</u>**

The analysis proceeds by introducing some behavioural assumptions. Here we restrict attention to competitive equilibrium.

Consumer demand functions take the following form:

$$Q_i^d = D_i(p,Y) \qquad \text{(A1.6)}$$

where $p = P_1/P_2$ is the (given) relative prices of the two commodities. Income (Y) is defined from the production side. To keep matters simple, there are no savings and to close the model, it is assumed that the governments tax revenue is transferred to households. Hence, disposable income is equivalent to net national income.

$$Y = pQ_1 + Q_2 \qquad \text{(A1.7)}$$

Transfers are not explicitly represented here and henceforth p denotes the consumer price, not the price received by producers.

Although the relative product price is fixed, allocation effects do occur when an environmental policy, in the form of an emission tax ($\tilde{t}$), is introduced. Firms, in making their production decisions must take this tax into account, as well as commodity prices (p), the resource price ($\tilde{r}$), and the technical parameters of the production function. Assuming profit maximisation, resource allocation will be determined as follows:

$$r = (p - tH_1') F_1'(R_1) \quad \text{(A1.8a)}$$

$$r = (1 - tH_2') F_2'(R_2) \quad \text{(A1.8b)}$$

$$r = tF_i^{r\prime}(R_i^r) \quad \text{(A1.8c)}$$

where $r = \tilde{r}/p_2$ and $t = \tilde{t}/p_2$.

Equations (A1.8a) and (A1.8b) indicate that firms will use the resource up to the point where the resource price is equal to the marginal value product of the resource, i.e. the marginal productivity of the resource evaluated at the producer price. The latter is defined as the consumer price, p, less the emission tax paid on a unit of output (i.e. pollution generated by one unit of output multiplied by the emission tax). For a pollution-intensive commodity, the producer price will be lower, ceteris paribus, since there will be a higher tax per unit of output. The imposition of a tax reduces the incentive to produce it. With respect to (A1.8c), the marginal value product of abatement is equated to the resource price. For a given level of r, an increase in the emission tax would induce a reduction in the marginal productivity of the resource in abatement and so the use of the resource in this activity must increase.

## General Equilibrium

In the closed economy, commodity markets must be in equilibrium so that $Q_i = Q_i^d$. For the small, open economy, this condition is replaced by equilibrium in the balance of payments.

With excess demand defined as

$$E_i = Q_i^d - Q_i, \quad \text{(A1.9)}$$

the balance of payments in terms of commodity 2 can be expressed as

$$Z = -(pE_1 + E_2).$$

For equilibrium in the balance of payments:

$$pE_1 + E_2 = 0. \quad \text{(A1.10)}$$

Given that p is determined in the world market, there are 18 variables in this system of equations: $Q_i$, $Q_i^d$, $S_i$, $S_i^p$, $S_i^r$, $R_i$, $R_i^r$, Y, r, $E_1$ and $E_2$.

The structure of the model is illustrated in Figure A1.3.

The effect of environment policy on each of these variables can be determined by totally differentiating with respect to the emission tax, t:

$$\begin{bmatrix} a_1 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & a_2 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & -tF_1^{r''} & 1 & 0 & 0 & 0 \\ tF_2^{r''} & tF_2^{r''} & tF_2^{r''} & 1 & 0 & 0 & 0 \\ F_1'D_{2y}' & -F_2'D_{ly}' & 0 & 0 & 1 & 0 & 0 \\ -pF_1'D_{2y}' & -F_2'D_{2y}' & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & p & 1 & 0 \end{bmatrix} \begin{bmatrix} dR_1 \\ dR_2 \\ dR_1^r \\ dr \\ dE_1 \\ dE_2 \\ dQ_2^d \end{bmatrix} = \begin{bmatrix} -Z_1'dt \\ -Z_2'dt \\ -F_1^{r'} \\ -F_2^{r'}dt \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

where $a_i = tZ_i'' - P_xF_i'' > 0$ and $P_x = p$ (for $i=1$) and $= 1$ (for $i=2$).

## Implications

It is assumed that the home country exports the pollution-intensive commodity, good 1, and imports the other good. Environmental policy will increase resource use in abatement activities, reduce resource use in the pollution-intensive sector and in both production activities taken together. Resource use in the less pollution-intensive sector may rise or fall. The production point on the transformation space is determined by the relative prices, p and t. Equilibrium in the resource market is achieved through adjustments in r.

Demand conditions determine the level of home consumption and hence the quantity available for export. Equilibrium in the balance of payments, given p, determines the level of imports. National income will fall, since resources are withdrawn from production and relative product prices are given. With regard to the change in exports and imports,

$$\left.\begin{matrix} Z_1' > Z_2' \\ F_1' D_{2y} + F_2' D_{1y} > 0 \\ a_2 p F_1' D_{2y} > a_1 F_2' p D_{1y} \end{matrix}\right\} \rightarrow d(-E_1)/dt,\ dE_2/dt < 0$$

Assuming sector 1 is pollution-intensive and $a_2 > a_1$, then exports will decline if commodity 1 has a lower income elasticity ($D_{2y} > pD_{1y}$). Home demand for commodity 2 will fall if it has a positive income elasticity,

$$\left.\begin{matrix} Z_1' > Z_2' \\ D_{2y} > 0 \end{matrix}\right\} \rightarrow dQ_2^d/dt < 0$$

Some of these results are illustrated in Figure A1.2. To simplify the diagram, only the production block (XYZ) of the rest of the world is depicted. This lies horizontally, cutting the transformation space of the home country at F, the point of antarky (no-trade). Here the relative price in the home country differs from the world price.

If trade takes place, a new equilibrium occurs at F', the gains from trade being shown by the trade triangle at that point. However, at F', environmental quality has declined.

The introduction of an environmental policy will result in fall in the production of good 1 and a rise in environmental quality. The economy shifts to G, where the improvement in environmental quality is achieved by reducing the gains from trade.

**Extension to the two-country case:**

The assumption of given relative prices can be removed by considering a two-country world. The equations for the home country are as before, but the model is augmented with conformable equations for factor demands, production functions, demand, net income and the resource constraint in the foreign country. It is assumed that the foreign country does not undertake environmental policy and so no resources are used in abatement. Denoting variables in the foreign country by an asterisk, the world market in commodity 1 is in equilibrium when

$$E_1 + E_1^* = 0.$$

The global budget constraint is given as

$$pE_1 + E_2 + pE_1^* + e_2^* = 0.$$

The relative price, p, common to both countries is now a variable. Walras' Law ensures equilibrium in the world market for commodity 2.

The model now comprises 23 equations in 23 variables $Q_i, Q_i^*, R_i, R_i^r, R_i^*, S_i^p, S_i^r, S_i, Q_i^d, Q_i^{d*}, r, r^*$ and p. Assuming non-inferior commodities, it can be shown (Ch.5 of Siebert et al.,1980) that, as in the small country case, environmental policy will reduce resource use in the pollution-intensive sector and in both productive activities. National income will fall if either the pollution-intensity of a sector is relatively high or if it has a large price elasticity of demand. If the demand for the pollution-intensive product (1) is less income elastic than the other commodity and this sector is "dependent" on the resource R ($a_2 > a_1$), the relative price of commodity 1 will rise and exports as well as imports of the home country will fall.

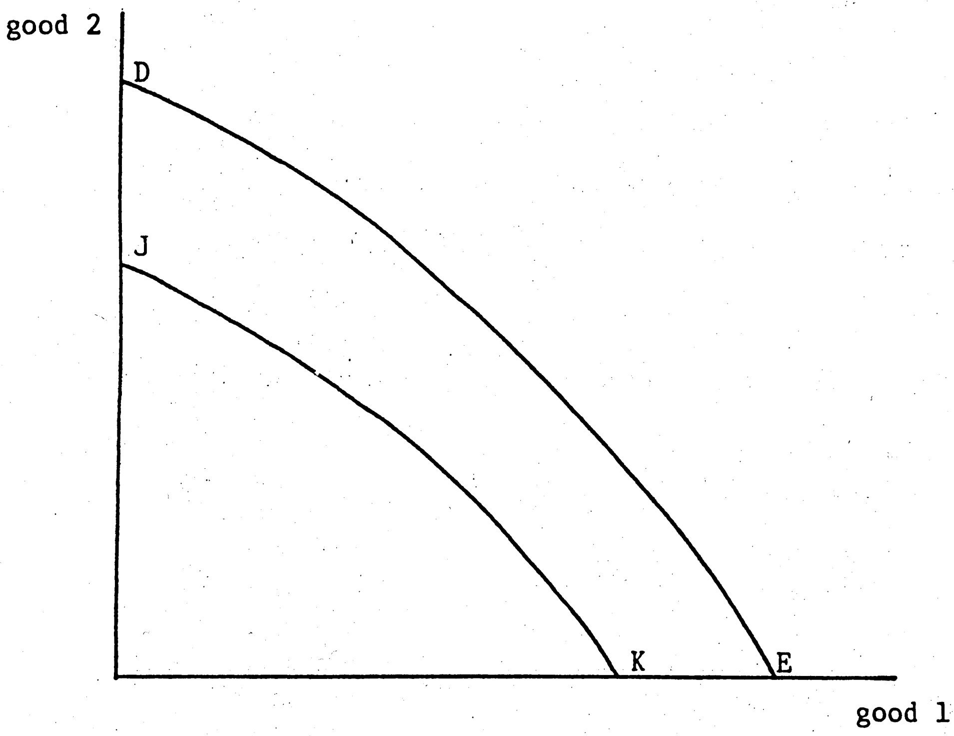


FIGURE A1.1 : Production Possibilities for Different Levels of Environmental Quality

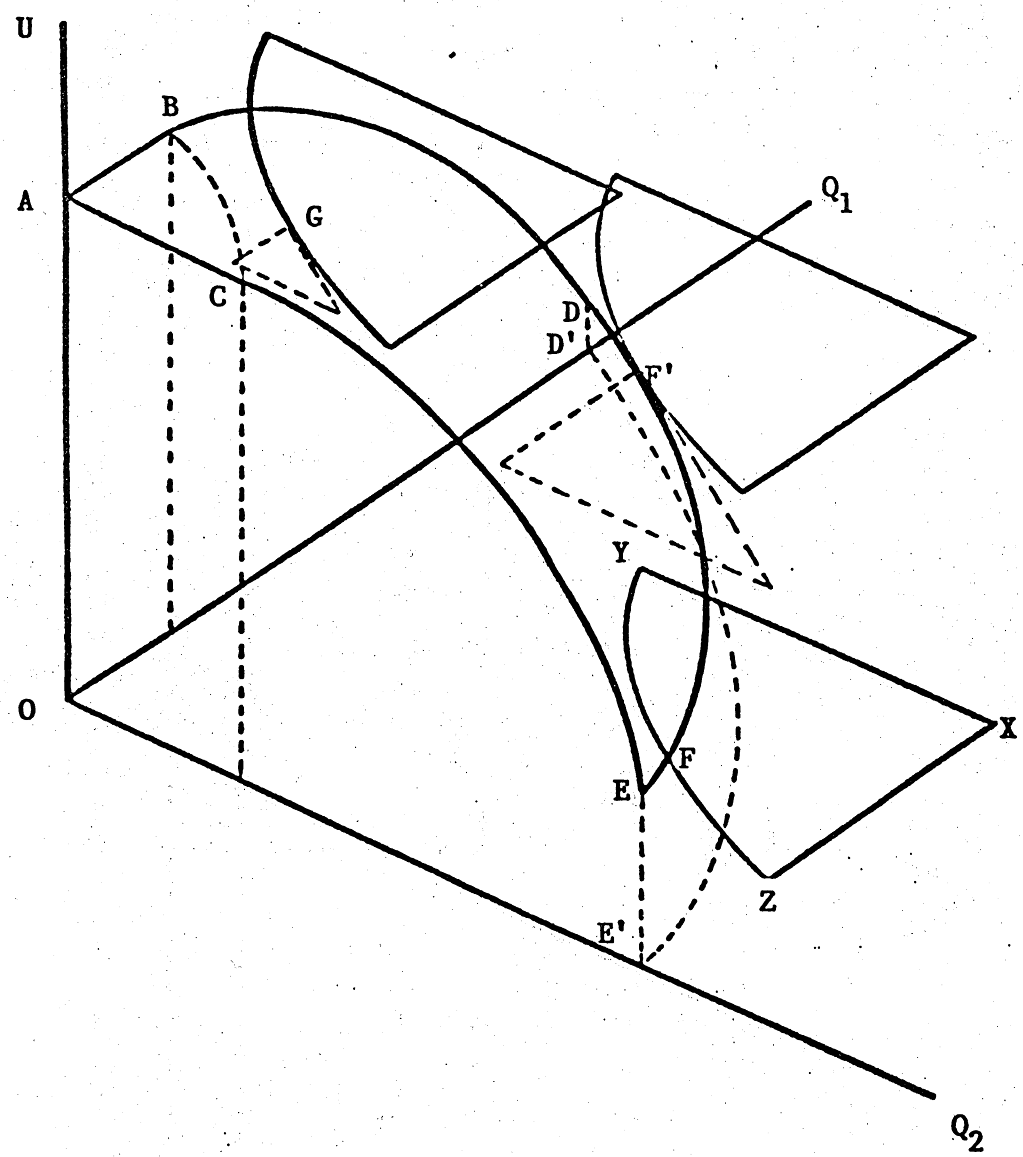


FIGURE A1.2 : Environmental Quality and the Gains from Trade

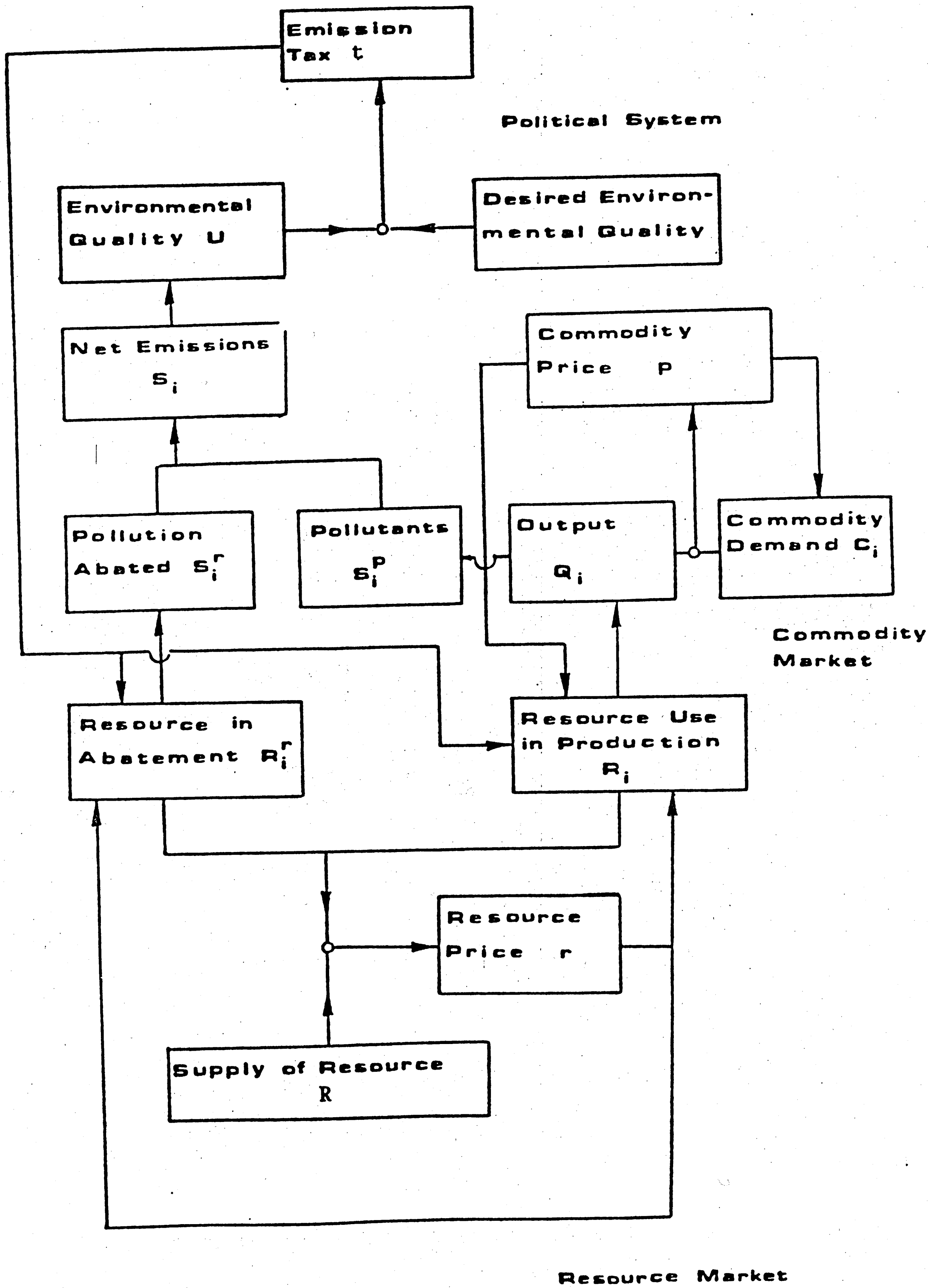


FIGURE A1.3 : Structure of the General Equilibrium Model