ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

PART I

REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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LONDON ENVIRONMENTAL ECONOMICS CENTRE

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ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

EXECUTIVE SUMMARY

REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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ENVIRONMENTAL ECONOMICS IN DEVELOPING COUNTRIES

LONDON ENVIRONMENTAL ECONOMICS CENTRE
FOR USAID-OECD-DAC

EXECUTIVE SUMMARY

Volume 1. **SUSTAINABLE DEVELOPMENT**

This volume summarises various definitions of 'sustainable development', including the one made popular by the Brundtland Commission. The Commission argued that sustainable development was development which met the needs of today's generation without compromising the needs of tomorrow's generation. Economists have translated this to mean that human welfare must be non-decreasing over time. In turn, this means that today's generation must expect to compensate future generations for harm being done by actions taken today. Compensation could involve the passing on of a stock of capital - man-made and natural (environmental assets) - which is no less than the current stock. The implications of sustainable development as far as environmental economics is concerned appear largely invariant with definitions. These relate to the need to price resources and goods correctly, by 'internalising' external effects, to evaluate environmental impacts and to modify the way we measure economic progress, and to emphasise the environmental impacts of macroeconomic policy.

Volume 2. **NATURAL RESOURCE ACCOUNTING**

This volume summarises recent developments in the field of environmental accounting focusing, in the main, on the developed country experience. It examines the current criticisms of the System of National Accounts, and the failure to incorporate the natural resource base and natural capital depreciation within the framework of the national accounts.

Detailed reference is made to the 'monetary' and physical approach, which broadly defines the two camps of thought. The physical approach endorses a set of separate 'satellite' accounts to summarise natural resource stocks and flows. The monetary approach requires that environmental assets, stocks, flows, and qualitative and quantitative changes in the state of environmental assets be valued and then used to develop an augmented measure of Net National Product. In examining the methods of accounting, the Norwegian, French and Canadian experience of developing the physical approach is highlighted and contrasted with the few attempts to monetise the national accounts in Japan, and for Indonesia. New work is under way on Costa Rica and Mexico.

Volume 3. **MONETARY VALUATION OF ENVIRONMENTAL ASSETS AND CHANGE**

This volume addresses the problem of environmental valuation. The purpose of valuation is to correct those prices that do not correspond to their 'true' economic values, and to calculate prices for those assets that are not valued at all. Valuation of the environment is crucial in a world where the optimal allocation of scarce resources cannot be relied upon by the decentralised workings of the price mechanism.

The volume summarises the diverse means of valuation, examining the methodological issues and the practical relevance of certain techniques in the developing country context. There is a detailed discussion of 'direct' and 'indirect' valuation techniques and their applicability in developing country economies. Direct valuation techniques encompass contingent valuation, hedonic pricing, hedonic wages, the travel cost method, and the production function approach. There follows case studies of the economic consequences of certain environmental projects: the benefits of afforestation, fisheries and hill forest development. Indirect valuation procedures comprise dose-response relations and the inference of a damage function.

Throughout this volume attention has been focused primarily on those techniques that have greater relevance for the developed rather than the developing nations. This reflects the bias in the literature, and the failure adequately to address the prevailing lack of data, freely functioning markets, and applicable techniques, within the developing nations. Nonetheless, recent work is showing that all the developed economy techniques have application to the developing countries.

Volume 4. **DISCOUNTING AND THE DEVELOPING COUNTRY EXPERIENCE**

Discounting is a fundamental tool of project evaluation. It enables the project analyst to compare and contrast costs and benefits that occur at different points in time.

This volume reviews the various methods of discounting in terms of project analysis, looking at the source of a social discount rate. Discounting affects environmental degradation in various ways. High discount rates lower the importance attached to long-term benefits or costs. It can reduce the attractiveness of projects such as forestry, because of the gestation period before a harvest can be secured, and reduce the extent to which long-term damages, e.g. from radioactive waste or global warming, are given adequate consideration. There is a detailed comparison of the social opportunity cost and the social rate of time preference in the context of the social appraisal of developing country projects and an assessment of how discount rates impact on resource use. The volume concludes with a discussion of ways to avoid adjusting the discount rate, and the 'endogeneity issue'. The endogeneity issue means that discount rates are determined by, as well as determining the state of the

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environment. In the light of this ambiguity theorists have argued that additional criteria should be employed in project analysis and in determining investment decisions. Some economists propose the use of sustainability criteria. They argue that, particularly in developing countries, the stocks of natural resources are below any reasonable estimate of what the long-run optimal natural capital stock should be. It would therefore be desirable for investment policy to incorporate natural capital stock requirements, preventing stocks from falling further below their already suboptimal levels.

Volume 5. **RENEWABLE RESOURCES AND PROPERTY RIGHTS**

This volume considers the renewable natural resource base - soils, biomass, water - and how its capacity for regeneration depends on the chosen management regime. Broadly, the types of resource management regimes consist of private ownership, 'common property' - the ownership by a reasonably well-defined community, and 'open access' - a situation in which there is no ownership at all. Conventional wisdom is that common property suffers 'the tragedy of the commons', overexploitation of the resource due to individual greed. Both theory and practice demonstrate that this is an oversimplistic conclusion. Many common property regimes involve the sustainable use of resources, but may break down due to overpopulation or responses to inefficient macroeconomic signals from central government. Theoretically, privatisation can conserve resources but outcomes are ambiguous if private owners have high discount rates. Open access resources do face high risks of extinction and this suggests the importance of establishing acceptable forms of property rights.

Volume 6. **POLICY FAILURE AND ENVIRONMENTAL DEGRADATION**

Natural resources and the environment will be degraded if their values are not fully recognised and integrated into decision-making processes by individuals in the market-place and by governments. Where this integration does not occur, there is said to be 'failure'. If markets fail fully to reflect environmental values, it is termed market failure. Where government decisions do not fully reflect these values there is policy or 'government failure'.

This volume examines the nature of policy failure in the developing nations. It considers inefficient pricing policies in the irrigation sector, an outcome of inadequate or misapplied administered price regimes. Similarly, pricing policies are examined in the energy sector, in livestock ranching, and in forest management, together with their impact on the profile of resource use and management. The prevalence of poorly focused input and output price subsidies, the provision of tax thresholds, cheap credit facilities, insecure land titling, and overvalued exchange rates, has led to the development of complex and inefficient incentive structures which promote rent-seeking and unsustainable resource use.

Volume 7. **AGRICULTURAL PRICING AND RESOURCE DEGRADATION**

In order to examine resource use and environmental degradation there is a need to develop our understanding of economy-environment interactions. Resource use, and consequently economic development, is greatly affected by internal factors such as pricing controls, relative price movements, international demand and trading controls.

This volume summarises the literature on agricultural pricing and its affect on land use, resource use and development. Price and exchange rate policies for agricultural outputs and inputs are considered in the light of their consequent effect on agricultural practices, agricultural growth, the adoption of soil conservation practices and their overall impact on the underlying resource base. Agricultural pricing policies are related to environmental degradation - desertification, deforestation, soil erosion, the unsustainable use of farm machinery, over-intensive and extensive agriculture. The relationships are shown to be complex and in need of substantial further investigation.

Volume 8. **INTERNATIONAL ENVIRONMENTAL POLICY**

Environmental problems do not respect political frontiers. Waste emissions in one country can impact on other countries, as with acid rain, or the pollution of international waters. The resolution of international environmental problems requires some form of international environmental policy involving the design of incentives to secure cooperation by individual countries.

This volume addresses international environmental policy, particularly the mechanisms through which international transfers can be effected. International conservation finance, debt-for-nature swaps, global environmental trusts, are all discussed with reference to their practicability, focus, and extent. The volume also considers structural adjustment loans and their environmental impacts. It is shown that structural adjustment is neither universally good nor bad with respect to environmental impacts and that significant further work is required.

The second section of this volume focuses on the 'greenhouse effect' and the implications of global warming. The cause and effect relationships are examined, as are the consequences of global warming for the developing nations. Potential policy reactions are considered - carbon taxes, tradeable permits, reforestation programmes, debt-for-nature swaps, and the role that aid agencies might potentially have in initiating corrective policy.

Volume 9. **POPULATION GROWTH AND ENVIRONMENT**

This volume reviews the state of knowledge on population trends and future projections. Natural trends are now leading to declining birth rates in many developing countries, but the experience of Africa is the exception. The reasons for the difficulty of accelerating population stability in Africa are investigated in terms of economic decisions faced by rural and urban households. The impact of population growth on the environment is then reviewed. This relates population change to pressure on resources (carrying capacity) and to the nature of the resources - e.g. whether it is common property or open access. Population change is often argued to stimulate technical change in agriculture. The arguments are reviewed.

Volume 10. **POVERTY AND ENVIRONMENT**

The conventional analysis of the relationship between poverty and environmental degradation characterises it as a reciprocal one. However the causality is complex. Poverty is cited as one of the 'push' factors that forces subsistence populations onto marginal lands, necessitating their unsustainable use as a result of the high private discount rates faced by such populations. This in turn contributes to their impoverishment and furthers environmental degradation. Very little is currently known about the dynamics between poverty and environmental degradation. What is known is that the causality is not solely uni-dimensional. Poverty is only one of the contributory factors that accelerate ecosystem destruction.

This volume summarises the recent work on poverty-environment linkages, addressing those factors considered to be significant in the cycle of environmental degradation. Reference is made to problems of scale, unequal access to productive resources, income strategies, government failure or misallocation, and the divergence between private and social discount rates. There then follows an account of the methodological approach to uncover the linkages between poverty and the environment. Attention is paid to the use of satellite imagery and GIS's as a means of augmenting socio-economic data, and providing the analyst with an overview of the profile of resource use.

Case studies are presented applying this methodology, assessing the push factors and incentives that promote environmental degradation, and mapping the process of environmental change.

ENVIRONMENTAL ECONOMICS IN DEVELOPING COUNTRIES

LONDON ENVIRONMENTAL ECONOMICS CENTRE FOR USAID-OECD-DAC

IDENTIFYING THE GAPS IN RESEARCH ACTIVITY

Introduction

The reports prepared by the London Environmental Economics Centre for US AID cover two issues:

- a brief expose of the nature of environmental economics problems in developing countries, together with abstracts of key items in the literature;

- a directory of research institutions working in the area or capable of working in the area without significant change of research direction.

We have identified gaps in the research activity. However, time constraints limited our search and some areas have not been itemised in any detail. These are:

(i) The labour market and environmental linkages. The literature has not addressed this as a fundamental area for concern. We feel that in the examination of incentives and particular policy responses to conservation and input subsidies, this is an area which deserves more coverage.

(ii) Urban pollution: cost-benefit valuations and the design of economic incentives.

(iii) International trade and environmental degradation - e.g. hardwoods trade.

(iv) Large investments - hydrodams, roads,and the environmental impacts of infrastructural investment.

(v) Wildlife and biodiversity.

(vi) Energy policy and its impact on the developing countries in terms of the overall profile of resource use and environmental degradation.

Need for Networks

We feel that despite the proliferation of bodies investigating environmental economics with particular reference to the developing countries, there is little coherence in the field. An international framework needs to be developed through which the efficient exchange of information and ideas can be facilitated. Further there is great need for the coordination of donor agencies, to ensure that competing projects do not inadvertently exacerbate incentive problems which may compound environmental degradation.

There follows a summary of the literature reviewed in the 10 volumes identifying the gaps, and drawing attention to areas of priority.

The categorisation into areas of precedence is as follows:

Priority Area ***
Area of Significant Interest **
Potential for Further Work *

The judgements about importance are our own.

1. SUSTAINABLE DEVELOPMENT

Definitions of Sustainable Development abound. There is some agreement that sustainable development is about non-declining human welfare and that this requires protection of the capital base of the economy, <u>including</u> 'natural capital' i.e. environments. The implications are clear:

(i) Pricing regimes should be made to converge upon the shadow value of the resources, that is their efficiency or opportunity cost prices.

(ii) Cost Benefit Analysis should be carefully undertaken to incorporate these shadow values and all project analysis should take account of the sustainability criteria. Where certain projects displace others or where resource stock depletion is legitimised, natural capital stock constancy can be adhered to at the macro-level by the initiation of compensating projects which need not pass traditional cost benefit criteria. However, some attempt must be made to value the resource stock and identify use, existence and option values in order for constancy to have any meaningful content.

(iii) Natural Resource Accounting is vital if developing countries are to be able to implement sustainable development and precautionary environmental policy. There is a critical importance of natural capital stock in the less developed countries.

Gaps: we need more theoretical work, but it is not vital. More stress is needed on the implications of sustainability criteria for project analysis and implementation and for the profile of long-term development.

2. NATURAL RESOURCE ACCOUNTING

Potential for Further Work *

There is still some methodological dispute. Broadly the central issues are, can we value the natural resource base, and how should uncertainty be incorporated into values that might adequately represent the resource base within the national accounts. The two camps of thought roughly divide into the Serafy school of capital depreciation versus the Repetto school of Net National Product and amended GNP measures.
The methodological disputes appear to be in hand and the dialogue has been thought-provoking and fruitful.

We would like to emphasise the potential importance of Geographical Information Systems and remote sensing, as a means of augmenting socio-economic data and providing a measure of changes in resource stocks. However we understand the limitations of satellite imagery in that vegetative cover cannot accurately be identified under certain types of depletion and management regimes.

The role of satellite accounts as a means of developing a database and a platform for the later incorporation of the natural capital stock into the national accounts appears vital.

Gaps: more LDC applied work, the construction of adequate databases, and funding for satellite accounts. This is of great importance if we are to be able to apply sustainability criteria within the developing nations.

3. MONETARY VALUATION OF ENVIRONMENTAL ASSETS AND CHANGE

Area of Significant Interest **

Most of the valuation studies currently being undertaken are developed country studies. The methodology, contingent valuation, travel cost methods. and hedonic pricing are however, inapplicable to the developing nations despite the fact that markets are not freely functioning.

Hedonic pricing with land values, shadow wages and morbidity studies are fruitful lines of pursuit. More extensive use should be made of the production function approach, particularly with reference to crop losses, forest productivity, etc. This presumes a knowledge of physical and ecological linkages, the data requirements are enormous and not generally met. Pilot databases must be devised, Geographical Information Systems should be developed to summarise the physical and ecological data.

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4. DISCOUNTING AND THE DEVELOPING COUNTRY EXPERIENCE

The discounting debate remains unresolved. Much of the theory and practice discussed in this volume feeds directly into the issue of sustainability criteria. The endogeneity of social rates of time preference which incorporate environmental factors has significant implications for sustainable development. If discount rates are raised how will this impact on resource use and environmental degradation? The literature is not conclusive and the implications for the resource base are as yet ambiguous.

Whilst further examination of this area is advised it is unclear what research any donor agency could profitably initiate in this area.

> Volumes 2.,3.and 4. have fundamental implications for Sustainable Development and sustainability criteria. Without careful application of Natural Resource Accounting and the methodological advancement of developing country valuation studies sustainability cannot be attained.

5. RENEWABLE RESOURCES AND PROPERTY RIGHTS

Priority Area ***

There is desperate need for more studies of developing country societal norms common property regimes - why some work and others do not. Specifically, further work could be initiated on the comparison of resource management under common property regimes, and the identification of the source of potential failure under communal management.

The 'tragedy of the commons' is not a foregone conclusion. Further research could profitably be initiated integrating economics and development anthropology, investigating social norms and social cohesion in LDC's.

STRUCTURAL ADJUSTMENT

6. POLICY FAILURE AND ENVIRONMENTAL DEGRADATION

Priority Area ***

There is a vast literature on incentives, with the existing emphasis being appropriate. This survey of the literature uncovered a multitude of areas where government policy either directly or indirectly contributes to natural resource degradation. the overwhelming conclusion is the need for incentive restructuring, and efficiency pricing to ensure that price signals correct for uninternalised externalities. The tax profile, the provision of concessions, credit facilities, administered pricing, direct and indirect subsidies, the failure to capture rents, the poor focus of subsidies and the resultant mismatch of needs and recipients must be addressed.

The prevailing pricing regimes, are not the sole source of government failure, legislative failure accounts for many of the incentives to degrade assets and farm unsustainably. Particular reference should be paid to the appropriate design of land tenure legislation, as a potential corrective measure.

7. AGRICULTURAL PRICING AND RESOURCE DEGRADATION

Priority Area ***

The full impact of agricultural pricing policies on environmental degradation and resource use have yet to be explored. The major gap is our knowledge of pricing-environmental linkages. Further work should be initiated, examining farmers responses to price changes, income and substitution effects, the take-up of new technology, the adoption of conservation practices, and the choice of intensive or extensive management regimes.

Input and output subsidies must be made apparent, particularly subsidies to pesticides, herbicides, capital machinery and the resultant ecological damage.

The implications for the cost benefit analysis of projects are significant: all CBA studies should have complete knowledge of the prevailing incentive structures, rent-seeking, the focus and mismatch of subsidies, the associated disincentives, and the economic and social loss from inefficient pricing.

Geographical Information Systems (GIS's) can play a greater role, adding a spatial dimension to socio-economic data.

What is apparent is that governments in general have little knowledge of the full profile and focus of their pricing policies. In general these evolve over time promoting inefficient rent-seeking activities as a result of inadequate, mismanaged and antiquated policy directives.

8. INTERNATIONAL ENVIRONMENTAL POLICY

Priority Area ***

(i) This is a comparatively new subject of study even within the area of LDC environmental economics.

(ii) We have chosen to focus restrictively on the implications global policy has for the developing nations, the threat posed to these nations by global warming and the potential for the development of carbon sinks and coordinative action within developing countries and between developing and developed nations.

(a) In respect of the greenhouse effect, the role of developing countries, their contribution to global warming through deforestation, and conversely the design of international economic incentives to prevent needless deforestation.

(b) The nature of resource transfers needed between developed and developing nations to induce cooperation in global agreements. The Montreal Protocol, tradeable permits, carbon taxes, Debt-for-Nature swaps, CFC substitutes, international pollution legislation etc. Innovative resource transfer systems are available, DFN or Debt-for-Sustainable Development which may provide a vital tool for donor agencies to ensure agreements remain tied to environmental aims.

Donor agencies have a central role to play as an instrument for effecting resource transfers to developing countries.

9.and 10. **POPULATION GROWTH AND THE ENVIRONMENT/POVERTY AND ENVIRONMENT**

Priority Area ***

This is an area which has been very well researched in terms of Development Economics and problems of scale, poverty and population growth. However the relationship between poverty, population and the environment has been little explored despite popular assumptions about the traditional causality with respecc to unsustainable resource use.

Some work has already addressed problems of scale, the relationship between population growth and the breakdown of common property systems. Further work must be initiated to examine the effects of technological change, particularly in the agricultural sector. Databases have been employed to document the effect of population change on the profile of resource use. However few studies, like those of Jagannathan, have been undertaken integrating GIS's and socio-economic data. The relationship between population growth, problems of scale, and population displacement - migration - needs to be carefully examined in order to uncover environmental impacts. Attention must be paid to internal incentive structures, population movement constraints, government and market failure.

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ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME ONE

SUSTAINABLE DEVELOPMENT

D.W. PEARCE

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SUSTAINABLE DEVELOPMENT

The Economic Meaning of Sustainable Development

Sustainable development can be interpreted as being fair to the future. It is about leaving the next generation a similar, or better, resource endowment than that which we inherited. Resources enable us to achieve society's goals, the maximum wellbeing of the population combined with special concern for the most disadvantaged, the poor, the sick, the infirm. But any generation can increase its wellbeing at the expense of the future by plundering resources now, by rapidly depleting exhaustible resources such as coal and oil, by removing more than the sustainable yield of renewable resources such as timber and fish, and by disposing of wastes to receiving environments in amounts greater than those environments can assimilate. Being fair to the future means behaving sustainably. It means taking only the sustainable yield from renewable resources and honouring the environment's limited capability for receiving waste. It means using exhaustible resources wisely so that, as they are depleted, the profits from their use are reinvested in technology and other forms of capital wealth.

The basic rule of sustainability - leaving the same or an improved resource endowment as a bequest to the future - is open to two broad interpretations. Everyone is familiar with the idea of <u>capital wealth</u> - the stock of machinery, factories, roads made by man. There is <u>human capital</u> too - the stock of knowledge that advances as man discovers, experiments and thinks. By now we should also be familiar with the idea of <u>environmental wealth:</u> the stock of natural assets such as tropical forests, freshwater, fisheries and wildlife. Less familiar is the idea of thinking of other environments as wealth too. The ozone layer is an environmental asset, as are the fundamental biogeochemical cycles that regulate the earth and life upon it.

The Broad Interpretation of Sustainability

On the first interpretation of sustainability as fairness to the future it is the <u>total stock</u> of all forms of wealth that must not be depleted. It is consistent with this view that environmental wealth <u>is</u> depleted as long as that depletion is compensated for by a building up of the other forms of wealth, human and capital wealth. Equally, if man-made wealth is run down, environmental capital must be built up to compensate. On this broad view of sustainability the two basic forms of capital - man-made and natural - are <u>substitutes</u> for each other. Deciding how much to

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have of each form of capital then depends on the values placed on them by society. If it is more important to clear tropical forest for agriculture or timber, then the broad interpretation of sustainability sanctions that process.

This view of sustainability can be found in the literature on sustainable development[1]. Several points can be made.

First, deciding how much to have of each form of capital rests on determining their correct values. To the economist this means finding the right prices. Pricing man-made capital presents little problem since it is bought and sold in the market place. Pricing the environment is much more difficult. It strikes many people as immoral since the environment is surely 'beyond price'. There are also few markets in environmental services: we do not buy and sell the services of the ozone layer, nor the watershed protection functions of tropical forests, nor the water purification functions of wetlands. To say that environments are 'beyond price' is unhelpful. If it means environments are infinitely valuable then the logical outcome is that we should never do anything to harm any form of environmental capital. A moment's reflection will show that such a rule would stultify human existence. If it means that environments are somehow outside the economic value system then we have little basis for choosing between environmental and man-made capital. The argument that environments are 'beyond price' is not illogical: of course there are moral arguments for preservation based on rights to existence. But there is an alternative route to conservation and it is more workable and persuasive. Even though environmental services are rarely bought and sold in markets, it is possible to get some idea of what those values would be if only there was a market. This is the economist's idea of a 'shadow price', the price that would rule if environmental goods and services were traded in the 'right' amounts[2]. So, sustainable development means getting national accounting systems to reflect, as far as possible, the shadow prices of the environment.

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[1]. See, for example, R.Repetto, World Enough and Time, Yale University Press, New Haven, 1986; K-G. Maler, 'Sustainable Development', Stockholm School of Economics, Stockholm, 1989, mimeo.

[2]. Strictly, shadow prices exist for all commodities whether they are marketed or not. Shadow prices are the prices that would rule if resources in the economy were optimally allocated. It is well known in economics that freely functioning markets will not secure such an optimal allocation because of what is known as 'market failure'. One conspicuous form of market failure arises because the prices of goods and services do not include the services of the environment that are used up in making those goods

The second observation follows from the first. Unfettered free markets cannot be relied upon to secure the 'right' amount of environmental capital. Market economies tend to behave as if environmental services were free goods, gifts of nature. But economies and environments interact in intricate and pervasive ways simply because of the laws of thermodynamics. It is an inescapable fact that economies cannot function without materials and energy, and it is equally inescapable that those materials and energy will reappear in natural environments as wastes[3]. But anything that is effectively sold at a zero price will be overused. Hence any economic system that treats environmental systems as free goods will overuse them. Environmental degradation is a symptom of 'market failure'.

The third observation about broad sustainability is that the proceeds of any resource depreciation must be reinvested in other assets to ensure fairness to the future. Put another way,. the 'rents' from exhaustible resources, or from the depletion of renewable resources, must not be consumed. This is a familiar feature of political debate in resource-endowed countries.

Sustainability as Conservation of Natural Resources

The broad interpretation of sustainable development is consistent with running down environmental wealth as long as man-made capital is substituted for it, and as long as the 'trade-off' is fully informed in terms of the right prices for the two forms of capital. But the sustainable development debate has tended to place even more importance on environment than is given in the broad view. The arguments for conserving natural assets so as to leave the next generation with a similar environment are considered below.

Many environmental assets do not have man-made substitutes. We cannot feasibly plug the hole in the ozone layer, nor substitute readily for the carbon cycle. The fact of non-substitutability should lead us to be even more cautious about running down environmental capital.

A further variation on non-substitutability is that we cannot replace an extinct species. Much environmental capital has the feature of being irreversible: once lost it cannot be regained. This may be contrasted with man-made capital which can be destroyed and rebuilt almost at will. Some people argue that the wellbeing obtained from some other asset will be just the same: although we cannot substitute for the rhinoceros or elephant, we

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[3]. Subject to recycling, of course.But we cannot recycle energy at all, while the second law of thermodynamics should remind us of the impossibility of 100% materials recycling.

can create some good which will give us equal pleasure. This 'substitution of wellbeing' argument ignores the important fact that wellbeing, or 'utility' in the economist's language, is not homogeneous. There are experiences which for many people are unique and for which there are no substitutes: the music of a great composer, the writing of a Shakespeare, the wonder of a rainforest.

The issue of irreversibility is important in developing economies where resource dependence is often very high. Loss of woody biomass means a loss of fuelwood and building materials. Loss of soil quality means loss of crops and loss of livelihood because of the effective lack of substitutes such as chemical fertilisers. Loss of water resources means a direct loss of livelihood because of the difficulty and often impossibility of transferring water from other areas. Irreversible losses therefore frequently mean severe loss of livelihood. Technological substitutes exist but not in 'feasible' form, such that there is ready access to them.

Finally, we do not fully comprehend how natural environments function and what services they provide. Yet in face of such uncertainty it seems dangerously risky to behave as if we know what we are surrendering by degrading our environment further.

For these reasons at least, sustainable development must mean compensating the future for any environmental losses by replacing those losses with similar assets. Simply pointing to a constant or increasing stock of total wealth is not enough.

The Economic Implications of Sustainable Development

We have dwelled at length on the meaning of sustainable development because such reflection points to several major steps that need to be taken in practice.

(a) Changing the National Accounting System

There is already a significant amount of effort going into the modification of the way in which we measure economic progress. The basic indicator is gross national product (GNP), which measures the aggregate value of the output in the economy in a given year. GNP ought to be related to society's wellbeing. If GNP goes up we ought to be able to assume that wellbeing has improved. But GNP is misleading in this respect. Consider what happens if people spend money trying to adapt to or prevent pollution. Their expenditures appear as a contribution to GNP. The environmental damage they seek to offset is not recorded at all. This is essentially the same point we made earlier: simply because environments do not generally have markets it does not

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mean that they have no economic value. But GNP essentially measures the value of marketed output. It ignores the environment. A more correct measure of GNP would net out the kinds of 'defensive' expenditures incurred to combat pollution.

In the same way, any environmental damage that occurs should be valued and deducted from GNP. National accounts statisticians are also used to making reasoned estimates of the amount of depreciation of man-made capital. They deduct this depreciation from GNP to get net national product (NNP). This is a better measure of wellbeing because it allows for the fact that some of the wealth from which GNP flows is subject to decay, depreciation. But NNP ignores natural wealth. It too is subject to depreciation, for example by running down reserves of oil or reducing the standing stock of forest. There is no logic to support including one form of depreciation and ignoring the other.

These types of modifications to the accounting systems are beginning to be made, but they are complex and costly in practice. A feasible alternative is to publish a separate set of resource accounts which show, in non-monetary units, just what is happening to the resources in a given country. Such accounts exist in France and Norway. More modest modifications can be made to sets of environmental statistics published in most developed economies but which are rare in the developing world. The main change is the need to show how changes in environmental variables are linked to changes in the economy.This at least avoids the error of managing the economy as if economy and environment are unrelated.

A separate volume deals with national accounting.

(b) Correcting Prices

Whether the broad or narrow view of sustainability is adopted the discussion showed that it is vital to ascribe the right economic values to natural resources. Two modifications are needed. First, the prices of natural resources should reflect their full value. The price of a resource is obviously linked to the cost of its extraction or harvest. The market mechanism will ensure that these costs are reflected in prices. But resource extraction and harvesting can also impose costs on others. If timber is removed unselectively from a tropical forest there is damage to the watershed through river pollution and soil erosion. Those costs are not reflected in the price of timber. The market has 'failed' because the timber price is not picking up the value of the natural environmental services it has effectively used. We can say that prices should not just reflect the extraction and harvesting costs, but also the environmental costs. There is one more adjustment to be made to resource prices. If a resource is harvested sustainably its stock will remain broadly constant over time. If it is used unsustainably its stock will be reduced and what is lost will not be available to the next generation. This lost future benefit from unsustainable management is called a user cost. Obviously, there must be a user cost involved in all extraction of an exhaustible resource. There is also a user cost attached to the non-sustainable use of a renewable resource.

We therefore have a basic rule for the 'proper' pricing of natural resources. Those prices should reflect extraction costs plus environmental costs plus user costs*.

The second adjustment is to the prices of commodities. Because the production of goods and services necessarily uses up environmental services which are treated as if they are free, those prices are not correct prices. The adjustment required is consistent with the 'polluter pays principle' - i.e. making the polluter pay for the costs of environmental clean-up or for the environmental damage done by the production of the good in question. This can be done by imposing a charge on the good for its pollution content. The charge will be partly passed on to the consumer in the form of higher prices. This may seem to be making the consumer rather than the polluter pay. But it is exactly what should happen. The consumer, after all, is the ultimate polluter: he signals to the producer what he wants and should therefore pay the full costs of its production. In practice pollution charges are rare: the main way in which the polluter pays principle is implemented is by making polluters pay the costs of regulations designed to achieve a given environmental standard. But it is time to begin much more imaginative policies involving pollution charges.

Separate volumes deal with market failure, 'policy failure' and the special problem of agricultural pricing in developing countries.

(c) Project Appraisal

The third illustrative modification required for the implementation of sustainable development practice is to alter the way in which we appraise investments. When deciding on a development project it is all too common to pay only lip service

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*. Economists relate prices to costs at the margin. That is the best allocation of resources (one that maximises the wellbeing of society) is achieved when prices everywhere reflect the cost of producing an extra quantity. The resource pricing rule outlined here is thus more strictly formulated as price equals marginal extraction cost plus marginal environmental cost plus marginal user cost, or P = MC + MEC + MUC.

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to the environment. This is especially true of the rules used by bilateral and multilateral agencies lending to the developing world. Practice is being changed slowly. The vital modifications needed are in terms of measuring the environmental effects of projects and getting environmental values integrated into the economic appraisal. The techniques for doing this are fairly widely available, although there is still a large amount of work to be done. A further change is required. Development projects will inevitably degrade some environmental assets even when environmental effects are properly priced. But allowing that degradation is not consistent with holding the stock of environmental assets constant over time. Thus it is necessary to alter the portfolio of investments to ensure that there are offsetting investments in the environment. These offsetting investments will not necessarily pass an orthodox project appraisal test. Their function is to compensate for the environmental losses incurred in other projects[5].

Conclusion

There seems to be broad agreement that putting sustainable development into practice means altering the way we measure economic progress. It also means altering the way we allocate resources within the economy. the price mechanism is very powerful allocator of resources because it relies on people acting in their own self-interest. It follows that we can use that self-interest motive to good effect by altering the signals that we send out to producers and consumers in the economy. But 'getting prices right' is only part of the story. Monitoring the environment to see how it is changing and investing in the environment to ensure that the stock of environmental assets is not reduced overall is fundamental to achieving sustainable development[6].

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[5]. This 'compensating project' idea is more fully explored in David Pearce, Edward Barbier and Anil Markandya, Sustainable Development and Cost Benefit Analysis, London Environmental Economics Centre, LEEC Paper 88-03.

[6]. This is a necessarily brief paper.The ideas in it are developed at length in David Pearce, Edward Barbier and Anil Markandya, Sustainable Development: Economics and Environment in the Third World, Edward Elgar Publishing, London, in press; and David Pearce, Anil Markandya and Edward Barbier, Sustainable Development, Resource Accounting and Project Appraisal: State of the Art Review, Report to the UK Department of the Environment, London, 1989.

ABSTRACTS OF PUBLICATIONS

The literature on sustainable development is now extensive. The following is a sample only.

E.Barbier
'The Concept of Sustainable Economic Development'
Environmental Conservation, 14, 1987

Reflects on difference of meaning between growth and development and relates development to broader issues than growth in real income per capita.

K.G.Maler
'Sustainable Development', mimeo, Stockholm School of Economics, Stockholm, 1989.

Formally develops the view that sustainability involves transfers of resources to the future as compensation for damage done by the present. Shows how the transfers result in a requirement to maintain capital intact, building on earlier work of Solow (see refs). Raises the issue of substitutability between types of capital. Tends to favour the 'broad' constant capital rule.

D.W.Pearce, A.Markandya and E.Barbier
Blueprint for a Green Economy
Earthscan, London, 1989

Popular exposition of the definitions of sustainable development as fairness to future generations, entailing that each generation leave the next a non-declining stock of capital. Authors favour the 'narrow' definition in which natural capital is given prominence. Spells out the implications for pricing, national accounting, cost-benefit analysis, policy stance towards the environment etc.

D.W.Pearce, E.Barbier and A.Markandya
Sustainable Development: Economics and Environment in the Third World
Edward Elgar Publications, London, 1990.

Pursues the 'constant capital' approach to sustainable development and illustrates with respect to case studies of Indonesia, Nepal, Sudan, Amazonia, Botswana.

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D.W.Pearce, E.Barbier and A.Markandya
'Sustainable Development and Cost benefit Analysis'
London Environmental Economics Centre, Paper 88-03, 1988, London

Investigates the possibility of imposing a 'sustainability constraint' on cost-benefit analysis such that a given portfolio of projects is constrained not to generate net environmental damage. The implications for shadow pricing are spelled out.

J.Pezzey
'Economic Analysis of Sustainable Growth and Sustainable Development'
Environment Department, World Bank, Working Paper 15, 1989, Washington DC.

Surveys various meanings of sustainable growth and development and relates them back to neoclassical economic growth literature.

M.Redclift
Sustainable Development, Methuen, London, 1987

Explores environmental degradation as part of the political process. Traditional development paths involve 'contradictions' in that they encourage degradation processes which cause development to fail. Stresses role of indigenous knowledge rather than outside 'expert' knowledge about development and environment. Environmental improvement involves political action on behalf of the poor.

R.Repetto
World Enough and Time: Successful Strategies for resource Management
Yale University Press, New Haven, 1986

Highly readable overview of the options available for securing sustainable development, concentrating on incentive mechanisms.

R.Solow
'On the Intergenerational Allocation of Natural Resources'
Scandinavian Journal of Economics, Vol.88, No.1, 1986

Formally demonstrates that intergenerational fairness requires that economic rents from exhaustible resources be reinvested and

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that this, in turn, is formally equivalent to 'keeping the capital stock intact'.

Stockholm Group for Studies on Natural Resource Management
Perspectives of Sustainable Development: Some Critical Issues Related to the Brundtland Report
Stockholm Studies in Natural Resources Management, No.1, 1988

A selection of essays on sustainability, including ecological analysis of the carrying capacity of the Baltic Sea, reflections on economics and the environment, third world issues and energy.

T.Tietenberg
Environmental and Natural Resource Economics, 2nd edition
Scott, Foresman and Co, Boston, 1988

An outstanding introductory textbook with a concise discussion in chapter 21 on 'sustainable growth'. This is one of the first publications to draw together the 'constant capital' approach to sustainable development.

R.K.Turner (editor)
Sustainable Environmental Management
Belhaven Press, London; Westview Press, Boulder, Colorado, 1988

Valuable collection of essays on various aspects of sustainability, including politics of sustainability (O'Riordan), economics and environmental values (Redclift), the polluter pays principle (Pezzey), and wildlife values (Willis and Benson).

ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME TWO

NATURAL RESOURCE ACCOUNTING

S. GAMMAGE

REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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VOLUME 2

NATURAL RESOURCE ACCOUNTING

2.1 INTRODUCTION

National income accounting developed in the inter-war years as economic philosophies, notably associated with John Maynard Keynes, demonstrated that economies could be manipulated to achieve macroeconomic goals such as price stability and full employment. A prerequisite for such economic management is a database showing how the relevant macroeconomic variables interact and change over time. By World War II, sets of national accounts, of varying quality, had emerged.[1]

It is now widely recognised that economic development cannot take place in disregard of the environmental effects of that development. More importantly for resource-dependent economies, no economy can secure sustainable development if it 'lives off its capital.' No rational businessman would count as income the proceeds of capital depreciation, and it should be no different for nations. Running down a natural resource stock is arguably justified if the proceeds are reinvested in other forms of capital: roads, industry, education, etc.[2] However even this process is risky if the comparative advantage of the economy is rooted in resource-based activities. For this reason at least it is essential that economic planners and managers understand what is happening to the resource base of the economy. Economies and environment necessarily interact. To understand that interaction requires a statistical base in the form of natural resource accounts.

The rationale for Natural Resource Accounting, (NRA), is usually couched in terms of the deficiencies of existing national income accounts and indicators. These criticisms may be summarised under the following headings.

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[1] However the oldest national accounts, those of the United Kingdom,can be said to date from Gregory King in 1688. See P. Deane and W. Cole, British Economic Growth 1688-1959 , Cambridge University Press, Cambridge 1962.

[2] For definitions of sustainable development expressed in terms of requirements to "keep capital constant" see D.W. Pearce, et al. (1989).

(a) The Welfare Criticism

Changes in Gross National Product (GNP) define what is traditionally meant by "economic growth". Growth is interpreted as a "good thing" because it is thought to be closely correlated with increases in welfare or happiness. Increasing real income per capita undoubtedly does make a major contribution, especially in developing economies. However, GNP does not adequately capture many of the factors contributing to happiness such as nutrition, health, or the full benefits of education. Consequently, there is a conflict between our aim, social welfare, and our limited means of measuring its achievement.

(b) Imputation

Values are imputed for some non-market goods, such as the flow of benefits from owner-occupied houses, but not for others such as environmental goods and services. This is a matter of convenience rather than logic, and convenience should not dictate the measure of economic progress.

(c) The 'Output Anomaly'

Environmental damage does not affect national income, while its repair causes income to rise, providing a disincentive for preventative actions.

(d) The 'Input Asymmetry'

Business expenditures on pollution control divert labour and materials away from items counted in the Gross National Product and toward the production of a cleaner environment, which is not counted in GNP.

(e) Measurement of Stocks

The measure of stock changes is vitally important if we are to detect whether an economy is or is not "living off its capital", or whether the development path is sustainable or not. The national accounts focus more on flows than stocks.

The rationale for natural resource accounting is more than the correction of national economic accounting. Natural resource accounting has the potential also to assist resource and environmental policy-making, and their integration in economic planning.

Before turning to the criticisms of the national accounts and the efforts to overcome their failings, we first outline the way in which the conventional national accounts are presented.

2.2 **DEFINING GNP**

GROSS NATIONAL PRODUCT (GNP) is the sum of the money values of all final goods and services produced during a specified time period, conventionally one year. Values are typically measured by market prices.

The treatment of government output however requires a departure from the principle of using market prices. Whilst the outputs of private enterprise are sold on recognised markets, the outputs of government offices are not. Indeed it is often difficult to define and quantify these outputs, so that governmental production tends to be valued at "factor cost", i.e. the cost of producing or providing the services and output.

Some goods that are produced but not sold on markets during the accounting period are nonetheless added to GNP. These goods are inventories which may be stockpiled by firms to absorb anticipated demand fluctuations.

The treatment of investment goods requires that they be regarded as final products, even though they could legitimately be seen as intermediate goods. As defined in the SNA accounts investment includes only newly produced goods. Thus:

$$GNP = C + I + G + (X-M)$$

That is, GNP equals consumption (C) plus investment (I) plus government expenditure (G), net of transfer payments which are financed out of taxes, plus the value of exports over imports, the balance of trade.

There are three "routes" to the measurement of GNP:

(a) GNP AS THE SUM OF FINAL DEMANDS.

Personal consumption expenditures
\+ Gross private domestic investment
\+ Government purchases of goods and services
\+ Net exports = Exports - Imports

= GROSS NATIONAL PRODUCT

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(b) GNP AS THE SUM OF INCOMES

Compensation of employees (wages)
+ Net interest
+ Rental income
+ Profits = Corporate profits + Proprietors' income

= NATIONAL INCOME

+ Indirect business taxes
- Subsidies

= NATIONAL PRODUCT

+ Depreciation on man-made capital

= GROSS NATIONAL PRODUCT

(c) GNP AS THE SUM OF VALUE ADDED

Wages
+ Interest
+ Rents
+ Profits

= TOTAL VALUE ADDED
= GROSS NATIONAL PRODUCT

2.3 INCONSISTENCIES IN THE NATIONAL ACCOUNTS: AN ILLUSTRATION

To illustrate the inconsistencies in the SNA accounts, Potvin (1989) considers the case of a supertanker running aground, causing an extensive oil-spillage. The impact on the national accounts can be summarised as follows:

(a) The production and transport of the oil to the site of the accident causes real national income to rise as the result of factor payments, labour remuneration during extraction and transportation, and the value of capital equipment purchased;

(b) National income did not decrease because oil reserves were depleted;

(c) The clean-up expenditures incurred to rectify the spillage, further inflated national income;

(d) The detrimental effects of the spillage, lowering ecological productivity and economic potential are not recorded in the accounts. There is no deduction made to reflect the reduced future fishing yields, and the negative impact on tourism;

(e) If the market response to the spillage is to cause a transient rise in oil prices, and profits across the petroleum industry are temporarily inflated, nominal national income will also rise. Whilst real national income, corrected for inflation, would not increase, the proportional contribution of this sector to real national income would expand;

(f) National income increased with the construction of the tanker, and yet there will be no equivalent decrease associated with the loss or damage of the vessel. Perversely, national income will further rise as the result of repairs to the tanker, or if the tanker has to be scrapped and replaced.

Other macroeconomic measures are similarly overestimated, such as gross and net domestic investment, which should incorporate the loss or depreciation of natural capital. If gross domestic investment is less than the depreciation of both man-made and natural capital, the economy is undermining its asset base, and shortsightedly employing the resource base to finance current consumption. It would seem that without incorporating some monetized valuation of environmental assets and resources within the established national income accounting framework, many lower income countries may mortgage their economies against a declining resource base.

Environmental accounting seeks to amend our notion of income. The main modifications would be to adjust conventional aggregates to incorporate the following:

- the impact of environmental degradation and depreciation, which should be reflected fully in the accounts,

- the treatment of defensive and clean-up expenditures, which should be seen as intermediate and not final expenditure,

- the adherence to a notion of sustainable development. This requires that the portfolio of assets, natural and man-made capital, should be managed to ensure a constant economic potential.

However the means of achieving this consistency in the accounts is the subject of much debate. There are two main approaches. One is to incorporate environmental considerations into the existing system of national accounts (SNA), and the other is to construct subsidiary accounts, or satellite accounts which represent stocks and flows of environmental variables denominated in physical units.

The physical approach involves a separate system of environmental accounts, typical examples of which are, energy balances, forest reserves, mineral stock accounts, records of emissions and measures of the state of ambient quality.

The monetary approach requires that environmental assets, stocks, flows, qualitative as well as quantitative changes in their state be valued or monetised. This ensures the compatibility of units of measurement, and means that environmental variables can be more easily integrated within the SNA.

The physical approach is easier to implement, and is not based on often controversial economic assumptions and valuation principles. The use of willingness to pay criteria to obtain money values is discussed in detail in Volume 3. One of the criticisms levied at the physical accounts is that they are of little use in establishing a visible link between environmental changes and economic activity. However, reasonably accurate flows can be identified, and causality attributed, given the careful monitoring of the output of pollutants and the activities of industries and households. In some cases a physical input-output matrix may be constructed, enabling the overall consequences of a change in the composition and level of final demand on aspects of the environment to be calculated. The physical accounts can represent the impact of economic activity on ecosystems. These satellite accounts do play an important role in that they can represent data in greater detail than would be possible in the national income accounts. However the physical accounts are limited, in that they lack a common unit of measurement. As such it is not possible to gauge the relative importance of these items, either with respect to each other,or with respect to non-environmental goods and services.

The monetary approach faces a number of difficulties. To some extent, what it is that we seek to measure has not been clarified. If it is current welfare, then a consumption adjusted measure would be appropriate, but if it is long-term welfare then some alteration must be made to GNP. In addition, valuation techniques advocated for use in developed economies may not be readily applicable for use in developing nations. This constitutes a substantial hurdle, since methods that have been devised to impute values to environmental assets rely on the use of willingness to pay and willingness to accept monetary compensation criteria, which assume a degree of consumer sovereignty that does not prevail in developing economies.

2.4 ENVIRONMENTAL ACCOUNTING: THE PHYSICAL APPROACH

The physical approach was pioneered by the Norwegian government which established a Department of Natural Resources in 1974 to develop and operate a system of natural resource accounts. The French " patrimony "accounts are administered by the Commission Interministerielle des Comptes du Patrimonie Naturel, established in 1978, and attempt to value "national heritage" including natural resource wealth and historical wealth. The Canadian government has also begun a system of satellite accounts to enumerate and quantify natural resources, Friend (1986).

The use of physical units of measurement has been chosen because:

- it avoids complex indexing
- it reflects physical scarcities
- it provides an accurate description of the physical processes of degradation, depletion and harvesting
- it ensures physical consistency and coherence
- it provides the necessary linkages for ecological analyses

Further, physical resource accounting should provide answers to the following questions:

(a) How much of each specific resource remains?

(b) What quantities of renewable and non-renewable resources are extracted and harvested?

(c) How are these resources administered, that is what are the physical rates of recovery, in the case of renewables, and of depletion in the case of non-renewables?

(d) What quantities of natural resources are imported/ exported?

(e) What quantities of natural resources are processed domestically?

(f) How efficiently are these resources processed, ie what are the input/output ratios for industry?

(g) What quantity of these resources are produced and consumed internally and for what purpose?

(h) Can the wastes and by-products of resource processing be traced? Are the effects localised or dispersed over a wide area?

(i) What proportion of these natural resources is recycled, or reused?

(j) What quantities are available for future use, and at what cost of exploitation, or extraction.

(k) What hypothetical future demands can be forecast, and what prices may be ascribed?

2.5 THE NORWEGIAN ACCOUNTING SYSTEM

Three main categories of resources are addressed in the Norwegian accounts, which were later reduced to two broad headings: material and energy resources; and environmental resources.[3]

INITIAL CLASSIFICATION

RENEWABLE RESOURCES	CONDITIONALLY RENEWABLE RESOURCES	NON-RENEWABLE RESOURCES
(i) Inflowing resources (solar and cosmic radiation)	(i) Environmental resources	(i) Recyclable minerals
(ii) Oceanic + Atmospheric (wind and waves)	(ii) Biological resources	(ii) Transient (fossil + nuclear fuels)

LATER CLASSIFICATION:

RESOURCE	PHYSICAL CLASSIFICATION
MATERIAL + ENERGY	Minerals: minerals, hydrocarbons, stone, gravel and sand
	Biological Resources: water, air and subsoil.
	Inflowing Resources: solar radiation, hydrological cycle, wind, ocean currents.
ENVIRONMENTAL	Status Resources: air, water, soil and space.

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3. See A.Friend (1989) and J.Potvin (1989).

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Note that some resources are entered in several categories, e.g. water, which appears both as a material resource (for hydro-electric power) and as an environmental resource, where its quality, extent, and purity is of relevance. The units of measurement and the accuracy of the data are highly dependent on the specific resource being considered.

These resource accounts are intended to run parallel to the conventional rational income accounts, and to supplement them with more diffuse data.

The individual accounts are broken down as follows:

(a) MATERIAL RESOURCES: ENERGY AND MINERALS

The mineral and energy stock accounts, principally oil and gas, are split into four sub-categories:

- developed reserves
- undeveloped reserves
- new fields
- revaluation and extraction

Reserves are considered to be developed when most of the basic investment has been made, and production has begun. Undeveloped reserves are those whose existence has been noted and their extent explored, but as yet remain unexploited. Revaluation occurs when previous estimates and forecasts are revised, as the result of new information being acquired. In harmony with the stock accounts, there are flow accounts, which trace the amounts extracted, plus those quantities imported and exported, and note their various uses: industry (a sectoral breakdown), households, government, inventories.

In conjunction with these accounts, the Norwegian government has developed an integrated modelling system to forecast pollution and future emissions. The input/output analysis employed reveals the direct and indirect uses of energy. They also have detailed accounts of energy end-use, produced for different sectors and classified by the type of production, consumption, and temperatures required.

The mineral resource account is updated every three years. The data collecting bureaus and ministries have run pilot accounts on a similar basis noting the size, extent, and cost of extraction (given the current state of technology) of: iron; copper; zinc; lead; titanium; pyrite; and aluminium. They also maintain a register of sand and gravel reserves, limestone, dolomites, quartz and silica.

(b) BIOLOGICAL RESOURCES: FISHERIES AND FORESTS

Within this category there are four sub-categories: reserves; recruitment (introducing external stock); revaluation; extraction and natural mortality. The quantification of biological resources requires a breakdown by geographical location, wherever possible,often necessitating the creation of artificial boundaries.

With respect to fisheries, the data gathering agents have to recognise a diverse number of species, and represent the composition, age structure and reproductive capacity of the fish stocks. These accounts are therefore very detailed. The main objective is to keep the catches at sustainable levels, and rebuild important stocks. This is hampered by the complex nature of the oceanic ecosystem, and the fact that some data are unavailable, particularly the extent of recreational and occasional fishing. Thus sales data significantly under-represent the amount of fish stocks consumed.

Data on the status of the forestry resources are integrated with land use, and the energy accounts, since a proportion of forest production is directly used to generate energy. An input/output analysis is drawn upon to represent:

- the forest balance, net of the volume of timber harvested

- felling, processing and end-use

- regrowth, and replanting

- the total mass balance of wood raw materials entering forest production, including the byproducts, wastes and emissions.

This work, initiated by the Norwegian Forestry Research Institute, was intended to supplement purely physical and biological forecasts of future stocks in order to determine the maximum sustainable yield.

Agricultural land use and hectarage is briefly noted, since most agricultural production is explicitly noted in current measures of value-added as they are entered in the national accounts.

(c) ENVIRONMENTAL RESOURCES

The accounts for the material resources have proved easier to compile than those for environmental resources. These accounts comprise two sub-accounts: an emissions account, which deals with the emissions of waste products into the air, water and land; and a state account, which describes the state of the environment at different points in time and changes in the environment in the intervening periods. Geographical boundaries have to be established and recognised before these accounts can have meaning. The emissions records for air pollution show the emissions of different gases by sector and region.

The accounts of the status of water resources are still in their early phases. Norway borrowed extensively from the French patrimony accounts, and modelled their data collection and representation closely on the French system. These accounts monitor the following:

- withdrawals
- consumption
- evapotranspiration
- climatic variability
- discharges of polluted water
- the quality, stock and flow of water resources
- the volume of water used in energy generation
- sectoral sources of pollutants

Table 2.1

An Illustration of the Norwegian Accounts

Period	Land Use After Development	Land Developed Total	Agri-Culture	Forest	Other Unbuilt
	Total	17322	6294	5785	5243
1955-65	Residential	10852	4078	4085	2689
	Other Built Up	6470	2216	1700	2554
	Total	21531	6842	8462	6227
1965-75	Residential	12771	3989	5789	2993
	Other Built Up	8760	2853	2673	3234

Emission Accounts in Norway
(Tons)

	Sulphur Dioxide 1980	Sulphur Dioxide 1982	Nitrogen Oxide 1980	Nitrogen Oxide 1982	Carbon Monoxide 1980	Carbon Monoxide 1982
Total	140	112	134	120	582	643
Agriculture	2	2	2	3	19	21
Manufacturing	108	84	30	20	34	68
Transport	11	11	38	37	35	40
Households	6	5	28	29	390	407

In compiling these data the Norwegian authorities sought to exploit existing sources of data collection. They also strongly adhered to the principle of parsimony, preferring simpler to more complex theoretical models. From these accounts they have developed macroeconomic models that attempt to address the interactive nature of ecological and biological systems, and thus divine future demands, prices, extraction and exploitation costs, and industrial profits. These are very much in the experimental stage, but they are expected to yield information that will enable economic valuations of these resources to be made, and channel policy decisions.

2.6 THE FRENCH RESOURCE ACCOUNTS

The French system of patrimonial accounting encompasses conventional resource accounting, in that it covers both natural resource wealth, and cultural heritage[4]. This system was intended to relate economic growth to the quantities of natural resources that must be consumed in order to sustain such growth. These accounts were structured with specific objectives in mind: the optimisation of the economic value of available natural resources; the determination of that fraction of GDP which should be set aside for the efficient protection of the environment; and to orient growth so that it does not threaten vulnerable ecosystems.

The system in its completed form should serve the following ends:

(a) to optimise the use of natural resources as factors of production;

(b) to describe the economic aspects of resource use;

(c) to treat resources as environmental goods, analysing the costs and benefits of policies, and changes in the quality of the environment;

(d) to take stock of national environmental heritage, and to define the long term implications of its transformation.

Underlying the construction of this accounting framework is the belief that a complex and comprehensive physical system of measurement must be established prior to addressing the problem of assigning monetary values to these resources. They are conceptually broader than their Norwegian counterparts, and whilst the basic accounting units are physical, the French have

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[4] See J.Theys in Y.Ahmad et al. (1989) and P.Corniere in OECD (1986).

incorporated the monetary valuations of stocks and flows that are marketed or contribute directly to market production.

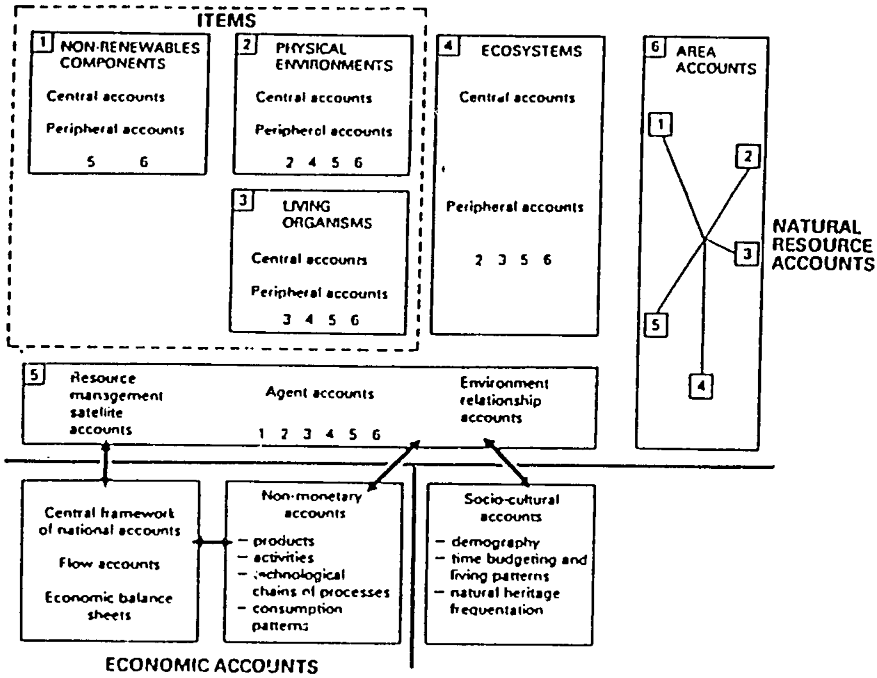
The French system defines the following categories;

> Central Accounts - which describe the state of the resource at specific points in time, and variations in it during the intervening period;
>
> Peripheral Accounts - which show the interrelation between one resource and another, and between human activities and the resource in question;
>
> Agent Accounts - which drawing on input/output analysis, describe flows to and from economic activities and the resource in terms of physical quantities. Furthermore they enumerate defensive expenditures, and the costs of repair, supervision, and development.

These satellite accounts supplement the core national income accounts with an extensive range of data sources, qualities, quantities, and ecological performance indicators (such as the ratio of resource extraction to current known available stocks, or the proportion of GDP that is composed of environmental expenditures), whilst leaving the conventional accounts unaltered.

Figure 2.1

Structure of the French Natural Resource Accounts



KEY: 1 – Stock at the beginning of the period
2 – Upward adjustment in known reserves
3 – Downward adjustment in known reserves
4 – Gross natural increase
5 – Natural depletion
6 – Increase due to resource development
7 – Depletion due to withdrawal
8 – Imports

2.7 THE CANADIAN SYSTEM OF RESOURCE ACCOUNTING

The environmental accounts are still in an early phase of development in Canada.[5] Pilot studies are underway to assess the feasibility of designing a system that will eventually be tailored to modify the conventional aggregate indicators of gross and net domestic product, GDP, NDP, and in addition two newly proposed aggregates, NDP2, NDP3.

GDP- is the sum of:
Compensation to employees
Operating surplus from property and entrepreneurship
Consumption of fixed capital
Indirect taxes less subsidies

NDP1- conventional NDP minus
Consumption of fixed man-made capital

NDP2- further deducts:
depletion and degradation of environmental assets
(calculated either as asset liquidation of depreciation)

NDP3- then further deducts:
expenditures on environmental protection and restoration.

As yet the accounts are in an embryonic state since their compilation relies heavily on the pre-established data collection agencies and government ministries. Fortunately there is a strong tradition of producing natural resource databases both at the federal and provincial levels. However, the choice of what data to collect and process is entirely dependent on the operational needs of the resource departments and their client industries. Therefore the most well-structured databases already in existence are those relating to mining, forestry, agriculture and fisheries. There is only limited information relating to areas of lesser commercial interest such as flora and fauna.

2.8 ENVIRONMENTAL ACCOUNTING: THE MONETARY APPROACH

Physical accounting has its shortcomings. It does not lend itself to aggregation because of the disparate nature of the physical units employed, and it does not draw full attention to the impact of economic policies on natural resources. Theoretically, there should be no conflict between accounting in physical and economic units, since the physical accounts are a necessary prerequisite

[5]. See A.Friend (1988), (1989) and J.Potvin (1989)

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for economic accounting. However the question of imputing economic values to natural resources is a controversial one.
In developing economies apparently rapid economic growth, high rates of saving and investment, and deceptively stable or near stable inflation can be bought at the expense of running down natural assets. Exported natural resources may bolster the terms of trade and balance of payments, but eventually the exchange rate becomes overvalued to the extent that relative prices become disturbed. Consequently a country's export of non-natural resource based products dwindles, and any comparative advantage the economy previously held is undermined. This phenomenon has come to be known as the "Dutch Disease". Very often the economy ends up saddled with a high external debt, because its capacity to repay creditors had been overestimated. This highlights the dilemma caused by the confused treatment of capital and income.

To redress the balance, a coherent approach to the following issues needs to be developed:

- Defensive Expenditures
- Environmental Degradation
- Natural Capital Depreciation.

(a) Defensive Expenditures

Defensive expenditures to mitigate the impact of environmental damage should not be attributed to GDP. Whilst those undertaken by firms are regarded as intermediate expenditures, those undertaken by the government or households do contribute to value added at present.

(b) Environmental Degradation

Measuring current welfare requires that an estimate be made of that proportion of environmental damage that is not corrected for. Residual pollution damage has a negative impact on welfare that remains unaccounted for in traditional GDP. Pearce et al.[6] summarise the proposed correction thus:

CURRENT WELFARE = MEASURED CONSUMPTION
- HOUSEHOLD DEFENSIVE EXPENDITURES
- THE MONETARY VALUE OF RESIDUAL POLLUTION DAMAGE

[6] Pearce, Markandya, Barbier (1989)

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See Volume 3. for a discussion of the methodology of environmental valuation.

(c) Natural Capital Depreciation

Central to the concept of sustainable income is not current welfare, but a measure of potential welfare. Were markets to operate freely and unfettered by intervention, legislation and other superimposed distortions, such as taxes and subsidies, measured national income would reflect the present and future welfare attainable.[Mirrlees (1969), Weitzman (1976).] In the absence of market failure, prices determined in all markets would equate with the marginal social cost of production. Yet market failure is the norm and not the exception.

One suggested correction relates to a more consistent treatment of environmental and physical capital. Many environmental economists endorse,the use of environmental depreciation, analogous to that already employed when deducting the depreciation of man-made capital. As the resource is depleted, the quantity extracted , valued at current prices, should be deducted from gross value added. However as Serafy [In Ahmad et al (1989)] has pointed out, this approach generates the following pitfalls:

(i) This correction, when employed, does not alter GDP as it stands. It produces a measure of NDP, i.e. net domestic product. Typically the concept of net product or income relies on estimates of man-made capital depreciation, and inventory use, which are founded on accounting traditions, country specific tax laws and allowances, and insurance practices. For this reason NDP has generally been regarded as an arbitrary measure.

(ii) Such net product deductions may misrepresent the relative wealth of individual nations. Countries with marketable natural resources are substantially better off than those with non-marketable resources, since they enjoy a higher standard of living by virtue of their resource endowment. Consider the case of a country which derives its entire receipts from the sale of a marketable exhaustible resource like petroleum.

(iii) If an amount equal to resource depletion was deducted from the value of gross receipts for mineral sales, the value of net income would automatically become zero. This representation of net product is virtually without meaning, and fails to reflect the comparative advantage given to such a country because of its resource wealth endowment.

Serafy (1989) concludes that the asset liquidation method yields a more appropriate and intuitive measure of resource depletion. Here the net proceeds of the sale of extracted reserves are discounted by a hypothetical rate of return expected by investors. This converts the asset into a perpetual income stream, the finite sum of receipts from the sale of the asset are transformed into an infinite series of "true income", where the discount rate chosen ensures that the capitalised values from the two series are equal. The annual earnings are divided into an income component, and a capital component, which should be invested each year to provide an income stream equivalent to that generated by the asset itself.

This captures the flavour of the debate to amend current income measures, with the aim of redefining the notion of current income so that it is more compatible with the Hicksian concept of sustainable income Hicks (1946). Instead of focusing on the discounted welfare of the economy,income should be measured as the flow of goods and services that the economy can generate without reducing its productive capacity. That is, the income it could sustain indefinitely.

At the heart of the definition of sustainable income is the notion of constant capital stock, both physical and environmental. Whilst even this measure may fail closely to approximate long term societal welfare, it does however prove to be a significant step in the right direction. An overall formula might be:

SUSTAINABLE INCOME =

MEASURED INCOME

minus HOUSEHOLD DEFENSIVE EXPENDITURES
minus THE MONETARY VALUE OF RESIDUAL POLLUTION
minus THE DEPRECIATION OF MAN-MADE CAPITAL
minus THE DEPRECIATION OF ENVIRONMENTAL CAPITAL (ECOSYSTEM FUNCTION DAMAGE, RENEWABLE CAPITAL, EXHAUSTIBLE CAPITAL)

2.9 **ATTEMPTS TO MONETISE THE PHYSICAL ACCOUNTS**

(a) The Japanese Experience

In 1973 the Japanese government announced its first measure of Net National Welfare, NNW, a modification of GNP[7], which consists of the following eight items:

- (i) NNW attributable to government consumption
- (ii) NNW attributable to personal consumption
- (iii) services attributable to household-related social overhead capital
- (iv) services attributable to personal durable consumption goods,
- (v) the monetised value of leisure time
- (vi) Extra-market activities, such as housewives' domestic services, etc
- (vii) (subtracting) environmental pollution
- (viii) (subtracting) losses due to urbanisation.

Investment, an important component of GNP, is excluded on the grounds that it constitutes an intermediate good. As an index of the quality of life, what contributes directly to welfare is the flow of services rendered by the capital stock.

The NNW attributed to government consumption (i) is classified by function: education; culture; social welfare, health, sanitation. Judicial and policing services are omitted since they are regarded as defensive expenditures and therefore do not constitute a net addition to social welfare.

The NNW attributed to personal consumption (ii) is calculated after the deduction of: the purchase of consumer durables; commuting expenses; and obligatory payments including ceremonial services.

The overhead capital stock services (iii) comprise: housing; city parks and gardens; schools; water supply; drainage; waste disposal. The values of such services are calculated assuming a depreciation rate of 6.5 % over a life-span of 25 years.

As far as services attributable to durable consumer goods (iv) are concerned the NNW measure excludes current purchases of consumer durables. However the flow of services rendered by these goods is incorporated in this measure.

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[7] See K.Uno (1988).

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The value of leisure time (v) is imputed using the average wage per hour, adjusted for age group and sex. The wage rate is assumed to approximate the opportunity cost of leisure time forgone. There is one caveat however, since the full employment experienced by Japan in the 60's, and with the advent of the oil crisis, the resultant increase in leisure time includes an involuntary component. This unfortunately results in an overestimation of the imputed value of leisure time, and few attempts have been made to guard against this.

The valuation of extra-market activities (vi) focuses mainly on the domestic services of housewives. Again these services are monetised using a surrogate market theoretic based on the average wage of female workers, covering those who are 15 or over, who are exclusively employed in domestic activities.

Environmental pollution damages (vii) are estimated using the hypothesised cost of restoring current environmental standards. Environmental damage due to air pollution, water contamination and waste disposal is calculated on the basis of returning the environment to a state that is consistent with current environmental legislation, and is hence somewhat arbitrary. Excess emissions are calculated and their removal or elimination costs estimated. Many items are dropped from the calculations because of the lack of appropriate and available data. Noise pollution and non-hazardous odours are excluded as are the damages caused to the environment because of certain development projects and improper land use.

The losses due to urbanisation (viii) include monetary valuations of the increase in commuting time, and the increased expenditure burden brought about by a rising number of traffic accidents. This calculation in no way reflects the loss of specific tracts of natural capital.

Some criticisms of this approach, with particular reference to the measurement of environmental degradation, may be highlighted. The analysis excludes the impact of residual pollution remaining once the standards have been met. Unless this standard is optimal, this measure will fail to correct fully for the environmental degradation experienced. The NNW calculations exclude defensive expenditures, which leaves the measure unadjusted for significant welfare-enhancing outlays. It is accepted that it is difficult to isolate items that fall into this category because of its arbitrary definitional nature, and that there is always a danger of double-counting if these expenditures also result in higher values for household and land services.

Table 2.2

Net National Welfare in Japan

(unit: billion yen, 1970 prices)

Fiscal year	1955	1960	1965	1970	1975	1980	1985
NNW gov't expenditure	1,199	1,374	2,254	2,988	3,865	4,283	4,887
NNW personal consumption	10,427	14,706	22,168	32,097	43,003	54,009	61,700
Gov't capital service	62	99	169	317	559	756	1,103
Personal durable goods service	91	195	755	2,342	4,187	5,270	6,813
Leisure time	4,871	6,098	7,325	10,509	16,759	18,961	20,816
Extra-market activities	1,876	2,388	4,068	7,213	12,707	12,571	13,079
Environmental pollution (deduction)	-38	-1,037	-3,735	-6,805	-5,729	-3,932	-3 103
Loss due to urbanization (deduction)	-452	-695	-889	-1,113	-1,119	-1,272	-1,514
NNW	18,036	23,128	32,116	47,548	74,231	90,646	103,781
GNP	17,268	26,183	41,591	72,144	93,260	118,105	143,387

Source: Uno (1988)

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Table 2.3

Japan: Losses Due to Pollution

(unit: billion yen, 1970 prices)

	Economic Council estimates				Kanamori estimates		Uno estimates	
Fiscal year	1955	1960	1965	1970	1970	1975	1980	1985
SO2		289.3	750.7	1,797.6	1,727.9	1,167.9	668.7	459.8
Soot and dust	34.6	89.3	117.4	400.9	368.7	375.9	316.9	272.6
Automobile exhaust gas	0	0	269.8	1,151.2	1,032.9	1,906.2	1,176.1	973.3
BOD		557.7	1,142.8	1,505.6	1,733.3	1,481.6	1,213.4	997.8
Factories		299.3	630.7	832.0	1,068.7	639.5	---	---
Homes		258.3	512.1	673.6	664.6	842.1	---	---
Waste			1,035.4	1,245.6	1,942.0	797.5	556.9	399.0
Non-industrial			87.0	106.7	34.5	66.7	26.5	14.1
Industrial			948.4	1,138.9	1,907.5	730.8	530.4	384.9
Total	34.6	936.3	3,376.0	6,100.9	6,804.8	5,729.1	3,932.0	3,102.5

Note: NOX emission from fixed origins is not included here due to unavailability of data thereof. Figires for 1955-1975 are from Kanamori, Takaso, and Uno, Economic Growth and Welfare---An Estimation of Japan's NNW---, The Japan Economic Research Center, 1977; those for 1980-1985 are estimates K. Uno (1988)

(b) The Accounts for Indonesia

The World Resources Institute has recalculated Indonesia's national accounts (Repetto et al. (1989)). The Indonesian exercise closely followed the dictates of the SNA, and successfully employed only those databases already in use in the calculation of conventional welfare indicators. Values were imputed to changes in the physical resource stock, and national income was thus modified. This approach was adopted because it was felt that information on stock changes due to resource extraction or discovery is more accurate than data relating to the total size and composition of the stock. At the end of each accounting period, the physical units were valued at the net prevailing price. Three types of resource were analysed.

(i) Forests and Timber Resources 1970-1984

These include values for the following:

- total growing stock,
- net growth and reproduction,
- harvesting,
- deforestation (transfers of land to other uses),
- degradation, deterioration due to natural disasters, and destructive exploitation.

The physical accounts measure timber volume and acreage, and the value accounts measure economic rent.

(ii) Petroleum Resource Accounts 1970-1984

The physical accounts enumerate identified and prospective reserves. However only proven reserves are regarded as having rental value. Thus the value accounts relate only to those resources in extraction. These reserves are valued at net price, that is the market price less the costs of extraction and transportation.

(iii) The Soil Accounts

These comprise estimates of soil erosion in physical terms; and the economic costs of such erosion, in terms of predicted yield declines, outlays on compensatory fertilisation programmes, lost farm income, and the capitalised losses in future production. Details of this valuation exercise are given in Volume 3.

The study attempted to prove that such resource adjusted national income statistics could be constructed using data that was already available even in less developed economies. As the results show, a significant reappraisal of Indonesia's economic performance should be made. In addition they underscore the notion that attempts to improve the accuracy of the accounts and extend the information base are entirely consistent with more prudent resource management.

Table 2.4

Modified Indonesian GNP

Comparison of GDP and "NDP" In 1973 Rupiah (billions)

Year	GDP[a]	Net Change in Natural Resource Sectors[b] Petroleum	Forestry	Soil	Net Change	NDP
1971	5,545	1,527	-312	-89	1,126	6,671
1972	6,067	337	-354	-83	-100	5,967
1973	6,753	407	-591	-95	-279	6,474
1974	7,296	3,228	-533	-90	2,605	9,901
1975	7,631	-787	-249	-85	-1,121	6,510
1976	8,156	-187	-423	-74	-684	7,472
1977	8,882	-1,225	-405	-81	-1,711	7,171
1978	9,567	-1,117	-401	-89	-1,607	7,960
1979	10,165	-1,200	-946	-73	-2,219	7,946
1980	11,169	-1,633	-965	-65	-2,663	8,506
1981	12,055	-1,552	-595	-68	-2,215	9,840
1982	12,325	-1,158	-551	-55	-1,764	10,561
1983	12,842	-1,825	-974	-71	-2,870	9,972
1984	13,520	-1,765	-493	-76	-2,334	11,186
Average Annual Growth	7.1%					4.0%

a. In constant 1973 Rupiah, billions. From the Indonesian Central Bureau of Statistics.

b. The flow of resources in each sector is elaborated in the sections on the specific resource later in the text. Positive numbers imply a growth in the physical reserves of that resource during the year.

Source: Repotto et al. (1989)

2.10 REVISING THE S.N.As

Were a consistent method of environmental evaluation to be developed, and consensus to be achieved, environmental policy considerations might become more explicit in economic management, and the potential for coordinated international action realised. To underscore the need for such accounting procedures, and the pressing revision of the UN SNA:

(a) Environmental and natural resource degradation endangers the potential for long term economic development, a point of special relevance to the resource-dependent economies.

(b) Most developing nations, being primary producers, are dependent on their resource base for food, shelter, and employment. Welfare in both the short term and the long term is inextricably bound up with the productive capacity of natural systems.

(c) The burden of degraded environments is frequently unfairly concentrated on the poor, whose concerns are already under-represented by the market mechanism.

The UN Statistical office has for some time been aware of the need for explicit environmental accounting, and has initiated much discussion as to the form in which the stocks and reserves of natural capital should be included in the national income accounts. The revision of the SNA published by the UN statistical office, suggested a more comprehensive assessment of natural stocks and reserves than was actually implemented by many governments. The SNA advocated the use of categories such as 'reproducible tangible assets' - forestry and livestock - and 'non-reproducible assets' - land and subsoil minerals.

The criterion for inclusion in the SNA is however highly restrictive. Such stock valuations can only legitimately occur if the assets are privately owned and used in the commercial production of goods and services, i.e market values can be easily assigned. Those natural resources under public 'ownership', such as the atmosphere, flora and fauna, surface waters, etc were excluded on the grounds that the SNA deals only with the market economy. The economic value of those resources that are non-marketable cannot readily be established. For those that are included the SNA advocates the use of <u>reconciliation accounts</u> that link balance sheet and flow accounts. These reconciliation or <u>satellite accounts</u> incorporate changes in opening stocks due to price movements during the period of evaluation, and due to physical changes, growth, discovery, depletion, extraction and natural loss. Those valuation principles that are employed rely heavily on market indices wherever possible, and if no direct

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price can be imputed the SNA appeals to the use of the present discounted value of the expected future income stream.

However there remain important omissions:

(i) The production of goods and services outside the enterprise sector.

(ii) The valuation of human capital, such as entrepreneurial skills and knowledge.

(iii) Within the government sector, goods and services are not directly measured but are valued at factor cost.

The UN Statistical Office endorses the use of balance sheets for reproducible and non-reproducible tangible assets, linking these to national income figures through satellite accounts. Depletion accounts should be calculated but only as subsidiary tables to supplement GNP figures. They do not advocate an integral measure which would augment GNP. The rationale for this is pragmatic. Until more statistical offices are regarded as being capable of calculating natural resource depletion, and generating depreciation figures, and until a code of practice has been established and unified standards set, the core national income accounts should not be modified.

2.11 THE QUESTION OF OPTIMAL RESOURCE EXTRACTION

Devarajan and Weiner (1988) explore criticisms of the various approaches to correcting the national income accounts. They argue that the proposed adjustments to the national income statistics, are at variance with accounting conventions and with the notion of economic welfare. The notion that a depletion charge should be deducted from national income to reflect non-renewable resource use is disputed. Devarajan and Weiner regard the "depreciation" analogy as being misplaced because depreciation on man-made capital is a non-cash item in the firm's accounts, whereas the depletion of a natural resource becomes a cash item in that it affects the price of the resource, and hence the revenue accruing to extraction.

They highlight the misleading qualities of two types of correction. The use of a depletion charge equal to the rent accruing to the scarce resource, or the investment of that portion of this rent equal to the discounted present value of the revenues from resource depletion, to ensure a perpetual future income stream.

In both cases the authors consider the correction illegitimate, since there has been no reference to the optimal use of the resource in question. They argue that if the resource is being optimally depleted there is no need to alter the national accounts. Only if the extraction/depletion of the resource is not optimal, should there be a correction made to GNP. They propose a means of adjusting GNP to reflect the over or under-exploitation of the resource base: subtract from current GDP the difference between future GDP in the case where the economy is pursuing an optimal resource extraction horizon, and future GDP under the existing extraction schedule.

In the case of sub-optimal depletion, the resource's scarcity value will not be correctly reflected in the market price. Given this market failure, and the resultant divergence between actual prices and shadow prices, the correction applied to national income should be made using shadow pricing.

However the notion of optimal/sub-optimal resource depletion rests on assumptions about the discount rate and changes in the underlying production function and technology. The technical and statistical resources required to employ such a correction far exceed the data-base and skills currently available to most of the developing nations. In the case of renewable resources the definition of optimal 'depletion' rates is even more complex, and even more difficult to apply.

2.12 CONCLUSIONS

From this review of environmental accounting the following conclusions may be drawn:

(a) at this stage in the development of the environmental accounts, emphasis should be placed on maintaining the satellite accounts. Seeking to incorporate the environmental accounts into the national income accounts should be a longer term aim. Such accounts could be expressed in purely physical terms or monetised, they should however stress the linkages between the environment/natural resource base and economic activity. In addition they should provide an accurate assessment of the natural resource balance sheet, and provide the underpinnings for a measure of sustainable development.

(b) Whilst attempts to monetise the environmental accounts have proved both enlightening and groundbreaking, the correct methodological approach has yet to be established.

(c) The relationship between sustainable income and long run welfare is still very much in debate. However there are strong reasons for endorsing the attempted measurement of sustainable income as the best proxy for long run potential welfare.

COMPENDIUM OF PUBLICATIONS

Y. J. Ahmad, S. El Serafy and E. Lutz.
Environmental Accounting for Sustainable Development
UNEP-World Bank Symposium (1989)
World Bank, Washington DC

A set of essays by various contributors, addressing the problem of resource accounting, and discussing the various approaches to it, with particular reference to the experience of some of the nations described in this chapter. The chapters are:

1. Environmental and Resource Accounting: An Overview
S. El Serafy and E. Lutz
2. Toward a Measure of Sustainable Social Net National Product
H. E. Daly
3. The Proper Calculation of Income from Depletable Natural Resources
S. El Serafy
4. Introducing Natural Capital into the SNA
A. Harrison
5. Measuring Pollution within the Framework of the National Accounts
D. W. Blades
6. Correcting National Income for Environmental Losses: Toward a Practical Solution
R. Hueting
7. Environmental Accounting in Development Policy:The French Experience
J. Theys
8 .Linkages between Environmental and National Income Accounts
R. B. Norgaard
9. Environmental and Nonmarket Accounting in Developing Countries
H. M. Peskin
10. A Proposed Environmental Accounts Framework
H. M. Peskin
11. Environmental Accounting and the System of National Accounts
P. Bartelmus
12. Recent Developments and Future work
E. Lutz and S. El Serafy

P. Bartelmus, C. Stahmer and J. Van Tongeren (1989)
SNA Framework for Integrated Environmental and Economic Accounting

OECD. Environment Directorate/ Economics and Statistics Department. Joint Seminar on the Economics of Environmental Issues. OECD, Paris

The authors discuss the attempt to reflect environmental concerns in an accounting framework which remains within the guidelines of the current SNA. They consider the objectives of environmental accounting, and the movement in this field towards a measure of sustainable net and gross domestic product. The paper concludes with a "desk study" which explores the case of a developing country and the alteration of the accounts to take on board not only the prescient environmental considerations but also the limitations of data collection, and processing.

F. M. Brouwer, W. A. Hafkamp and P. Nijkamp (1986)
Achievements in Modelling Environmental and Resource Issues in the Secondary Sector', **The Science of the Total Environment**, 55 pp285-307.

This paper addresses methodological issues regarding statistical econometric modeling techniques for environmental and resource planning. After a review of a selected set of integrated models, a plea is made for an integrated systems approach in order to improve the coherence and consistency of integrated economic-ecological models. The paper also formulates a set of design criteria for integrated environmental models, and these criteria are used to evaluate three recently developed design principles, viz. the satellite design, the multiple layer projection design and the super model design. The paper concludes with an outlook for further research.

S. Devarajan and R. J. Weiner (May 1988)
'Natural Resource Depletion and National Income Accounts', mimeo,

John F. Kennedy School of Government,
Harvard University.

This paper explores current means of adjusting GNP to reflect asset depreciation. Devarajan and Weiner conclude that the only legitimate correction occurs when the resource is not being optimally managed. They note that as long as the price received for the asset reflects its scarcity value, there is no reason to adjust the national accounts. If depletable resources are being over or under-exploited however, their scarcity rents will not be indicated by their prices. Thus the question of whether to correct GNP reduces to a question of optimal natural resource management.

Federal Statistical Office, Wiesbaden, F.R. of Germany (1989)
'Conceptual Development of an Integrated System of Environmental Accounting', Joint Seminar on The Economics of Environmental Issues.

OECD, Paris.

This outlines the proposed German satellite accounting system. The design sets out a separate accounting system independent of the national accounts, but with explicit linkages. Such linkages are intended to expose economic/ecological interactions, trace causality, and record the net impact on the environment. This "integrated system of environmental accounting" should reflect the qualitative and quantitative status of the environment.

A. M. Friend (1986)
'Natural Resource Accounting and its Relationship with Economic and Environmental Accounting', <u>mimeo</u>

Statistics Canada
Ottawa, Ontario.

This paper discusses the purpose, process and framework of NRA. Friend considers stock-flow accounting in the SNA, natural resources and GNP and the current status of natural resource data. He proposes a thermodynamic model of economic activity which would reflect economy-environment interactions.

A. M. Friend (1988)
<u>Land Use Statistics in Natural Resource Accounting Systems</u>

Statistics Canada,
Ottawa, Ontario

This essay underscores the need for land use statistics in the Natural Resource Accounts, and explores methods of mapping spatial configurations of land use, and its changes over time; modelling the dynamic inter-relations between man and the environment; and utilising archival records and established data bases to incorporate a more fluid analysis of land use into the national accounts.

A. M. Friend (1989)
Technical Report on Natural Environment Statistics: Social, Economic, and Natural Activities, Section A.

UN Statistical Office
New York

The author gives a breakdown of the categories employed and the data sources in use in the Canadian Natural Resource Accounts, based on the UN framework for the development of environment statistics. It explains the Canadian approach to monitoring the human/ecosystem interactions, and the potential for monetising these accounts, although its focus is mainly on the physical quantification of these assets.

A. M. Friend and R. H. Moll (1988)
Macro Evaluations of Natural Resource Stocks in the SNA: Forestland and Timber Stands

Statistics Canada
Ottawa, Ontario

In this paper the authors explore those economic and non-economic characteristics of natural resource assets that should be taken into account to calculate their monetary value.They use the example of forest reserves to raise questions and suggest possible methodologies. They emphasise that the role of natural resource assets in the SNA reflects the GDP paradigm, since their contribution to the economic product may remain undocumented in the presence of market failures and externalities. Further the non-economic contributions such as the maintenance of healthy ecosystems, the quality of life and human health remain largely unexplored.

A. M. Friend and D. J. Rapport (1989)
The Evolution of Information Systems for Sustainable Development

Institute for Research on Environment and Economy

The authors explore a conceptual framework for a comprehensive approach to environmental accounting. The framework incorporates a critical set of indicators of ecological integrity at the ecoregion level, tracks stocks and flows of natural resources, and provides a description of the complex integrative relationships of the System of National Accounts (SNA), Natural Resource Accounts (NRA), and State of Environment Reporting (SOE Reports). The emphasis is on the applied side of macro-information systems of "ecological economics" as it has so far evolved from the experience of "official government statistics".

The final section briefly reviews developments in Canada and suggests some future directions.

A. J. Gilbert (1987)
Environmental Indicators and their Use in Resource Management

Institute for Environmental Studies
Free University, Amsterdam

This report addresses the inadequacy of current environmental indicators, and their failure to reflect the impact of policy changes. It discuses the development of a computer data base IRENE, which would enable a more eclectic summary and collation of environmental data.

A. Gilbert, W. Hafkamp (1986)
Natural Resource Accounting in a Multi-Objective Context

Institute for Environmental Studies
Free University of Amsterdam

The accounting structure outlined in this article, is intended for inclusion in the data system IRENE, which is designed to collate environmental data and to assist policy-making for renewable natural resources.

A. Gilbert (1990)
'Natural Resource Accounting: Botswana as a Case Study', in J.Dixon *et al.*, **The Economics of Dryland Management- A Case Study Reader**, Earthscan, London.

Using the framework developed for IRENE, Gilbert addresses the problems of resource accounting in Botswana. This case study attempts to construct a set of natural resource accounts using results and data from previous studies. This lies within the boundaries of satellite accounting with the emphasis being on the construction of a comprehensive system of physical accounts enumerating stocks, flows, resource use and interactions with economic activities.

J. M. Hartwick (1990)
'NNP and Economic Depreciation of Natural Resource Stocks and The Non-Renewable Resource Exploring Extracting Firm and the r% rule', Discussion Paper 741.

Institute for Economic Research,
Queens University, Kingston,
Ontario

This paper is in two parts. The first expands on the calculation of the depreciation of the stock of natural resources, with comments addressed to two recent papers:

T. R. Stauffer "Accounting for Wasting Assets: Measurement of Income and Dependency in Oil-Rentier States", **The Journal of Energy and Development** No. 1, Autumn 1985;

J. S. Landefeld and J. R. Hines, "National Accounting for Non-renewable Natural Resources in the Mining Industries." **The Review of Income and Wealth**, Series 31. No. 1, March 1985. The second examines Hotelling's Valuation Principle.

R. Hueting and C. Liepert (1987)
'Economic Growth, National Income and the Blocked Choices for the Environment', mimeo.

International Institute for
Environment and Society,
Wissenschaftszentrum Berlin fur
Sozialforschung, Berlin

This paper draws attention to the error of identifying productivity growth with economic growth and an increase in economic welfare. It proposes a corrected national income measure, one which is more consistent with the notion of sustainable development, and describes the drawbacks and advantages associated with such an approach.

J. Landefeld and J. Hines (1985)
National Accounting for Non-Renewable Natural Resources in the Mining Industries, **The Review of Income and Wealth**, Series 31. No 1.

The authors address the problems of monetising the resource accounts, confining their analysis to non-renewable natural resources in the mining industries. They survey three valuation methods:Present Value Method;Land Price Method;Net Price Method; and discuss the volatility of each measure. Landefeld and Hines conclude that given the problems and uncertainties associated with each of these measures, such potentially varying and highly sensitive values should be confined to satellite accounts. This information should exist in a form which complements the national accounts, providing supplementary insight into the depletion of reserves, but should not be used to amend the accounts themselves.

O. Lone (1987)
'Environment Committee Group on the State of the Environment Natural Resource Accounting : the Norwegian Experience'

OECD, Paris
Environment Directorate,

The author reviews the experience of the Norwegian Natural Resource Accounts 1975-1987. He discusses the historical development of these accounts, cites those ministries responsible for organising and collecting environmental data,elaborates on those methods of environmental forecasting already in use, and gives a detailed breakdown of the accounts.

W. Magrath and P. Arens (1989)
The Costs of Soil Erosion on Java: A Natural Resource Accounting Approach, World Bank, Environment Department Working Paper No.18.

Soil erosion is analogous to the depreciation of man made assets. Unlike the depreciation of capital assets, however, the effects of soil erosion are not reflected in conventional measures of economic welfare. This occurs because efficient markets seldom exist for soil resources, because of the pervasive influence of externalities on the true costs of soil erosion, and because systems of national accounts are biased to treat natural resources as free goods. As a result, policymakers do not have the information required to adequately weigh the benefits and costs of alternative soil conservation policies. The basic requirements for calculating the on-site costs of resource degradation are understanding the dimensions of the physical processes of change, understanding the impact of those processes on the production of valued goods and services, and understanding the ways in which economic activity adjusts to these changing circumstances. To effect this, the authors developed three linked models:

(i) A geographic information system (GIS) based model was used to integrate data on soil type, topography, rainfall and landuse, to estimates of levels and distribution of erosion.

(ii) To estimate the productivity consequences of erosion, a model was developed focusing on rainfed agricultural land.

(iii) An economic model of farm responses to falling productivity and of farm profitability, was used to value the erosion process.

W.Nordhaus and J.Tobin (1973)
'Is Growth Obselete', In M.Moss (ed) **The Measurement of Economic Natural Resource Accounts: Pilot Study Concerning Forest Resources**, Discussion Paper ENV/Se/88.20, Pais

This article is the seminal text on NRA, it addresses 3 problems raised by those who question the desirability and possibility of future growth:

(i) how good are measures of output currently used for evaluating the growth of economic welfare,

(ii) does the process of growth inevitably waste natural resources,

(iii) and how does the rate of population growth affect economic welfare?

The authors analyse the conventional measures of economic welfare, re-examining the neo-classical treatment of factors such as population growth, final expenditures, capital adjustments, non-market activities and externalities.
R. B. Norgaard (1989)
'Three Dilemmas of Environmental Accounting',

Department of Economics
University of California at Berkeley

Norgaard criticises the attempt to resolve the problems of resource accounting, by developing an accepted consensus-led accounting framework intended to be applicable in all cases. He proposes an alternative strategy, the development and use of multiple approaches, which would be scientifically more rigorous and more "fail-safe". He cites three major inconsistencies in the current SNA accounting framework, the tension between Keynesian macroeconomics and Neo-Classical microeconomics; the inadequacies inherent in existing market prices which fail to reflect true revealed preference which hamper aggregation exercises; and incomplete knowledge of the interactions between the economy and the environment. He concludes that given these major flaws in the development of a consistent accounting framework, that multiple approaches should be pursued, employing multiple methodologies.

Statistic Sentralbyra, Oslo , Norway
The Central Bureau of Statistics, Norway. Annual Report 1986

The Central Bureau of Statistics,
Oslo

This report describes the main activities of the Central Bureau of Statistics, the economic analysis and forecasting employed and cites econometric research currently underway.

OECD Paris (1986)
Information and Natural Resources

Environment Directorate, OECD, Paris

This booklet comprises four essays which address the need for resource accounting, and the methodological difficulties that arise. There is a brief account of the French system of patrimonial accounting, which illustrates the example of the Inland waters accounts. The Norwegian resource accounts are discussed as are the uses of satellite observation, remote sensing, its benefits and limitations.

1. Introduction
J.Maini
2. A System of Natural Resource Accounts in Norway
P.A.Garnasjordet, H. Viggo Saebo
3. Natural Resource Accounts in France. An Example: Inland Waters
P. Corniere
4. Use of Remote Sensing for Natural Resource Management
M. Lenco

D. Pearce, A. Markandya and E. Barbier (1989)
Blueprint for a Green Economy

Earthscan Publications Limited
London

Chapter 4 deals with the problems of accounting for the environment. It gives a concise account of the aims of environmental accounting, a breakdown of the two main approaches to resource accounting,and an illustrative view of the development of resource accounting in Norway, France, Japan, etc. This chapter concludes that whilst economies should move towards an integrated measure of sustainable net product, the focus should remain upon the physical accounts, since consensus has yet to be achieved as to the form and application of monetary accounting techniques.

C. Perrings, A. Gilbert, D. Pearce and A. Harrison (1989)
Natural Resource Accounts for Botswana: Environmental Accounting for a Natural Resource-Based Economy

LEEC paper 89-11
London Environmental Economics Centre,
London

This paper summarises the rationale for Natural resource Accounting and the recent experience with the various different approaches. The paper focuses on the construction of a system of NRA for Botswana, the selection and definition of extractive resource sectors, non-extractive resource sectors, and resource dependent sectors. The authors discuss the availability, quality and type of Botswanan data. They recommend that an intermediate indirect approach be adopted (mixed unit accounts) as a precursor to the creation of fully monetised natural resource accounts. The production of parallel accounts, the standard national accounts and the mixed unit accounts summarising environmental indices in the input-output matrix devised.

H. Peskin (1986)
'The Environmental Accounts Framework', mimeo.

Edgevale Associates,
Silver Spring,
Maryland

This paper reviews the theory of environmental asset services, pollution abatement, tolerance criteria and valuation concepts. It discusses investment and depreciation, and applies this to environmental degradation. There is an explanation of the inadequacies of the current measures of national income, particularly the response of the conventional accounts to non-market and environmental activities. Peskin suggests a modified accounting structure which consists of explicit environmental indicators.

H. M. Peskin (1988)
'A Program of Research in Support of the Development of Integrated Environmental- Economic Accounts, mimeo.

This article, prepared for the World Bank, outlines current research needs, and data requirements of the burgeoning literature on resource accounting. It discusses the design and setup of data-bases for monitoring resource depletion and environmental degradation, and the skills necessary for its implementation.

H. M. Peskin (1989)
Accounting for Natural Resource Depletion and Degradation in Developing Countries
World Bank, Environment Department Working Paper No.13.

This paper presents an approach for measuring environmental and natural resource depreciation based on an application of conventional capital theory. The important distinction between physical depreciation and true economic or "value" depreciation is emphasised. Economic depreciation can be shown to equal physical depreciation plus real capital gains (which may be either positive or negative). \only economic depreciation is appropriate for theoretically valid adjustments to gross income. The paper illustrates, with respect to environmental assets, how the two depreciation concepts can widely diverge over time. The paper discusses the relationship between economic depreciation and the value of services generated by environmental and natural resource assets and the determinants of these service values. The theory suggests that as environmental assets are used, positive and negative services may be generated. Furthermore, the value of these services depend on the values placed on the services by potential as well as current users. The paper presents a modification of the conventional economic accounts that is, in principle, capable of displaying all the uses of environmental and natural resource assets. The depreciation concepts and the accounting framework are illustrated with two empirical examples: the modification of the Tanzanian national accounts to reflect the household production of fuelwood and the depreciation of fuelwood stocks; and the Repetto analysis of the depreciation of Indonesian forests.

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H. M. Peskin (1989)
'Environmental and Non-market Accounting in Developing Countries', in Y. Ahmad et al. (1989).

This focuses on the restrictive nature of the conventional accounting framework, particularly with respect to the developing nations. Peskin illustrates with the example of Tanzania, and explains why many of the proposed methods of environmental valuation are simply not applicable in a developing economy.

H. M. Peskin (1989)
'A Proposed Environmental Accounts Framework' in Y.Ahmad (1989)

This paper highlights the neglect of many subsistence non-market activities in current aggregates, and points out how the conventional use of prices to indicate the opportunity cost of certain activities may fail woefully in the developing economies.However this paper directs environmental analysis towards a more cost- based foundation, since consumer surplus methods are seldom relevant in the developing context.

H. M. Peskin and J. Peskin (1989)
'The Valuation of Non-market Activities in Income Accounting', **The Review of Income and Wealth**, Series 24, No.1, March. pp71-91.

The authors present a framework for including non-market activities in the national accounts. They point out that a plurality of values exist for non-market activities which are sensitive to the purpose for which the calculation is to be used. However the need to revise national income accounting procedures has lead to the development of various approaches to enable such valuations to be made. Implementation is foreseeable since in many cases the data-bases already exist.

H. M. Peskin (1990)
A Survey of Resource and Environmental Accounting Practices in Industrialised Countries

World Bank, Washington DC

Peskin reviews many of the recent developments in environmental accounting, highlighting present inconsistencies and contrasting the different approaches. This survey provides a comprehensive overview of different systems of resource accounting with selective illustrations from each. Peskin also emphasises the need for improved resource and environmental accounting in most developing nations since they have both heavily resource-based economies and severe environmental quality problems.

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J. R. Potvin (1989)
Economic-Environmental Accounts: A Conspectus on Current Developments

Report prepared for Corporate Policy Group
Environment Canada,
Ottawa.

Potvin gives an account of the historical development of the UN SNA, and its current stance on environmental accounting. It further outlines the Canadian government directives on environmental research, and those techniques employed to date in representing the resource wealth of Canada.

R. Repetto (1989)
'National Accounts and the Environment', mimeo.

Environment Directorate
OECD, Paris

Repetto criticises the employment of satellite accounts, arguing that few developing countries have adopted their use, that they de-emphasise the importance of natural capital degradation, and depletion, and that they are of little use in policy decisions. Repetto suggests making immediate corrections to the national accounts, treating defensive expenditures by governments and households as intermediate costs, and allowing for the quantitative depletion and qualitative degradation of natural capital to be regarded as analogous to capital consumption. His focus is concentrated on developing a measure of "Sustainable Gross Domestic Product", with which to alter current welfare measures.

R. Repetto, W. Magrath, M. Wells, C. Beer, and F. Rossini (1989)
Wasting Assets: Natural Resources in the National Income Accounts

World Resources Institute
Washington DC

The issue of integrating natural resource accounts with the traditional economic accounts, is addressed. The report pays particular attention to the problems faced by the developing economies. It gives a well-structured overview of the issues central to the debate, and illustrates with an account of the Indonesian experience, providing adjusted GDP figures in the light of forest, oil and soil depreciation.

K. Uno (1988)
'Economic Growth and Environmental Change in Japan: Net National Welfare and Beyond', mimeo.

Institute of Socio-Economic Planning,
The University of Tsukuba,
Tsukuba, 305 Japan.

This article explains the Japanese approach to resource accounting, and their attempt to monetise non-market activities and environmental degradation. It gives a detailed breakdown of the environmental components of the Net national welfare aggregate, and discusses the valuation techniques employed.

ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME THREE

MONETARY VALUATION OF ENVIRONMENTAL ASSETS AND CHANGE

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REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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VOLUME 3

MONETARY VALUATION OF NATURAL RESOURCES AND ENVIRONMENTAL CHANGE

3.1 INTRODUCTION

"The purpose of valuation techniques is to correct those prices that do not correspond to the 'true' economic values and calculate prices for those assets that are not valued at all."[1]

The valuation of the environment is crucial in a world where the optimal allocation of scarce resources cannot be secured by the decentralised workings of the price mechanism. It is possible in certain cases to disaggregate the flow of goods and services from environmental resources and assign monetary values to these functions as a means of quantification. This would enable policy-makers to achieve coherence in the evaluation of the direct and indirect benefits and costs issuing from certain economic choices. Valuation techniques are designed to recover the underlying preference structure from the observable market variables. If the individual acts as a price-taker in all markets where goods and services are bought and sold, and if we assume that general equilibrium holds in the economy we may attempt to recover this utility function. If these markets are perfectly competitive, the prices arrived at will reveal the correct marginal valuations of those goods and services exchanged. However many environmental goods cannot be bought and sold on markets, and thus their value is not directly revealed. In this case other methods must be employed to elicit a valuation from the prospective consumer. However before consideringthese valuation techniques, it will be helpful to establish what we mean by economic value.

3.2 TOTAL ECONOMIC VALUE

This concept is of central importance in the valuation of natural and man-made environments since it is tailored to provide a perspective on the various benefits that accrue to environmental enhancement, preservation and improvement. It divides benefits into two categories: user benefits and intrinsic benefits.
User Benefits relate to the use to which environments and natural products are put, the discharge of wastes and other emissions, and the provision of services that remain "unpriced" inputs into industrial processes. Intrinsic Benefits are an attempt to assign

[1] K-G.Maler (1989).

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monetary values to environmental preferences unrelated to a specific use. For instance many individuals value the continued existence of blue whales, whilst they appear to have no direct linkage with this species, through use or observation. The assurance of the continued existence of a certain environmental asset, and the continued access for future generations of consumers, yields a benefit to today's consumer which may be monetised.[2]

User benefits include both consumptive and non-consumptive values. The consumptive value of wildlife, (the direct useage) would be the benefit derived from hunting or culling. Non-consumptive benefits are enjoyed without reducing the availability of access for others , analagous to the consumption of a public good. In addition there is the option value of these assets, which measures the value of potential use of the asset at some stage in the future.

TOTAL USER BENEFIT = CONSUMER SURPLUS +/- OPTION VALUE

EXISTENCE VALUE = INTRINSIC VALUE

TOTAL ECONOMIC VALUE = TOTAL USER BENEFITS + TOTAL INTRINSIC BENEFITS

Consumer Surplus is the summation of the area under the demand curve above the market price. This gives the aggregate of the willingness to pay, measuring the net surplus to consumers purchasing the good at the ruling market price.

3.3 BENEFIT ASSESSMENT AND COST BENEFIT ANALYSIS

" Benefit assessment is the widely accepted phrase for procedures which involve placing as far as possible a monetary value on the social advantages thought to accrue from improvements in natural and built environments."[3]

In this context, benefit assessment has been traditionally used to indicate the strength of environmental preferences. It also plays a crucial role on the evaluation of regulatory policy through the use of Cost Benefit Analysis (CBA). CBA provides an analytical framework for evaluating the consequences of economic

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[2] For a discussion of user benefits, and existence values see K-G.Maler (1989) pp 10-14.

[3] D.W.Pearce and A.Markandya (1989)

choices, and as such it provides a consistent set of criteria with which to judge the impact of policy. The procedure is to maximise the present value of all benefits less that of all costs, subject to sp.cified constraints. This differs from commercial project appraisal in that the costs and benefits to all members of society are included in the calculation, not only the monetary expenditure less receipts. In addition the social discount rate at which the project is valued may.differ from the market or private discount rate.[4] CBA is not merely an accounting technique whereby costs and benefits are guaged using the price mechanism , but an attempt to provide a consistent procedure for evaluating government policy in terms of its full consequences. If succesful, it's main advantage is that it will decentralise decision making for the purposes of evaluating private sector projects.

The requirements that benefits exceed costs prior to establishing the social desirability of a project, merely ensures that the value to society of the benefits obtained are at very least equal to the value of the resources employed to achieve this specific policy aim. Thus CBA is firmly rooted in an accepted notion of economic efficiency.

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[4] The social discount rate is a concept analagous to the rate of interest at which present valuations are calculated over a given time horizon. The social discount rate however may embody notions other than the opportunity cost of capital and the riskiness of the project in hand. The social rate of discount may be viewed as the weight placed by society on the distribution of future increments to consumption brought about by the introduction of the project under consideration.
P.Dasgupta, A.Sen and Marglin (1972).

Cost benefit analysis estimates the shadow prices associated with a particular project.[5] Shadow prices are in essence the vehicle which enables CBA to record the full benefits and costs of a project or policy action subject to maximising an objective function. The objective function summarises those aims and requirements which it is felt that the project should achieve. Note that the definition of the objective function has particular implications for the set of shadow prices devised. There is no unique set of shadow prices associated with a particular project. It is for this reason that benefit estimation is fraught with uncertainty. It is not unusual to find conflicting estimates of the benefits accruing to the project.

However the appeal of CBA lies in its presentation of figures which are easy to aggregate and which are mutually compatible, being expressed in an index of common units. Alternative forms of project appraisal tend to present an array of potential impacts, the implications of which may be obscure.

CBA concentrates fixedly on economic efficiency, a focus of distinct appeal in policy analysis, but much of the theory of project appraisal in developing countries has been developed to allow for distributional impacts [6]. Further, CBA can be tailored to reflect disparate policy aims. It is its flexibility which enhances its appeal. The underlying purpose in attempting a monetary measure of benefits and costs is to provide a rationale for investing in environmental improvements. It is to ensure that the monetary sum reflecting the costs of such improvements

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[5] " Shadow Prices may be defined as the value of the contribution to the country's basic socioeconomic objectives made by any marginal change in the availability of commodities or factors of production." Thus shadow prices will depend on both the fundamental objectives of the country and the economic environment in which these marginal changes occur.They differ from market prices in that the incidence of market failure or distortion, capital constraints, and informational constraints,lead market prices to diverge from the true social cost of the good or service in question. The economic environment being typically determined by the physical constraints on resources and by various constraints that limit the government's control over economic development. Any changes in objectives or constraints will therefore alter the underlying shadow prices. Squire and Van der Tak. (1975).

[6] Squire and Van der Tak (1975)

embodies the value to society of expending these scarce resources. Since resources are scarce it is vital that we establish whether the gains from policy implementation exceed the resource costs. This can only be executed if the benefits and costs are measured in the same units.

3.4 DIRECT AND INDIRECT VALUATION

The various approaches to the economic measurement of environmental benefits may be roughly divided into two categories, direct and indirect techniques. Direct Valuation focuses on environmental gains as the result of policy, and seeks to measure the monetary value of these gains. This may require the identification of surrogate markets, where close approximates to the environmental asset in question may be marketed such as the sale of forest timber providing an assessment of the stumpage value of a certain forest. The surrogate market approach uses established markets in which goods or factors of production are exchanged observing that environmental benefits or costs are frequently attributes of these goods or factors. The experimental approach simulates a market by eliciting valuations of non-marketed benefits or costs from respondents in controlled circumstances. Indirect Valuation techniques do not seek to measure the revealed preferences of individuals directly. This procedure relies heavily on physical linkage information with either market or surrogate market valuation. An illustration of this would be the valuation of damage to health. This requires establishing the epidemiological link between doses of a pollutant and the response in the form of deteriorating health or morbidity. Having established the physical linkage, the next stage is the valuation of the damage suffered with each incremental dosage of pollution. This can be undertaken using studies of how people behave in response to occupational health hazards and the risk of occupational mortality.

3.5 DIRECT VALUATION METHODS AND THEIR APPLICABILITY IN DEVELOPING ECONOMIES

(a) Contingent Valuation

Contingent valuation methods (CVM) rely on the direct approach.It exploits "willingness to pay" criteria, where services are given hypothetical market values, enabling the investigator to develop a schema of precedence. It surveys individuals asking people what they are willing to pay to receive a benefit, and/or what they are willing to receive in the form of compensation to tolerate a cost. This may be undertaken using either surveys or questionnaires, or employing the experimental approach whereby respondents are subject to given stimuli and their reactions noted. The aim of CVM is to elicit valuations or bids which would approximate those price signals received if an actual market existed. It is "contingent" in the respect that the hypothetical market envisaged comprises not just the good or service in question, but the institutional framework, the mode of finance, the concentration of the burden of taxation etc. The importance placed on this method in developed economies is a function of the following:

(i) It is frequently the only available method of benefit estimation in the absence of a market.

(ii) It is applicable to most environmental policy considerations.

Willingness to Pay

The concept of a benefit should encompass the notion of "what people want". Individual preferences should guide our understanding of what a benefit constitutes. Various techniques are available which enable economists to determine individual preferences. One of the simplest methods is to analyse individual behaviour in the face of competing choices. It seems a reasonable assumption that a positive preference for something may be signalled or revealed in the form of peoples' "willingness to pay" (WTP) for that good or service.

Each individual may express a different willingness to pay dependent on personal characteristics, budget constraints, perception of liability, and informational constraints etc. However, since the focus of this exercise is to assess social desirability, we can aggregate the sum of individual preferences or WTP's to secure a measure of Total Willingness to Pay, ΣWTP. This ΣWTP gives a monetary indicator of preferences. Since as already noted market prices seldom reflect the shadow value to the consumer of the good or service in question. WTP must therefore incorporate the margin of consumer surplus in excess of the ruling market price. Individuals may purchase that good or service at the market price which may in fact not equate with their willingness to pay. They may in fact be willing to tolerate a higher price. If so the benefit they receive in consumption exceeds the price paid to receive the good or service. This excess is known as consumer surplus which may be both positive or negative, indicating the range of preferences along the demand curve.[7]

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[7] Contingent valuation can be performed using "willingness to pay" and/or "willingness to accept" valuations. These methods differ in their underlying assumptions. For a technical exposition see D.W.Pearce and A.Markandya (1989).

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WTP = MARKET PRICE + CONSUMER SURPLUS

(b) Problems with the Contingent Valuation Approach

The discussion of the shortcomings of contingent valuation methods focus mainly on the biases that can result. Biases that can occur are:

(i) Strategic bias arises when the respondent being questioned chooses not to reveal his/her true preferences in the belief that he/she might gain from this. In particular this addresses the "free rider" problem. If the respondent believes that he/she will be taxed on the basis of the valuation bid offered the individual will have an incentive to understate his/her valuation, secure in the knowledge that the good will in fact be provided for by others' payments. If however the respondent believes that his/her own taxes will be unaffected by his/her valuation, there is an incentive to overstate willingness to pay thereby affecting the level of provision of the good in question. This problem is of particular relevence to a type of good known as a public good, one where the individuals consumption of that good does not diminish the total amount of that good available for others to consume. This property of non-excludability is prominent in the category of environmental goods.

However a means of identifying strategic bias in the sample is readily available. We assume that the distribution of bids should in most cases closely approximate the distribution of income in the sample. Thus this provides us with a convenient test, if the distribution of bids is significantly different from the underlying distribution of income we may conclude that the sample exhibits strategic bias.

(ii) Design bias occurs when the respondent is questioned alters the response received.

- Starting point bias is when the chosen initial point or bid suggested by the interviewer preconditions the range over which these bids are considered.

- Vehicle bias relates to the suggested instrument of payment. Respondents may be sensitive to the mechanism by which they receive transfers or pay for the good in question. The possibility of averting behaviour or substitution between activities to avoid the costs or distort the amount of benefits received, will significantly alter the response. One way of testing for this form of bias, is to consider various different mechanisms of transfer the average or mean bid should not differ significantly with the type of vehicle.

- Information bias occurs when the sequence in which information is revealed to the respondent alters the response elicited. The description of the good itself, its location, its extent, all can greatly alter the respondents perception of its value. Tests for such bias are complex and usually rest on either witholding information from one group and supplying information of different qualitv and type to sections of those groups being questioned. Such tests are not in general conclusive and suggest little means of correcting for this type of bias.

(ii) Hypothetical bias relates to the contrived nature of the exercise. Contingent valuation techniques attempt to elicit bids that would closely approximate those values revealed in the market were an actual market to exist. However in actual markets there is a cost imposed on the purchaser who fails to acquire full or near full information on the price distribution he/she faces. There is also substantial evidence that measures of WTP and WTA differ, which casts light on the motivations of consumers and further the free rider problem. Willingness to Accept is that monetary compensation , which if given as a transfer, would exactly compensate the individual for having a negative consequence imposed upon them. There is an incentive for the individual to misrepresent the costs incured and gain more than compensatory payment.

(iv) Operational bias arises when the contingent valuation exercise fails to replicate the "operating conditions" of the market place. This has led to a set of conditions being advocated to minimise this form of bias. The criteria include, familiarity with the good in question, comprehension of the form in which preference is revealed and a knowledge of the importance of consuming different quantities of the good. We do not assume full information however since it is felt that consumers are seldom availed of full information in addition this would undermine the appliccability of this technique for the assesssment of existence values.

3.6 OTHER METHODS OF DIRECT VALUATION

(a) Hedonic Pricing

This illustrates the surrogate market technique of valuation. It has long been recognised by economists that the value of a tract of land is related to the stream of benefits that subsequently accrue to the plot of land over its lifetime of useage. Among the potential yield of services are the following: agricultural output; shelter; access to other sites; the environmental quality of the area. The property value and the land value approaches to the measurement of benefit estimation are based on the notion that certain of the environmental attributes will be reflected in the market price of land. The assumption is that that property buyers will reveal their valuation to a bundle of environmental attributes (some structural, some aesthetic, some environmental) in terms of their willingness to pay. Given that different locations possess different environmental qualities, this should result in a spectrum of prices and property values. If proximate pieces of land are priced differently, such differences are usually reducible to one of two factors: the capitalised value of land productivity; or the unpriced environmental qualities. Hedonic pricing enables statisticians, with the use of multiple regresssion techniques, to disaggregate these values and

(i) identify what components of the market price reflect which attributes,

(ii) infer how much individuals are willing to pay for an improvement in environmental quality, and what the social value of that improvement is.

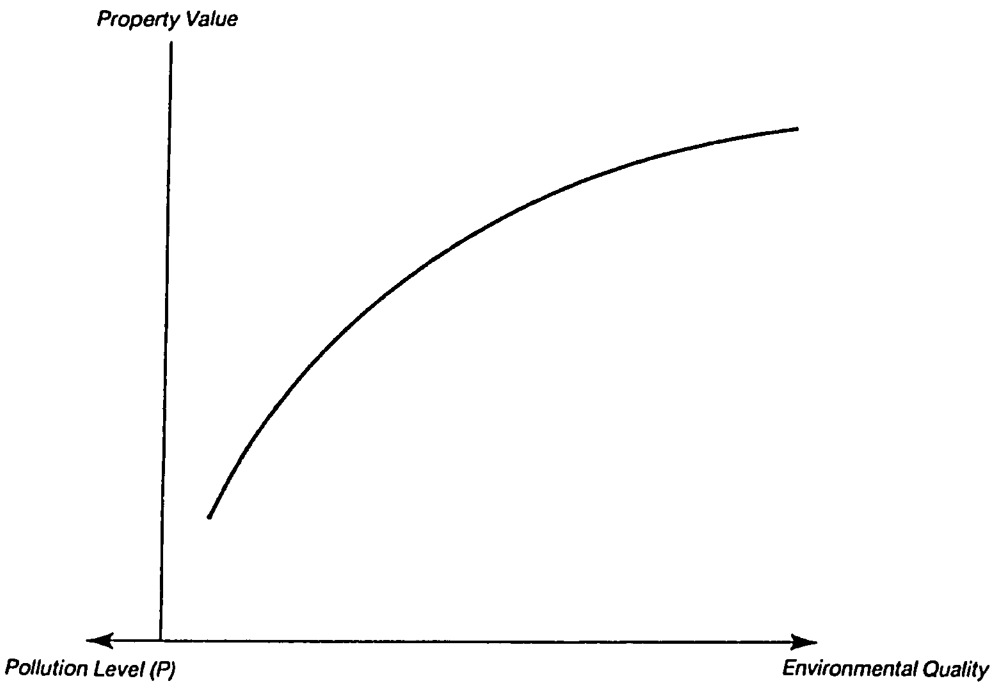
The market price of the land is regressed against a number of variables designed to pick up the influence of the different components determining the overall land value. The variables should capture the incremental influence of location specific attributes, factors such as the aesthetic quality of the land, its relative importance as a natural habitat for wildlife, ecosystem functions,proxy variables such as income to pick up the influence ofsocio-economic determinants of property and land values etc. The data gathered can be either related to a small number of similar tracts of land over a period of years (time series), or covering a large number of diverse tracts at a specific point in time (cross section), or straddling both types of samples (pooled data). By examining land prices, and the capitalised value of agricultural production, the residual can be determined.Part of this residual represents the "surrogate" value of environmental qualities, or other unpriced attributes.

(b) Inferring the Demand for Environmental Quality

The estimation of a relationship between property or land values and environmental quality indicators is only the initial stage of the hedonic price approach. The estimated relation is then used to infer the social and individual costs of environmental pollution, or the benefit of reducing the burden of pollution.

Figure 3.1

Property Values as a Function of Environmental Quality



Pearce and Markandya (1989)

Figure 3.1 shows the type of relationship between pollution and property values that might be discovered through the hedonic pricing approach. Typically as the pollution level declines so property values rise, but at an ever decreasing rate. In order to obtain an estimate of the demand for environmental quality, we need to establish how much households are willing to pay for given levels of environmental quality. Aggregation of these values, under the assumption that households are identical, results in an approximation of the underlying demand curve for environmental quality. However households will differ in income, budget constrants, preferences and in the acquisition of information. Thus the hedonic price approach gives only a limited picture of those unerlying preferences, and the demand structure. However techniques are available that enable economists to compensate for this and develop a more coherent picture of demand.[8]

3.7 PROBLEMS OF INFERENCE: WITH PARTICULAR REFERENCE TO THE HOUSING MARKET

There are a number of difficulties associated with these inference procedures.

(a) The assumption of general equilibrium is often seen to fail in many contexts. If the procedures are to correctly reveal the demand for environmental quality, then each household should optimise its consumption of the bundle of characteristics it wishes to purchase given the budget constraint it faces. However this requires the efficient working of an unfettered market. In the case of house prices, this is clearly not so, a large proportion of housing stock remains in public control, subsidised and subject to rationing. One prominent failure of the assumption of general equilibrium derives from the means of sale. It is assumed that in a perfectly competitive market the price at which a good is sold represents the highest bidders willingness to pay for that good. This is clearly not what occurs in the housing market. Sellers receive bids in sequence, and must either accept or reject them. Those prices used to signal the valuation of environmental qualities by individuals may not in fact be a true approximate of revealed preference. This is further complicated by the lack of access to perfect capital markets, borrowing constraints, and imperfect information. All of which dilute the competitive nature of these markets, causing prices to diverge from their true value.

[8] D.W.Pearce and A.Markandya (1989)

(b) Market segmentation occurs, the housing market in particular cannot be aggregated and data pooled since they posess diverse and unique characteristics. This if highlighted by the fact that mobility between connurbations[9] is severely restricted whether by institutional or social impediments. The demand for environmental quality should therefore be assessed separately for each area, since the aggregation of dissimilar data could result in biased estimates.

(c) Averting behaviour. Evasive action may be undertaken, enabling a household to ameliorate the effects of environmental bads such as pollution, or overcrowding. There are alternative means of mitigating the effect of environmental pollution, other than shifting location. In the case of air pollution a household may install filters, with noise pollution it may decide to purchase double glazing. Freeman (1979) finds that this has quite extreme consequences for the estimation of environmental benefits from property values. If this averting behaviour results in physical changes to the house itself, this will enhance the market value of the property. Variables should be included in the regressions used for the hedonic pricing exercise that would capture this averting behaviour. However such data is seldom available.

(d) Imperfect information is another reason why observed prices may not convey the true value of ambient environmental quality. Households may be expected to pay for environmental quality only to the extent that they percieve the lack of it to have a delaterious effect on their health. The lack of knowledge of health risks associated with certain forms of environmental pollution, will inevitably lead to an underestimate of the social benefit of reducing such pollution. This underestimate is very difficult to correct for, merely adding an estimate of the health costs in the regression will not compensate for this. We know that despite the lack of perfect information, to some extent these environmental qualities are already capitalised in property values. To risk double counting, could only obscur the true valuations of the benefits we wish to measure.

(e) The time horizon over which benefits are measured may distort our estimate of willingness to pay. Much of the hedonic price literature focuses on the impact on property prices of certain environmental attributes. These prices

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[9] A large agglomeration of closely located urban centres.

yield a valuation of the capitalised present value of the stream of future benefits derived from the environment in a given state. This value must then be decomposed into the value of benefits accruing over shorter time periods. In order to get the annual benefits from the price data, we need to know what the annual return on the property is, taking into account market distortions such as rates of tax and their incidence. If expectations are dynamic, and the future levels of pollution are expected to vary, this too will be reflected in current property values. thus interpreting the derived hedonic price as the price of the current level of environmental quality could lead to an upwardly biased estimate of the willingness to pay.

(f) The statistical problems of estimation are another cause for concern. An issue of particular importance in the estimation of hedonic price equations is the choice of the functional form by which the dependent variable, house prices or property rents, is related to the explanatory variables. The decision to model this relationship as being either linear or non-linear has precise implications for the impact of environmental qualities on market price of housing or property rental values. There are also those problems associated with measurement errors, and the inclusion of irrelevant variables and the exclusion of relevant variables which have consequences for the efficiency and bias of the parameter estimates, and the fit of the regression as a whole.[10]

(g) In the case of the developing economies however these markets are often not developed to the extent that such a technique could be widely employed. Land may not be marketed, instead being inherited, or claimed without recourse to such a market. If such a study were undertaken the sample could exhibit a highly skewed income distribution, reflecting only the valuations of the very rich. Nonetheless, the investigation of land values is a promising area of further investigation.

.8 HEDONIC WAGES AS A MEANS OF GUAGING WILLINGNESS TO PAY OR TO ACCEPT COMPENSATION

This technique is analytically similar to the use of land or property values to reveal environmental preferences and the valution of environmental attributes. We assume that in a perfectly competitive labour market, the wage paid to the worker equates with the individual workers marginal product. Any premia

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[10] See J. Johnston, "Econometric Methods" McGraw-Hill (1984)

above the marginal product wage represents additional wage increments due to factors such as efficiency wage considerations, implicit contracts,compensating differentials, risk etc. Having made allowances for factors other than those that might reveal environmental preference, or human life valuations we run a regression which allows us to diffract the wage into its component parts. We would expect, other things being equal, that employers would want to set lower wages the greater their expenditure on safety, and the provision of an unhazardous working environment. Similarly the employees might be willing to accept higher wages in compensation for exposure to increased health risks. Thus we can establish a market for safety, and this attributed price will be the hedonic wage. It is a subject of much heated debate among labour economists as to what factors determine the nominal wage, however two factors may be of particular relevance to the valuation of environmental benefits: the risks to life and health; and the presence or absence of urban amenities. It is assumed that the implicit price of an urban amenity would provide a trade off value between air pollution and income.

Various criticisms emerge from an analysis of this technique.

(a) We require that the labour market be unfettered and not centrally planned, without wage floors and ceilings. Labour must be able to migrate freely between areas, implying no rigidities in the housing markets and locational constraints, which further implies that capital market imperfections should be ruled out.

(b) We require that workers perceptions of their health risks be accurate, and information be freely available.

(c) Risk aversion may vary between individuals, unionised and non-unionised labour, and between firms. Thus figures may understate or overstate aggregate measures of the shadow value of environmental benefits. This analysis is necessarily based on a notion of constant relative risk aversion amongst individuals.

(d) Another problem is that wage risk studies relate to compensation received for increases in risk above some accepted average level. The studies of benefits from reduced pollution focus on the willingness to pay for such reductions in the overall level of pollution. As already noted whilst the difference between these two measures should be insignificant, many studies observe wide divergencies.

(e) Such wage risk studies concentrate on the valuation of a voluntarily accepted risk. The resultant valuation may be inapplicable in the case of an involuntary risk suffered, in which case the compensation required may greatly exceed that indicated by figures from hedonic wage studies.

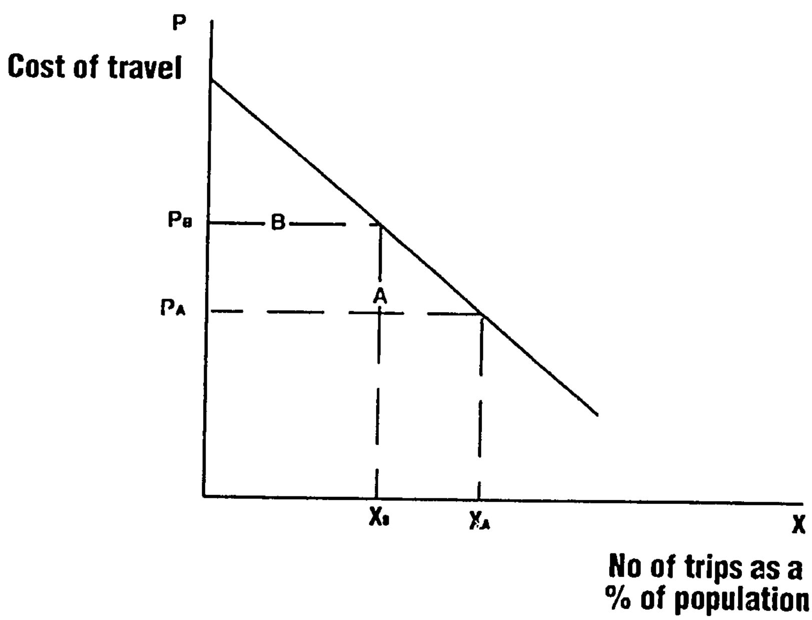
(f) Further the waged economy relates to only a small proportion of the total population in developing economies.In an economy where subsistence agriculture is the norm hedonic wage exercises would reveal very little. The prevailing wage in those sectors of the economy that are waged, is unlikely to reflect these compensating differentials.

3.9 THE TRAVEL COST METHOD: ESTIMATING THE DEMAND FOR ENVIRONMENTAL GOODS AND SERVICES

This approach has been used extensively in developed countries to value the provision of recreational goods and services. The underlying theory relies on the proposition that the individuals observed behaviour can be used to derive a demand function for environmental goods and services that are unpriced, regarding travel costs as surrogates for variable admission or "access" costs.

Figure 3.2

Illustration of the Travel Cost Method



Suppose we have a given environmental asset, a lake, that may be reached by inhabitants of the surrounding area. The number of "trips" undertaken by visitors from region A expressed as a percentage of the total population living inthe surrounding area is x_A. The travel cost for these journeys is p_A. Visitors from region B which is further from the site than region A make x_B number of percentage trips to the lake, with each journey costing p_B. Given these observations we can develop a distance decay equation for these recreational trips, which also incorporates certain socioeconomic and locational attributes, as a vector of characteristics specific to the site. A day tripper from region A earns a consumer surplus equal to A + B per trip. Multiplying this consumer surplus value by the number of trips from region A yields the total consumer surplus accruing to inhabitants in region A. Similarly the total consumer surplus may be calculated for region B. Summing these consumer surplus values and we have a measure of willingness to pay for access to the environmental asset. Various modifications can be made to this equation allowing us to take on board environmental quality indicators and asses the value attributed to incremental improvements or declines in that quality offered. It should be noted however that the amount of the travel cost per se is not equal to the value of the environmental asset. The travel cost data are only used to estimate a demand curve.

Problems of estimation are present:

(a) The Data on Travel costs and Travel Times

Some of the data required for an accurate measure of the costs of visiting a site, are as yet unavailable. The costs of visiting a site comprise the observed transportation cost and the unobserved opportunity cost relating to the time spent in transit and the time spent at the site itself. Unless some measure of the opportunity costs involved is included in the analysis, the results will be biased. Those individuals with high oppportunity costs will be deemed to have a lower willingness to pay for the number of visits that they do in fact make, and thus the estimated demand curve will be in fact flatter than the true demand curve. It is extremely difficult to find a measure of these opportunity costs, since the value of time can only be proxied by other variables such as the relevant wage rate of the individual. The wage is in this case not necessarily the correct proxy either, since:

(i) the individual is not necessarily free to work during that time spent in transit;

(ii) the wage rate paid and the remuneration received are not equal due to taxation. Which wage rate should be applied is a matter of some debate, should an allowance be made for sex, full or part time participation in the labour force, and are such data available;

(iii) there are psychic costs to working, which might not be equable with those incured on the journey;

(iv) the relevant loss of earnings may include more than one person's, since the family or household may consist of multiple earners.

(b) <u>The Data on Household Characteristics</u>

Some of the assumptions made about the nature of household consumption may be false.

(i) One of the main household characterstic variables employed in the TCM is income. We assume that as household income increases so does the willingness to pay for access to the environmental asset. This is based on the generally accepted notion of the environment as a normal good, but this might not always be true for each consuming household. In the case of developing countries, the environment is generally a necessity rather than a luxury good, which has important implications for the elasticity of demand, and the social norms surrounding the potential services the environment may yield.

(ii) Other variables which we might wish to include might not necesarily be available to us. Variables such as a measure of the social background and educational status of the family, or persons in question, a measure of recreational preferences, time constraints and commitments of the family, disability, race, sex and age etc. All these variables might add light to the chosen form of recreation and whether such analysis reveals a true measure of willingness to pay.

(c) <u>Data on the Recreational Amenities</u>

Data on the recreational facilities must also be included in this analysis, variables describing the locational characteristics such as area, flora, fauna, amenities, environmental quality etc.

(d) The Specification of the Demand Curve

One of the many problems associated with environmental benefit estimation is that whilst the final "values" obtained are highly sensitive to the precise form the demand function is assumed to take, the statistical techniques employed to test the fit or significance of the regression cannot discriminate between the different specifications.[11]

(e) Estimation Problems

The estimation problems are themselves complex. To note but a few:

(i) There is the problem of the joint determination of the number and the length of the visits, without including a length of stay variable we will get a biased estimate of willingness to pay. To illustrate, if those who come from further away spend less time at the site then the opportunity cost of the visit may appear lower than for those who come from nearby and remain for a longer period of time at the site. Ignoring the length of time spent consuming the environmental good will yield a steeper demand curve than the true relation.

(ii) Another problem is related to the treatment of the number of visits. This can only take discrete non-negative integer values. However the estimation technique itself assumes that it is a continuous variable taking both negative and positive values. There are techniques being developed which employ distributions that more closely approximate the type of distribution of the number of visits.

(iii) An issue of great importance relates to the restricted information set available. Whilst we do indeed have data on a number of visitors to the site, we do not have the corresponding information on the number of people who did not visit the site. This biases our results, since there is a pool of potential respondents who have not revealed their consumer surplus valuations of the environmental asset.[12]

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[11] For an explanation of econometric theory see J. Johnston Econometric Methods McGraw-Hill International Book Company

[12] For a discussion of truncation bias see D.W.Pearce and A.Markandya (1989) pp 45-46
Smith and Desvouges (1985)

(f) Applicability for Developing Countries

While this technique has been tailored most specifically to the recreational use of the environment, it has direct relevance to LDCs where many national parks etc. are subject to high recreational demand by local people.

3.10 THE PRODUCTION FUNCTION APPROACH

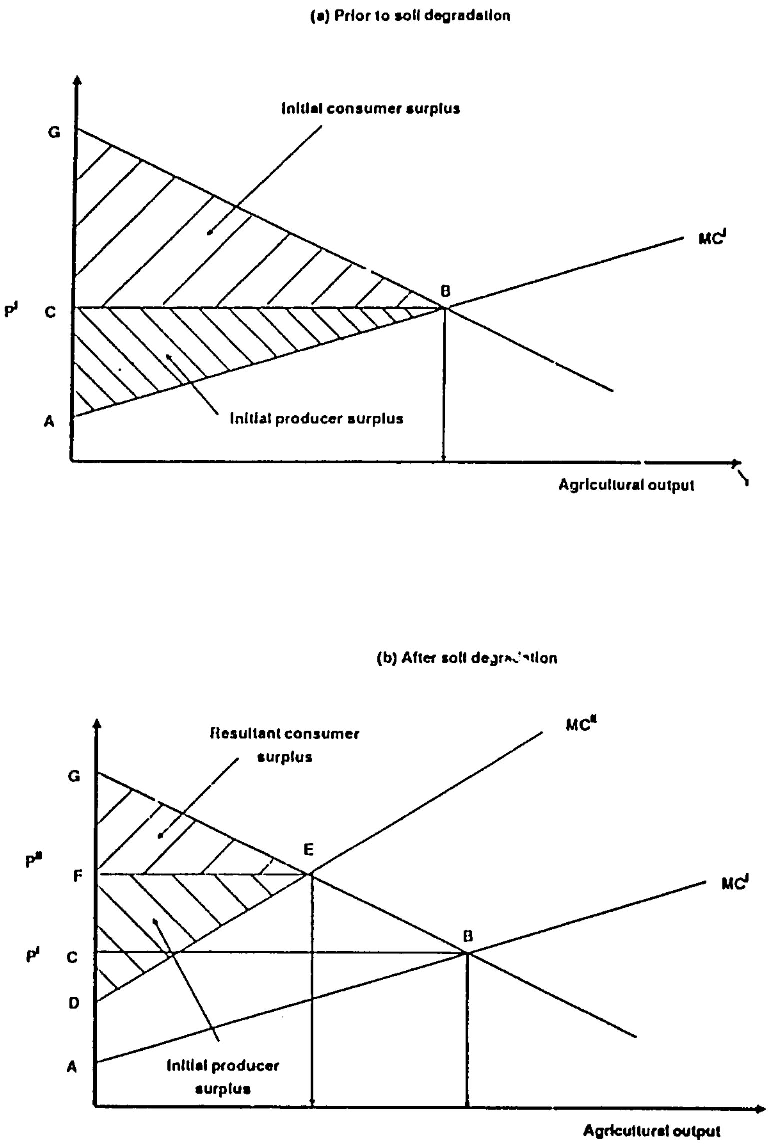
The Production function approach measures the economic value of a change in the supply of a resource as the value of the production change brought about as the supply of the environmental resource alters, holding all other inputs constant. In the case of a large discrete change in the supply of the environmental resource, and possible substitution between factors, the resource supply change must be measured as the difference between profit after the change and profit before the change. In the case of declining soil fertility, for example, if the increased acidification of the soil due to pollution causes a significant change in production methods, the economic value of the loss due to this pollution should be viewed as the change in agricultural profit after all the adjustments have occured.

Consider a case where the output price is allowed to alter in response to discrete changes in the quantity and quality of inputs supplied. This will cause a change in both producer surplus (profit) and consumer surplus, brought about because of the output price being altered. Declining soil fertility, which will raise the costs of producing a given amount of output, and increase agricultural prices.

Figure 3.3

An Illustration of the Production Function Approach

The effect of soil degradation on Agricultural Output and Prices



source K-G Maler (1989)

GEB is the demand curve for agricultural produce. MC′ is the marginal cost curve before the soil fertility declines. The equilibrium price is initially P′. The pollution causes the soil acidity to rise and fertility accordingly declines, shifting the new marginal costs curve to MC", and the new equilibrium price becomes P". The original measure of producer surplus was ABC, yet after the change in soil fertility the producer surplus becomes DEF. The loss in producer surplus is:

$$\Delta PS = ABC - DEF$$

The change in producer surplus ΔPS can be either positive or negative. If the declinbe in soil fertility can be more than offset by a rise in consumer price, the producers may be better off because they can switch the increased cost to the consumers. However the consumers always lose since the price of the agricultural good has risen, the change in consumer surplus is:

$$\Delta CS = CBEF$$

Hence the total loss from the decline in soil fertility due to the pollution is:

$$\Delta TV = CBEF + \{ABC - DEF\}$$

In the more complex case of many price changes occuring because of the pollution causing production to alter, the policy maker should examine the changes in all the consumer surpluses and producer surpluses that result. This would require a general equilibrium model, which would express the interdependencies between markets. As long as this output can indeed be measured, the value of the qualitative change in resource inputs can be evaluated. This technique is relatively simple and has acute relevance for the developing economies. Many of the resource problems that affect developing economies seem to be those that alter inputs into production processes, e.g. soil erosion, water logging, overgrazing.[13]

[13] K-G.Maler (1989) pp38-43. For a discussion of valuation approaches in the case where output is not directly measureable pp55-79.

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3.11 CASE STUDY 1. THE ECONOMIC CONSEQUENCES OF AN AFFORESTATION PROJECT IN NIGERIA

This case study examines the costs and benefits of undertaking investment in a rural afforestation project in an arid area of Nigeria. In particular Anderson[14] considers the benefits that could derive from establishing shelterbelts (an extended form of windbreak comprising multiple rows of trees which stretches over several kilometers) and farm forestry. This analysis employs the production technique discussed above, to assess the costs and benefits of such an investment.

Such a project had been mooted to prevent the continued destruction of trees and woodland in Nigeria because of the demand for fuelwood, agricultural land, and fodder for livestock. A history of overgrazing and the unsustainable use of timber had led to progressive environmental decline, and had made the topsoil vulnerable to dessicating winds. This resulted in

- a substantial decline in farm tree stock in the arid zone,
- a decline in soil fertility,
- the unsustainable harvesting of tree stocks,
- and the encroachment of public forest and game reserves.

In 1978 the federal government initiated the Arid Zone Afforestation Programme, which was terminated in 1984. There were two main objectives to this programme:

(a) to establish a nursery network and a seedling distribution system, to encourage sustainable yield forest farms,

(b) to set up a system of shelterbelts which would retard the effects of the winds on soil productivity.

To identify the costs and benefits of such a programme, first requires that we disaggregate the hypothesised costs and benefits into observable factions.

The <u>benefits</u> can be summarised as follows:

(a) the benefits that derive from preventing further declines in soil fertility,

[14] D Anderson (1987)

(b) benefits that derive from increases in soil fertility because of the improved moisture retention and nutrient recycling,

(c) increases in the output of livestock products resulting from the extra dry season fodder that becomes available because of the larger crop yield from more sustainable agriculture,

(d) the value of the tree products themselves: firewood, fruit, etc.

These are increases in three different outputs from the project. Increases in agricultural outputs because of the improved soil fertility, increases in livestock products, and increses in tree products. Hence three production functions need to be estimated.

The <u>costs</u> can be summarised as follows:

(a) Those costs arising from the shelterbelts,

- the value of the land that was effectively lost to productive output by being consigned to shelterbelt use.

- the costs of fencing, posts, and operational costs, labour, seeds, fertilisers etc.

(b) Those costs arising from farm forestry,

- the costs of setting up nurseries,

- the training costs and deployment of agricultural "agents" to disseminate ideas, give advice and generally act as consultants,

- the costs of management, state management and project management,

- the costs to farmers (measured as the value of labour inputs).

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Results

The study deliberately analysed the shelterbelt and farm forestry programmes separately. In the farm forestry case the benefits accrue over a longer time horizon, and the yields are effectively smaller than in the farm forestry case. The net present values[15] were calculated using a 10% discount rate over a period of 30 years. This resulted in positive net present values for both the shelterbelts and farm forestry projects. Various different scenarios were postulated in the analysis of these costs and benefits, different yields, different rates of soil erosion, yet they all resulted in a positive net present value. Shelterbelts were found to yield more certain returns than the farm forestry programme, but to have significantly higher costs. Farm forestry was found to yield higher but less certain returns, and to be associated with greater risks.

One of the important implications of the different scenarios considered was that it is prudent to protect the better soils to avoid the threat of rapid degeneration. Benefits were found to be lower when the rates of erosion rise from 1 to 2 per cent a year. This is because at higher rates of erosion, the value of enhancing the fertility of an increasingly degraded soil is much less than the value of enhancing soil fertility when the degradation is minimal.

3.12 CASE STUDY 2. THAILAND FISHERIES DEVELOPMENT [16]

This is an ex-post analysis of a fisheries development project funded by the Asian Development Bank. It highlights the need for project evaluation to have a wide horizon in order to take account of the effects that may result from the "misuse" or redirection of capital facilities provided by the project itself. The Thai fisheries project was approved as being both economically sound and socially desirable. However the capital for the project was redirected with consequent economic losses and the unintended depletion of resources. In 1975 the Asian Development Bank granted a loan to the Thai government to develop its pelagic fishery, a resource that was not yet fully exploited. The loan was to secure the purchase of 13 gill-netting and purse-seining vessels and five land-based cols stores. However by 1978 approximately 70% of the project vessels had been converted into trawlers which were profitable to operate on a private basis, and were being used to catch the already endangered and overfished

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[15] For a discussion of Net Present Value see D.W.Pearce and A.Markandya (1989)

[16] J.A.Dixon et al (1988)

demersal stocks. This analysis concludes that whilst the project was initially thought to be economically and socially welfare enhancing, in the light of the misuse of project capital, there were no measured gains. The net loss from the overfishing of the demersal stock far outweighs the gain from developing the pelagic fishery. The consequent increase in unemployment in already depressed coastal areas further underscores this conclusion.

3.13 CASE STUDY 3 THE NEPAL HILL FOREST DEVELOPMENT PROJECT [17]

This study employs the production function approach, to assess the monetary value of the physical changes in production brought about by the introduction of the project. The forests of Nepal are subject to continual degradation, the unchecked harvesting of timber, overgrazing, and the lack of adequate supplies of unpolluted water has contributed to the destruction of the forests. As a result of this the coherence of natural vegetation has been so reduced that run-off has increased, it has been estimated that each year 240 million cubic meters of eroded soil is washed downstream by rivers and their tributaries. It was proposed that a systematic hill-forest management project should be introduced to provide a sustainable yield source of fodder and fuelwood for rural and urban communities. Three branches of the project were envisaged:

(a) to develop a system of management planning for the entire area, which would comprise a forest inventory, operational planning and the dilineation of subplots of forest land;

(b) the improvement of shrubland and timber-stand, which requires the tending of 16,000 hectares of shrubland andthe improvement of 7,000 hectares of timber-stand, and the provision of additional within the 27,000 hectares of forest;

(c) the afforestation of 4,000 hectares of grasslands within the total area of the forest, with different species being propagated for use as fuelwood, fodder and fencing materials.

The projected land use with and without the introduction of the project was forecast, assuming that the pressure on forest reserves would rise over the next 20 years. It was concluded that without the introduction of the project, the consequence of the continued indiscriminate removal of vegetation, shrubland and forest cover water runoff would increase in both velocity and

[17] J.A.Dixon et al (1988)

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volume, exaccerbating the already severe siltation problems occuring below the hills.

The project was hypothesised to retard the alarming process of soil erosion, and to limit landsliding and subsidence. Further it was felt that establishing vegetation cover on the now barren hill slopes would improve the local hydrological cycle, increasing the recharge of aquifers. The project will also remedy shortages of fuelwood and livestock fodder, and reduce the destructive and illicit removal of forest cover by engendering community support and cooperation. In addition it will also improve agricultural productivity, since the provision of adequate supplies of fuelwood will enable dung use to be channeled into fertilising activities, instead of being used as a substitute source of fuel.

The project evaluation took the form of a cost benefit study, valuing the different outputs from the various land uses.

(a) Grazing land was valued in terms of its productive capacity in terms of agricultural output, milk and fertiliser. Since market prices were used to value these outputs, it was important to establish that these prices reflected the true opportunity cost, or marginal willingness to pay for these goods. Taxes, subsidies, and price-ceilings must be taken into account in order to divine the true "shadow price" of these outputs if it is felt that market values do not reflect revealed preference.

(b) Pasture production was valued at five times that of grazing land, since its output was approximately five times higher.

(c) Unmanaged scrubland was also valued in terms of its productive capacity. Cattle are grazed on this land and this therefore contributes as a valuable input in the production of milk and fertiliser, there is also some harvesting of avaiable supplies of fuelwood.

Various valuation methods were considered:

Direct Market-Value Approach
It was felt that because the fuelwood markets were small and isolated, that the market price may not represent the true value of fuelwood outside the market. The project analysts therefore sought to persue alternative valuation methods.

Indirect Substitute Approach
This approach relies on values determined by the market for the alternative uses of the goods closest substitute. In this case a ready substitute had already been found to compensate for the

lack of available fuelwood. Cattle dung was being dried and and burned when wood was unavailable. The opportunity cost of using dung as a source of fuel rather than fertiliser was estimated in terms of the losses of foodgrain production, since cattle were being grazed to produce dung as fuel when previously that dung had been used as fertiliser to enhance the productivity of soils on which foodgrains were being grown.

Indirect Opportunity Cost Approach
This approach seeks to measure the opportunity cost of time spent carrying fuelwood from the forest, assuming that fuelwood is common property.

The total land values under alternative management systems were calculated. The effect of the project on the reduction in soil erosion, landslides and flooding was not easily quantifiable and was therefore omited from the study. Thus the benefits accruing to the project were valued solely as the difference between the land values with and without the introduction of the management scheme. It was concluded that the project would yield a positive net rate of return.[18]

3.14 INDIRECT VALUATION PROCEDURES

Indirect valuation techniques focus on "dose-responses" the relation between some environmental good or bad and the benefits or costs associated with the consumption of that good or bad. This is not a technique which seeks to measure direct revealed preference in the market, since it mainly applies to cases where individuals have less than full information about the consequences of consuming the environmental good or bad in question. Various types of "dose-response" studies have been undertaken: the effect of pollution of health; the effect of pollution on physical assets such as buildings, monuments,urban climate; the effect of pollution on acquatic ecosystems or vegetation. In general wherever a causal link can be identified, a dose-response study can be performed, such a technique is therefore particularly applicable in the study of environmental problems. Direct methods will not yield meaningful measures of "true" environmental damage if no account is made of the linkage between cause and effect.

Having established a dose-response relationship, we can then construct an estimate of the "damage function". The damage function relates the physical damage done to the level of pollution tolerated. This damage function can be monetised to reflect the cost per unit of damage suffered, which can then be

[18] J.A.Dixon et al (1986).

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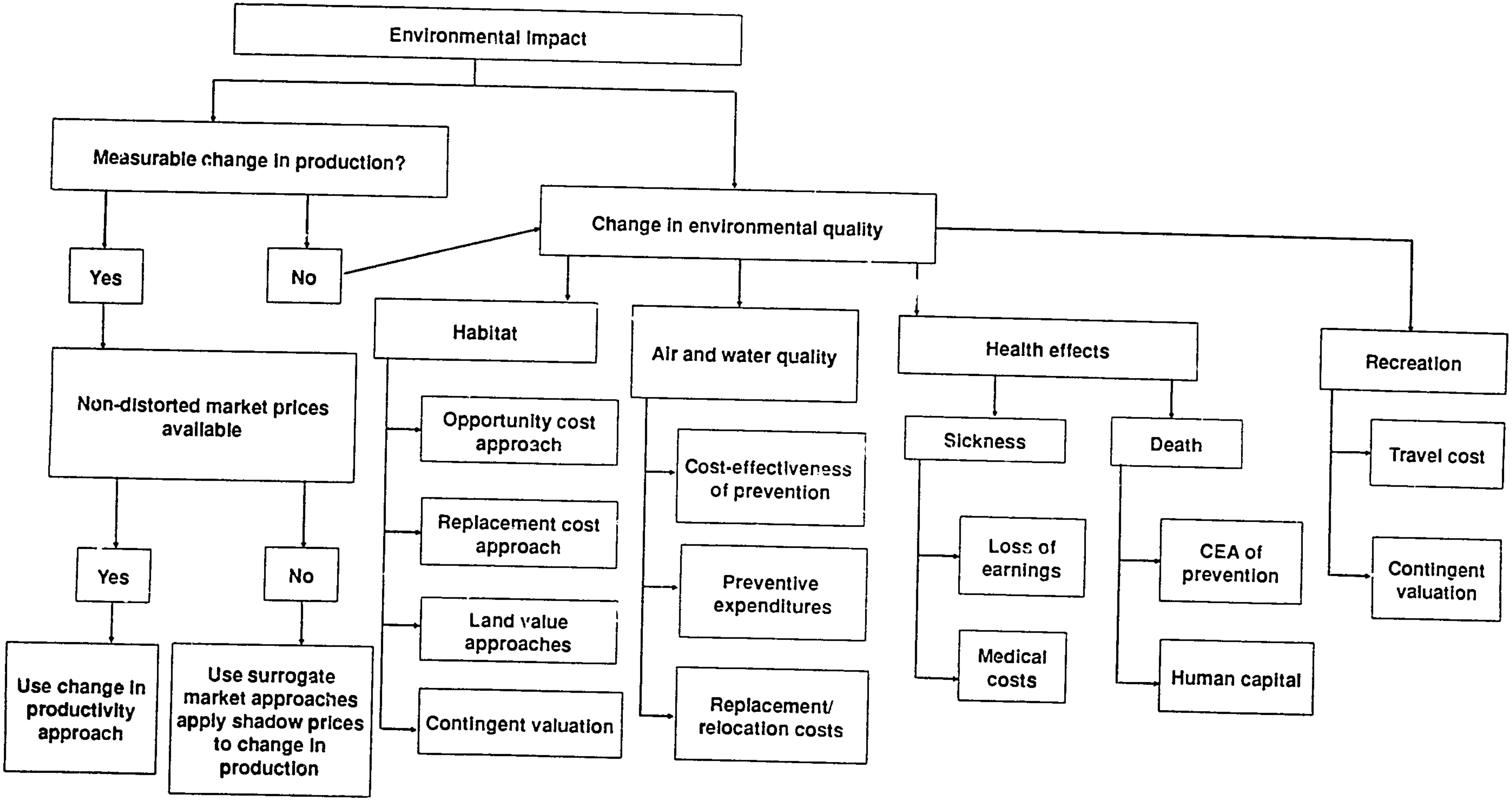
used to construct a measure of the benefit of environmental policy.[19]

3.15 CONCLUSIONS

In developing countries the most useful valuation approaches to date have generally been those that require fewest assumptions, the least technical manipulation and simple operational mechanics. The approaches that rely on market prices, assessing changes in productivity, relocation costs, and generally employing production function techniques etc have proved to be the most useful. However, other approaches can be very useful despite their apparent limitation to developed economies. travel cost procedures, for example, may be used not just for recreational site valuation but for valuing unmarketed fuelwood and water. Land values in particular deserve further attention.

[19] D.W.Pearce and A.Markandya (1989) pp49-57, give an explanation of the methodology of dose-response techniques, and highlight a few such studies undertaken.

Flow chart of Environmental Valuation Procedures, Source Dixon



Environmental Effect	Economic Impact	Benefit (B) Cost (C)	Representative Valuation Technique
A) Environment on Dams			
1) Soil Erosion - upstream, sedimentation in reservoir	reduced reservoir capacity; change in water quality	B,C	change in production, preventive expenditures, replacement costs
B) Dams on the Environment			
1) Chemical Water quality-changes in reservoir and downstream	increased/reduced treatment cost, reduced fish catch, loss of production	B,C	preventive expenditures, changes in production
2) Reduction in silt load - downstream	loss of fertilizer reduced siltation of canals, better water control	B,C	replacement costs, preventive expenditures avoided
3) Water Temperature changes (drop)	reduction of crop yields (esp. rice)	C	Changes in production
4) Health - water related diseases	sickness, hospital care, death	B,C	loss of earnings, health care costs
5) Fishery - impacts on fish irrigation, spawning	both loss and increase in fish production	B,C	changes in production, preventive expenditures
6) Recreation - in the reservoir or river	value of recreation opportunities gained or lost, tourism	B,C	travel cost approach, property value approach
7) Wildlife and Biodiversity	creation or loss of species habitat and genetic resources	B,C	opportunity cost approach, tourism values lost, replacement cost
8) Involuntary Resettlement	cost of new infrastructure, social costs	C	replacement cost approach, "social costs", relocation costs
9) Discharge variations excessive diurnal variation	disturbs flora and fauna, human use	C	relocation costs, changes in production
10) Flood attenuation	reduces after flood cultivation; reduces flood damage	B,C	changes in production, flood damages avoided

Selected Environmental Effects of Major Storage Dam Projects and their Economic Impacts, source Dixon (19)

Conceptual basis/method	Description	Advantages	Disadvantages	Additional references
1. Benefit-cost analysis	Evaluates policies based on a quantification of net benefits (benefits-costs) associated with them.	Considers the value (in terms of what individuals will pay) and costs of actions; translates outcomes into commensurate terms; consistent with judging by efficiency implications.	No direct consideration of distribution of benefits and costs; significant informational requirements; tends to omit outputs whose effects cannot be quantified; tends to lead to maintenance of *status quo*, contingent on existing distribution of income and wealth.	Pearce and Nash (1981)
2. Cost effectiveness analysis	Selects policy that will minimize costs of realizing the policy goal or objectives.	No need to know the benefits, focus is on information often more readily available; provides implicit values of the objective (e.g. marginal cost of increasing by one unit).	No consideration given to relative importance of outputs; degree to which all costs considered will be important to judgments as to "best" approach; how to treat social costs resulting from side effects.	Pearce and Nash (1981)
3. Multiple criteria analysis	Uses of mathematical programming techniques to select projects based on objective functions including weighted goals of decision maker, with explicit consideration of constraints to action and costs.	Offers consistent basis for making all project or regulatory decisions; fully reflects goals and constraints incorporated in model; allows quantification of implicit costs of constraints; permits prioritizing of projects.	Results only as good as inputs to model; unrealistic (1978) characterization of decision process; must supply the weight to be assigned to goals; large information needs for quantification.	Cohon (1978) Zeleny (1982)
4. Risk-benefit analysis	Evaluates benefits associated with a policy in comparison with its risks.	Framework is left vague for flexibility; intended to permit consideration of all risks, benefits and costs; not an automatic decision rule.	Too vague; factors considered to be commensurate are not.	Fischoff *et al.* (1981)
5. Decision analysis	Step-by-step analysis consequences of choices under uncertainty.	Allows various objectives to be used; makes choices explicit. Explicit recognition of uncertainty.	Objectives not always clear; no clear mechanism for assigning weights.	Norton (1984)
6. Environmental impact assessment	Detailed statements of an action's impacts, adverse effects, alternatives; requires a balancing of economic and environmental benefits and costs.	Explicitly requires consideration of environmental effects; ability to monetise does not preempt numeration of all benefits and costs of an action.	Difficult to integrate descriptive analyses of intangible effects with monetary benefits and costs; no clear criteria for using information in decision.	Andrews (1984)

Source: Adapted from Smith (1986). Decision analysis added.

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A COMPENDIUM OF PUBLICATIONS

NOTE: There is an extensive literature on the theory and practice of valuation in the developed economy context. We have made no attempt here to survey this literature. We have instead cited some of the main synoptic works which will guide the reader to further detailed studies and theoretical work. As far as developing country work is concerned, however, there is a far more limited literature.

D. Anderson (1987)
The Economics of Afforestation: A Case Study In Africa
World Bank Occasional Paper Number 1. New Series.

World Bank
Washington DC

This book begins with a discussion of the problems resulting from unsustainable timber production, unchecked grazing and farming methods and the resultant soil degradation and decline in fertility. Anderson considers the policy options available, the public operation of forest tracts, farm forestry, and the establishment of shelterbelts or extended windbreaks. He categorises the prospective risks and returns on investment in rural afforestation in the arid zone of Nigeria. Ennumerating the costs of such soil degradation, the loss of trees, the reduced agricultural yields, the encroachment on remaining forest reserves, and the desertification that results. In identifying the costs and benefits from introducing a programme of forest farming and shelterbelts, Anderson, outlines the data requirements for a detailed cost benefit analysis study. He highlights the informational problems accompanying such a study, with particular reference to the paucity of empirical research in this arid zone. Employing the production function approach he analyses the effects of shelterbelts on wind velocities and crop yields in the Majjia valley comparing it with similar studies in different countries. He concludes that such a project should be introduced since both shelterbelts and farm forestry yield a positive net present value. This survey is of particular use in identifying the types of research and data collection methods that should be employed in order to undertake such a study.

E. Barbier (1988)
'Economic Valuation of Environmental Impacts', **Project Appraisal** Vol.3, pp 143-150.

Barbier examines the data and the methodological requirements for the economic valuation of environmental impacts, using a study conducted for UNDP in Indonesia. In assessing the impact of environmental degradation, economists must take into account the multifunctionality of resources, thus Barbier stresses the need for adequate data to fulfil this prerequisite. He discusses the valuation of these multiple functions, examining user cost, inter-temporal user cost, and social cost. One of the most important data base reqiurements that Barbier notes is that it must be flexible, enabling planners to collect information on diverse aspects of the environment-economy interactions. Data collected for valuing aspects of the economy-environment interlinkages should also be used to monitor the valuation exercise itself. Barbier is concerned that indicators should be chosen to fulfil this dual function.

J.Bishop and J.Allen (1989)
The On-Site costs of Soil Erosion in Mali

World Bank, Environment Working Paper No.21.
Washington DC

Land degradation in the Sahelian countries of West Africa is widely perceived as a critical threat to econoic development. Some studies have quantified the extent of physical decline locally but few have attempted to determine its economic impact. There is some evidence that current rates of depletion of Sahelian land resources may be excessive from an economic perspective, due to insecurity of land tenure and poorly developed capital markets. This paper attempts to evaluate the gross on-site costs of soil erosion in Mali, a nation in which subsistence farming accounts for about 1/5 of national income. Mean local rates of soil erosion by rainfall are estimated and mapped using data derived from a land resources atlas of Mali and the Universal Soil Loss Equation (USLE). The analysis concerns only cultivated land within a north-south swath of Mali, comprising roughly 1/3 of the country's most productive agricultural areas. Using a range of assumptions the impact of erosion on crop yields, estimated rates of soil erosion on farm land imply average annual yield penalties in the study area between 2% and 10%. These losses are expressed in terms of foregone net farm income, using farm budgets recorded in Burkina Faso. Estimates of foregone farm income are compared to the costs of a relatively inexpensive soil conservation technology. Areas are identified where such investment may be justified as shown by a higher level of estimated farm income forgone. The

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report suggests that economic returns to agriculture will be overstated by conventional benefit-cost analysis. Under conservative assumptions of a ten year time horizon and a 10% discount rate, the present value of current and future net farm income foregone nationwide, due to one year of average soil loss, is estimated at US$31 to US$123 million, 4-16% of agricultural GDP.

J. Bojo (1989)
Cost-Benefit Analysis of Soil and Water Conservation Projects. A Review of 20 Empirical Studies.

Stockholm School of Economics Sweden
This paper summarises the arguments for and against the use of cost-benefit analysis, critically reviewing 20 empirical studies relating to soil and water conservation projects. It provides the policy analyst with a concise overview of the problems and pitfalls associated with the operation of such techniques. There is a discussion of the evaluation criteria, the identification of costs and benefits, the valuation or monetisation of such measures, with emphasis on the distributional consequences of policy. Bojo concludes that in many cases there is a lack of coherence in policy aims coupled with an inconsistent rationale for many of the assumptions which form the cornerstones for such analysis and which hampers valuation exercises. However that despite these obvious limitations, with "appropriate care" CBA may still improve decision-making. This cites an array of projects which have been undertaken in both developed and under-developed countries, the literature is accessible and non-technical in content, yet it addresses problems of utmost relevance to policy analysts.

J Bojo, K-G Maler, L Unemo (1988)
Economic Analysis of Environmental Consequences of Development Projects

Stockholm School of Economics,
Stockholm

This text addresses distortions in economic systems, market failures, government failures, externalities, public goods and bads, and how each of these relate to continued environmental damage. There is a chapter on General Equilibrium Models and their application, and a discussion of cost benefit analysis, planning and decision criteria, with a section on discounting and the environment. The authors discuss intergenerational equity and the importance of the time horizon over which benefits are measured. Various valuation techniques and their applicability in the developing economies are considered, with detailed references to case studies. This text has many useful citations and provides policy analysts with a critical appraisal of those studies that have already been undertaken. It is mainly concerned with the applicability of valuation techniques and gives a non-technical but highly thoughtful explanation of the current problems facing policy makers in the developing countries.

G.Brown and W.Henry (1989)
'The Economic Value of Elephants', LEEC paper No. 89-12

London Environmental Economics Centre,
London

The authors attempt to address the problem of imputing monetary valuations to the declining populations of Kenyan elephants. They employed both a contingent valuation an a travel cost approach to analyse tourists' valuations. The results of the two techniques were quite comparable and together produced a single estimate of about $25 million annually for the continued viewing access to the elephant herds. Respondents also reported that if the elephants were to decline by another 50% at least one half of the tourists would no longer find Kenya an attractive destination to visit or to recommend as a touristic experience. The study does not estimate existence value for non-users or option value, concentrating solely on use values.

S.Castillo and R.Gottfried (1990)
'Management of an Ecosystem as a Multiproduct Asset in a Developing Country Context' mimeo, submitted to International Society for Ecological Economics

Several difficulties exist in the economic literature on the value of an ecosystem. First, few authors rigorously adress the interrelations between goods and services provided by an ecosystem. Second, economists tend to approach ecosystem value in terms of consumer and producer surplus, concepts particularly difficult to measure in developing countries. Finally, the literature generally has not viewed ecosystem values from the perspective of the role of the system in development. This paper attempts to develop a methodology which treats the ecosystem as a multiproduct asset and which enables one to examine the implications for development of various types of ecosystem utilisation. The paper utilises a recursive linear programming model which maximises the net present value of the flows of the entire package of interrelated ecosystem goods and services over time subject to various biophysical, socioeconomic and ecological constraints. The model assumes that all the human productive activities in the entire ecosystem can affect in various ways the quantity of ecological goods and services produced by any one

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parcel in the system. The ecological outputs of a parcel in turn constitute an input to the economy's production of goods and services. People also consume a subset of the ecological outputs indirectly without the use of economic inputs. The paper discusses how to include uncertainty, risk and sustainability considerations in the constraints and ends with a discussion of the advantages and shortcomings of the model.

J.A. Dixon (1987)
'Experience and Lessons from Environmental Applications of Economic Analytical Methods',

East-West Centre Honolulu

This paper surveys the type of techniques currently available to economists and gives a breakdown of environmental effects, their economic impact and the most applicable valuation technique. The focus of this article is towards the important policy directives which such valuation techniques yield. Dixon summarises the different valuation problems faced in the developed and undeveloped economies, and then considers two cases in the Phillipines of attempts to analyse environmental costs and benefits. The first case concerning the Tongonan Geothermal Power Plant, analyses the consequences of disposing of "wet" geothermal fluid from a power plant located on the island of Leyte. The wastewater byproduct contained various heavy metals and other known toxic substances. Various disposal options were under consideration, ranging from the proposed reinjection of geothermal wastewater on site, to the disposal of untreated or treated waste into two nearby rivers, and ocean outfalls. Dixon does not give a detailed description of the study, he however notes that when the calculated costs and benefits were monetised this was able to give valuable guidance to policy makers. The second case examined Bacuit Bay, and the economic-environmental interactions of its three main industries, logging, fishing and tourism. Assessing the costs of continued logging, against that of a logging ban. Dixon concludes that whilst these techniques are of importance in guiding policy decisions, there are other important facets of the decision-making process that are not guided solely by the objective assessment of costs and benefits, and that the political realm often dominates.

J.A.Dixon, M.Hufschmidt. (eds) (1986)
Economic Valuation Techniques for the Environment
A Case Study Workbook

Johns Hopkins University Press
Baltimore

Whilst there is a brief introduction on the role of economics in valuing the environmental effects of development projects, the focus of this book is almost exclusively on case studies. Each case study describes its objectives and its horizon, or sphere of influence. Practical issues such as the quality of data, the use of relevant discount rates, and the type of valuation procedure employed are discussed in the context of particular projects.
There is a hypothetical case study which illustrates the dichotomy between observed market prices and the "shadow prices". This hypothetical study discusses net benefits and net present value in the context of Cost-Benefit analysis. There is also a chapter on discounting, and the choice of an appropriate time horizon. There then follows the case studies: valuation of environmental quality aspects of agricultural projects in Korea; the case of the Tongonan Geothermal power plant project in the Philippines; the valuation of the loss of marine resources due to coastal development in Tokyo Bay; water pollution control options in China etc. Each study gives a very detailed account of the methodology, data collection, and the data catchment area, the time horizon and the problems encountered in performing the valuation exercise.

J. Dixon, R. Carpenter, L. A. Fallon, P.Sherman, S. Manipoke (1988),
Economic Analysis of the Environmental Impacts of Development Projects

Earthscan, London

This book is an update of the earlier work by Dixon for the Asian Development Bank. It focuses on the impact of development projects on the environment, and explores various techniques for evaluating the effects of policy on the environment. It gives a non-technical overview of the methodology of environmental valuation. As an appendix it contains some interesting case studies which highlight the practical requirements, the data bases employed and the informational constraints faced. These five case studies illustrate the applicability of the production function approach, relying on physical changes in the production of goods and services valued at market prices. The first case of the Nepal Hill forest development project assesses changes in the values of milk, fertiliser and forest production to discern the

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impact of a watershed management and forest development project. The second focuses on the cost-effectiveness of several proposed waste-water disposal methods for a geothermal plant in the Phillipines. The third is a Thai fishery project which has the unintended effect of depleting available fish stocks. The fourth considers the effect on the environment of the disposal of effluent from an Indonesian Palm oil mill. The last study examines the on-site and off-site effects of alternative land-management approaches in the uplands of Northern Thailand.

M.M. Hufschmidt, E.L. Hyman.(eds) (1979)
Economic Approaches to Natural Resource and Environmental Quality Analysis

Tycooly International Publishing
Dublin

Proceedings and Papers from a Conference on Extended Benefit-Cost Analysis held at the Environment and Policy Institute East-West Center, Honolulu, Hawaii.

This is a collection of articles with particular emphasis on environmental valuation and project analysis in developing countries. These comprise valuation of extra-market goods, and the potential applications of the travel cost method and contingent valuation procedures in Asia and the Pacific Basin; general equilibrium models of environmental damage; the use of Cost-Benefit analysis for multi-objective planning, and a discussion of the theory of transaction costs highlighting the case of water pollution control in Thailand. There is also a section on International and global aims and the coordination of policy with focus on the case of CFC emissions. Several case studies are presented, although not exclusively developing country examples.

P-O Johansson (1987),
The Economic Theory and Measurement of Environmental Benefits

Cambridge University Press,
Cambridge

This text focuses on the microeconomic underpinnings of much of the theory of environmental valuation, and covers some quite technical material. The author examines the concept of consumer surplus, compensating and equivalent variation and discusses problems of aggregation, distortion under rationing or quantity constrained regimes. There is also a discussion of hedonic pricing and the travel cost method with a few illustrative examples, which considers the implications of discrete versus continuous choices. Johansson adresses the problem of inter-generational equity introducing the notion of instantaneous consumer surplus, and considers measures of welfare change under conditions of risk and uncertainty. Johansson develops a model with renewable resources with a finite discrete time horizon. He then goes on to discuss the Brown and Hammack model for the allocation of prairie wetlands in the north central US and southern Canada, which is expressed in an infinite continuous time horizon. He concludes that the variations over time in benefits and/or costs makes the decision as to when a project should be undertaken of the utmost importance. This is done as a precursor to the subject of welfare change measures in a risky world, under price uncertainty. In the last chapter he discusses the complexity of attempts to monetise the value of environmental assets, and the further complication that arises when we consider an uncertain supply of that environmental asset. Much of this analysis employs quite sophisticated mathematical techniques, however it gives a superb insight into the problems of environmental valuation and its informational prerequisites.

R.A.Luken, R.M.Wolcott, R.D.Morgenstern and J.M.Campbell (1990)
EPA's Use of Benefit-Cost Analysis:1981-1986

Economic Studies Branch, Office of Policy Analysis, Office of Policy, Planning and Evaluation
U.S. Environmental Protection Agency

This report discusses the contributions that benefit-cost analysis has made to EPA's ergulatory process and examines the limitations of benefit-cost analysis as well. It analyses the various statutary provisions that affect EPA's use of these analyses in regulatory decision making. Finally, it describes how EPA is working to improve its benefit-cost analyses in the future.

D.MacRae, and D.Whittington (1988)
'Assessing Preferences in Cost-Benefit Analysis: reflections on Rural Water Supply Evaluation in Haiti'

Journal of Policy Analysis and Management, Vol.7, No.2, pp 246-263 (1988)

This article examines an area of cost-benefit methodology which has come under increasing philosophical scrutiny in recent years: the appropriate treatment of individuals' preferences. The authors illustrate some of the difficulties involved in assessing preferences in the context of a concrete example: the evaluation of a rural water supply project in Southern Haiti. Four problems in the application of cost-benefit principles are discussed: (i) how to count the social value of private water taps connected to homes if they are prefered for prestige reasons, (ii) how to assess husbands' preferences concerning the time saving by wives who previously carried water from more distant sources, (iii) how to count preferences based on a respondent's desire to support general community welfare, and (iv) how to evaluate a water project when people's preferences may change after the new water system is installed. The authors argue that policy analysis will be improved by presenting philosophical arguments as to why some preferences should be included in the evaluation and others ignored.

K-G Maler (1989)
'Valuation of Costs and Benefits from Resource Use', mimeo,

Stockholm School of Economics

Maler discusses the role of utility theory and consumer surplus in the valuation of the environment. He outlines the premises of Cost Benefit Analysis and highlights its use as a form of project appraisal. There is a discussion of Use value and Preservation value, the General Equilibrium approach to valuing the environment, and Social Accounting and the use of input output analysis. He discusses in detail the production function approach in cases where output is observable and unobservable, and outlines a case study by Dennis Anderson employing this technique in appraising the benefits accruing to an afforestation project in Nigeria. Whilst Maler endorses contingent valuation methods on the grounds that they can in principle guage the total value of a resource, he notes that in most developing economies it is the user value which is of central importance. In this case the production function approach is particularly useful. Throughout the article he stresses that we need be mindful of the concepts in hand. The measurements arrived at are intended to value the impact on individual welfare as measured by compensating variation, or equivalent variation. These consumer surplus measurements may appear arbitrary when monetised, however if the valuation exercise adheres in principle to the theory, these measures should be consistent. As a means of providing policy directives valuation performed on this basis should at the very least provide us with an ordinal ranking of project precedence.

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A. P. J. Molp , J. B. Opschoor (1988)
'Developments in Economic Valuation of Environmental Resources in Centrally Planned Economies', **Environment and Planning**, Volume 21, pp 1205-1228.

This article discusses the theoretical underpinnings of the Marxist approach to the valuation of environmental resources. The authors consider those problems peculiar to centrally planned economies and the institutional and structural rigidities inherent in the economic infrastructure. They highlight the present state of pollution and the impediments to its resolution, the conflicting aims of socialist government, the priority of economic growth, the complexity of planning systems, enforcement difficulties, and the dirth of pressure group activity. This article does however stress that the Soviets have made concerted efforts to incorporate environmental aims within existing policy and legislation. Moll and Opschoor emphasise the distributional impact which result from the failure to value the environment and correct for the uneven regional distribution of natural resources. The valuation techniques employed are rooted in the labour theory of value, which in some cases may lead to a zero valuation of those resources which are as yet unexploited and have had no labour input expended on their "recovery." The authors also discuss the theory of differential rents, and reproduction costs, valuation techniques which attempt to overcome this obstacle. They conclude with a comparison of neo-classical valuation models and those of centrally planned economies. The article is non-technical, and yet very informative.

D.W. Pearce and A. Markandya (1989)
Environmental Policy Benefits - Monetary Valuation

OECD Paris

This book explores the methodology of benefit estimation and gives a detailed explanation of Cost Benefit Analysis, direct valuation techniques such as hedonic pricing, contingent valuation, and travel cost methods, and indirect valuation procedures. There is also a chapter on discount rates and their determination, with particular focus on the present valuation of environmental projects. This volume deals only with the developed economy valuation issue.

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M.Schecter (1989)
A Comparative Study of Environmental Amenity Valuations

University of Haifa
Haifa

This paper provides a comparative study of direct and indirect approaches to valuing environmental amenities (i.e. public goods), specifically air quality in terms of its human health effects. The application of three indirect valuation methods (via market goods) is reported: the health production function, cost of illness, and a consumer preference for non-market good model. The first and third methods are behaviour based approaches, under which willingness to pay for the environmental good is derived by explciting relationships in consumption between the public good and observed consumer behaviour in connection with the market goods. The second is instead based on a physical relationship (e.g., dose response functions) between the environmental good and an attribute gauging physical or physiological phenomena (e.g., health). The direct valuation approach encompassed several contingent valuation formats: open-ended, repeat probe-bidding, and referenda style binary choice. The application of all four methods was based on data from a household survey of a large stratified sample of households from Haifa metropolitan area in Northern Israel. The estimates of welfare change derived by the various methods are discussed and compared. In general, albeit with a few qualifications, they strengthen the case for using direct approach methods.

D.Whittington, V.K.Smith, A.Okorafor, A.Okore, L.K.Ruiz, A.McPhail, J.L.Liu. (1990)
Giving Respondents Time to Think in Contingent Valuation Studies
Infrastructure and Urban Development Department

World Bank,
Washington

This paper reports the first effort to evaluate whether giving people 'time to think' influences their answers to willingness to pay (WTP) questions. The analysis is based on data collected in three villages in Nigeria. In-depth personal interviews were conducted with heads of households or their spouses to determine households' willingness to pay for two types of improved water service: public taps and private connections. This paper gives a detailed account of the study area and the research design. The authors describe their analytical framework for modeling the determinants of households' WTP bids and summarise their findings. The final chapter outlines their overall conclusions and the perceived implications for future applications of contingent valuation methods.

D.Whittington, X.Mu, and R.Roche(1990)
'Calculating the Value of Time Spent Collecting Water: Some Estimates for Ukunda, Kenya'

World Development, Vol. 18, No. 2, pp 269-280, (1990)

This article presents two procedures for estimating the value of time spent hauling water in developing countries. Both approaches are used to derive estimates of the value of time for households in Ukunda, Kenya. The results indicate that households in this vallage place a surprisingly high value on the time they spend collecting water, a value approximately equivalent to the wage rate for unskilled labour. These findings suggest that the economic benefits of improved water services in developing countries may be much greater than is commonly realised.

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ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME FOUR

DISCOUNTING AND THE DEVELOPING COUNTRY EXPERIENCE

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REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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VOLUME 4

DISCOUNTING AND THE DEVELOPING COUNTRY EXPERIENCE

4.1 INTRODUCTION

The benefits and costs involved in an investment occur over time. Simply adding up costs and subtracting the total from the sum of benefits, regardless of when the costs and benefits occur, would be misleading. It would ignore people's preferences for having benefits now and for postponing costs to a later period. Discounting is the means whereby the flows of costs and benefits are 'collapsed' in time to facilitate comparison whilst, at the same time, allowing for this time preference.

The future costs and benefits of a particular project are discounted by the appropriate discount rate and added to obtain their discounted present values. The difference between the two is the net present value (NPV) of the project which has to be greater than zero for the project to be desirable. The existence of a positive net present value is a necessary but not sufficient condition for project acceptance. Government budget constraints will mean that not all projects yielding positive net present values can be undertaken. Capital should be allocated by ranking the NPV of these projects, and deciding upon their viability given the government budget constraint.

The discount factor is used to reflect the fact that $1 benefit occurring at some distant point in the future assumes a typically lower value in the present. This lower present value is justified by appealing to the notion of diminishing marginal capital productivity and the rate of time preference, topics discussed later. Suffice it to say that the discount rate is positive.

Cost-Benefit Analysis of competing projects relies upon the valuation of all these factors. Whilst much of the literature is devoted to the estimation of appropriate discount rates, perhaps the more focal issue is the proper measurement of costs and benefits. Nonetheless environmentalists claim that high discount rates perpetuate environmental degradation. This volume summarises the environmentalist critique and suggests that, rather than adjusting the discount rate, these concerns can be better incorporated into project analysis by careful cost and benefit valuations or applying additional constraints to the objective function.

4.2 AN ILLUSTRATION OF DISCOUNTING

A Glossary of Terms

r	=	the discount or interest rate expressed as a decimal
n	=	the number of years the project will span
t	=	the relevant year typically expressed as a subscript
B_t	=	the benefit occurring in year t
C_t	=	the cost occurring in year t
Σ	=	the summation sign, sigma, that indicates the sum of som function over a particular range of values, in this cas time.

Consider investing \$1 in year 0 at an interest rate r. The yield in year 1 would be \$(1 + r). If we reverse the procedure we can illustrate how discounting can value a cost or a benefit occurring in year t at its present value in year 0. The value \$1 in year 1 will hold for the investor in year 0 is:

$$\frac{\$1}{(1+r)}$$

This quantity could be invested in year 0 to yield \$1 in year 1, i.e.

$$\frac{\$1}{(1+r)} x(1+r) = \$1$$

Similarly a \$1 holding in year 2 can be expressed as a present value thus:

$$\frac{\$1}{(1+r)^2} since \frac{\$1}{(1+r)^2} x(1+r) x(1+r) = \$1$$

We can now derive the general formula for discounting a benefit (or cost) incurred in year t, B_t.

$$\sum \frac{B_t}{(1+r)^t}$$

The determination of project viability and the desirability of investment relies on the calculation of the Net Present Value. The Net Present Value (NPV) is obtained by comparing the stream of costs and benefits over the lifetime of the project. Thus:

$$NPV=\sum \frac{B_t}{(1+r)^t}-\sum \frac{C_t}{(1+r)^t}=\sum \frac{B_t-C_t}{(1+r)^t}$$

The internal rate of return (IRR) is defined as that rate of return on the investment that equates the present value of benefits and costs. This is found by performing an iterative process, which will converge upon the appropriate rate, giving a zero Net Present Value for the project. The calculated IRR must then be compared to a discount rate to determine whether the investment in the project should be undertaken.

Another means of discerning whether a project should be undertaken, that is analytically equivalent to the Net Present Value criterion, is the Benefit Cost Ratio. This ratio compares discounted benefits with discounted costs. A ratio in excess of 1 implies that the project generates net benefits over its economic lifetime, whereas a ratio of less than 1 implies that the project results in economic losses.

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$$B/C=\frac{\sum B_t/(1+r)^t}{\sum C_t/(1+r)^t}$$

Competing projects must be ranked according to their Net Present Value to enable planners to choose between these projects.

The preceding analysis has made no mention of government budget constraints, obviously the inclusion of such a budget constraint will alter the acceptance rankings of certain projects. Where planners are unconstrained by cost all projects yielding a positive Net Present Value should be accepted. Where a cost constraint has been imposed, the object is to select those projects that yield the greatest total Net Present Value. To achieve this projects should be ranked according to their contribution to Net Present Value per unit of constrained cost. In this case the most adaptable measure to employ is the Benefit Cost Ratio, which can be carefully calculated to reflect the present value of constrained costs in the denominator and the gross benefits net of remaining costs in the numerator.

Figure 4.1

Comparisons of the Three Measures of Present Value

	Net present value	Internal rate of return	Benefit-cost ratio
Selection or ranking rule for:			
Independent projects:			
No constraint on costs	Select all projects with NPV > 0; project ranking not required	Select all projects with IRR greater than cut-off rate of return; project ranking not required	Select all projects with B/C > 1; project ranking not required
Constraint on costs	Not suitable for ranking projects	Ranking all projects by IRR may give incorrect ranking	Ranking all projects by B/C where C is defined as constrained cost will always give correct ranking
Mutually exclusive projects (no constraint on costs)	Select alternative with largest NPV	Selection of alternative with highest IRR may give incorrect result	Selection of alternative with highest B/C may give incorrect result
Discount rate	Appropriate discount rate must be adopted	No discount rate required, but cut-off rate of return must be adopted	Appropriate discount rate must be adopted

Source: Adapted from Gittinger (1982).

4.3 CHOICE OF THE APPROPRIATE SOCIAL DISCOUNT RATE

The desirability of an investment is determined by four factors:

(a) The stream of benefits that it generates.

(b) The stream of costs that it imposes upon society.

(c) The relevant time horizon over which these costs and benefits occur.

(d) The discount rate applied to these costs and benefits.

4.4 A COMPARISON OF THE SOCIAL RATE OF TIME PREFERENCE AND THE SOCIAL OPPORTUNITY COST

The following diagram illustrates two methods of determining the appropriate social discount rate. In a 'first best' world these two measures would be equivalent. However economies are subject to multiple distortions thus measures of the social opportunity cost and the social rate of time preference diverge.

Figure 4.2

A Simple Two Period Model of Discount Rates

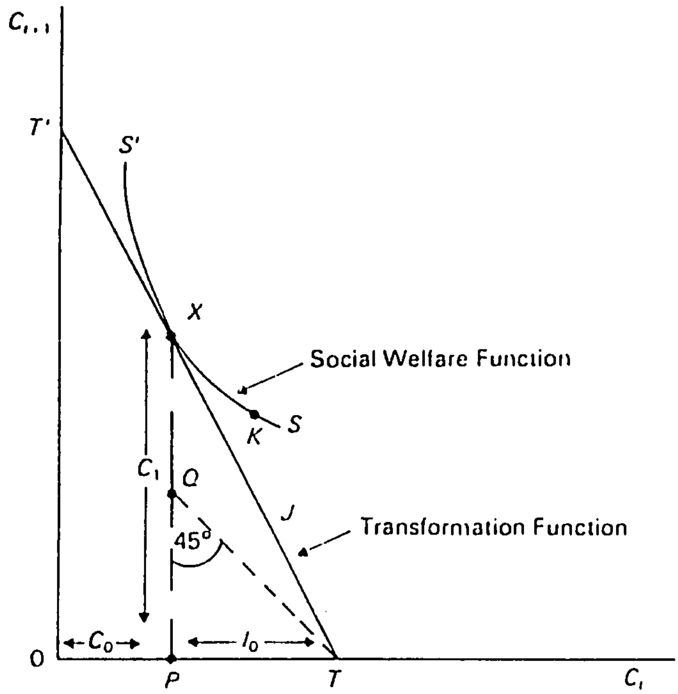

Figure 4.2 provides the essential analytical framework for the determination of a social discount rate. Consumption in year t+1 is measured along the vertical axis with consumption in year t along the horizontal axis. Consumption is the numeraire since individuals welfare is presumed to be a function of their consumption rather than their levels of income. The line TT describes the relationship between consumption in period t and consumption in period t+1, it is the <u>intertemporal production possibility frontier</u>. Were it to form a straight line with OT' equal to OT this would imply that the sacrifice of one unit of consumption in period t would enable society to consume exactly one unit of consumption in period t+1. In general we assume that forgoing one consumption unit in period t, allowing it to be used for capital investment earning an interest rate i, would yield an amount in excess of the original value of the consumption unit (1 + i). This embodies the notion of capital productivity. T'T is represented as a straight line here for analytical convenience the analysis is not altered if we have a continuous curve mapping the transformation of consumption units over time. Typically this curve would be convex to the origin reflecting the usual

assumption of the diminishing marginal productivity of capital. At point X on T'T, C_0 is consumed in the first period and C_1 in the second period. To secure the consumption of C_1 units in period two, PT units of consumption must be foregone for investment. This diagram will also give a measure of the productivity of capital. Gross Capital Productivity is given by the ratio of future consumption to current investment:

$$\frac{PX}{PT} = \frac{PQ + QX}{PT} = \frac{PQ}{PT} + \frac{QX}{PT}$$

But since by construction PQ = PT this equality can be rewritten:

$$\frac{PX}{PT} = 1 + \frac{QX}{PT}$$

We have that Gross Capital Productivity equals 1 + the Net Capital Productivity, which is the Internal Rate of Return, or the Marginal Efficiency of Capital r.

We reached this conclusion because of the following equality:

$$\frac{PX}{PT} = \text{the slope of } T'T.$$

$$\frac{QX}{PT} = \text{Slope of } T'T - 1 = r$$

The tangency of the Social Indifference curve (the intertemporal welfare function) with the Transformation Function will yield the optimal amount of consumption in the two periods. The slope of S'S indicates the rate at which society is prepared to substitute future for present consumption. It is constructed such that society is indifferent between all consumption points along its locus. Consider a hypothetical movement from K to X. Society must forego an amount of consumption C_t say C_t to secure an incremental increase in consumption in period C_t+1, C_t+1. The marginal (additional) utility resulting from these changes in present and future consumption are denoted dU_t and dU_t+1 respectively. By definition the levels of utility at points K and X are equal, we can write:

$$\text{slope of } SS' = \frac{dU_t}{dC_t} \quad \frac{dU_{t+1}}{dC_{t+1}}$$

$$dU_t = MU_t \quad \text{and } dU_{t+1} = MU_{t+1}$$

The slope of SS' is simply the ratio of the two marginal utilities of consumption. As we move along the social indifference curve from K to X we require greater and greater consumption in period t + 1 to compensate for a unit loss in current consumption.

$$\frac{dC_{t+1}}{dC_t} > 1$$

We can now sign the ratio of the two marginal utilities of consumption.

$$\frac{MU_t}{MU_{t+1}} > 1$$

Writing the excess of this ratio over unity as s we have

$$\frac{MU_t}{MU_{t+1}} = 1 + s = \text{slope of } SS'$$

Thus s can be seen as the <u>social rate of time preference</u>.

In a perfect world, where there are no distortions present in the form of taxes and subsidies, where prices reflected their social opportunity costs and where capital markets were efficient, the social rate of time preference would equal the social opportunity cost of capital. In a second best world r and s typically diverge. The choice of which rate to apply to the project time horizon therefore remains problematic.

4.6 <u>THE SOCIAL OPPORTUNITY COST APPROACH</u>

The social opportunity cost approach is intuitively appealing, for it incorporates the objective that no project should be undertaken unless it secures a return at least equal to that which could have been achieved had the forgone expenditure been invested elsewhere. As an example, no <u>public</u> investment should be undertaken if it does not achieve as high a rate of return as any forgone private expenditure that may be 'crowded out'. There are however, numerous problems associated with this approach.

(a) What rate should be chosen to represent the SOC? Public investments are assumed to incur lower rates of risk than do private investments, since, appealing to insurance theory, risks are pooled across projects and across large numbers of people. This highlights the divergence between private and social rates of return. The appropriate rate of return would therefore be comparable with those rates faced by the private sector on marginal low-risk investments. The private sector projects must be at the margin since public investments are assumed to displace only such projects. However, some government projects are high-risk reflecting unique decisions for which no precedent has been set.

(b) The empirical estimation of such rates is further complicated by the fact that such rates are prone to fluctuate over time, exhibiting very little stability. In developing countries data are often inadequate or incomplete greatly inhibiting estimation.

4.6 THE SOCIAL RATE OF TIME PREFERENCE

It is often argued that the SRTP is a more readily applicable rate to use in project discounting. The social rate of time preference reflects more than this notion of "impatience". It will also reflect the fact that increasing societal wealth causes future societies to be richer than current ones, and that an additional $1 of benefit will command less utility than it does currently. This is formalised by appealing to the concept of diminishing marginal utility of consumption. This is written as:

$$s = STPR = ce + p$$

where c is the rate of growth of real consumption per capita, e is the elasticity of the marginal utility of consumption and p is the pure time preference rate of interest. The component ce encapsulates the idea that future societies are likely to be richer and that we should attach less weight to their gains. The component p reflects the notion of pure time preference, i.e. impatience.

However as with the social opportunity cost rate, the social rate of time preference is subject to many criticisms:

(a) Should this rate be devised from an average of individuals' time preferences. Can such individuals time preferences be inferred by revealed preference, or are such rates being obscured by rent-seeking activities? Economists dispute whether there is any meaningful way to measure the value of e, the elasticity of the marginal utility of consumption. The debate centres on the measurability of utility, the problem of interpersonal comparison of utility and even the stability of preferences over time for a given individual.

(b) The argument assumes that real consumption c will increase over time. This may seem reasonable in the light of the growth patterns of many of the richer nations, but the experience of the developing countries may belie this. Some economists even argue that this apparent consumption growth was bought at the expense of the natural environment and the degradation of the natural capital stock. Hence this argument collapses to one of the proper measurement of consumption. This raises the <u>endogeneity</u> issue, for high discount rates can lead to environmental degradation because of the discrimination against sustainability practices, which in turn may promote a fall in real consumption per capita. The discount rate is thus not independent of the level of environmental quality and real consumption.

To illustrate the view that c will not necessarily be positive for developing countries examine the following table which shows how a social rate of time preference would be calculated for Sub-Saharan African economies.

Table 4.1

Illustrative Social Rates of Time Preference Calculated for Sub-Saharan Countries (based on 1973-1983 data)

	c	s e = 1 p = 1	s e = 1 p = 5
<u>Low Income Countries</u>	- 1.9	- 0.9	3.1
<u>Middle Income Countries</u>	- 0.1	0.9	4.9

Source A. Markandya and D. Pearce (1988)

From this we can see that growth in real consumption per capita was negative throughout this period for both low and middle income countries. It is also interesting to note that employing a pure rate of time preference of 5% yields discount rates substantially below those usually employed in project analysis. To derive rates of 10-15% we require that p increases to between 12-17% in the low income case, and 10-15% in the middle income case.

(c) The estimation procedures are protracted and complex. The meaningful measurement of such variables is greatly disputed, and the data requirements and computational needs may exceed the capacities of the developing countries.

The sources of time preference can be roughly divided into three categories. The pervasive conclusion being that the rate of time preference is in general positive or at least non-negative.

(i) <u>Pure myopia</u> - individuals exhibit a preference for benefits occurring in the present against those which occur in the distant future. This form of "impatience discounting" is fundamentally irrational, since it conflicts with the notion of lifetime welfare maximisation allowing, short-term decisions to override long-term welfare considerations. However it is a generally accepted feature of individual behaviour.

(ii) <u>Risk and uncertainty</u> - it is suggested that a benefit or cost is valued less the more uncertain is its occurrence. Expected uncertainty increases the more distant the point of receipt from the present. The declining value becomes a function of time and is thus formally expressible as a discount rate.

(iii) <u>Diminishing marginal utility of consumption</u> - the concept of increasing societal wealth, where as countries become richer the utility deriving from a $1 increment in future benefit or cost is less than that derived currently.

There are other alternatives to these discount rates which attempt to address many of the problems raised in this summary of discounting. The literature is extensive, and we will not embark on a synopsis of the competing methodologies here. No single school of thought commands consensus amongst economists. Some prefer the SOC approach fearing that alternative routes to devising a discount rate may result in the misallocation of resources within the public sector and between the private and public sectors. Others prefer to adhere to the principle of consumer sovereignty, where consumer preferences are considered indicative of needs and wants, in this case the SRTP is appropriate. Still others prefer to modify the cost-benefit criterion and allow the shadow price of forgone investment to and the extent to which benefits occur in a reinvestable form to aid the decision-making process.

4.7 THE DISCOUNT RATE AND THE PROJECT TIME HORIZON

The choice of the discount rate has considerable implications for the meaningful time horizon of the project. To illustrate this "sensitivity" examine table 4.2. A present value of $13.80 is yielded by the receipt of a benefit of $100, 100 years in the future, if the discount rate is 2% . If the discount rate is 5% the equivalent present value of this $100 occurs in under 40 years. At a discount rate of 10% the equivalent present value occurs in under 20 years.

Table 4.2

Discount Rate

Time (years)	2%	5%	8%	10%
0	$100.00	$100.00	$100.00	$100.00
10	$82.03	$61.39	$46.32	$38.55
20	$67.30	$37.69	$21.25	*$14.86
25	$60.95	$29.53	*$14.60	$9.23
40	$45.29	*$14.20	$4.60	$2.21
60	$30.48	$5.35	$0.99	$0.33
100	$13.80*	$0.76	$0.05	$0.01

The asterisk equates present values across different discount rates, illustrating how the time horizon of the project contracts with increases in the discount rate.

4.8 THE SOCIAL APPRAISAL OF DEVELOPING COUNTRY PROJECTS

Since the publication of the OECD manual in 1968 [1] it has become accepted that substantially different methods should be used for appraising projects in developing countries from those used in developed countries. In particular, shadow pricing has become more extensively used in project appraisal in developing countries. This is in part because a significant proportion of developing country economies are based on subsistence agriculture, in which market prices for factors and outputs simply do not exist. A shadow price is one which is imputed as reflecting the true marginal value of a good or the opportunity cost of a resource, where market prices are incomplete subject to distortions, or non-existent. Where market prices do exist, they seldom reflect the opportunity cost of the good or resource in question, since developing country economies are subject to many price and quantity distortions:

(a) Government intervention in the form of input and output price controls. Subsidies, quotas restrictions, credit market interventions, tax concessions, all contribute to price distortion.

(b) Currency overvaluation in conjunction with import restrictions and inelastic export demand, further entrench the divergence between actual and efficient prices.

(c) The prevalence of imperfect markets for factor inputs, particularly labour immobility, underemployment and skill acquisition, compounds internal price distortion.

(d) Capital market imperfections, saving deficiencies, government legislative and administrative failures.

(e) Extreme inequalities in the distribution of income and wealth.

(f) Partially monetised economies with significant barter trade and subsistence agriculture sectors.

(g) Regional and sectoral distortions are typically perpetuated by labour immobility and depressed infrastructural investment in communications.

[1] Little and Mirrlees (1968)

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4.9 HOW DISOCUNT RATES IMPACT ON THE ENVIRONMENT AND RESOURCE USE

Conventional discounting procedures are alleged to discriminate against environmental quality and resource conservation. They do this in several ways:

(a) by lowering the social weight attached to long-lived effects such as nuclear-waste .isposal, ozone layer depletion, global warming, ecosystem damage from micropollutants etc;

(b) by discriminating against investments with long gestation periods, notably afforestation with slower growth species;

(c) by accelerating the depletion of <u>renewable resources</u> generally: the higher the discount rate the more likely is extinction (see Volume 3. Renewable Resources and Property Rights, and below);

(d) by accelerating the depletion of <u>exhaustible resources</u>: the higher the discount rate the more is early extraction favoured (see below).

However there is no <u>established</u> link between high discount rates and environmental degradation. Generally high rates may shift cost burdens forward to later generations, but if the discount rate is also a determinant of the level of current investment, such high rates may also retard the pace of development, which will affect the rate at which natural resources are utilised. High discount rates will also discourage development projects that compete with environmentally benign land uses - watershed development as opposed to existing wilderness. Changes in the discount rates employed in project analysis also affect the <u>type</u> of development. Where the discount rate is low projects spanning longer time horizons will be entered into, hence the profile of development to which the economy is historically committed depends greatly on the discount rates employed. Exactly how the choice of the discount rate impacts on the overall profile of natural resource and environment use in any one country is ambiguous.

With regard to <u>exhaustible resources</u> the higher is the discount rate the faster is the rate of resource depletion and thus the shorter is the interval before which the resource is exhausted. With a high discount rate, a lower value is automatically placed on future extraction relative to present consumption. Following the dictates of optimal resource depletion, which seeks to maximise the discounted net benefits from a given stock of the

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resource, present extraction will increase as the discount rate rises.

In the case of <u>renewable resources</u> the discount rate determines the rate at which harvesting occurs. The higher is this rate the more risk there is that stock depletion will occur. Optimal renewable resource consumption requires the imposition of sustainable management regimes. The long-run rate of harvesting must therefore equal the potential rate of regeneration. However if the discount rate rises above the maximum biological growth rate of the stock the resource may be depleted and extinguished completely.

Natural resource exploitation is also affected by the difference between private and social discount rates. Individuals facing high private discount rates may choose to exploit the resource beyond its potential regeneration. However methods for correcting this do not rely on altering private discount rates, since such rates are not easily manipulated. Correction mechanisms typically employ the definition of tenurial rights, legislative controls, and the alteration of existing incentives.

(a) Private discount rates can indeed be seen to impact on the profile of resource use. It is an accepted fact that individuals facing high private discount rates may choose unsustainable resource management regimes and exploit exhaustible resources to extinction. This is particularly visible in the case of the resource poor occupying marginal lands, and in certain open access regimes. However there is a problem of measurement error which obfuscates the issue. It is impossible to <u>infer</u> private discount rates from resource use patterns. Degradation could be the result of distorted incentive structures and need not be directly due to the existence of high private discount rates. High discount rates often <u>reflect</u> poverty. Poverty induces some over-exploitation of resources to secure immediate consumption. Such high rates cannot be used to infer <u>socially desirable</u> levels of exploitation.

(b) At a firm level the relationship becomes more complex. The choice of resource use may be governed by the market rate of interest or the opportunity cost of capital. However in developing countries capital market imperfections and restricted access to credit markets coupled with government failures and the documented limited response to monetary variables serve to disguise this causality. Firms may indeed respond to high discount rates by over-exploiting resources. Conversely, such high rates may inhibit the development of such resources.

Some economic and environmental theorists have argued for additional criteria to be employed in project analysis and in determining investment decisions. Markandya and Pearce (1988) propose the sustainability criterion. They argue that particularly in developing countries, the stocks of natural resources are below any reasonable estimate of what the long-run optimal natural capital stock should be. It would therefore be desirable for investment policy to incorporate natural capital stock requirements, preventing stocks from falling further below their already suboptimal levels.

One recurrent theme in this summary has been the need to integrate environmental factors into investment appraisal. Several strains of thought would suggest that this be done by adjusting discount rates:

(i) by adding a premium to discount rates to reflect risk and uncertainty about the environmental consequences of particular investments;

(ii) by lowering discount rates to reflect the interests of future generations.

The next section looks at some alternative approaches to adjusting discount rates.

4.10 WHERE DISCOUNT RATES ARE AN INAPPROPRIATE MECHANISM FOR REFLECTING ENVIRONMENTAL CONSIDERATIONS

(a) The Treatment of Environmental Risk

Adapting discount rates to incorporate environmental risk requires assumptions about that risk that are unlikely to be realistic. Consider an investment which has a high environmental cost associated with the final years of the project - perhaps arising from the need to dismantle equipment which contains toxic materials. If the cost of this is uncertain and the environmental damage unknown, the investment is likely to be less desirable than if the ensuing costs were known with certainty. The discount rate can be adjusted upwards to incorporate a risk premium when discounting the future benefits and similarly adjusted downwards when discounting the future costs.[2] Whilst the direction of the adjustment is correct, there is little foundation for believing that the present value of the discounted costs correctly represents the uncertainty associated with dismantling the capital. Manipulating discount rates adjusting for risk imposes

[2] For proof of this see Annex 4. Markandya and Pearce (1988)

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a time profile on the project which need have no foundation in reality. Further, the adjusted discount rate procedure requires information on certainty equivalence (how the probability of an events occurrence alters the values assigned to that occurrence) which is better incorporated in the valuation of the project.

(b) Irreversibility

Certain investment outcomes might involve the irreversible depletion of a resource. Irreversibility can be addressed by adjusting the discount rates. However Markandya and Pearce argue that irreversibility is better represented in the valuation of the costs and benefits than it is by manipulating discount rates, and, by default, the time horizon of the project.

(c) Intergenerational Equity

As has been already noted, high rates of discount are argued to discriminate against future generations.

> (i) Projects with social costs that occur at some distant point in the future and net social benefits that occur in the near-term will be likely to pass the standard cost-benefit test the higher is the discount rate. Future generations may thus bear a disproportionate share of the costs of the project.
>
> (ii) Similarly, projects with social benefits that occur at a distant point in the future are less likely to be favoured by cost-benefit tests. Future generations are thus denied a higher proportion of societal benefits.
>
> (iii) The higher the discount rate the lower will be the overall level of investment, and hence the lower will be the level of capital stock inherited by future generations.

It might be, however that existing preferences do incorporate the interests of future generations. Utility might be expressed as a function of current consumption and the utility of future generations, a function of their consumption opportunities. Whatever the determination of individuals preferences, the incorporation of intergenerational equity considerations within project appraisal is best performed by the addition of constraints to investment criteria. One constraint is to 'maintain capital intact' - i.e. to ensure that current generations pass on to future generations a stock of capital assets, man-made and natural, no less than the existing stock. This way, future generations are compensated for any damage done by current generations. Some authors focus this 'constant capital' requirement on natural (environmental) assets only. The

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argument here is particularly relevant to resource-poor countries where dependence on natural resources is likely to remain very high. In practical terms resource-consuming projects should use only the sustainable yield, or should include stock regeneration as a cost of the investment. Thus constancy of the natural capital stock can be ensured. Actual compensation need not be undertaken by each project at the micro level. It is sufficient to ensure that the portfolio of competing investments entails compensatory investments in resource regeneration. It is also not necessary for compensatory projects to pass the standard cost-benefit criteria, since it is designed to honour the sustainability requirement. If the compensating investment reveals a negative rate of return, this will indicate the sum of sustainability costs omitted from the operation of other projects.

COMPENDIUM OF PUBLICATIONS

K.J.Arrow and R.C.Lind (1970)
'Uncertainty and the Evaluation of Public Investment Decision', **American Economic Review**, Vol.60

In this article the authors consider the problem of uncertainty, risk and public investment criteria. They examine the allocation of risk among individuals in the case of perfect and imperfect markets in order to determine the appropriate discount rates.

M .Brady (1989)
'The Role of Risk Assessment and the Rate of Discount in Benefit-Cost Analysis: Modelling Irreversible Energy Externalities', **International Journal of Environmental Studies** (1990), Vol.35

Current theoretical and applied work in energy analysis, which uses a benefit-cost rate of discount approach, does not properly take into account the significant differences in the risks of the different energy alternatives, whenever energy alternatives are evaluated from a long run, sustainability framework. A simple variational calculus model is developed to enable an energy environmental planner to incorporate nonsustainable, irreversible risk into a benefit-cost framework.

S.P.Brown (1982)
'A Note on Environmental Risk and the Rate of Discount'
Journal of Environmental Economics and Management (1983) No.10

This paper examines the use of risk-adjusted discount rates to evaluate future environmental risks. It is determined that the risk-adjusted discount rates should be lower - not higher - than the risk-free rate if evaluation of future environmental risks is to point toward optimality.

J.Dixon and M.Hufschmidt (1986)
Economic Valuation Techniques for the Environment

Johns Hopkins University Press
Baltimore

This book addresses the problems associated with the cost benefit analysis of environmental systems. The proper valuation of costs and benefits, the issue of compensation, discounting and the appropriate time horizon are all considered in the various case studies presented. Reviewed in valuation chapter.

A.C.Fisher (1988)
'Energy and Environment in the Long Term' **Energy Policy** (1990)

University of California,
California

An interesting feature of many of the environmental impacts of energy production and consumption is that they may be of very long duration -indeed are, for all practical purposes, irreversible. Particular attention thus needs to be given to ways of evaluating distant future impacts, dealing with the uncertainty that inevitably arises, and possibly even restructuring the welfare-theoretic base of the analysis. A review of recent analytical developments indicates a series of adjustments that have the effect of increasing the present value of the costs of such impacts, making the responsible energy activities less desirable from the standpoint of economic efficiency.

A.Markandya and D.Pearce (1988)
Environmental Considerations and the Choice of the Discount Rate in Developing Countries

World Bank Environment Department Working Paper
Washington

This paper considers the role of discount rates in project appraisal, and the problem of incorporating environmental considerations into investment criteria. It reviews much of the literature on the appropriate sources of discount rates and their associated pitfalls. markandya and Pearce consider the correct treatment of risk and uncertainty, irreversibility, and intergenerational equity. The authors suggest that such environmental concerns are best approached by adjusting our measurement of costs and benefits and with the addition of a constant natural capital stock constraint. It contains a detailed summary of the computational requirements for discounting, and the methodological approaches that define the different schools of thought on discounting.

D.Pearce and K.Turner (1990)
The Economics of Natural Resources and the Environment

Harvester Wheatsheaf
London

In particular the chapter on discounting reviews the issues at the focus of the debate on discounting. This gives a non-technical summary of the calculation of various discount rates, comparing and contrasting the relevant measures. the authors consider the critique of discounting and the adjustment of discount rates advanced elsewhere in the literature.

A.K.Sen (1967)
'Isolation, Assurance and the Social Rate of Discount'
Quarterly Journal of Economics Vol.81

Sen examines the relationship between private and social rates of discount. In the first section of the paper he considers the prisoners' dilemma. Whilst in remaining sections Sen applies this general framework to the question of optimum savings and the social rate of discount.

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ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME FIVE

RENEWABLE RESOURCES AND PROPERTY RIGHTS

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VOLUME 5

RENEWABLE RESOURCES AND PROPERTY RIGHTS

5.1 INTRODUCTION

Natural resources can be broadly divided into two categories - exhaustible and renewable resources. Exhaustibles have a finite stock , their consumption implies the irreversible depletion of that stock. The underlying economic choices relate to the optimal rate of resource depletion. This contrasts with renewables[1] which are resources capable of regeneration - e.g. fisheries and forests. In this case the economic decisions relate to the sustainable management of such resources. Their capacity for self-renewal does not, however, imply that they will be renewed. Renewal depends acutely on the chosen management regime employed. A forest that is clear-felled, with the cleared land then being given over to livestock, will not typically renew itself. Even if the agricultural use is only temporary, forest renewal may be drastically impaired because of soil compaction, erosion and interference with the hydrological regime. In order to guarantee renewal the forest must be subject to sustainable use. This requires that only the sustainable yield is harvested. The sustainable yield is one which enables equivalent regrowth, ensuring that rates of depletion never exceed possible regeneration rates. Fish stocks are fished sustainably when only fish in a certain state of maturity are consumed enabling the younger fish stock to age and breed. From this we can easily see that the economic issue of sustainable management again collapses to an issue of optimal rates of resource depletion.

5.2 WHAT IS THE OPTIMAL RATE OF RESOURCE DEPLETION?

Consider the example of a fishery. In order to determine the optimal rate of resource depletion we must first examine the rate of population growth of the fish stocks. Figure 5.1 shows such a population growth curve.

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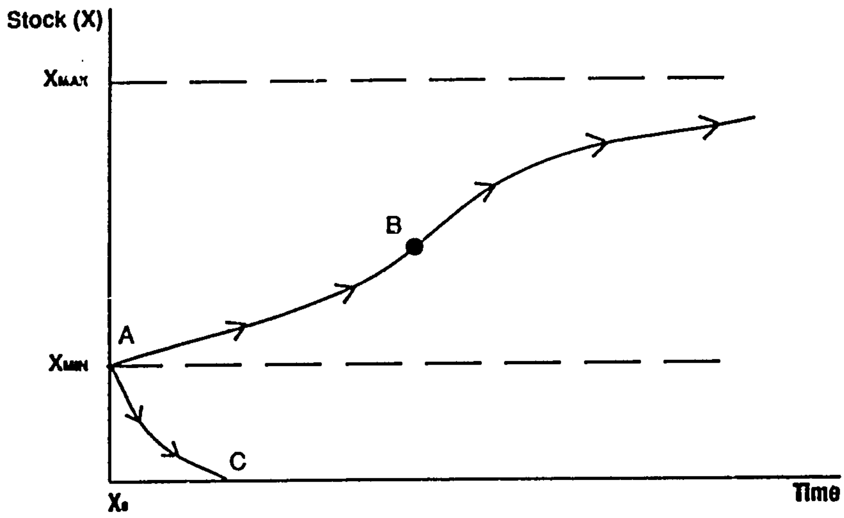
[1] Resources that yield a constant flow of services over time, such as solar radiation or tidal wave energy, are also termed renewables. These are not the subject of this chapter which confines itself to biologically renewable resources.

Figure 5.1

Population Growth Curve

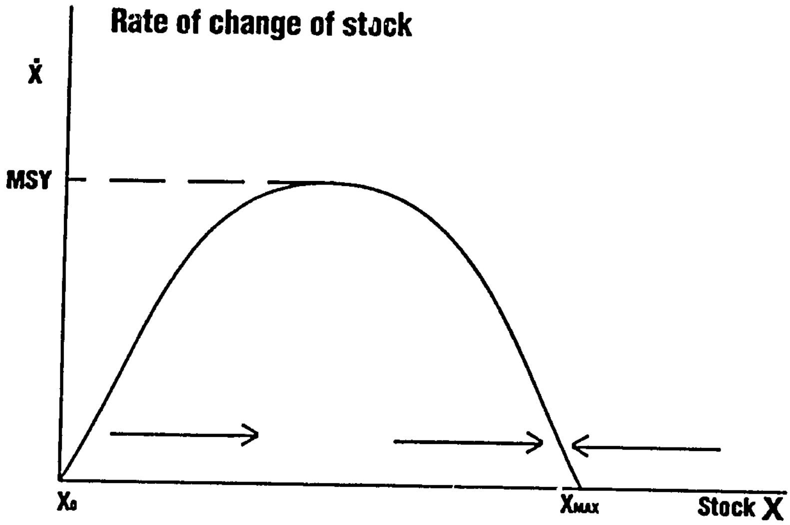


It is a logistic function. At low levels of fish stocks the fish multiply rapidly, between A and B in the diagram. They are then forced into competition for their food, and the growth rate slows accordingly, from B onwards. Eventually the stock will converge to its equilibrium state, determined by the maximum population that the habitat can sustain: its carrying capacity, shown as Xmax. The growth curve has a minimum value at Xmin, rather than at Xo. This is because biological populations require a discrete number before breeding can occur, therefore Xmin is the minimum viable population. If the population falls below Xmin it will tend towards zero along the portion of the curve AC.

Figure 5.2 graphs the same population growth curve in terms of rates of growth. This curve shows the rate of change in X, fish stocks. This is a time derivative which expresses population fluctuations over time. It is written as $\dot{X}$ against the actual stock of the resource.

Figure 5.2

Rates of Population Growth



The rate of growth is positive at first, reaches its maximum at point B, and then declines until it converges on that replacement rate which corresponds to the population carrying capacity. Rates of growth below Xmin are not represented since this would be complex to portray. Figure 5.2 is a sustainable use curve. We can select any stock level and choose that corresponding yield, equivalent to the rate of growth of that resource, which may be harvested without reducing resource stock in the next period.

> One apparently obvious management solution is to choose the maximum sustainable yield, MSY. This is deceptively attractive for it implies that we can take the MSY in each fishing period, allowing the stock to regenerate intertemporally. This policy would also appear to yield the maximum catch. However this choice fails to take into account external economy - environment interactions which may alter the fish population. Further there is no analysis of supply the cost structure of the extracting industry and profit maximising considerations.

The following figure 5.3 displays rates of population growth graphed against "effort". Effort is a measure of the fishing inputs applied to the resource - it might be man-hours, or trawlers. At higher levels of effort there is a consequently lower level of fish stocks. Emax now corresponds to maximum effort and thus zero stocks, Xo.

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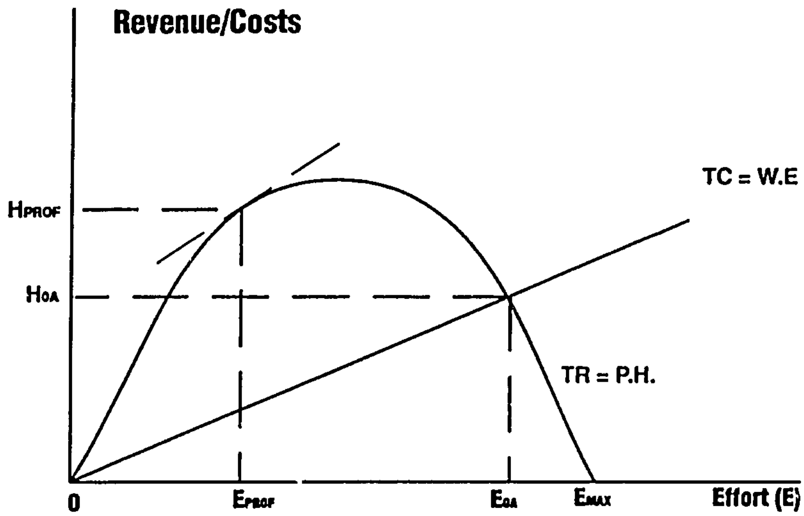
Figure 5.3

Rates of Population Growth per Units of Effort



The yield curve can be converted to a total revenue curve by assuming that each tonne of harvested fish commands the same price. Harvest H times price P gives total revenue:

$$TR = P.H$$

A total cost curve can be superimposed by assuming that each unit of effort E commands the same price W, be it in terms of wages or capital equipment cost.

$$TC = W.E$$

Suppose the fishery is single owned. This single owner will aim to maximise profits Eprof, where the vertical distance between TR and TC is at a maximum, shown by the tangent to the curve, parallel to TC. Eprof does not correspond to maximum sustainable yield in this diagram, it would do only if the costs were zero.

> This suggests at a superficial level of analysis, that the property rights of firm ownership may well secure the conservation of that resource. This contrasts directly with the well-established view that private ownership may lead to resource extinction.

This conclusion is however crucially dependent on the cost structure of the firm, the rate of population growth, and the single owner's attitude to time.

Suppose that the resource is subject to open access. An open access rescurce is one which has no owners and which can therefore be used by anyone. Examples are the atmosphere, the oceans outside of territorial limits and the ozone layer. Many agents may exploit the potential profits that accrue to resource use. This corresponds to the case of international waters where sovereignty is not established and territorial rights do not exist. In this case ownership rights remain undefined and there are no established codes of practice, resource extraction is seldom sustainable. Private profit maximisation is sought by all competing entrants regardless of the rates of extraction. Thus whenever TR exceeds TC, entrants will harvest the resource, ceasing only when TC exceeds TR to the right of Eoa. Eoa is thus the open access equilibrium. Eoa does not result in the extinction of the resource in this case, however it is dangerously close to Emax, increasing the potential for extinction. Moreover, if there is a minimum critical size constraint to the resource, Eoa could be even more risky. Further, the flatter is the TC curve, the closer is Eoa to Emax. Essentially, the lower is the cost of harvesting the greater the chances of extinction. The African elephant is an example of a resource at risk because of low 'harvesting' costs.

The risk of extinction imbedded in the open access scenario, is often referred to as the tragedy of the commons[2]. But, strictly, common property differs from open acces in that there are some rules of behaviour by users of the resource. These rules are typically designed to conserve the resource. Examples of common property resources include Antartica, territorial waters, many grazing lands, publicly owned forests, and so on.

5.3 INTRODUCING TIME, A DYNAMIC ANALYSIS

Figure 5.3 is essentially static. It fails to incorporate information about the way in which prices might vary over time. Further the choice of a particular resource management regime is not linked to the user's discount rate. Discounting enables economists to represent the fact that costs and benefits accruing to resource users in the future are typically of less importance than those costs and benefits experienced now. This encapsulates the idea of the "rate of time preference". Many justifications exist for this:

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[2] After Garrett Hardin (1968).

(a) We may expect to be richer in the future, technology and information may change. Thus a dollar in year 1 is worth more than a dollar in year 20.

(b) There is also an element of impatience. Immediate benefits may be valued more highly than uncertain benefits in the future.

(c) There is uncertainty: benefits now are worth more than uncertain benefits in the future.

(d) The "productivity of capital" also varies over time. Investments typically yield a flow of services over time. The summed value of these services must exceed the investment cost for that investment to be economically viable. The fact that capital yields a flow of services in excess of the initial capital outlay motivates the productivity theory of discounting.

The discount rate is of critical importance in determining the rate at which both renewable and exhaustible resources are depleted.[3]

One of the basic rules for the optimal use of a resource can be summarised as follows:

MARGINAL PRODUCT OF THE RESOURCE + RATE OF CAPITAL APPRECIATION = DISCOUNT RATE

The marginal product of the fishery resource is the rate at which the fishery grows. The rate of capital appreciation captures the possibility of collecting capital gains by leaving the fish unharvested. Such gains will occur if the price of fish is rising through time. Leaving the fish in their unharvested state will cause their value to appreciate.

The fishery should be harvested in such a way that this rule is upheld. Consider the following scenario. Imagine that the discount rate is 10%, the growth rate is 3% and that prices increase at a rate of 5%. The choice lies between harvesting 100 tonnes of fish now at $100 per tonne, or waiting until a later date.

[3] A. Markandya and D. Pearce (1988)

Table 5.1

Optimal Depletion and the Discount Rate

	Fish Now	Wait
Revenue	$10,000	$10,800 *
Discounted Value	$10,000	$9,818 +

(* $10,800 because the stock grows at 3% to become 103 tonnes, which are then sold at $105 per tonne. + $9,818 =$10,800/1.1)

Waiting is obviously not worthwhile and the harvest takes place now. If the discount rate exceeds the combined "own growth" and capital gain, the resource will be harvested sooner rather than later. If the discount rate changes to 6%, the calculations can be repeated, exhibiting a different outcome.

Table 5.2

Optimal depletion and the Discount Rate

	Fish Now	Wait
Revenue	$10,000	$10,800
Discounted Value	$10,000	$10,189

It now pays to wait since the discount rate is below the combined growth and capital gain effect.

Where the discount rate equates with the sum of the growth and capital gain effects, the resource user will be indifferent between extracting now and waiting. In the above scenario, if the discount rate becomes 8%, the discounted value of the catch will be $10,000, equivalent to the immediate value of the catch. The rule highlights the trade-off between harvesting fish now and allowing the fish to remain in the water adding to future yields. At the optimum, the two present values are equal.

5.4 GAME THEORY AND ITS APPLICATION TO RENEWABLE RESOURCES

The above discussion distinguishes between common property resources, res communes, owned by everyone, and open access resources, res nullius owned by no-one. These are distinct from private property resources owned by someone. It might appear that the conferral of private ownership can secure greater resource conservation than can common property or open access rights. This statement has considerable implications for the bestowal of resource rights, and the potential such rights might hold for improved environmental conservation. However, before we can establish such a principle, we must analyse the advantages and disadvantages of common property, open access and private property regimes.

In examining the possible outcomes for renewable resource use, game theory has been most enlightening. Game theory has been used to model behavioural dynamics by biologists, psychologists, and economists. The decisions of each participant to the game are considered, taking the actions of all other agents as given. Agents for the most part are assumed to be utility maximising and rational, that is they seek to maximise their own benefit, be that profit, revenue, or output. Two different game theoretics have assumed considerable prominence in the literature: the prisoners' dilemma, and the assurance game.

(a) The Prisoners' Dilemma

The prisoners' dilemma relates to the hypothetical scenario where two prisoners are held in separate cells unable to communicate or cooperate. The prisoners are accused of a jointly executed crime. Each is open to confess or deny participation. If A confesses she will be released and B would be sentenced to imprisonment. Similarly, if B confesses to the crime, she will be released and A would be sentenced. If both A and B deny involvement they will be held in jail for one year on technicalities. If both confess they will each receive a three year sentence. The options are captured in a "payoff matrix" represented in table 5.3.

Table 5.3

Payoff Matrix for the Prisoners' Dilemma

		B: Confess	B: Deny
A	Confess	-3, -3	0, -6
	Deny	-6, 0	-1, -1

The first entry in each pair corresponds to A's payoff and the second to B's. We examine each pair of payoffs and ask what is the optimal reply that each agent could make given the strategy of the other player. It is always better for A to confess regardless of what B does. If B denies involvement, A will be released. If B confesses, A will diminish her sentence by confessing receiving 3 years if she does so, and 6 years if she denies involvement. For A, the options -3 and 0 dominate -6 and -1. The same is also true for B, if she confesses regardless of the choices made by her partner she will also receive a smaller sentence. Thus the strategy for both players is always to confess. The solution yields the point -3, -3, confessing is an optimal reply for both partners. This forms a Nash Equilibrium - one where A's choice is optimal given B's choice, and similarly B's choice is optimal given A's choice.

It is obvious from inspection that both participants could improve the solution by moving to the outcome -1, -1. This solution Pareto dominates the outcome -3, -3. That is, no one is made worse off and gain occurs for at least one participant. In this case both prisoners would gain: it is a strict Pareto improvement.[4] However both opt for an inefficient strategy since there is no cooperation available to them, and no means of enforcement. Were an agreement to be struck by both parties that they would each deny, this agreement would not be credible. Each prisoner would have a strict incentive to renege on this agreement and confess given that the other has denied. This agreement cannot be upheld. This typifies the difficulties inherent within non-cooperative games. No binding agreements can be negotiated, enforcement is

[4] For a definition of Pareto optimality see H. R. Varian (1987).

not possible, and therefore the players are consigned to the "inefficient" outcome.

The prisoners' dilemma can be usefully employed to elaborate upon many of the issues of managing renewable resources.

(i) Many renewable resources are not under private ownership. There are consequently large numbers of actual or potential users.

(ii) Each agent has an incentive to overuse the resource, since this will yield a higher level of personal profit. The dominant strategy is therefore to maximise profit without regard to the extent of resource use.

(iii) If all participants act in this way the resource will risk over-exploitation.

(iv) Any agreement is unlikely to be upheld because of the incentive to renege.

If this analysis is correct it holds important implications for the management of renewable resources. One apparent solution is their privatisation. This would mean that many users may be dispossessed of their customary or even legal resource rights. Another solution could be in the form of careful state regulation. However these conclusions are sensitive to the horizon over which the game is played. Once we extend the game to a multi-period setting, which is repeated each period, these conclusions alter. Suppose the resource user A defects from an agreement this year. If the game is to be played in the following year, then the other players can punish A imposing a cost upon her. The existence of such a threat enables agreements to be enforced only if the cost of reneging on the agreement is sufficiently high. This "tit for tat" strategy, or mixed strategy response is often witnessed in international agreements which are renewed on a regular basis. Coordination is essential. Obviously the force of such behaviour is limited if the game is played only a few times. It is more likely that agreements will be upheld if the game is repeated indefinitely. However games with finite repetitions still face the incentive to renege inherent in the prisoner's dilemma.

(b) A Public Goods Model

An alternative way of highlighting the contrast between the cooperative and non-cooperative solutions is in terms of the public goods model.

Consider a group of producers who generate pollution, in the same quantities, as a byproduct of their activities. Each producer faces the same benefit function, which describes the benefits of abating pollution when all producers abate. Each producer also faces an abatement cost function. The global objective is to maximise net social benefits, the least cost achievement of the maximum abatement levels.

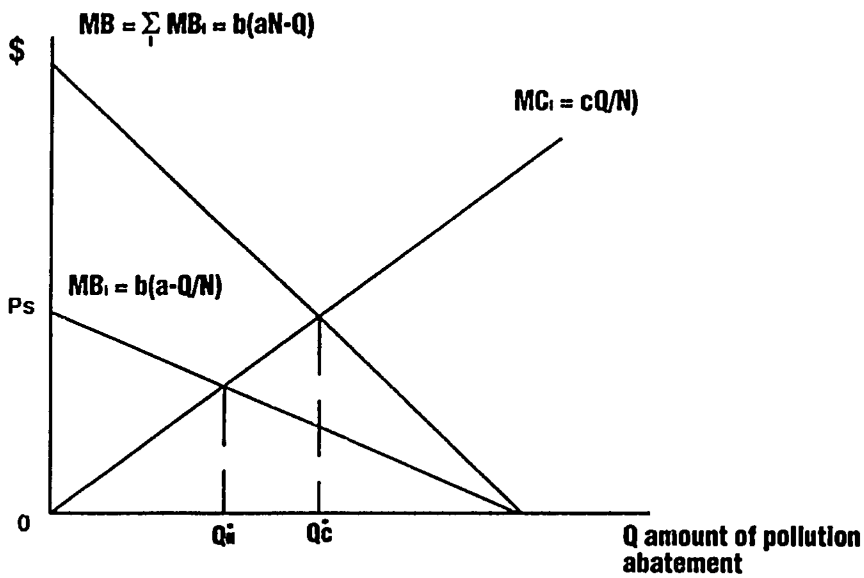
Qc* and qc* are the cooperative solutions in terms of the socially desirable level of abatement and the desirable level of abatement by each producer.

The non-cooperative outcome can be obtained as follows. Each producer is assumed to chose her abatement level in the belief that the abatement levels of all other producers are given. Each firm then equates its marginal benefit from abating with its marginal cost of abatement, achieving the efficient outcome.

Figure 5.4 shows this solution diagrammatically.

Figure 5.4

Pollution Abatement Within a Public Goods Model



The cooperative solution, Qc* is seen to result in a greater degree of pollution abatement than the non-cooperative solution Qn*. Yet the non-cooperative solution is the one that will emerge in the absence of a binding agreement. In the case of the fully cooperative outcome the externality is completely internalised, in the non-cooperative outcome the externality is only partially internalised.

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(c) The Assurance Game

Many theoreticians do not regard the prisoners' dilemma as being the most appropriate model to represent the "common property" issue for renewable resource management. The assurance game reflects an interdependence between the players, and consequently has two equilibria.

Suppose two partners are married, that is they are committed to mutual solutions in some way. They may have different preferences however. One prefers to go to the ballet, and the other to go to the cinema, but neither wishes to attend either event alone.

Table 5.4

The Assurance Game

		B: Ballet	B: Cinema
A	Ballet	1, 2	-1, -1
A	Cinema	-1, -1	2, 1

Partner A prefers the cinema to the ballet; partner B prefers ballet to the cinema. A derives 2 units of "pleasure" from attending the cinema if B accompanies her, and 1 from the ballet if B accompanies her. A would prefer to attend the ballet with B rather than go to the cinema alone. This game therefore has two equilibria, in contrast to the prisoners' dilemma which has one. The two equilibria are: if both go to the ballet the payoff is (1, 2), and if both go to the cinema the payoff is (2, 1). The players therefore choose between these equilibria. Having made a decision to opt for one or other of the equilibria, the agreement is likely to be upheld, since the utility loss imposed on the dissenting parties is greater than the utility gained from keeping the agreement. Once the assurance is obtained there is no incentive to renege.[5]

[5] Runge (1981)

Supporters of this type of game argue that the over-exploitation of renewable resources in open access and common property situations can be solved by cooperative agreement. They argue that the mutual interdependence of agents in the common property scenario is more accurately reflected by the assurance game than by the prisoners' dilemma. In the case of the prisoners' dilemma the solution requires the imposition of external controls by the state. In the assurance game, this external control mechanism is not required.

(d) Conclusions

Both the prisoners' dilemma and the assurance game have important implications for the proposed renewable resource management regime, and how it should be structured.

(i) If the prisoners' dilemma paradigm is applicable, it will be necessary to devise incentive systems to discourage defection. Such devices need not be in the form of cash payments or in kind transfers, they may rely on the strengthening of community bonds, or the reinforcement of mutual ties.

(ii) If the assurance game is applicable, the cooperative solution may require the strengthening of institutional constraints.

However both are of limited value as descriptions of reality. The horizon over which the game is played must be considered, the possibility of mixed strategy games should be explored. "One shot games" reveal very little about the dynamics of interactive behaviour. However once games enter an extended horizon, their explanatory and hence predictive power tends to diminish. The analyst is often presented with a multitude of possible outcomes.

5.5 EXTENSIONS TO GAME THOERY

(a) Resource games tend to be repeated. Thus the game's horizon needs to be extended to a multi-period one. This opens up the possibility for "coercing" defectors, imposing a cost upon those who renege on the agreement. This implies that mixed strategy games can be pursued, cooperative outcomes may be sought being upheld by the threat of collective punitive action against agents who renege.

(b) These examples have for the sake of simplicity been two-party games. In reality there will be a number of participants. To extend the number of participants to an "n party" game would therefore yield richer results. In a multiperson game each agent has far less control over the outcome. In such a game motives other than pure self-gain surface e.g. concern for the common good, the maximisation of global aims.

In such games issues of strategy, ethics, and expectations play a greater role. However the incentive to be a free rider may increase if the costs of participating and the numbers of participants are high. A free rider is an agent who chooses not to contribute to the provision or protection of a good under the assurance that other agents will provide. The free rider thus gains utility from the provision of the good without bearing the costs of providing the good.

Bromley and Chapagain (1984)[6] devised a hypothetical bidding game to investigate the incentive to free ride among Nepalese farmers. They offered to divide a Rs100 "windfall" (roughly an average family's annual tax contributions) between private consumption and a village investment that would be matched by the government earning a 10% rate of return. Respondents stated on average that they would contribute 49.29 to the public good with the remainder reserved for private investments.[7] This would support the view that the incentive to free ride is sufficiently low where community bonds are well established.

It seems likely that ethical considerations play an important part in the provision of public goods, the extent to which such studies can be employed as indicators of the level of contributions towards public goods is open to dispute. Were the game to be extended to a multi-period setting it seems plausible to expect that contributions would decline. The net payoffs to the contributing players were lower with the public good provision than they would have been with their private consumption, 13% as compared with 20%.

However, despite this, in a multiperiod game it seems that there are opportunities for learning, teaching, punishment and reward. Participants can observe the results of earlier plays and adjust their strategies accordingly. One interesting result of extending the period of play for the prisoners' dilemma scenario is that sustained cooperation appears to alter the players' payoffs.[8]

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[6] D.Bromley and D.Chapagain (1984) 'The Village Against the Center: Resource Depletion in South Asia' American Journal of Agricultural Economics, Vol.66,No.5

[7] Magrath (1989)

[8] Runge (1982)

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The resulting game becomes more closely aligned to the assurance game. This is very much in contrast to the widely noted deterioration of non-exclusive resources in developing countries. This may represent the conversion of an assurance game into that of a prisoners' dilemma.

5.6 RESOURCE MANAGEMENT REGIMES

The preceding analysis of resource management in terms of game theory suggests that communal management will break down because of the incentive to free ride, and the emergence of mistrust amongst the players. Communal management might work if a system of "assurances" can be obtained, and defection can be treated punitively. Privatisation appears to be one solution to the inefficient use of resources, similarly state control may provide the only other stable regime.

Figure 5.4 characterises property regimes in terms of rights, duties and privileges.

Figure 5.4

Property Regimes

STATE PROPERTY	Individuals are bound to observe the resource use rules determined by the controlling agency.
PRIVATE PROPERTY	Individuals have a right to exercise private profit maximising behaviour, which is in some cases consistent with the social optimum.Others must respect individual property rights.
COMMON PROPERTY	A management group has the right to exclude non-members, who in turn have a duty to abide by this exclusion. Co-owners comprise the management group and have mutual rights and duties.
OPEN ACCESS	There are no defined users or owners. Individuals have privilege but no rights to resource use.

Adapted D.Bromley

Property is a right to a flow of benefits, a right which remains secure as long as others observe this right. A privilege is a use unaccompanied by any right and can be exercised by others who possess no rights either. This occurs in the open access case.

5.7 EXTERNALITIES AND THE DEFINITION OF PROPERTY RIGHTS

The Coase[9] theorem states that an externality will be internalised, regardless of the direction of that externality, where property rights are clearly defined, enforced, and recognised; and where the transaction costs associated with transfer payments are negligible. In such a case the framework exists for the resolution of that externality, without recourse to state intervention or coordination. This theorem forms the cornerstone of the belief that the conferral of property rights can resolve the tragedy of the commons.

The application of this theorem can be viewed in the following example. Consider two sets of agents acting in an area of forest and lowland agriculture. A uni-directional externality exists in that the actions of the foresters directly affects the productivity of the lowlands. The removal of forest cover can lead to the increased siltation of downstream rivers, and the interruption of the hydrological cycle as the result of watershed destruction. Forest cover is essential for maintaining ecological balance, ensuring that the water regime is uninterrupted, protecting against dessicating winds, and preventing wind and water erosion.

Coase argues that the direction of the externality depends exclusively on the property rights defined. If the foresters possess the legal right to deforest their land at whatever rate is privately optimal, then it is the cultivators who suffer from the exercise of these rights. In the absence of a binding agreement between parties, the foresters will chose a privately optimal solution involving greater deforestation than is socially desirable. Suppose that it is the cultivators who exercise defined rights regarding the amounts of siltation and flooding that they are willing to tolerate as a result of deforestation. The foresters actions are inhibited by the exercise of the cultivators' rights. Again, in the absence of a binding agreement between parties, the outcome may be sub-optimal. There may be insufficient deforestation.

[9] R. Coase (1960)

It is clear from this analysis that the resolution of an externality may depend acutely on the assignation of property rights. The distribution of ownership rights affects the distribution of income and demand consequently influencing the rate and direction of resource exploitation.

(a) <u>Privatisation</u>

One apparent solution to the problems of resource over-use in an open access or common property scenario is privatisation. This make take several forms, one of which is the conferral of <u>land title</u> to individuals through documentation in conjunction with the enforcement of land titles by the authorities. Title without such enforcement or accompanying legislation will be largely meaningless. The documentation is often essential where owners may be threatened by outsiders with rival claims to the land, or in the case where land improvement raises land values attracting speculators. However some attempts to confer land titles have been met with opposition. In French West Africa land titles were rejected by communities who held a greater belief in the system of customary title conferred by tradition. In either case however there must be a mechanism through which land title or ownership is enforced.

Lack of ownership security is likely to result in various forms of uncertainty which may contribute to resource degradation.

(i) Without the security of tenure, the landowner will be unlikely to realise the value of land improvements. Consequently there will be little incentive to invest in long term projects to enhance soil conservation.

(ii) If land values rise the occupier will have no accepted entitlement which may prevent take-over by wealthier parties. This usurpation of rights may be by parties less interested in conservation, perhaps because land acquisition is being used as a hedge against inflation or as a means of securing tax concessions.

(iii) Land will not be sold on the open market. As a result land ownership may not be conferred upon the highest bidder. However in developing countries there is reasonable evidence to support the notion that high value-added does not correlate strongly with environmentally benign land use.

(iv) Secure tenure enables land owners to access credit schemes in the formal sector. Insecure tenure

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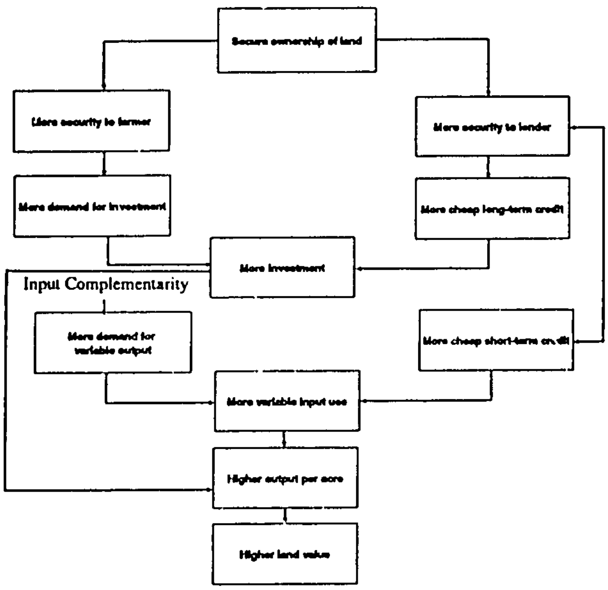
> means that landholders have no collateral acceptable to the formal sector and therefore those seeking credit must borrow in the informal sector at typically higher interest rates. The risk of loan default increases and the land is likely to be repossessed by the loaning agency, whose environmental concern may be startlingly low. [10]

Figure 5.5 summarises the linkages between secure land title and land values and productivity.

Figure 5.5

Land Titling and Land Productivity

Land Titling and Land Productivity



Source G. Feder, "Land Ownership Security and Farm Productivity in Rural Thailand", Journal of Development Studies, (1987).

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[10] In rural Thailand 90% of the medium and long term loans were received by farmers with land titles, even though such farmers were only 50% of the sample investigated. Legal owners offering land as collateral obtained between 50 and 520% more credit the equivalent farmers without collateral. Furthermore interest rates on formal credit were one third of those on non-institutional informal sector credit.

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Another argument that supports the privatisation solution is that resource rights tend to become better defined as resource scarcity increases. This evolution of resource rights suggests that they are therefore extremely effective. In societies where population pressure is low, there is no need to establish rights to tracts of land that are not under immediate pressure. Effectively the marginal value of land is zero, because it is in excess supply. Such conditions favour the growth of "usufructuary" rights - rights to the use of land but not to ownership. As the population grows so pressure on hitherto open-access resources may result in the natural development of rules and conventions about resource use, effectively turning open-access resources into common property resources, as the assurance game paradigm would predict. Non-marginal land comes under increasing pressure as population growth forces the increased subdivision of land and the reduction in fallow periods. Further population pressure induces even more precise property rights detailing individual exclusive use and ownership.

Were this evolutionary view of the development of individual property rights correct, we would expect to see a greater enforcement of individual property rights in land or resource scarce countries. Some argue that this is indeed the case in parts of Africa. Differences in the land tenure systems are attributable to the relative scarcity of land created by varying degrees of population pressure and the reliance on commercial agriculture.

Whilst land titling, or the establishment of tenure may indeed alter the rates of resource degradation there are other factors that determine the rates of resource exploitation. Optimal resource exploitation depends on individual discount rates, rates of regeneration and the price to cost ratio of extraction or harvesting. Finally private property does not resolve the issue of external effects imposed by one owner upon another, unless the parties can come together to bargain over the externality.

(b) State Ownership

The state ownership of land might at first appear to provide a solution to this "tragedy of the commons", since the state would then internalise the externalities that promote the over-use of common resources. However for state ownership to remedy this incentive to over-use, it must resolve the conflict of interests between agents. The state must then establish and enforce acceptable rules of resource use, and it must have the capacity to monitor events to ensure that these rules are upheld. Sadly state ownership has seldom been able to establish such control over resource use, and state ownership regimes have not achieved their objectives.

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In Nepal, faced with excess demands for forest fuelwood, fodder and other products, the government nationalised all non-registered forest and wasteland in 1957. In 1961 the state extended the definition of forest land to include all land adjoining forest areas which had been left fallow for more than two years. The aim was the sustainable use and management of forest reserves. In practice, the supervision of forest use was impossible, government resources were minimal and the terrain made access very difficult. Monitoring was virtually non-existent and regulations were unenforceable. The legislation itself was untenable. Fuelwood was not supposed to be collected without the authority of a forest ranger, this was clearly not a viable proposition. Timber for housebuilding required a permit from distant forest offices. Needless to say, permits were seldom sought. More significantly, communities that had hitherto made some effort to protect "their" forests from outsiders, now had no legal authority to prevent use by others. The forest lands were no longer considered theirs, hence there was no incentive to protect them. The regulation allowing land left fallow for two years to be appropriated by the state discouraged fallow agricultural practices, accelerating soil degradation through overcultivation. The Nepal forest nationalisation experiment was short-lived, efforts were made in the late 1970's to hand the forests back to the communities.[11]

In Tanzania the freehold tenure of land was abolished shortly after independence was achieved in 1961. The land became state-owned, with these freeholds being converted to 99 year leases. In 1967 the government introduced the ujuama policy, which promoted "villagisation". Rural inhabitants were forced to coalesce in village units and an alien system of collective agriculture was devised, enabling state assistance to be more focused. However only the villagisation process was complete in the late 1970's. Tanzania underwent a period of economic crisis partly because of the nearby war in Uganda, but also because food production fell significantly. Productivity on the few established collective farms was well below that on those private farms that had survived the cooperativisation policy. factors contributing to this low productivity were:

(i) poor administration of the programme;

(ii) failure of the communal organisation to take into account the heterogeneous nature of the population, particularly different ethnic groups;

(iii) poor government supply of inputs and the

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[11] Arnold and Campbell (1985) in 'Panel on Common Property Resource Management' (1986)

inadequate provision of marketing outlets;

(iv) the lack of appropriate enforcement mechanisms;

(v) the lack of defined tenure for individually farmed and collectively farmed land.

(vi) transactions in land continued amongst the elite, increasing inequalities.

The lessons to be learned from such experience are obviously that any state management of resources must operate over defined and pre-established population groupings. Individuals' rights must be well protected, enforcement mechanisms must be employed, and areas of state management must be containable in size.

(c) Communal Management

There is an established conviction among anthropologists and sociologists that local communities best understand their own environments and have a historical knowledge of sustainable resource management. Certainly the evidence is that tribal and peasant knowledge of soils, natural medicines, risk minimising cropping strategies, etc is formidable. In most cases elaborate and rigorous rules and regulations exist to ensure the sustainable use of natural resources. Such social groupings rely heavily on mutual support and cohesive action. Whilst this is indeed verifiable it would be dangerous to conclude that such communities necessarily exhibit the "virtue of care" for nature. Most successful examples of communal management systems occur in contexts where resource scarcity is not a prominent issue. Communal systems vary substantially within the broad types of land-users - agriculturalists, and transhumants. Generalisations are thus far from easy. Further, the reasons for the breakdown of communal systems have not necessarily arisen from the conflict between individual and collective objectives. Various reasons have been cited.

(i) Colonial rule has been cited as one of the reasons for the collapse of some communal management systems. The imposition of colonialist rule often interferes with traditional systems of self-regulation and resource management by of promoting cash economies. To obtain surpluses required to purchase market products, farmers would overuse their land and degrade resources. This frequently resulted in the displacement of subsistence cultivation to marginal lands, contributing to the loss of forest land and bringing many into conflict with transhumants.

Shifting agriculture and transhumance was discouraged, despite the fact that both systems were suited to climatic and geographic conditions. The creation of forest reserves and game parks also deprived traditional land-users of their livelihood. in general colonialism reduced the land available to indigenous populations, particularly shifting cultivators and transhumants. Institutions were interposed between cultivators, livestock farmers and the rule-makers. Decision making was centralised and did not draw on the accumulated information of local inhabitants. Restrictions on migration further exacerbated resource over-use. Migration had traditionally been an instrument for adjusting localised resource scarcity. These restrictions effectively enforced resource over-use, containing populations in already marginalised lands.

(ii) Population growth or scale effects typically increase the pressure on communal systems, often promoting the increased subdivision of land plots. Large numbers of resource users become increasingly difficult to coordinate. Communal systems may be assumed to have an optimal size. Once a maximum has been reached such systems tend to dissolve. Many writers argue that in the Sahel a period of relatively high rainfall, accompanied by public health improvements coupled with the emergence of deep water well technology, encouraged population expansion and increased livestock numbers. When rainfall fell below average, the use rate was too high, and the existing communal systems began to diffract.

(iii) Technological innovation can also induce resource over-use. This was apparent with the introduction of motorised fishing boats in San Miguel Bay in the Philippines, chainsaw technology in the Amazon forest and the high velocity rifle in assisting elephant poaching. However the effects of technology depend acutely on the prevailing social values. Many countervailing examples exist. The introduction of steel axes among the Siane in Papua New Guinea did not increase forest destruction. Whilst the axes educed the time required to clear and fence gardens, these gardens grew no bigger in size or number. The inhabitants chose to devote their free time to other prestige-enhancing activities.

However, those theorists who support the assurance game paradigm would argue that systems of communal management can operate effectively. Crucial to the success of such regimes is the efficient exchange of information amongst players. [12] This would imply that there is an optimal number of participants which should not be exceeded. Cooperative solutions are more likely to be upheld where the locus of decision making is relatively small. Informational exchange is thus more rapid and efficient, uncertainty is reduced.

5.8 CONCLUSIONS ON COMMON PROPERTY REGIMES

(a) Open access regimes expose resources to a high risk of degradation, despite there being in many cases a hypothetical equilibrium where average profits are zero and the resource is used sustainably. The risk occurs where the resource stock is not known with any accuracy and because the minimum viable resource stock size can be frequently quite high.

(b) Open access regimes must be distinguished from common property in which sets of rules typically exist for the management and sustainable use of the resource. Common property resources also harbour an in-built risk or tendency to over-exploitation because of the conflict between the private and the collective good. However where common property regimes do collapse it cannot be assumed that they do so because of these inherent internal contradictions. Many other factors contribute to the destruction of common property systems: the superimposition of a colonial structure reflecting alien cultural values; exogenous technology change; and population growth.

(c) Privatisation, conferring individual property rights to resource use or ownership, often compounds incentives for individuals to develop resources. Even where common property regimes are stable and sustainable, they may not result in rising levels of income over time. Privatisation may create dynamic incentives to improve land and resources. However privatisation is also consistent with optimal resource degradation, and with the continued existence of externalities between owners. Careful monitoring of privately owned land is advisable to ensure that the conferment of property rights and resource-use rights produce an environmentally beneficial outcome.

(d) Common property management regimes do work, especially when the incentives for cohesion and communality are high. This is more likely to occur where the benefits gained from such organisation are high, and where social norms and conventions foster communality.

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[12] C.F. Runge (1981)

A COMPENDIUM OF PUBLICATIONS

J.Arntzen (1987)
'A Framework for the Economic Evaluation of Collective Fencing in Botswana" In J.Dixon and D.James **Economics of Drylands Management - A Case Study Book**

This case study deals with the problems of land degradation and diminishing crop productivity in Botswana. The benefits and costs of collective fencing, from private and social perspectives, are discussed. Insufficient data were available to actually estimate the present value of net benefits but the exposition outlines the major benefit and cost categories and shows how a full economic evaluation would be carried out. Studies such as this will hopefully encourage greater use of economic assessment techniques within Botswana.

S.Barrett (1989)
'On the Overgrazing Problem'
LEEC paper 89-07

IIED/UCL London Environmental Economics Centre
London

This article develops a model of optimal range management which explicitly recognises the dynamic interaction between livestock and carrying capacity. Compared with the usual bioeconomic model, the ratio of animals to carrying capacity must be 'too small' in equilibrium. Furthermore, it may be optimal to overshoot the equilibrium following a drought. It is conjectured that the severe overgrazing in places like Africa's sahel occurs not in an equilibrium situation but in times of drought when forces compel herders to hold onto their livestock just when optimality demands that they destock as quickly as possible.

S.Barrett (1989)
'On the Nature and Significance of International Agreements'
mimeo

London Business School,
London

Barrett addresses the problems of international coordination and potential policy to provide a coherent framework for achieving international reductions in greenhouse gas emissions. He develops a game theoretic model which illustrates cooperative and non-cooperative solutions analysing the conditions required for a stable equilibrium to be reached.

L.C.Braat and J.B.Opschoor (1987)
'Risks in the Botswana Range-Cattle System' in J.Dixon and D.James **Economics of Drylands Management - A Case Study Book**

This paper presents a study of range-cattle interactions.A generic computer simulation model is used to explore the risks of traditional cattle farming in Botswana. The risks are partly of environmental origin, e.g. droughts, and partly of human origin, such as overstocking. The essential management problem in attaining a sustainable range-cattle system is to match the highly variable grazing capacity of the range with cattle stocking rates. The situation is complicated by erratic rainfall, lack of accurate carrying capacity estimates and a mix of cultural and economic factors.

D.Brokensha and A.P.Castro (1984)
'Fuelwood, Agro-Forestry and Natural Resource Management: the Development Significance of Land Tenure and Other Resource management/Utilisation Systems'

Agency for International Development,
New York

This paper considers the resource management regimes for forest and woodfuel. The authors address the problems of resource management strategies, land tenure and modes of livelihood. They also examine the effects of government interventions in forest, tree and land management.

J.M.Conrad and C.W.Clark (1987)
Natural Resource Economics

Cambridge University Press
Cambridge

Chapter 2 is devoted to renewable resources. This is a highly technical exposition of growth functions, production yield functions, and the objectives of renewable resource management. Conrad and Clark examine the criticisms of maximum sustainable yield policies and their unstable properties. They also discuss why the tragedy of the commons is much misunderstood, being founded on a model that assumes the cost of driving resources to extinction is infinite. An open access resource is considered, where entry decisions are based on the costs of acquiring capital, the possible sunk costs associated with that investment, and entry decision rules based on myopic forecasting and rational expectations. This alters the conclusion of over-exploitation for which this model is famed.

P.Dasgupta and G.Heal (1979)
Economic Theory and Exhaustible Resources

Cambridge University Press
Cambridge

Chapter 5 considers renewable resources. The authors examine population growth curves and develop models of resource exploitation in the absence of regulation. They underscore that a distinction should be made between the social value of the stock in its natural environment and its social value as an exploitable resource. they conclude that commercial profitability as a criterion for resource exploitation can in certain circumstances be consistent with the aim of conservation. Renewable resources tend to be seriously depleted in cases where profit maximisation rules are followed in conjunction with free access to that resource. Altering either one of these characteristics can avert resource depletion.

J.A.Dixon (1989)
Session IV; Tools for Coastal Area Planning and Management Coastal Resources: Assessing Alternatives

Environment And Policy Institute,
East-West Center,
Hawaii

This paper discusses the potential of socioeconomic analysis as a tool of management of common property natural resources, especially as it allows the evaluation of alternative scenarios. The failure of market forces to account for 'externalities' implies that management interventions are needed to ensure long-term use of and long benefits from common property natural resources. this is illustrated by a case study from Bacuit Bay, Palawan, Philippines, where logging-induced erosion has killed coral reefs and negatively impacted fisheries and tourism. Forest conservation could have provided long-term benefits.

G.Hardin (1968)
'The Tragedy of the Commons' **Science**, 162,

This is the seminal article on the resolution of externalities occurring in the case of common property resources. It supports the Pareto inefficient outcome characterised in the prisoners' dilemma. In this article Hardin considers the bonds that link humanity, and the possibility of mutually supportive agreements.

He suggests that the conferral of property rights might resolve the tragedy of the commons. This is a highly dogmatic tract which focuses more on philosophical issues than economic ones, and which fails to draw a distinction between common property and open access resources.

W.Magrath (1989)
The Challenge of the Commons: The Allocation of Nonexclusive Resources

World Bank, Environment Department. Working Paper No.14
Washington

This paper examines the forces that determine the allocation of resources which are not subject to completely private ownership. The paper develops the distinction between common property, in which collective action controls resource use, and open access where individual decision making prevails. It is shown that open access regimes are inefficient, but that, although potentially unstable, common property regimes can generate satisfactory outcomes. Policy interventions and socio-economic factors that influence the successful management of nonexclusive resources are reviewed from both theoretical and resource perspectives.

A.Markandya and D.Pearce (1988)
Environmental Considerations and the Choice of the Discount Rate in Developing Countries

This paper considers the role of discount rates in project appraisal, and the problem of incorporating environmental considerations into investment criteria. It reviews much of the literature on the appropriate sources of discount rates and their associated pitfalls. markandya and Pearce consider the correct treatment of risk and uncertainty, irreversibility, and intergenerational equity. The authors suggest that such environmental concerns are best approached by adjusting our measurement of costs and benefits and with the addition of a constant natural capital stock constraint. It contains a detailed summary of the computational requirements for discounting, and the methodological approaches that define the different schools of thought on discounting.

162.

Panel on Common Property Resource Management (1985)
Procedings of the Conference on Common Property Resource Management
Board on Science and Technology for International Development
Office on International Affairs National Research Council

National Academy Press (1986)
Washington

The papers in this volume address the problems of common property resources subject to communal management systems. There is a section on the theory of common property resources, collective action, and resource management regimes. There then follows a series of case studies: fisheries, elephants, water resources, range and pastureland, agricultural land, forest and bushland. This book provides an extensive overview of the debate, and essential summaries of the current status of economic theory with regard to common property resources.

P.J.Pearson (1989)
'Common Property, Privatisation and Environmental Policy: the Case of Natural Resource Degradation in the Third World'

European Association of Law and Economics, Sixth Annual Conference Vienna (1989)

University of Surrey

This paper aims to contribute to the emerging debate over the relative merits of the instruments that can be used to influence the processes that underlie natural resource degradation. It focusses particularly on group action and on privatisation and attemmpts to clarify the policy issues and objectives involved. deforestation is used as the m,ajor empirical example.

C.F.Runge (1981)
'Common Property Externalities: Isolation, Assurance, and resource Depletion in a Traditional Grazing Context',
The American Journal of Agricultural Economics, Vol.63

Runge considers the paradigm of the tragedy of the commons in the context of an overgrazing model. In particular he adresses the conclusion that a necessarily Pareto inferior outcome will result from the exercise of individual rights to resource use. Runge examines separable and non-separable externalities, and the possible solutions thereof. He stresses that inferior outcomes do not necessarily result from the strict dominance of independent individual strategies as is the case of the prisoners' dilemma. Runge proposes that a richer representation

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of interaction between agents is given by the assurance game. Cooperative solutions are more likely to be upheld where the locus of decision making is small. In such a case the exchange of information about the actions of others is relatively efficient, satisfying those prerequisites for collusion.

ENVIRONMENTAL ECONOMICS IN
THE DEVELOPING WORLD

VOLUME SIX

POLICY FAILURE AND ENVIRONMENTAL DEGRADATION

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VOLUME 6

POLICY FAILURE AND ENVIRONMENTAL DEGRADATION

6.1 INTRODUCTION

POLICY FAILURE AND MARKET FAILURE

Natural resources and the environment will be degraded if their values are not fully recognised and integrated into decision-making by individuals in the market-place, and by governments. Where this integration does not occur, there is said to be "failure". If markets fail fully to reflect environmental values, there is said to be market failure. Where government decisions do not reflect these values there is policy failure or government failure.

This volume considers policy failure.

6.2 THE NATURE OF POLICY FAILURE

Governments "fail" in many ways. They might, for example, subsidise the use of environmentally damaging inputs such as fertilisers or pesticides, encouraging their excessive use. They might hold prices down for agricultural produce, lowering farm incomes and making it difficult to generate the financial surpluses required to ensure investment in soil conservation. They might overvalue exchange rates, encourage ecologically inappropriate crops, provide incentives for deforestation, and so on.

Such policy failure is not confined to the developing world.

(a) An example of Policy Failure

In most OECD countries, water is supplied through markets which are controlled either directly or indirectly by governments. A purely private water market may be subject to market failure in that prices may fail to reflect the full social costs of consumption and disposal. Water is in most cases a common property resource, with no clear rights of ownership assigned to either one individual or a group of individuals. The misuse of water creates external costs which fall on others, as in the case of downstream pollution. However intervention can be also be costly.

Consider the case of water supplied from the Sacramento/San Joaquin Delta to the rich agricultural areas of the Westlands Water District in California, some 150 miles to the south. The water is supplied at prices so low that they no longer cover the costs of operation and maintenance. Prices fixed at about $10 per acre-foot, compare with a supply price of about $100 per acre-foot.[1] The majority of the water is used for irrigation purposes. It has been estimated that the implied subsidy averages some $217 per acre, with the average farm receiving around $500,000 in subsidy per year. These are only the financial costs, and take no account of the opportunity cost involved. The environmental impacts of the water extraction are also ignored.

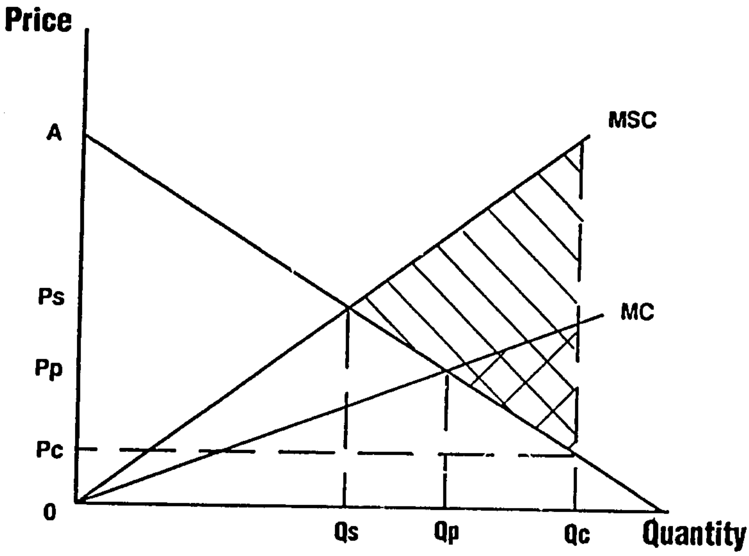
(b) <u>The Economic Costs of Intervention</u>

The costs of intervention are best described by the resultant <u>welfare loss</u> that occurs by ill-conceived intervention, such as price-ceilings, quantity regulation etc. Price controls are often applied to environmental goods in order to benefit the poorest members of society. Price controls are also employed to encourage industrial and agricultural activity, providing essential environmental inputs at an effectively lower cost. In the case of underpricing however there is often a consequent welfare loss.

[1] See K. Frederick (1989)

Figure 6.1

The Effects of Price Controls



Here the MC curve is the firm or the individual's private Marginal Cost curve. In this example private MC diverges from the Marginal Social Cost curve MSC. The socially desirable price and quantity is P_s, Q_s, where the Marginal Social Cost equates with demand ensuring that the market price fully reflects the MSC of the input. The private optimum without input price control is given by P_p, Q_p. However, if the firm faces the controlled input price the private optimum becomes P_c, Q_c. By setting the price below private marginal cost the resource is demanded in higher quantities than would occur in a marginal cost pricing scenario. The distortionary effect can be measured in terms of quantity by the distance Q_c Q_p. The distance Q_p Q_s measures the extent of market failure. A measure of the welfare loss or deadweight loss imposed on society by the pricing control is given by the triangle ECF. The area under the demand curve gives a measure of total willingness to pay, or total benefit, whilst the area under the marginal social cost curve gives total social cost.
If marginal cost pricing was followed this deadweight loss would be significantly smaller than if the price control was imposed.

6.3 REASONS FOR POLICY FAILURE

There may be several reasons for imposing price controls. Two are notably:

(a) The prices of essential goods are often held artificially low in order to achieve distributional aims.

(b) Low input prices are often used to encourage agricultural and industrial development.

However the costs of achieving these objectives may be very high indeed, since resources are used up in subsidising the activities that produced the price controlled good. Further the extent of loss imposed on society depends crucially on how that revenue was raised, and the associated disincentives that follow from an increased tax burden.[2] In terms of the environment, the effects of expanding output from Q_s or Q_p to Q_c in the diagram is to increase the potential demands on environmental quality by increasing the level of wastes discharged into the natural environment. It is often the case, particularly in the developing world, that subsidies are applied to products which are particularly damaging to the environment - commercial fuels, transport, fertilisers, pesticides and irrigation water.

The potential for government failure extends across the complete spectrum of governmental activities. Such failures include market intervention, marketing and price controls, inappropriate tax policy, bureaucratic and institutional inertia, and inadequate information exchange. A frequent source of failure is the lack of focus on the relative prices of goods,regardless of the overall level of prices it is the relative prices that matter and the income and substitution effects associated with a certain set of relative prices.

6.4 PRICING IN THE IRRIGATION SECTOR

In 1987 a survey of 149 World Bank projects was undertaken in order to see if the Bank's pricing guidelines were followed.[3] In general, these guidelines recommend that efficiency prices based on opportunity cost be employed. In the coal sector for example, an efficient price is considered to be either the "border price" (the export or import price) or the long run marginal cost of production. These guidelines in general omit environmental

[2] See A.Atkinson and J.Stiglitz Public Economics (1980)

[3] D.Julius and A.Alicbusan (1988)

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considerations. However this survey was intended to explore only if these narrow 'efficiency prices' were in fact adopted, and not to consider the wider environmental implications of such a pricing policy. The survey concludes that cost-plus pricing rules were often followed in an attempt to protect high cost mines from closure, which meant that in several countries the coal sector was being effectively subsidised. However in most cases efficiency prices were adopted.

In the case of the irrigation sector, the survey recognised that such pricing is generally feasible only where volumetric metering is possible, in tubewell or pumped schemes. Where other systems are employed - gravity-fed systems and canal irrigation - volumetric metering is often impossible and such pricing therefore inappropriate. In this case beneficiaries of the irrigation scheme could be taxed on land enhancement or increased crop production in an effort to recover the costs of production and transportation. Distributional considerations have usually mitigated against the widespread charging for irrigation water, yet beneficiaries are often landowners rather than tenants, hence these distributional concerns are seldom realised in practice. Actual prices were found to be generally below the costs of supply. Often they were set without an inbuilt incentive to conserve water, setting the charges on the basis of irrigated acreage regardless of the water quantity consumed. As a result a number of schemes failed to recover even the operating and maintenance costs,let alone make any contribution to capital cost recovery. Cost recovery was estimated at 7% of the total costs of supply.

One of the negative environmental impacts of charging such low prices for irrigation, is that the irrigated land becomes waterlogged. In India 10 million hectares of land have been lost to cultivation through waterlogging and 25 million hectares are threatened by salinisation. In Pakistan some 12 million hectares of the Indus basin canal system is waterlogged and 40% is saline. Worldwide it has been estimated that approximately 40% of the world's irrigation capacity is affected by such salinisation. The environmental degradation as the result of mismanaged irrigation schemes is not merely confined to the immediate area. Irrigation from river impoundments or dams produces downstream pollution, and upstream siltation as the land around the reservoir is deforested. Whilst it is clear that not all the environmental damage that results can be attributed to inefficiently low prices, there is an increased burden placed upon the environment by such pricing. By adopting prices that are too low, more irrigation water than is needed is demanded, wastage is inevitable, and this exaggerates the perceived need for irrigation schemes and dams. Prices no longer give accurate signals, and demand is artificially distorted.

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The failure to charge market-clearing prices for irrigation water gives rise to rent-seeking. This economic rent arises because of the difference between what the farmer would be willing to pay for the irrigation water and what is actually paid. Where price controls are imposed these rents can be very large indeed. The following table shows prices charged as a percentage of estimated farmer benefits in several countries. In Indonesia, for example, these charges amount to 8-21% of benefits. In terms of rents the farmer secures 79-92% of benefits at no cost. The data reveal that the marginal valuations of irrigation water by farmers are very high, and that they exceed the prices charged by several times. Raising the charges by small amounts will not impact on demand because these marginal valuations are so high. However the most salient point must be that the benefits that accrue to irrigation arise not from its low price, but from its availability. Raising the price of irrigation water will not reduce the social benefits of irrigation. It is also necessary to examine the incentives which result from such consistent under-pricing. The artificially low price, cushions the farmer against the effects of inefficient water management. Excessive wastage occurs, and there is no incentive to innovate poorly functioning and outdated irrigation apparatus. Inefficient irrigation negatively affects agricultural output. Because charges are so low excess demand results, giving a premium to those who can secure water rights by being first in line to receive water. This leaves many farmers without access to sufficient water, and further compounds the inefficiencies built into the system by this under-pricing. Under such a scheme, water tends to be allocated by acreage, and not by crop requirements, another source of inefficiency. It is this oversight that promotes rent-seeking: there is an incentive to secure control of the allocation mechanism. These high rents become capitalised in higher land values making the desire to compete for control of the allocation mechanism more intense. This competition invariably is not expressed through the market, but it takes the form of bribery, expenditures on lobbying, and selective political contributions. The allocators of the water rights similarly expand their bureaucracies and secure benefits for themselves. This rent-seeking can only exacerbate distributional inequities, favouring the already rich and powerful, and discriminating against the poor and unorganised. Further, because this rent-seeking encourages wastage it greatly harms the environment, adding to the social costs of policy failures.

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Table 6.1

Rents in the Irrigation Sector

COUNTRY	CHARGES	RENTS
Indonesia		
high benefit estimate	8	92
low benefit estimate	21	79
Korea		
high benefit estimate	26	74
low benefit estimate	33	67
Nepal	5	95
Philippines	10	90
Thailand	9	91
Pakistan	6	94
Mexico		
high benefit estimate	11	89
low benefit estimate	26	74

Charges are expressed as a percentage of benefits.
Source: adapted from Repetto (1988)

6.5 PRICING IN THE ENERGY SECTOR

Commercial energy - coal, oil, gas, electricity - is widely subsidised in developing countries. As with irrigation water, the effects of the subsidy are to encourage wasteful uses of energy and add to the problems of air pollution and waste disposal. In this case the economic impacts of the subsidies tend to be more dramatic, since they are a drain on government revenues and thereby divert valuable resources away from more productive sectors, reducing energy exports and thus adding to external debt, and encouraging energy intensive industry at the expense of more efficient industry.

The decision to subsidise energy production is often for distributional reasons. Certain energy forms are disproportionately consumed by the poor, as in the case of kerosene which is a widely used energy source for low income families. Hence a rise in the price of this good is likely to

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impact negatively on social welfare. Distributional arguments are cited in the case of subsidies to diesel fuel, or to justify a very low rate of tax. However in this case such arguments are less convincing. Most diesel fuel is used for freight vehicles the effect is to subsidise manufacturing output which is more likely to be consumed by higher income groups.

Subsidies to heavy fuel oil are justified on protectional grounds often using the "infant industry" argument. An infant industry is very vulnerable to world price fluctuations, and whilst it is being established subsidy cushions it against such instability. However, even though there are gains to such energy subsidisation, they must be offset by the incentives such subsidies provide for internal inefficiencies.

There are two measures of subsidy. The financial measure which indicates the difference between prices charged and the cost of production. That is the financial cost to the economy of subsidising energy production. The economic subsidy measures the net difference between the opportunity cost value of the energy source and its actual price.This gives a more accurate notion of the true cost of subsidy since it is consistent with a shadow price approach. This opportunity cost value or shadow price is measured by either the price of the fuel at the country's border if the energy is traded internationally, or the long run marginal cost of supply, in the case when such resources are not traded. Oil, gas and coal are typically valued at their "border prices" whereas electricity is valued at its marginal cost of supply.

The following table shows the ratio of domestic to border prices for the main petroleum products, gasoline, kerosene, diesel, and heavy fuel oil. A ratio in excess of unity indicates that the country is pricing at above shadow prices, while a ratio below unity indicates that the fuel source receives a net economic subsidy. the final column is a weighted average of the four products. Certain of the countries subsidise all products -Colombia, Ecuador, Egypt, Mexico, Peru and Venezuela. Kerosene is subsidised in India, Indonesia, Pakistan, Sri Lanka and Tunisia. Diesel is subsidised in Argentina. Fuel oil is subsidised in Argentina, Brazil, India, Kenya, Pakistan and Tunisia. The largest subsidies seem to be concentrated in the oil-exporting developing countries, Ecuador, Egypt, Indonesia, Mexico, Peru, Tunisia, and Venezuela. whilst the level of subsidy has declined over the period 1981-1985 as more rational pricing policies are pursued, subsidies remain in general widespread. Oil importing countries tend to tax petroleum products but the highest tax is on gasoline, being used to cross subsidise the other products.

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As this table shows, gasoline tends to be taxed, reflecting distributional objectives since cars are effectively used mainly by the richer social classes. In many cases the motivation for the tax is to subsidise other petroleum products.

Table 6.2

Petroleum Products pricing in the Developed and the Developing World

Ratio of Retail to Border Prices for Selected Petroleum Products, 1981 and 1985

Country	Date	Regular unleaded petrol	Household kerosene	Diesel oil	Heavy fuel oil	Total
Argentina	1981	1.23	0.90	0.60	0.43	0.78
	1985	1.91	0.97	0.81	0.74	1.18
Brazil	1981	2.77	1.21	1.62	0.76	1.70
	1985	1.60	1.09	1.24	0.78	1.25
Canada	1981	1.10	0.80	1.27	–	–
	1985	1.74	1.24	1.73	1.15	1.59
Chile	1981	1.83	1.22	1.70	1.33	1.62
	1985	1.63	1.51	1.51	1.26	1.49
Colombia	1981	0.78	0.81	0.86	–	–
	1985	0.71	0.63	0.79	0.58	0.71
Ecuador	1981	0.54	0.22	0.32	0.43	0.43
	1985	0.90	0.27	0.61	0.41	0.70
Egypt	1981	0.55	0.15	0.13	0.05	0.15
	1985	0.74	0.13	0.72	–	–
Ethiopia	1981	1.96	1.02	0.89	0.91	1.13
	1983	2.26	1.23	1.54	1.29	1.70
France	1981	2.72	–	2.17	1.05	2.03
	1985	2.85	–	2.55	1.23	–
Ghana	1981	3.47	1.58	2.73	1.37	2.70
	1983	3.80	1.69	2.99	1.57	3.05
India	1981	2.21	0.63	1.07	1.12	1.07
	1985	1.94	0.64		0.84	0.90
Indonesia	1981	0.84	0.20	0.30	0.50	0.50
	1985	1.67	0.72	1.03	1.25	1.12
Japan	1981	2.26	1.19	1.54	1.05	1.47
	1985	2.63	1.49	2.06	–	–
Kenya	1981	2.28	1.01	1.58	0.89	1.49
	1983	2.13	1.07	1.70	0.89	1.57
Korea	1981	3.48	1.27	1.28	1.34	1.40
	1985	3.43	1.56	1.59	1.27	1.61
Mexico	1981	0.43	0.24	0.18	0.11	0.26
	1985	0.75	0.29	0.49	0.16	0.48
Morocco	1981	2.51	1.39	1.47	0.90	1.33
	1983	3.05	1.53	1.60	1.19	1.59
Pakistan	1981	1.74	0.91	1.07	0.63	1.09
	1983	1.69	0.84	1.10	0.54	1.05
Peru	1981	0.88	0.16	0.62	0.62	0.61
	1985	0.94	0.79	0.74	0.72	0.79
Sri Lanka	1981	–	0.66	1.03	0.88	–
	1983	–	0.73	1.17	0.95	–
Thailand	1981	1.86	0.95	1.21	0.96	1.23
	1985	1.80	1.10	1.30	0.91	1.29
Tunisia	1981	1.95	0.37	0.79	–	–
	1983	2.00	0.60	0.93	0.64	0.90
Uganda	1981	2.97	1.63	1.83	1.16	2.06
	1983	3.83	2.36	2.71	–	–
UK	1981	2.53	1.33	2.72	1.40	2.20
	1985	2.56	–	2.77	1.31	–
USA	1981	1.18	1.09	1.09	0.91	1.13
	1985	1.39	–	1.73	0.95	–
Venezuela	1981	0.13	0.09	0.10	0.12	0.12
	1985	0.77	0.41	0.30	0.25	0.55
West Germany	1981	2.52		2.28	–	–
	1985	1.12		2.28	0.98	–

Based on weighted average of the four petroleum products. Figures are averages for the last quarter of 1985 or 1983 annual averages where 1985 data were unavailable. Sources: World Resources Institute calculations based on World Bank data.

Source K.Kosmo 'Commercial Energy Subsidies in Developing Countries' (1989)

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Table 6.3

Economic Subsidies to Energy in Selected Countries

Country	Size of Subsidy $m	Subsidy as % of all Exports	Subsidy as % Energy Exports
Bolivia	224	29	68
China	5400	20	82
Egypt	4000	88	200
Ecuador	370	12	19
Indonesia	600	5	7
Mexico	5000	23	33
Nigeria	5000	21	23
Peru	301	15	73
Tunisia	70	4	10
Venezuela	1900	14	15

This table shows the size of the economic subsidy for selected oil-exporting countries. These subsidies create an additional distortion in that they divert potentially exportable energy to the home market, adding to balance of payments difficulties and eventually to international indebtedness. The scale of the distortion can be gauged by looking at the subsidies as a percentage of all exports. In Egypt for example this policy failure has significant effects, subsidies are equal to 88% of all exports and are twice the value of oil exports.

It must be concluded that such pricing policies have associated incentive effects, which must be taken into consideration when policy is being designed. The income and substitution effects must be considered and so also must the macroeconomic consequences of such policy, and the environment-economy interactions that result.

6.6 PUBLIC POLICY AND LIVESTOCK RANCHING

In excess of one third of the world's land surface cannot support rainfed agriculture. These regions provide most of the world's rangelands, approximately half of which are located in the developing countries and support 30-40 million pastoral nomads. However most of the rangelands suffer from some form of environmental degradation, they are significantly losing productivity. Much of this deterioration can be attributed to poor management and innapropriate government policy. Desertification and dessication of the soils is the result of overstocking with homogenous herds that selectively overgraze preferred grasses, exposing and compacting bare soil. Soil erosion intensifies, soil porosity and water percolation decrease, water tables decline, and sparse shrubs replace pre-existing grasses. Some recent estimates suggest that over 70% of developing country rangelands are moderately to severely desertified, but there is an extensive debate about the meaning and measurement of desertification.

Many governments have applied concentrated support to livestock development, providing vital infrastructure, credit subsidies, and associated livestock services. Controls have rarely been adequate, and ranching has invariably been encouraged in certain climatically unstable regions. As a direct result of these policies stocking rates have risen drastically to exceed range carrying capacities in low rainfall years when forage production is typically at its lowest.

In Latin America, governments have offered generous fiscal and financial incentives: tax concessions, tax ceilings, long-term loans at low or even negative real rates of interest, depreciation allowances, and other preferential credit facilities. Given such inducements, pasturage regions have increased by 350 million square kilometers between 1966 and 1983, an extent equal to 1/4 of the currently cropped area.

These incentives have resulted in large tracts of forest land being degraded and given over to livestock ranching. In general much of the converted forest land is unsuitable for livestock ranching, the soils are rapidly undermined, compacted and desertified. The resultant loss of ecological wealth and biodiversity may outweigh the economic gain from farming marginal lands. A recent analysis by the World Resources Institute illustrates how these fiscal incentives promote short-lived, unproductive livestock projects that are economically and environmentally unsound. Rents are mainly captured by private investors. Survey data on the structure of costs and revenues from a selected number of 24 large-scale, government-supported cattle ranches in the Brazilian Amazon were merged to derive a typical profile of costs and returns.

This is represented in summary form in the folowing table, giving all the costs and revenue streams in present value form per hectare of fully developed ranchland.

Table 6.4

Structure of Costs and Revenues for Typical Government Sponsored Cattle Ranches in the Brazilian Amazon

		US$/hectare
(i) Capital Costs		
1.	Land acquisition[a]	31.70
2.	Forest clearance[b]	65.95
3.	Pasture establishment[c]	26.36
4.	Fencing[b]	19.38
5.	Roadbuilding[b]	6.31
6.	Misc. construction[b]	1.25
7.	Cattle acquisition[c]	90.87
(ii) Annual operating costs		
1.	Labour costs	5.23
2.	Herd maintenance	4.25
3.	Pasture maintenance	9.47
4.	Facility maintenance	14.87
5.	Administration	0.82
(iii) Average Revenues from Cattle Sales		22.50

(a) Typical ranch size is 49,000 ha, although average area of pasturage is 10,500 hectares.

(b) Estimates applied to schedule of pasture creation and stock increase.

(c) Based on initial herd of 4000 head.

Source R. Repetto (1988)

Table 6.5

Economic and Financial Analysis of Government-Assisted Cattle Ranches in the Brazilian Amazon

(i) Economic analysis	Net Present Value ($m)	Total Investment Outlay ($m)	NPV Invest. Outlay
A. Base case	-2,824,000	5,143,700	-.55
B. Sensitivity analysis			
1. Cattle prices assumed doubled	511,380	5,143,700	+.10
2. Land prices assumed rising 5%/year in excess of general inflation rate	-2,300,370	5,143,700	-.45
(ii) Financial analysis			
A. Reflecting all investor incentives: tax credits, deductions and subsidised loans	1,875,400	753,650	+2.49
B. Sensitivity analysis			
1. Interest rate subsidies eliminated	849,000	753,650	1.13
2. Deductibility of losses against other taxable income eliminated	-658,500	753,650	-0.87

Source R. Repetto (1988)

Government policy has promoted large investments leading to the conversion of vast areas of tropical forests to low productivity pasturage and livestock operations of little economic value. These incentives have entrenched existing inequalities in the allocation and distribution of land, severely degraded natural environments and resulted in substantial government revenue losses.

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6.7 PUBLIC POLICY AND TROPICAL DEFORESTATION

(a) The Rate of Deforestation

Tropical deforestation is a matter of increasing global concern. It occurs because of the need for clearance for agriculture and logging, the demand for fuelwood and fodder, and in the event of natural disasters such as fires, floods etc. The underlying reasons include pressure from an expanding marginalised population in search of subsistence land; the development process itself, and government policy which either deliberately or inadvertently encourages deforestation. Determining the relative importance of each of these is difficult, not just because such causes tend to compound each other. Logging frequently opens up previously unexploited areas for agriculture. The development of infrastructure, roads and dams, further contributes to the pressure on the forests resources. Whilst forest does tend to regenerate if left undisturbed, once cattle have been introduced into such an area this regeneration process can be irreversibly halted.

In the Brazilian Amazon subsidies and other policy distortions have been estimated to account for at least 35% of all converted forest areas until 1980. The depletion of forest cover is attributed to the following:

(i) Tax incentives for capital investment, particularly industrial wood production and livestock ranching.

(ii) The provision of rural credit programs for agricultural production, various forms of mechanised agriculture, cattle ranching and silviculture.

(iii) The subsidisation of small farming settlements.

(iv) Export subsidies to cattle, agricultural and forest products.

Whilst some forest conversion in the tropics provides farmers and ranchers with valuable new holdings, much leaves only degraded soils unsuitable for ustained agricultural production. The loss of tree cover in watersheds increases erosion, flooding, and sedimentation. In semi-arid areas deforestation depletes essential organic matter and exposes the soils to wind and water erosion. There is also loss of biodiversity, and the potential threat of extinction to many species of animals and plants.

Developing countries also suffer direct economic losses through deforestation. Whilst some forest conversion is an expected component of economic development, in most countries conversion has been inefficient and detrimental to long term economic growth. In the main this has been attributed to policy

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mismanagement, and inappropriate incentives. Throughout the developing countries, governments have assumed responsibility for forest management, controlling more than 80% of the closed forest area. Vast tracts of forest land have been mined as exhaustible resources, with what rent governments have been able to capture from this being used to service foreign debt. As a result of government supported agricultural programs, extensive areas of forest have been sacrificed to ranching, agricultural settlement, river impoundments, mining, and other uses. These practices are for the large part unsustainable and yield lower returns than the maintenance of cohesive forest cover.

An additional loss beyond that of the forest cover itself, is that from the production of forest related byproducts. The exports of rattan, honey, natural silk, sandalwood, nuts, fruits, and a variety of cosmetic and pharmaceutical products from Indonesia totalled $120 million in 1982, almost 50% of the Indonesian governments total revenues from timber production.

Many developing countries have encouraged forest clearance, sacrificing most of their economic value to logging as a result of shortsighted exploitation. The stumpage value of an accessible virgin forest of commercial species commands huge potential economic rent. This rent derives from the excess value above the costs of logging and clearance. These rents can be captured by governments as a source of revenue, forcing the costs of forest clearance to more closely approximate their true opportunity costs. Royalties, land rents, licence fees, harvest and export taxes can be employed as a means of converting this rent into vital government revenues. Where these rents remain uncaptured, the true opportunity costs of deforestation are ignored, the rents accrue to private interests in the form of excess profits encouraging further depletion and unsustainable farming practices.

In general the developing countries have failed to adopt forest revenue systems that begin to capture some of these rents. In Indonesia, log exports from Sumatra and Kalimantan, two of the main concession areas, generated average rents of $61 per cubic meter, that is the difference between the logs' export value and the total cost of harvest and shipment. The total identifiable government revenue, including royalties, taxes and fees, averaged only $30, less than half the available rents.

Table 6.6

Government Rent Capture in Tropical Timber Production In $US Millions

(1) Country and period	(2) Potential rent from log harvest	(3) Actual rent from harvest	(4) Official government rent capture	(5) 4/3 %	(6) 4/2 %
Indonesia 1972-82	4,958	4,409	1,654	37.5%	33.0%
Sabah 1979-82	2,065	2,064	1,703	82.5%	82.5%
Ghana 1971-74	-	-	29	38.0%	-
Philippines 1979-82	1,504	1,001	141	14.0%	9.4%

(1) Potential rent assumes that all harvested logs are allocated to uses eg - direct export, sawmills, plymills- that yield the largest net economic rent.

(2) Actual rent totals rents arising from the actual disposal of harvested logs.

(3) Rent capture totals timber royalties, export taxes, and other official fees and charges.

Source R. Repetto (1988) From unpublished research, World Resources Institute.

(b) Charges Affecting Forest Clearance

Governments affect the rate of deforestation not only by the level of their charges for the use of public forests, but also by the form that these charges take. To illustrate, most charges levied on forest clearance and logging practices are based on the volume of timber removed, not on the volume of marketable timber removed. Licensees then harvest selectively, removing only the most valuable trees, high-grading. This encourages more extensive harvesting as larger areas of forest land are opened up to other uses. In the process of selective logging much of the remaining forest cover is destroyed, because logging operations cause extensive damage to underlying soils, the subsoil root network, soil drainage and increase rates of erosion. In Sabah and Indonesia, estimates of damage from such logging operations range from 45% to 75% of the unharvested trees. Flat charges per cubic meter harvested, unless finely differentiated by species, grade and site condition, promote high-grading with the resultant loss of forest cover, biodiversity and soils.

Where charges are carefully differentiated, forest clearance is less inefficient. In Sarawak, Malaysia, specific charges are levied according to tree species, consequently the area suffers less from high grading and extensive forest damage is reduced. If such highly differentiated charges are infeasible, ad valorem charges, income taxes, or site rents, can be employed to prevent high-grading, since even inferior trees are likely to have a positive stumpage value to the licensee.

"Improved forest revenue systems and their administration can promote more efficient use of valuable Third World forest resources, reduce wasteful deforestation, and simultaneously increase the economic benefits that accrue to local economies." [1]

(c) Industrialisation Incentives and Forest Clearance

Certain industrialisation incentives have been engineered to promote local employment opportunities, increase local incomes, and encourage export-base diversification. However inappropriate industrialisation policies have encouraged deforestation and the short-term exploitation of the forest reserves. Heavy subsidies to industrial inputs have cushioned inefficiencies and encouraged wastefulness. For example, Ghanaian plymills require 2.2 cubic meters of logs for each cubic meter of output, compared to 1.8 cubic meters of log inputs in Japanese mills.

Tax concessions, waived export taxes, credit subsidies, input and output price distortions have greatly contributed to inefficient forest clearance as the result of industrialisation incentives packages.

(d) Property Rights and Tenurial Relations

The institutional and social framework also contribute to forest clearance, particularly in the forest-poor of the developing nations. Open access regimes, and failed communal management systems have increased forest degradation. Although most woodlands are central, provincial, or local government lands, individuals' access to forest tracts are seldom effectively regulated or policed. By default, woodlands become open access or common property resources. Individuals lack adequate incentives to preserve or invest in tree stocks, consequently these resources are mined exhaustively.[2]

(e) The Economic Replacement Cost Issue

Governments in many developing countries often set prices for trees harvested from public lands at levels far below their economic replacement cost. The replacement costs include both reafforestation and maintenance. The license fees, stumpage fees, and other charges for harvesting wood from publicly managed forests comprise only a fraction of the replacement costs. In China, for example, annual wood production exceeds annual growth by at least 30%, forest fees and charges cover only 1/3 of the costs of reafforestation.

The following table compares stumpage fees with estimates of replacement costs from World Bank appraisal reports. As a result of poaching, non-collection of charges, and poor policing of forests under public management, the quoted prices substantially overstate average revenues.

Table 6.7

Comparison of Stumpage Fees and Replacement Costs per Cubic Meter for Selected Countries

Country (currency)	Estimated Stumpage fees	Replacement Costs	Stumpage fees as a % of Replacement Costs
Ethiopia (Birr)	4.0	8.3-18.6	22-48
Kenya (KSh)		57.6	33
- deadwood collected by headload	2.0-5.0		
- purchases by concessionaires	19.2		
Malawi (MK)	2.88		16-58
- government plantations		18.0	
- private plantations		5.0	
Niger (CFAF)	85.00	13,610.0	0.6
Rwanda (FR)	160.00	600.0	27.0
Senegal (CFAF)	185.00	9,250.0	2.0
Sudan (ES)	0.67		2-12
- bushland		10.2-46.2	
- low rainfall savannah		5.7-27.9	
- high rainfall savannah		1.6- 8.6	
Tanzania (TSh)			
- plantation poles	60-88	66.0	91-133
- bush poles	20-30	30.0	67-100
- fuelwood plantation	12.00	25.0	48.0
- fuelwood brush	6.0	9.0	67.0

Source R. Repetto (1988)

The market will in general tolerate a much higher level of stumpage and license fees, since existing charges represent only a small fraction of retail market prices. The fact that there are large potential rents to extract from logging and forest clearance operations, indicates that charges could be raised.

Table 6.8

Fuelewood Wholesale-Retail Price Spreads in Selected Developing Countries

Country	Stumpage Fee	Retail Price (Urban Market)	Wholesale-Retail Price Spread %
Ethiopia (Birr)	4.00	60-80	94
Kenya (KSh)	19.20	398.75	95
Malawi (MK)	2.88	33.25	91
Niger (CFAF)	85.00	6,646.00	99
Rwanda (FR)	160.00	600 (est)	73
Senegal (CFAF)	185.00	12,308.00	98
Sudan (ES)	0.67	21.75	97
Tanzania (TSh)	6.00-12.00	45.00	80

Source R. Repetto (1988)

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The following table gives an estimate of the orders of magnitude for the annual rate of deforestation. Although the direct clearance of forest for agricultural purposes seems to dominate, selective logging, removing the canopy cover but not all trees, still affects the rates of soil erosion.

Table 6.8
Rates of Deforestation in the Developing World
(million hectares p.a.)

Purpose	Closed Forest: Tropical Forest	Closed Forest: Moist Tropical	Open Woodland
agriculture	7.27	6.11	
agriculture and fuelwood			3.81
selective logging	4.40	3.70	

Source IIED and WRI World Resources Report 1988-1989.

6.8 GOVERNMENT POLICY AND DEFORESTATION IN THE AMAZON

The deforestation of Amazonia has been the focus of much attention in the last decade. Brazil with some 3.5 million square kilometers of tropical forest concentrated in the Amazon Basin, comprising 30% of the worlds total, has suffered substantial tree loss. This table indicates how rapidly the rates of forest depletion have accelerated over the last few years rising from 16,000 square kilometers per annum between 1975 and 1978 to 60,000 square kilometers between 1980 and 1988. Again forest clearing is mainly for agricultural reasons, much of the land being turned over to pasture. The conversion of forest to pasture consist primarily of landholdings in Para, Mato Grosso, and Goias which are the principal livestock states. More than 70% of this artificial pasture was on landholdings in excess of 1000 hectares. Some conversion to pasture has arisen because smallholdings growing crops have been abandoned and taken over by large landowners for cattle. It is important to note the composition of wealth associated with the ownership of cattle ranches, since policy should be designed to curtail inefficient cattle ranching whilst maintaining distributional objectives. It is also important to note that much of the timber extraction in Brazil comes from this land conversion and not from selective logging. The productive lifespan of these cattle ranches is very low, further once a tract of land has been ranched in such away the resultant soil erosion and the destruction of natural ecosystems only contribute to this decline in productivity. It is also extremely disturbing to see the timber industry being exploited on an entirely unsustainable basis.

Table 6.9

Deforestation in the Amazon

LANDSAT Surveys of Forest Clearing in Legal Amazonia

ate or	Area	Area cleared							
		Square kilometers				Perc 'ge o,' state or territory			
rritory	(square kilometers)	By 1975	By 1978	By 1980	By 1988	By 1975	1978	By 1980	By 1988
re	152.589	1.165.5	2.464.5	4.626.8	19.500.0	0.8	..6	3.0	12.8
napá	140.276	152.5	170.5	183.7	571.5	0.1	0.1	0.1	0.4
nazonas	1.567.125	779.5	1.785.8	3.102.2	105.790.0	0.1	0.1	0.2	6.8
iiás	285.793	3.507.3	10.288.5	11.458.5	33.120.0	1.2	3.6	4.0	11.6
iranhão	257.451	2.940.8	7.334.0	10.671.1	50.670.0	1.1	2.8	4.1	19.7
ito Grosso	881.001	10.124.3	28.355.0	53.299.3	208.000.0	1.1	3.2	6.1	23.6
rá	1.248.042	8.654.0	22.445.3	33.913.0	120.000.0	0.7	0.8	2.7	9.6
ndônia	243.044	1.216.5	4.184.5	7.579.3	56 000.0	0.3	1.7	3.1	23.7
raima	230.104	55.0	143.8	273.1	3.270.0	0.0	0.1	0.1	1.4
otal	5.005.425	28.595.3	77.171.8	125.107.8	598.921.5	0.6	1.5	2.5	12.0

ource: Fearnside (1986b) and World Bank estimates.

In light of this, it would seem perverse that the Brazilian government adopted a general policy of encouraging livestock development by economic incentives. The 1960's saw the introduction of "Operation Amazonia" an attempt to open up Amazonia encouraging development and settlement. These incentives have been numerous and diverse:

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(a) Investment Tax Credits allowed Brazilian corporations to obtain up to 50% credit against their income tax liabilities, if these savings were used for investment in the development of Amazonia. Before the enactment of these projects they had to be approved of by the Superintendency for the Development of Amazonia (SUDAM). Initially the acceptable projects were confined to industrial ventures, however in 1966 livestock and service sectors were included. Although a rule designed to prohibit livestock development in areas of rainforest was introduced in 1979, it has been effectively ignored. Of 950 projects approved by SUDAM before 1985, 631 of these were in the livestock sector, accounting for much of the deforestation of southern Para and northern Mato Grosso, and perhaps 105 of overall Amazonian deforestation. The average ranch sizes are 24,000 hectares, and several are over 100,000 hectares. Employment generation has been minimal, and in some cases negative since ranching displaced other more labour intensive activities such as nut gathering. SUDAM has committed itself to over $700 million in subsidies, yet despite this only 92 livestock projects were awarded certificates of completion and these secured very low average production levels. The rates of return are typically intrinsically low because forest soils are unsuited to ranching. Initial stocking rates of 1 animal per hectare at the outset quickly reduce to 0.25 animals per hectare after 5 years. Much of the clearance that occurs is for the fiscal benefits, or for land value speculation, since clearance and occupation are the only way to ensure land title.

(b) Approximately 90% of pasture formation is not assisted by SUDAM. However an extensive and well-developed subsidised credit system exists for crop and livestock ventures. These schemes have almost certainly diverted some developments from the less vulnerable regions to Amazonia. Not only were these schemes detrimental to the ecosystem balance of the Amazon, but they were also inherently inequitable. Credit-worthiness depended on land titles, thus the poor and untitled were unable to secure credit. In 1987 the subsidy element of rural credit was abolished, which should be in general beneficial to the environment. However in a few cases the removal of cheap credit has forced crop farmers to resort slash-and-burn as well as to livestock raising.

(c) The development of infrastructure has greatly contributed to the rates of deforestation. The National Integration Policy (PIN) established in 1970 allocated significant funds to the construction of roads, including the 15,000 kms east-west transamazon highway. A 20 kilometre strip of land was to be kept clear on either side of the highway for agricultural settlement. The motives of the highway programme were presented as being partly economic and social, opening up mining areas and relieving poverty in selective areas, however it must be accepted that a dominant motive was to secure national boundaries. Very little resettlement eventually took place, mainly because the soils adjacent to the highway were unsuited to agriculture and the forest clearance had contributed to the growth of populations of mosquitoes. Agricultural inputs were expensive, because of the large distances over which they had to be transported, and the same factor inhibited market sales. For the most part the environmental losses associated with the Transamazonia highway have probably ben small precisely because the project failed.Contrasting this experience with that of the north-south Cuiaba Porto Velho highway, which opened up the Rondonia area in the centre-west of Brazil to uncontrolled settlement. Substantial clearing took place along the highway, farmers exhibited a marked preference for livestock, and compensatory programmes introduced to retard the rates of deforestation failed. One of the reasons for this failure was institutional ineptitude, a rule whereby 50% of a plot was to be cleared went unenforced, subsidies for fertilisers intended to promote tree crops were never forthcoming, and finally no action was taken to prevent the land speculation which became rife in Rondonia. One calculation suggests that the clearance of 14 hectares of land for use as pasture, and then subsistence cropping over a two year period and then the sale of the rights of possession could result in a $9,000 capital gain. Incentives remain for such speculative land occupation, since the capital gains taxes are easily avoided by under-reporting, and the income tax code generally exempts agricultural income from taxation. this land speculation also encourages pasture formation because the costs of maintaining pasture are in general lower than that for crops.

In Amazonia it is policy towards agriculture which has accelerated the rates of deforestation. However in many cases policies aimed exclusively at the forest sector itself have encouraged deforestation in other countries. In general:

(i) Governments have systematically overstated the value of forests for timber, and have understated the value of non-timber forest products and the general productive functions of forests.

(ii) The value of forests as reservoirs of genetic information and sources of biodiversity has largely been ignored. The timber value of woods other than those emphasised as being of commercial value has been damaged because of this lack of information.

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(iii) For the most part the value of forest soils for agriculture have been greatly overstated. Policies to encourage agricultural development have been implemented with little thought to the low rates of return, and the consequent loss of biodiversity.

(iv) Forests have been shortsightedly employed as population sinks, spillover areas for crowded populations, without giving thought to the livelihood potential of such areas or to the environment-economy interactions.

(v) The forest sector has suffered serious underinvestment, and has been exploited to secure dubious employment and agricultural benefits. It has long been regarded as a low priority resource, mainly because its ecosystem functions were unexplored.

6.9 CONCLUSION

This volume indicates how institutional inertia, and misguided policy can impact negatively on the environment. The incentiv problem would seem to suggest that more explicit use be made of the self-interest of the individual and the common interests of groups of individuals. Devising effective and adequate policy to prevent natural resource degradation and depletion will require a complex knowledge of the underlying social norms and preferences. Incentives are likely to vary distinctly from one community to another.

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A COMPENDIUM OF PUBLICATIONS

E.B. Barbier (1990)
'Natural Resource Degradation, Policy, Economics and Management'
Paper for ODI Conference **The Environment, Development and Economic Research**, London.

This paper reviews recent developments in economic research on natural resource degradation in developing countries. It summarises the current gaps in our understanding of this problem and outlines future research needs. The discussion focuses on national and sectoral policy issues, the management of key natural resources - tropical forests, water resources, wetlands, drylands and arable soils. Barbier highlights the complex incentive structures that have developed over time through policy acretion, and highlights how these determine resource use. He emphasises that there is very little empirical understanding of the linkages between price changes, agricultural supply and demand responses, and natural resource usage.

E. B. Barbier (1988)
The Economics of Farm-Level Adoption of Soil Conservation Measures in the Uplands of Java

World Bank,
Environment Department Working Paper No. 11
Washington DC

Barbier examines the incentives for an upland farmer on Java to invest in soil conservation packages, he captures this in a simple model relating profitability to erodibility on privately owned land. The model is used to examine how this relationship is in turn influenced by changes in relative prices, the farmer's discount rate, different soil qualities, slopes and depths, input prices and population, including migration for off-farm employment. Although the result of the analysis is relatively straightforward - upland farmers will not modify their land management practices and farming systems unless it is in their direct economic interest to do so - the incentives for farming households to adopt conservation packages vary significantly. For example, in some cases, such as growing horticultural crops on volcanic soils in the steep uplands, there is little incentive for farmers to invest in conservation as soil erosion appears to have negligible effects on farm profitability. Other incentive effects can be traced directly to government policies, such as maintaining high relative prices for cassava and vegetables, high subsidies for fertilisers and the general poor availability of rural credit at affordable rates. More complex incentive effects arise from the relationship among the availability of off-farm employment, population pressure and land management in the uplands.

H. P. Binswanger (1989)
Brazilian Policies that Encourage Deforestation in the Amazon,
Environment Department, World Bank,
Working Paper No. 16,
Washington DC

This paper concentrates on the deleterious effects of general tax policies, tax incentives, land allocation, and agricultural credit, on the extent of deforestation in the Amazon. Binswanger focuses on five particular incentives which lead to the accelerated destruction of the Amazonian forests.

a) The existing means of land allocation which provides deforestation incentives. Squatters obtaining title to land are allowed under regularisation rules to acquire up to three times that area which they have cleared.

b) The existence of a progressive land tax which motivates the conversion of forest to crop land or pasture. Land tax can be significantly reduced depending upon the intensity of land use. Forest land is considered unused, thus a farm containing forest land is taxed at higher rates than one containing pasture or arable land.

c) The provision of agricultural tax havens further exacerbates deforestation. Agricultural income is effectively taxed at extremely low rates, if at all.

d) The design of a tax credit scheme which benefits corporate livestock ranches, subsidising inefficient ranch holdings established on deforested land.

e) A system of subsidised credit is also available for SUDAM approved ranches, this contributes to accelerated deforestation through the support of inefficiently large ranches.

Binswanger concludes that any policies implemented in the Amazon must take into account the established incentive structure, and where possible attempt to modify and amend it. He advocates a coherent system of land use planning that protects the more marginal lands in forest reserves, and establishes biological reserves. Further Binswanger stresses the importance of adequate enforcement mechanisms.

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J. Browder (1988)
'Public Policy and Deforestation in the Brazilian Amazon' in R. Repetto and M. Gillis (eds) **Public Policies and the Misuse of Forest Resources**,

Cambridge University Press,
Cambridge

This paper details the extent of deforestation region by region. In his analysis of deforestation Browder considers factors such as population growth and migration, the displacement of small farmers, inflation, rates of interest and government policies. Browder brings some interesting social and political motivations into play and provides complex economic and financial breakdown of the operation of a typical SUDAM supported ranch. Browder argues against the displacement of forest land in favour of alternative uses. It has been asserted that forest destruction may be justified if the alternative uses of forest land can be proved to bring about unambiguous benefits. In the case of cattle ranching Browder argues that not only is it economically untenable in the light of the need for enormous subsidies, but that it is also harmful to the environment. Conservation of the Amazons forest lands must be initiated on the basis of their value as an economic asset, which can generate benefits in perpetuity for the human and animal population.

George Foy and Herman Daly (1989)
Allocation, Distribution and Scale as Determinants of Environmental Degradation: Case Studies of Haiti, El Salvador and Costa Rica

World Bank, Environment Department Working Paper No.19
Washington DC

The authors consider the causes of environmental degradation in terms of the misallocation of resources as the result of government policy or market failure. They also consider how distributional factors may increase pressure on resources, leading to greater environmental degradation. Finally the authors consider the total human resource use relative to the carrying capacity of the environment, which they have termed "scale". After analysing each of these countries, they conclude that one of the most important causes of environmental degradation is maldistribution and the excessive scale of human resource use. Misallocation was not deemphasised, for it played an important role in exacerbating the overuse of resources. They give an insightful array of policies and corrective measures that may be employed to ameliorate the effects of "scale" and maldistribution. Research is needed on the theoretical macro-

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level integration of the problems of allocation and scale. They argue that their presentation of the "scale" dilemma has an incipient solution in the integration of natural resources into the national accounts, aiding the resolution of key environmental problems. Furthermore they stress that policy makers should integrate conventional macroeconomic stabilisation policy with that of environmental sustainability. In particular the authors advocate the use of structural adjustment loans which consider the effects of export incentives and other policies on environmental sustainability. Macroeconomic adjustment programmes which do not incorporate the scale constraints may result in the trade off of economic debt for the more serious long term accumulation of ecological debt.

M. Gillis (1988)
Indonesia: Public Policies, Resource Management, and the Tropical Forest, in R. Repetto and M. Gillis (eds) **Public Policies and the Misuse of Forest Resources**,

Cambridge University Press,
Cambridge

Gillis documents the case of Indonesia where deforestation and forest degradation constitutes a major problem. He focuses on poverty, the social and institutional framework, and policies that fail to provide disincentives against deforestation. There is the issue of royalties and license fees which contribute to forest depletion, the shortcomings of reforestation programmes, and the difficulties of committing tropical forest to sustainable yield farming because of the 70 year growing cycle. Gillis also considers at length the incentive structure, the taxes, subsidies, allowances, timber rents, migration policies, exchange rate, foreign trade and export incentives.

M. Kosmo (1989)
'Commercial Energy Subsidies in Developing Countries' in **Energy Policy** June (1989).

Kosmo examines the extensive use of commercial energy subsidies to petroleum products, electricity, natural gas and coal, throughout the developing world. In almost all of the countries studied the prices were found not to reflect opportunity costs. Kosmo drives home the point that many of the developing countries will face serious balance of payments problems if steps are not taken to reduce these subsidies, to curb domestic oil consumption, and preserve exports. World energy prices have currently stabilised, thus opportunity exists for countries to rationalise energy prices, since the economic and political costs of transition are relatively low.

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M. Kosmo (1989)
Economic Incentives and Industrial Pollution in Developing Countries

World Bank Environment Department Division Working Paper No. 1989-2
Washington DC

This paper examines the role of economic incentives and pricing policies in the management of industrial pollution. Specifically the paper focuses on input pricing, output pricing, trade policy, pollution charges and other taxe and subsidy instruments. The effects of various pricing instruments on resource allocation and, in turn, incentives for investments in industrial pollution abatement are addressed. Policy reform must consider the environmental implications of economic incentives and pricing policies. Although policies such as effluent charges and tax incentives for installation of pollution abatement equipment or relocation of industry should be considered, measures first need to be taken to remove existing distortions that discourage pollution abatement. Subsidies for water, electricity, and other forms of energy, price controls on final products that discourage product recovery by industrial enterprises, and trade policies which favour highly polluting industries are the most urgent areas for reform. Such reforms will improve the rate of return on investments in water and energy conservation and for product and by-product recovery.

D. Mahar (1989)
Government Policies and Deforestation in Brazil's Amazon Region,

World Bank,
Washington DC

This paper reviews the results of policy in the Amazonian region and their contribution to deforestation. It provides a useful insight into the shortcomings of current policies and thereby gives a basis for policy analysis, enabling policy makers to avoid the problems of government failure. Mahar gives a recent history of policy in the Amazon region and its intent, highlighting the pitfalls into which legislation can easily fall.

T.Panayotou (1989)
<u>The Economics of Environmental Degradation Problems, Causes and Responses</u>

Harvard Institute for International Development, Cambridge, Massachusetts, prepared for United States Agency for International Development

Panayotou examines resource degradation in terms of the market failures that accelerate environmental degradation - insecurity of resource ownership, thin markets, externalities and spillover effects, myopic planning horizons and high private and social discount rates. He also considers policy failures - project-related policy failures, urban industrial market and policy failures, trade policy failures and structural adjustment policy effects on resource degradation. The author reviews current policy in Amazonia, China, Kenya, Thailand, Papua New Guinea and Singapore citing both market and policy failures and the potential policy reforms.

D.Pearce (1988)
The Sustainable Use of Natural resources in Developing Countries
From R. K. Turner (ed) **<u>Sustainable Environmental Management:Principles and Practice</u>**,

Chapter 5. Belhaven Press,
London

The author considers the causal factors of natural resource degradation (NRD) and its extent. Pearce considers the marginal opportunity cost of non-sustainable resource use, which serves as a measure for the severity of NRD. In this article Pearce explores the causes of NRD, discussing the tragedy of the commons, noting that in this case there is a stable equilibrium where the resource is used sustainably. This paper takes a critical look at governmental failure and advocates that policy should be designed to take on board the unique social and economic preferences peculiar to the underlying incentive structure.

D. W. Pearce, E. Barbier, A. Markandya, (1990)
Sustainable Development: Economics and Environment in the Third World,

Chapter 5, Edward Elgar, London,

Chapter 5 considers the problems of sustainable forest resource management in Indonesia. The authors discuss the sources of deforestation, its costs, and the institutional and social framework that gives rise to deforestation incentives. They consider the demand for land its allocation and distribution, the avaliability of extractable rents and the existing forest management regimes. Throughout this discussion the authors pay careful attention to the potential policy reforms and the curernt incentive structure.

R. Repetto (1988)
Economic Policy Reform for Natural Resource Conservation

World Bank, Environment Department Working Paper No.4
Washington DC

Repetto summarises policy failure and outlines the need for incentive reforms. He considers various types of agricultural pricing scenarios and describes the consequent loss of forest cover and biodiversity,the effects on rates of soil degradation and erosion. He emphasises the linkages between input subsidy mismanagement and ecological destruction with respect to irrigation, the use of pesticides, fertilisers, and mechanised inputs.

I.Sebastian and A.Alicbusan (1989)
Sustainable Development: Issues in Adjustment Lending Policies

World bank, Environment Department Divisional Paper No.1989-6
World Bank, Washington

This paper considers structural adjustment lending to support policy reforms in developing countries. The central question examined in this report is whether the Bank's adjustment lending operations have caused environmental degradation in the developing countries. Whilst the general findings do not support this thesis, the authors do consider questions of policy failure and how such failures should be addressed within lending policy. The authors consider agricultural output price adjustments, changes in producer prices and export taxes, agricultural input price adjustments, reductions in subsidies for fertilisers, pesticides, farm equipment and credit schemes. This analysis makes careful note of the prevailing incentive and legislative structures and considers potential reform programs.

D.Southgate and D.W.Pearce (1988)
Agricultural Colonisation and Environmental Degradation in Frontier Developing Economies

World Bank, Environment Department Working Paper No.9. Washington DC.

Developed in this paper is a microeconomic model of agricultural colonists' choices among resource development options. The authors use the model to demonstrate that, under tenurial conditions typically found along a developing country agricultural frontier, a cycle of excessive deforestation and exhaustive management of existing farmland is bound to emerge. They also show that changing economic incentives or introducing new farming or resource management techniques can result in mixed environmental impatcs. For example, because it can diminish the scarcity value of labour, the introduction of conservation tillage can accelerate land clearing. Similarly, although it might render more benign the environmental impacts of any given level of migration to fragile lands, extending information on improved systems for managing those lands might also accelerate migration to hillsides, tropical forests, and other areas traversed by agricultural frontiers. They also discuss the implications of these and other results of the causal analysis of land degradation for the design of projects. In particular, the linkage between small farmers' decisions regarding the management of existing agricultural land and their decisions regarding land clearing needs to be appreciated when evaluating existing and alternative land tenure regimes, agricultural pricing policies, 'technical' solutions to resource degradation problems, and conservation projects.

W. Teplitz-Sembitzky and G. Schramm (1989)
Woodfuel Supply and Environmental Management

The World Bank and Energy Department, PPR. Industry and Energy Department Working Paper Energy Series Paper No. 19. Washington

The deterioration of the woodfuel resource base in developing countries is being increasingly perceived as a problem of land management. Given this focus, the economics of natural resource use can provide a framework appropriate for an integrated analysis of environmental and energy related issues of biomass resource management. The resulting policy implications underscore the virtues involved in the trend towards privatisation and commercialisation in agriculture and land titling. The government's role in this process is to improve and reinforce the incentive system for a more efficient and environmentally benign utilisation of natural resources, unless imbalances are pervasive and need to be redressed immediately. This article addresses the

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problems of woodfuel demand and supply, resource use in the village economy, and the policy implications. The authors consider common property, free access and private ownership regimes and compare their outcomes.

D.Whittington, A.Okorafor, A.Okore, A.McPhail (1990)
Cost Recovery Strategy for Rural Water Delivery in Nigeria

Infrastructure and Urban Development,
The World Bank

This paper is part of an effort to develop methodologies for estimating households' willingness to pay for improved water services. Special emphasis is being given in this research program to testing the usefulness and reliability of contingent valuation techniques in developing countries. This paper considers those economic and political factors that have made cost recovery for rural water systems so difficult in the Nsuska district of Anambra State, Nigeria. The authors interviewed 395 households in three communities in Anambra State concerning their household water use and storage practices, water expenditures, willingness to pay for improved water quality, and household socio-economic characteristics. The results of the analysis support the view that successful cost recovery in the rural water sector requires careful consideration of households' preferences regarding the way in which funds are collected for public water systems and the timing of such payments. the authors believe that a kiosk system in which individuals pay by the bucket for water would be more responsive to households' cash flow needs, and would provide a less expensive, more reliable and more flexible water vending system than the existing one.

1. R. Repetto (1988)

2. See Volume 5. S.Gammage and D.W.Pearce (1990)

ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME SEVEN

AGRICULTURAL PRICING AND RESOURCE DEGRADATION

S. GAMMAGE

REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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VOLUME 7

AGRICULTURAL PRICING AND RESOURCE DEGRADATION

7.1 INTRODUCTION

In order to examine resource use and environmental degradation we must first develop our understanding of economy-environment interactions. Resource use and consequently economic development are greatly affected by internal factors such as pricing controls, relative price movements, credit, taxes, subsidies, social norms and legislative practices. Resource use is also affected by external factors, exchange rate movements, international price movements, international demand and trading controls. The division between external and internal factors is not clear-cut. Relative prices are influenced by trade and exchange rate policies. Government policy is to a great extent determined by exchange rate movements, international competitiveness can be artificially maintained through a committment to undervalued exchange rates. Governments may be locked in to producer support prices which they may endeavour to uphold despite falls in international resource prices. This erodes government surpluses and therefore reduces government funds available for competing needs and investments.

This chapter attempts to summarise the literature on agricultural pricing and its affect on land use, resource use and development.

7.2 PRICE AND EXCHANGE RATE POLICIES

Price and exchange rate policy impact significantly on agricultural production. However, the general analysis suggests that such policies are not the most important factors affecting agricultural production and growth. Recent studies have shown that these policies have a relatively limited impact compared to other factors such as government manipulation of farm input supplies, population growth, government stimulated agricultural investment, etc.

In support of this one study undertaken by the World Bank [1] regards price and exchange rate policies as contributing to poor agricultural performance in Sub-Saharan Africa. Whilst there is considerable variation in agricultural growth between African countries, and similarly in policies, there is a general framework into which most policies and price distortions fall.

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[1] K.M.Cleaver (1985)

(a) Low Retail Food Prices

Official retail food prices for specific staples are kept artificially low. In order to achieve this two types of policy are pursued:

(i) Low official prices are paid to farmers/producers by parastatals or marketing boards, ensuring that final consumer prices are held artificially low. The burden of such pricing controls therefore falls on the producers.

(ii) Conversely these parastatals may pay high prices to the farmers/producers, whilst selling cheaply to consumers. Since these parastatals are government supported, the government effectively subsidises the consumer. Parastatals may also import foodstuffs, selling at a loss to ensure that subsidised food staples reach the consumer.

(b) Uniform Pricing

Pan-territorial uniform pricing is frequently employed. Farmgate prices (producer prices) are thus artificially fixed at the same level throughout the country, adjusting regional price disparities. Similarly wholesale and retail prices may be subject to such controls.

(c) Parallel Markets

Flexible price markets often coexist alongside price controlled markets, despite governments actively discouraging this in many cases. In these parallel markets prices are relatively free, although they are undeniably influenced by prices paid by competing parastatals.

(d) Exchange Rate Overvaluation

The exchange rates are often overvalued. Such a policy is typically employed in conjunction with import quotas and duties, as part of industrial protection measures. Vulnerable industries can be insulated against international competition. Whilst exchange rates are usually pegged and not freely floating in African countries, they are periodically adjusted. Adjustment also occurs when other currencies move relative to the pegged rate, or when domestic price inflation differs from that of other country trading partners. Governments typically seek to contain the impact that these relative price movements have on their exports and imports, contributing to internal price distortions.

(e) Subsidised Farm Inputs

Farm inputs are often subsidised. Ceilings on interest rates, credit subsidies, tax concessions can all be applied effectively to reduce the cost of vital inputs. Subsidies are often applied to fertilisers, irrigation water, certain types of high yield crop seeds, government research. These subsidies greatly affect the type and extent of resource use.

(f) Agricultural Export Taxes

Taxes are often levied on agricultural exports and are often used in conjunction with fixed official producer price supports, which effectively stabilise domestic prices insulating producers from volatile international price movements.

(g) Implicit Taxes

Although income tax is not typically levied upon farmers, an implicit tax results because of exchange rate policies and price fixing. Farmers are thus denied a free market on which to sell their goods, their incomes are effectively controlled by government activities.

7.3 POLICY MOTIVATION

As we have noted consumers often face artificially low retail food prices. One of the policy objectives could be distributional. Food is subsidised in order to provide the poor with their minimal nutritional requirements at a price that they can afford. Another equally important objective could be that of social and political stability. Those who are the main beneficiaries of subsidised food prices are often the urban populations who are not necessarily members of the extreme poor. Such urban beneficiaries are often a source of social and political instability, and are often the majority of the electorate. Governments may employ such policies to command political support and ensure social and political stability. A final objective could be the control of price inflation in staple foods. The trade of such staples contributes significantly to the maintenance of the cash economy.

These pricing policies impose a huge economic cost upon the government and upon its limited tax base. It is possible to achieve such objectives without the accompanying price distortions and at the expense of constrained economic development. Further, the resultant resource degradation that such policies often generate is at variance with the aim of sustainable economic growth.

7.4 DIRECT AND INDIRECT COSTS OF AGRICULTURAL PRICE POLICY

(a) Low Retail Food Prices, High Farm Producer Prices

(i) Direct Effects

Where parastatals guarantee low retail prices and high producer prices, the financial losses are subsidised by the government. There is thus financial transfer from the government to the parastatals. Government surpluses are eroded, and investment often declines. In Tanzania the financial losses incurred by such pricing policies in 1980-1981 amounted to twice the recurrent budget for agriculture. In Cameroon subsidies to the cotton parastatal alone were approximately 25% of agriculture's current budget in 1981.

(ii) Indirect Effects

The maintenance of artificially low consumer prices has caused the inevitable substitution in consumer diets of subsidised foods for non-subsidised foods. Producers of the unsubsidised foodstuffs suffer as their market shrinks accordingly.

Land substitution also occurs where producers switch crops into the subsidised food products. In many cases this has had the effect of drawing marginal lands into production, and encouraging rent-seeking unsustainable farming practices.

(b) Low Retail Food Prices, Low Farmer Producer Prices

(i) Direct Effects

Ensuring low retail food prices by paying producers at artificially low prices greatly affects crop production, land use, and the short-run and long-run potential supplies of these agricultural products. The supply elasticities, that is the percentage change in output that occurs in response to a one percent change in real prices, differ greatly in the short and long-run. This has important implications for aggregate agricultural production, agricultural investment, and land use.

The following table gives an example of how such elasticities differ in the short and long-run, they are among the lowest of the elasticities calculated and therefore represent the most limited of responses.

Table 7.1

Agricultural Supply Elasticities in Sub-Saharan Countries

Crop	Country	Short-Run Elasticity	Long-Run Elasticity
Cocoa	Ghana	0.39	0.77
Coffee	Africa	0.12	0.44
Cotton	Uganda	0.25	0.25
Groundnuts	Nigeria	0.24	0.24
Palm Kernels	Nigeria	0.22	0.22
Palm Oil	Nigeria	0.29	0.29
Rubber	Liberia	0.14	0.22
Sisal	Tanzania	0.06	0.48
Tobacco	Malawi	0.48	0.48

Source M.Bond 'Agricultural Responses to Prices in Sub-Saharan African Countries' IMF (1983). In K.Cleaver (1988)

This suggests that a 100% decrease in the price of cocoa paid to Ghanaian farmers will reduce the short-run production of cocoa by 39%. The long-run effect on the production of cocoa is even more severe, this 1% price decrease will reduce the long-run production of cocoa by 77%.

This supports the belief that farmers respond to changing commodity prices by altering their production of certain types of crops. However this tells us little about the overall changes in aggregate production. If cotton prices in Uganda decline relative to the price for coffee, farmers may substitute coffee production for cotton production, given technological and capital constraints. The effect that this has on aggregate agricultural production is ambiguous. This highlights the importance of distinguishing between the response of agricultural output to a general increase in prices and its response to changes in relative prices. A general increase in agricultural product prices can only result in higher output if additional resources, land, labour, technology, are brought forward. In many developing countries additional resources do not respond quickly to changes in aggregate demand. Relative price changes may promote significant agricultural response as substitution between crops and resources occurs. However the effect on aggregate output is ambiguous. Yet surveys indicate that certain responses can be mapped. If the products for which official prices are set artificially low command a significant proportion of farm output, farmers may revert to subsistence cultivation and black market trade across country borders. In some cases farmers may abandon agricultural production and seek alternative sources of income. This has on occasion promoted rural-urban migration, and contributed to the impoverishment of the rural poor. The cultivation of higher-priced agricultural products is infrequently undertaken, since the capital cost of changing crops and following alternative cultivation techniques is often inaffordable. In general, pricing policies which 'cap' prices contribute to declining aggregate production. The immediate production response is compounded in the long-run as farmers' incomes decline, so too does agricultural investment. Low prices also interact with the availability of credit, further reducing agricultural investment. As farm income declines access to credit markets is reduced. The availability of credit is vital to bridge gaps between production costs and sales. Hence many farmers are forced into subsistence farming, or to abandon cultivation completely.

Conversely, where agricultural prices are set artificially high, farmers are drawn into the cash economy, intensifying production, and extending land under crop. This can have a negative long-run effect on aggregate agricultural production whilst temporarily increasing current aggregates. Land is left fallow for increasingly smaller periods of time, and more unsustainable farming practices are initiated as the result of rent-seeking activities.

7.5 THE EMPIRICAL ANALYSIS OF THE IMPACT OF LOW FARM PRICES ON AGRICULTURAL GROWTH

The argument stated above are difficult to substantiate empirically. Casual observation, and anecdotal evidence would seem to support these supply responses However, aggregate supply responses cannot be gauged by simply averaging individual commodity supply responses. The time lags inherent in these scenarios make the aggregate response difficult to ascertain. Data is often inaccurate or incomplete, and the extent of the black economy difficult to project. An added complication, is that if agricultural prices for cash crops increase in aggregate, cash crop production may increase at the expense of the production of subsistence crops. Subsistence crop production is not documented, thus measures of aggregate production are insufficient. For these reasons the use of time series data for agricultural production, and traditional regression theory are often difficult to apply.

'Agricultural production' typically refers to export crop production, since the data for export crops is invariably more reliable and readily available than the corresponding data for food crops. The majority of internally marketed food production occurs through unregistered and informal channels. Where documentation does exist, it pertains to areas on the periphery of urban centers, and is thus not extensive. Such data also disproportionally exhibit regional price distortions, and are not representative of prices prevailing across these boundaries.
Official production indices reveal marked inconsistencies, aggregates are often maintained by several government ministries and appear contradictory. Where producer prices are officially fixed, there is widespread evidence that such trading does not occur at these prices. Such anomalies only serve to complicate the task of divining the effects of pricing regimes on aggregate agricultural production.

(a) Methodology

Fones-Sundell's study of agricultural pricing proceeds as follows.[2]

It was first necessary to determine the extent to which farmers faced price discrimination in the sample of 31 Sub-Saharan African countries studied. Price discrimination was measured comparing farmgate prices with import and export parity prices adjusted to reflect farmgate prices in the countries' trading partners. This gave an indication of the degree of nominal protection that was being applied to the particular agricultural product. Average farm level nominal protection coefficients were then derived for the 31 countries. Data covering a large number of commodities was drawn from World Bank Agricultural Sector Surveys which had taken place, pooling 5 years of relevant statistics. The index employed is thus subject to a large degree of measurement error, however it may indicate general trends.

Countries were then categorised into those experiencing low, medium and high levels of price discrimination. Price discrimination refers to all forms of producer support prices, fixed at different levels, as summarised on page 2.

[2] M.Fones-Sundell (1987)

Table 7.2

Price Discrimination and Agricultural Growth Rates

Countries with Low or No Farm Price Discrimination	Average Growth Rate of Agricultural Production (1970-1981) % p.a.
Chad	0.7
Malawi	4.1
Upper Volta	1.4
Rwanda	3.0
Somalia	-0.6
Central African Republic	2.3
Kenya	4.2
Lesotho	4.3
Zimbabwe	-0.5
Cameroon	3.9
Botswana	8.5
Congo	2.1
Ivory Coast	4.7
	2.9

Countries with Medium Farm Price Discrimination	
Mali	4.0
Burundi	2.2
Niger	-3.0
Sudan	2.3
Senegal	2.6
Liberia	5.0
Zambia	1.8
Nigeria	-0.4
	1.8

Countries with High Farm Price Discrimination	Average Growth Rate of Agricultural Production (1970-1981) % p.a.
Zaire	1.5
Ethiopia	0.9
Uganda	-0.8
Tanzania	3.3
Guinea	-0.7
Benin	0.0
Sierra Leone	2.4
Madagascar	0.3
Togo	1.5
Ghana	0.0
	0.8

Table 7.2 reveals a marked dispersion in agricultural growth, and the extent to which policy discriminates against farm producer prices.

From inspection, this would indicate that countries in which producer price discrimination was low experienced higher average agricultural growth rates, 2.9% p.a. compared with 1.8% and 0.8%.

Price distortion of all forms may be regarded as depressing rates of agricultural growth and contributing to complicated internal incentive structures.

7.6 AGRICULTURAL PRICING POLICIES AND ENVIRONMENTAL DEGRADATION[3]

If there were no transport costs, no government imposed price distortions, import taxes, quotas or subsidies the gap between producer prices, consumer prices and world prices would be equalised through arbitrage. Arbitrage occurs when profits are competed away, causing market prices to fully reflect the social cost of output. However the conditions for arbitrage to hold require the operation of perfect competition, the resolution of all externalities, and the efficient exchange of information. Distortionary pricing and border constraints, import duties, taxes and quotas, allow rents to be maintained and impedes the natural process of arbitrage.

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[3] S.Barrett and C.Heady (1988)

Where agricultural pricing policies result in such distortion, prices diverge from their socially efficient values, their shadow prices, and the incentive structure no longer promotes the efficient use of resources. This has important consequences for the renewable natural resource base. The operation of producer support prices in conjunction with input subsidies may encourage the use of certain agricultural methods which may have adverse effects on other agricultural activities. If this externality is not internalised, it will not be fully reflected in the price mechanism. The following illustration of how such pricing policies impact on desertification in the Sahel serves to emphasise however, that setting agricultural producer prices equal to prevailing world prices may not resolve these externalities. World prices consistently fail to reflect the shadow prices of agricultural products, since environmental externalities remain unresolved worldwide. Pricing policies can be usefully employed to ensure that ecologically destructive farming methods are not pursued, whilst the use of ecologically beneficial methods are encouraged. It is not the reliance on pricing policies per se that results in poorly devised incentive structures, rather it is their misuse that can entrench ecological destruction.

(a) Desertification in the Sahel

Desertification describes the process of environmental degradation, or declining biological productivity in arid or semi-arid lands. If this process continues unabated, soil erosion increases as watersheds and vegetative cover diminish, this leads to the extension of desert-like conditions. Desertification can be the result of various forms of environmental degradation. The environmental indicators of desertification are numerous, reductions in vegetative cover, increasing rates of soil erosion, soil compaction, salinisation and waterlogging on over-irrigated lands, nutrient leaching, and general reductions in soil fertility. This study of desertification focuses on the consequences it holds for agricultural output, livestock and fuelwood yields, and on economic performance.

Desertification in the sense of declining soil productivity is not a trivial problem in the Sahel, it is pervasive. One recent study of the Sudano-Sahelian region revealed that 96% of the regions 814 million hectares of rangeland, 85% of its 27 million hectares of rainfed cropland, and 13% of its 2 million hectares of irrigated land had been affected by desertification. [4] Extensive desertification is concentrated in the rangelands, yet the economic impacts are felt more severely in the croplands. The economic costs per hectare of salinised irrigated lands and desertified rainfed cropland are estimated to be 100 and 33 times

[4] Y. F. Ahmad and M. Kassas (1987)

greater respectively than the equivalent economic cost of desertified rangeland. [5]

(b) Causes of Desertification

(i) Drought due to climatic variation is one of the single most important factors contributing to desertification.

(ii) Environmental mismanagement has also contributed to the extensive degradation of the Sahelian lands. This mismanagement has manifested itself in overgrazing practices, insufficient afforestation, the spread of agriculture throughout marginal lands, unsustainable farming practices, shorter fallow periods, inefficient production mix with the overuse of environmentally destructive crops, policies that have encouraged environmentally destructive inputs such as deep machine ploughs on thin soils, and insufficient investment in soil conservation such as terracing, agroforestry etc.

Mismanagement is almost wholly due to poor pricing policies, input subsidies, unsound property regimes, legislative measures, unresolved market and government failure. The ensuing incentives promote resource exploitation, and rent-seeking activities which are ecologically destructive.

In Niger the government provides open access irrigation pumping stations. This has unfortunately led to severe overgrazing in the vicinity of these wells. Overgrazing leads to soil compaction, erosion and eventually to desertification. Whilst there is a zero access price for the use of these wells, the social costs are positive and significant. This externality could be potentially internalised or resolved by altering the property regime, conferring communal management or fixed access rights, or by charging a fee for use of the facilities.

The price mechanism can provide a useful tool for internalising externalities. However, it is not the only source of correcting poorly structured incentives. The choice of the appropriate mechanism will depend on the unique and country specific determinants of environmental destruction. Social structures vary significantly. It is worthwhile noting that the "fee" solution would not be viable in Muslim countries where water is imbued with religious and sanctified properties.

[5] H. E. Dregne (1984)

7.6 A BREAKDOWN OF PRICING POLICIES AND THEIR EFFECT ON ENVIRONMENTAL DEGRADATION

Demand indices and satellite imagery can be used to monitor effect of changes in pricing regimes. However, the changes in agricultural prices and their affect on conservation practices are more difficult to assess. To analyse the effects of such price changes on farming and conservation practices we must examine how such changes impact on decision making and choice variables.

Farmers face a number of decisions: the choice of cash crop cultivation or subsistence agriculture, the choice of crop and cropping methods; the choice of inputs and their quantities, labour, machinery, fertilisers; the long run choice of how much land to put under tillage or crop. These decisions are overdetermined by the farmgate prices which they face, the availability of rents, credit subsidies, tax concessions, income and budget constraints.

(a) Output Price Distortions

Consider the theoretical environmental impact of an increase in farmgate prices. The effect of this price rise on soil conservation is likely to be ambiguous. The farmer must choose a cropping practice that balances the short-term benefit of erosion against the long-term benefit of conservation. The use of more erosive cropping practices, shortening the duration of fallow periods or decreasing the amount of land under permanent vegetative cover, can temporarily increase yields in the short-run. However the consequences of such actions will impact on long-term soil productivity. The choice of sustainable agricultural practices will depend acutely on the temporary or permanent nature of the price rise and the farmers' expectations of this, and the internal or private discount rate faced by farmers.

If the output price rise is considered to be permanent, the benefits of short term resource exploitation increase, so too will the benefits of long term conservation practices. It is likely that both benefits will increase equivalently and that the net affect on conservation practices will be neutral. However this scenario fails to include the effects of internal discount rates on the choice of agricultural practices. If individual farmers face very high private discount rates the value of the long-term rise in benefits accruing to soil conservation may be less than the value to the farmers' of the short term benefits of unsustainable farming practices. This will significantly affect the choice of farming practices. If the price rise is permanent, the effect of a rise in agricultural incomes may decrease private discount rates altering the amount of present consumption farmers are willing to forgo for future consumption. Whilst the price rise may not have a direct effect on present soil conservation practices, it may have an indirect effect, raising agricultural incomes and leading farmers to attach greater weight to future consumption and hence to the adoption of less destructive cropping practices.

Barbier [6] explores the issue of changes in the relative price of agricultural output and the subsequent effect on the adoption of soil conservation packages, using a model relating profitability to erodibility on privately owned land. Output is assumed to be a positive function of soil depth and a vector summarising all traditional productive inputs. However the use of these inputs increases soil loss at an accelerating rate. The farmers are also faced with an alternative combination of inputs which summarises appropriate soil conservation measures. This "package" may involve changes in cropping patterns, fertiliser application, the adoption of terracing measures or the choice of the crop itself. Barbier found that in the long run, the cost of soil erosion increases unambiguously as the relative price of the agricultural output, produced with the traditional input package, rises. Whether the long run soil depth will decrease, remain the same or increase, depends on whether the negative impact on soil erosion of this increase in the output price will exceed the positive impact on the current productivity of the traditional production methods. Consequently the impact of a change in the relative price of the output is significantly influenced by the effect of the increased use of productive inputs on soil degradation. This effect may in turn be influenced by the soil characteristics.

(i) On the poor quality shallow limestone-based soils, found in certain of the upland areas studied, the marginal productivity of the soil is generally low, hence the boost to soil productivity of using additional productive inputs is close to zero. Despite this low marginal productivity the response to output price increases is to increase the use of productive inputs. However the impacts of these inputs on soil degradation are substantial. Thus, as the price of the output increases so does the long run soil degradation, and soil depth declines drastically.

(ii) This contrasts with the experience of cropping practices on the deep, highly productive volcanic soils. Here the marginal productivity of the soil is quite large and additional productive inputs yield significant soil productivity returns. Further, the topsoil extends to a greater depth, increasing the time period before which soil erosion severely reduces

[6] E. B. Barbier (1988)

soil productivity. Thus the long run impact of current cropping practices on decreased topsoil depth and soil productivity may be negligible.

These soils are also particularly suited to erosive high-value horticultural crop cultivation. However since the topsoil depths are so great and the rates of erosion exert little influence on soil productivity, incentives to invest in soil conservation measures are depressed. Further the impacts of erosive high-value crops are not localised, the full cost of such cropping practices are not felt by the farmers themselves and this externality remains largely unresolved. Over the period 1976-86 the terms of trade for such crops have improved substantially, with relative prices rising largely because of government import controls and increased urban demand. In conjunction with the topsoil status this has further inhibited investment in conservation measures.

Policy failure occurs not only with the maintenance of artificially high farmgate prices, or other such subsidies to agriculture. Often the prevailing ouput prices do not reflect the true economic cost of the resources employed. Where this can be seen to have a significant effect on resource use and cropping practices is in forest clearance. There is now sufficient economic evidence linking the tropical deforestation problem to mismanaged incentives and poorly structured policy. All too often the pricing policies pursued in countries with tracts of tropical forest distort the full cost of deforestation: [7]

(i) The prices determined for tropical timber products derived from converted forest land do not reflect the true economic cost in terms of forgone timber rentals, forgone minor forest products and other direct uses such as tourism, disrupted forest protection and other ecological functions, the loss of biodiversity, and the loss of option or existence values.

(ii) The direct costs of harvesting and converting tropical forests are often subsidised and/or distorted, thus promoting needless forest cover depletion and watershed destruction.

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[7] E. Barbier (1990)

Figure 7.1

Raised Output Prices, Farming Decisions and their Environmental Impacts

- Trigger
  Raised Farmgate Prices
  - Responses
    - Switch crops (No Aggregate Response)
      - Substitution Between Commercial Crops
        - Resource Impact Depends on
          - Suitability of New Crop to soils, farming practices, conservation methods, adopted;
            - could result in soil degradation cassava, peanuts or Soil less Degrading/ enhancing coffee, tea
      - Substitution Between Commercial/ Subsistence
        - Resoure Impact Depends
          - Nature of commercial crop
          - How Subsistence Agriculture is practiced
            - Movement to Marginal Lands: Deforestation soil Degradation
    - Aggregate output Expands
      - Intensive Agriculture
        - Generally little damage **But** can result negative impact of fertiliser pesticides. excessive irrigation
      - Extensive Agriculture
        - Deforestation from Agricultural Expansion

More Generally due to poor information poorly managed pricing of Agricultural inputs etc.

Note: this provides a very general descriptive response to raised agricultural output prices, it ignores output price input price dynamics; input resource and time constraints; and rationed access to capital markets and credit facilities.

(b) Input Price Distortions

(i) Fertilisers and Soil Conservation Inputs

Inputs such as fertilisers are often used to offset the effects of soil loss on output. For example, if erosion reduces soil depth farmers may respond by employing seed varieties that are more responsive to fertiliser or more tolerant to toxic materials in the subsoil, this effectively extends the crop rooting zone. However the rate of erosion is determined more by the type of farming practice than by the use of particular inputs. Thus the removal of input subsidies is unlikely to have a direct effect on soil conservation, yet there may be indirect effects. Those inputs employed to offset the detrimental effects of erosion-induced productivity declines may themselves be environmentally harmful. If the price of fertiliser rises farmers may respond by increasing the use of irrigation water. This can promote increased salinisation and waterlogging. In addition this rise in input price may reduce agricultural incomes altering private discount rates and thus affecting soil conservation and sustainable farming practices. [8]

The Barbier study (1988) also focuses on the effects of an increase in the cost of the traditional input package and its subsequent effect on the adoption of alternative inputs with a conservation component. In the long run, an increase in the costs of the traditional input package will result in decreased soil degradation. However the profile of soil erosion depends on the impact of reduced soil degradation relative to its effect on soil productivity. Thus on poorer quality soils, where the impact of additional productive inputs on soil productivity is negligible whilst their impact on soil degradation is high, an increase in the cost of the traditional input package might promote conservation investments.

However, the prolonged exposure to certain subsidised inputs, such as fertiliser, might provide a disincentive to invest in conservation measures. The increased application of fertilisers might artificially boost soil productivity in the short run, even on severely degraded soils. Such subsidies encourage farmers to apply fertilisers to increase yields rather than to consider the adoption of more expensive yet environmentally benign methods of maintaining soil productivity such as "green manuring", mulching, and compost application. Carson [9] noted that in Ngadas, East Java, farmers were using over 1,000 kg of subsidised chemical fertilisers per hectare to produce two 10 tonne potato crops. These yields were less than half what could be obtained with

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[8] C. Heady and S. Barrett (1988)

[9] B. Carson (1987)

improved soil management techniques. They subsequently began to increase their use of organic fertilisers in response to this realisation. This underscores the point that agricultural subsidies to certain inputs can retard the adoption of adequate conservation measures and the use of environmentally benign cropping practices.

Consider an increase in the cost of soil conservation inputs. As soil protection becomes more expensive, the long run soil value will increase. The relative impact of increased soil degradation must be weighed against the potential boost to current soil productivity from the use of additional productive inputs. It is this that determines the long run decline in topsoil depth. Barbier notes that in general, for most of the uplands of Java, we would expect to see a long-run increase in soil erosion. Most of the upland conservation projects have chosen to subsidise certain inputs, particularly farm labour. Labour is an essential requirement for most of the proposed conservation schemes. These subsidies provide essential incentives for the poorer farmers to adopt conservation practices. For example, in Gubugklakah, East Java, only the relatively wealthy farmers engaged in the more profitable commercial apple production were able to afford to construct the backsloping tied ridges which conserve topsoil and retard soil erosion rates.[10] Whilst Barbier draws attention to other examples of conservation measures not being adopted because of farmer's budget constraints, he also observes that bench-terracing is increasingly being taken up by non-input-subsidised farmers. Despite their use of non-subsidised inputs being less than project farmers who were subsidised for these inputs, the "spontaneous" adaptors nevertheless significantly increased their income.

(i) Subsidies of conservation packages need not always be necessary where farmers do not face restrictive budget constraints and economic gain can be perceived.

(ii) Subsidies, where they are employed, should have minimal distortionary effects and be aptly focused to ensure that benefits are not being transferred to the non-poor with needless revenue losses.

Designing appropriate policy responses to control soil erosion and land degradation is particularly hampered by developing country data limitations and the dirth of micro-economic analyses of farmers' responses to erosion and their incentives to adopt soil conservation measures. There are some indications that subsidies to non-labour inputs such as inorganic fertilisers can artificially reduce soil erosion costs to farmers. Certainly their is anecdotal evidence that on resource-poor lands farmers substitute subsidised fertilisers for manure, mulches and

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[10] Carson (1987)

nitrogen-fixing crops that are environmentally benign.

Conversely, shortages of inorganic fertilisers brought about through the deliberate rationing of cheap fertiliser imports can lead to sub-optimal application and may encourage unsustainable farming practices.[11]

(ii) Pesticides

The widespread use of agricultural pesticides poses a serious threat to health and ecosystems alike. Very little is known by users about the dangers in using highly toxic substances. Farmers and farmworkers are often extensively exposed to pesticides that are banned or severely restricted in the U.S. and other industrial countries.

In Indonesia, Malaysia, and Thailand fish stocks in irrigated paddies, irrigation channels, and ponds have been greatly reduced by pesticide poisoning. In Indonesia the pesticide Sevin was used to eradicate the brown planthopper in rice fields, although it is known to accelerate the evolution of new planthopper biotypes. As a result of Sevin application the pest resistence of two Indonesian rice varieties was destroyed, and that of high yielding hybrid rice crops was drastically impaired. These ecological consequences have sharply increased the risks of crop losses and raised the costs of plant protection in the affected areas.

At a worldwide level, by 1980 over 400 insect pests had developed resistance to pesticides, as had certain varieties of weed, rodents, and microorganisms that cause plant diseases. The number of pesticide resistant species is growing exponentially with the result that many species are resistant to a whole range of chemicals. Pest resistance has brought farmers in some regions to the point of bankruptcy, and as the costs of developing new safe and effective pesticides rise, these problems are becoming more serious.

Despite this realisation many developing country governments are heavily subsidising pesticide sales to farmers. In nine developing countries in Asia, Latin America, and Africa, subsidy rates range from 15 to 90% of full retail cost, with a median level of 44%. These subsidies cost governments hundreds of millions of dollars in direct outlays and foregone revenues, Table 7.3.

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[11] E. Barbier (1990)

Table 7.3

Estimated Average Rate and Value of Pesticide Subsidies

Country	Percentage of Full Retail Costs	Value ($U.S. millions)	Per Capita ($U.S.)
Senegal	89%	4	0.7
Egypt	83%	207	4.7
Ghana	67%	20	1.7
Honduras	29%	12	3.0
Columbia	44%	69	2.5
Ecuador	41%	14	1.7
Indonesia	82%	128	0.8
Pakistan	negl	negl	-
China	19%	285	0.3

World Resources Institute, Paying the Price: Pesticide Subsidies in Developing Countries (December 1985)

These incentives were originally devised to give impetus to farmers to adopt unfamiliar agricultural technologies. Despite the revision of thought with respect to the application of pesticides many of these subsidies remain. In some countries subsidies are rationalised as offsets to producers for agricultural prices which are being held artificially low.
Since pesticide subsidies are provided through tax and tariff concessions, low-interest farm credits, and incentives for local manufacturers, as well as through direct marketing subsidies, many governments do not even have accurate estimates of the total amounts of subsidy available.

Little research or analysis has been undertaken to discover how price subsidies affect farmers' decisions regarding pesticide use, the distributional impacts of such subsidies, their focus and the resultant ecological damage. Repetto found that in Honduras, Ecuador, and Pakistan, a substantial proportion of the subsidies provided by the respective governments were being absorbed by business in high distribution margins, contrary to policy aims. To the extent to which subsidies reach target farmers, their distribution conforms to the distribution of landholdings, which is in most of these countries highly skewed. Yet most occupational poisonings and pesticide-related illnesses are concentrated amongst the landless hired farmworkers or small farmers.[12]

[12] R.Repetto (1988)

(iii) Irrigation

The majority of irrigation developments in the developing countries are through public investments, which are heavily subsidised. Distributional considerations, political concerns and the prevalent belief that water holds "free good" status, have led to charges well below the true cost of supply. This has led to inefficient allocation, poorly maintained irrigation networks, rent-seeking, and wastage. This has also furthered unnecessary investment in major surface water developments, such as dams, canals and other large scale irrigation networks. The environmental impacts of such policies are significant:

- The discincentive to conserve water can lead to problems of water-logging, salinisation and water scarcity.

- Major irrigation investments and their associated infrastructure - dams, canals, communications - have significantly altered environments, the characteristics of pre-existing human settlement, forest and vegetative cover, watersheds and resource use. Large tracts of land have been opened up for commercial usage, populations have been displaced, agricultural and forest land has been irretrievably lost, and hydrological systems have been extensively altered. These factors have contributed markedly to increases in rates of erosion, sedimentation, salinisation, water-logging and water table disruption.

In India 10 million hectares of irrigated land has been lost through water-logging and 25 million hectares are threatened by salinisation. In Java water scarcity has become a severe problem. Agricultural irrigation demands account for about 47% of the total potential water resources available and 75% of the dry season/year flow. Given the expected future demands for all water usage, the poor cost of recovery and the prevailing inefficiencies in irrigation, water scarcity is becoming a chronic problem.

(iv) Mechanisation Subsidies

Throughout much of the developing world the mechanisation of agriculture has been promoted, employing a wide variety of both direct and indirect subsidies. Agricultural machinery and equipment receive favourable tariff and exchange rate treatment and they are typically afforded high priority when rationed foreign exchange is allocated. Excise and sales taxes are waived, domestic taxation is minimal, and liberal depreciation allowances, credit and fuel subsidies are provided for mechanised inputs. In Brazil the government allows owners to claim up to six times the purchase price of farm machinery in depreciation allowances, thus creating significant tax shelters for large farmers.

These direct and indirect subsidies are highly inefficient, inequitable and often lead to unsustainable farming practices and significant land degradation. Generous mechanisation subsidies lead to inefficient patterns of agricultural production, inducing farmers to use equipment even when it is both uneconomical and impracticable to do so. This has resulted in labour displacement, reducing rural employment prospects and exacerbating rural poverty and rural-urban migration. Equipment subsidies have also promoted inefficient forest clearance by lowering the financial costs of land preparation, and changing the scale and impacts of the operation.

Machinery subsidies favour large landowners and large farm operators, indivisibilities, economies of scale, capital constraints and differential access to credit facilities perpetuate this inequality. Small holders unlikely to benefit from these subsidies are put at a comparative disadvantage to larger farmers. In addition, since many smallholders derive significant amounts of income from agricultural wage labour, mechanisation has greatly reduced their income-earning opportunities.

Mechanisation incentives have also resulted in excessive damage to natural systems. For example, forest clearance with heavy equipment has had devastating effects on underlying soils. Bulldozers have been used to clear tracts of forest land and in the process many of the vital nutrients in the biomass have been lost, thin topsoils have been greatly degraded, compaction has occured preventing water from percolating through the soils and erosion rates have been increased. Even in the less vulnerable soils, where compaction has occured the soil porosity has been reduced contributing to increased runoff, leaching and heightened susceptibility to erosion.

> " In general, therefore, reducing or eliminating subsidies for agricultural mechanisation, is a good example of a complementary policy change, which would serve the objectives of economic efficiency, equity, fiscal stability, and natural resource conservation."[13]

(v) Credit Subsidies

Credit subsidies are as widespread as fertiliser and mechanisation subsidies. They are often employed as an indirect means of achieving subsidies to other inputs. They are typically complex and interact with the established profile of taxation to produce highly inequitable subsidies to large farmers.

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[13] R. Repetto (1988)

Special loan funds are often established in developing countries for:

- purchasing specific inputs, such as chemical fertilisers, pesticides, mechanised inputs, etc;
- acquiring specific assets, such as cattle or tractors;
- purchasing specific crops, such as rubber or oil palm;
- developing tracts of land, clearing forests, constructing conservation works, building on-farm irrigation structures, etc;

Interest rate ceilings are imposed by regulation; loans are often subsidised, usually allowing lending agencies to discount their loans with the monetary authorities at favourable rates. In inflationary economies, the real rate of interest can often be well below zero. Default rates are also often very high, since the lending institutions are largely absolved from risk.

The allocative, distributive and efficiency effects of offering such credit subsidies are unclear, so too is their impact on the profile of resource use. Only when loans are tied to specific and verifiable activities, the acquisition of certain assets and the pursuit of certain activities which might otherwise have been marginally attractve, can ecosystem degradation be attributed to credit subsidies. The fungibility of such credit schemes prevents many environmentally unsound activities from being traced to the provision of credit.

What can be concluded is that where the incentive structure is sufficiently complex, the sustained provision of credit can only serve to obscure price signals and produce further distortionary effects. The analysis of credit should focus carefully on the recipients of discretionary allowances and tax ceilings, drawing attention to the entrenched inequities and the probable impacts on resource use.

7.8 SUBSIDY REMOVAL OR RESTRUCTURING

The decision whether to remove input subsidies should be made with careful thought to the price elasticities of these inputs, the potential agricultural supply response and the consequent effects on environmentally destructive farming practices. Amongst the developing nations there exist a wide dispersion of such price and output elasticities. This can only serve to highlight the diverse effects that input subsidisation may have on farming practices, agricultural output and agricultural incomes.

Table 7.4

Fertiliser Demand Elasticities

Country	Mean	Range (No. of Estimates Reported)	Mean	Range (No. of Estimates Reported)
Asian Countries	-0.40	-0.27 to -0.51 (4)	-0.90	-0.87 to -0.92 (2)
Taiwan	-1.27	-0.55 to -2.03 (3)	-1.61	-0.90 to -2.97 (3)
Thailand	-0.84	-0.83 to -0.85 (2)		
Philippines	-0.44	-0.30 to -0.59 (2)	-2.92	-2.91 to -2.94 (2)
Korea	-0.43	-0.17 to -0.70 (2)	-0.92	-0.88 to -0.95 (3)
Japan	-0.46	(1)	-0.73	-0.72 to 0.75 (3)
India	-0.85	-0.17 to -1.08 (7)	-1.62	-0.34 to -2.48 (4)
Sri Lanka			-0.87	-0.87 to -0.88 (2)
Pakistan	-0.82	-0.49 to -1.48 (7)		
Mean Sample Asian Countries	-0.73		-1.44	
Brazil	0.72	-0.33 to -1.12 (3)	-1.94	(1)
Egypt: Nitrogen	-1.11	-0.68 to -1.65 (4)		
Phosphorus	-2.22	-0.96 to -3.06 (4)		
Mean Sample Devg. Countries	-0.92		-1.52	
U.S.	-0.78	-0.39 to -1.71 (9)	-1.73	-1.10 to -2.10 (3)
U.K.	-1.40	-1.10 to -1.70 (2)		
Mean: All Sample Countries	-0.94		-1.54	

Table 7.5
Farm Machinery Demand Elasticities

COUNTRY	SHORT-RUN	LONG-RUN	ELASTICITIES a/	COMMENTS
			-0.002	
Taiwan	-1.00			
			-0.005	
Philippines	0.08 n.s.			
Thailand	-0.29			Farms with animal-power farming systems
	-0.40 to -0.48			Farms with tractor-power farming systems
Japan	-0.57			Supply response of rice corn cotton
Egypt	-0.77 to -2.38		-1.36 -1.78 -3.03	Study by Binswanger
U.S.	-0.85 to -1.09			By Griliches: price reflects the actual prices paid for tractors
	-0.25 to 0.45	-1.50 to -2.60		
	-1.20 to -1.80	-6.90 to -10.30		By Griliches: price reflects the farm mortgate interest rate

Table 7.6
Cross-Price Elasticities of Fertiliser, Machinery and Labour[a]

COUNTRY	F-M/M-F	F-L/L-F	M-L/L-M	COMMENTS
Taiwan	-0.002/-0.23	-0.98/-0.23	-0.98/-0.002	
Philippines	-0.72/-0.45	0.35/ 0.01	0.16/ 0.01	
Thailand	5.73/ 0.05	53.06/ 0.09	0.19/ 0.04	With animal-power farming systems
	-0.20/-0.01	-1.76/-0.05	0.04/0.02	With tractor-power farming systems
India		-0.35/-0.14 0.14/ 0.10 0.07/ 0.02 -1.61/-0.003		wheat crop paddy cotton gram
Egypt	-1.27/-0.42	-2.49/-0.58	-2.11/-1.49	For nitrogenous fertilizers
	-1.24/-0.02	-3.10/-0.04	-2.11/-1.49	Phosphorous
U.S.	-0.10/-0.02	-0.49/-0.06	0.26/ 0.13	

Source Alicbusan op cit

a - F is fertiliser, M is farm machinery, L is labour. The input pair symbol e.g. F-M, denotes the change in the qunatity demanded on the lefthand-side input F due to a change in the price of the righthand-side factor M.

7.9 EXCHANGE RATE POLICY AND AGRICULTURAL GROWTH

Another possible source of variation in agricultural growth in many countries is the consistent over-valuation of the exchange rate. The IMF 1982 World Economic Outlook reported that real effective exchange rates for African countries appreciated by 44% over the period 1973-1981. This appreciation was rarely a deliberate result of domestic policies. Rather it occured involuntarily as fiscal and monetary expansion policies are pursued with the intention of stimulating aggregate demand and economic growth. This increase in demand feeds through to an increase in price inflation. Where inflation occurs that is in excess of that experienced amongst the country's direct trading partners, this puts pressure on exchange rates forcing them to appreciate. Governments may employ trading quotas and tariffs to protect vulnerable industries from external competition, this often occurs with newly developing or ailing industries. This allows the domestic industry to increase the price of its output, hence it is equivalent to an outward shift in the industry demand curve. The official exchange rate will typically overvalue domestic currency relative to foreign currency, since domestic prices will be higher than foreign prices. However, real exchange rate fluctuations can result because of relative movements in the values of other countries' currencies. Domestic currency appreciation is not necessarily due to internal policy. It is generally asserted that exchange rate overvaluation will impact negatively on agricultural growth.

(a) Direct Effects of Exchange Rate Overvaluation

When domestic currency is significantly overvalued, domestic exporters receive less domestic currency in real terms from international trade. Agricultural exports are thought to be particularly vulnerable to such exchange rate movements since agricultural supply elasticities are typically quite high. Producer prices are thus kept artificially low by an overvalued exchange rate, unless parastatals intervene to guarantee fixed output prices. Empirical studies show a high response of export crop production to such price variations. The response differs over time generally exhibiting larger long-run supply elasticities.

(b) Indirect Effects of Exchange Rate Overvaluation

Exchange rate overvaluation causes direct "income effects" and also indirect "substitution" responses. An overvalued currency means that the domestic purchasing power in terms of foreign imports has risen. The domestic currency cost of imported foodstuffs decreases, consumers substitute foreign imports for domestically produced foodstuffs. Food is often imported duty free, domestic producers are forced into competition with artificially cheapened foreign food supplies. This adds to downward pressure on already depressed domestic prices, discouraging the production of importable foodstuffs.

7.10 AN EMPIRICAL ANALYSIS OF THE IMPACT OF EXCHANGE RATE OVERVALUATION ON AGRICULTURAL GROWTH[14]

The 31 countries that comprise Sub-Saharan Africa, for which adequate data were available, were divided into two groups: those experiencing a positive real rate of currency depreciation during the period 1970-1981, and those experiencing real rates of currency appreciation. A real rate of appreciation or depreciation is found by adjusting exchange rate movements against the rate of domestic price inflation. The exchange rate was divided by the rate of domestic inflation. This is not a conventional measure of the real exchange rate, which would be the trade weighted change of the exchange rate adjusted for the difference between the domestic inflation rate and the trade weighted average inflation rate of the country's trading partners. If the above hypothesis were to be correct, countries with depreciating currencies should exhibit a higher rate of agricultural growth than those with appreciating currencies.

[14] K.Cleaver (1985)

Table 7.7
Countries Experiencing a Positive Real Rate of Currency Depreciation 1970-1981

Country	Real Rate of Currency Depreciation % p.a. average	Agricultural Growth Rate
Chad	2.4	0.7
Ethiopia	4.2	0.9
Mali	0.1	4.0
Malawi	0.3	4.1
Upper Volta	0.3	1.4
Benin	0.4	0.0
Sierra Leone	0.9	2.4
Kenya	2.0	4.2
Senegal	1.9	2.6
Lesotho	1.4	4.3
Liberia	1.1	5.0
Zambia	3.4	1.8
		2.6

Table 7.8
Countries Experiencing a Currency Appreciation
(negative real rate of depreciation)

Country Rate of	Rate of Depreciation	Agricultural Growth Rate
Zaire	- 3.3	1.5
Uganda	- 11.7	- 0.8
Rwanda	- 4.1	3.0
Somalia	- 3.7	- 0.6
Tanzania	- 0.5	3.3
Guinea	- 5.5	- 0.7
Central African Republic	- 2.8	2.3
Madagascar	- 0.8	0.3
Niger	- 2.4	- 3.0
Sudan	- 1.8	2.3
Ghana	- 16.8	0.0
Nigeria	- 5.6	- 0.4
Zimbabwe	- 0.4	- 0.5
Cameroon	- 0.8	3.9
Botswana	- 0.1	8.5
Congo	- 2.1	2.1
Ivory Coast	- 3.2	4.7
		1.5

From inspection of Table 7.8 the hypothesis appears to receive some support. Countries whose currencies appreciated had lower rates of agricultural growth than those countries whose currencies depreciated. Statistical analysis suggests that the rate of currency depreciation has a slightly greater impact on agricultural growth than does the operation of fixed producer pricing.

Agricultural growth was regressed upon a number of relevant variables thought to be significant in determining growth: the percentage of public expenditure as a proportion of GDP; the degree of public involvement in farm input supply; population growth. The regression is similar to that run for producer pricing distortions, except that the rate of depreciation is substituted for the distortion variable. In comparison the two separate regressions yield the result that the rate of depreciation has a slightly greater effect on the growth of agricultural output than does the amount of producer price distortion. The other included variables exhibit similar coefficients across the two regressions, indicating that their estimated relative contribution to agricultural growth is approximately accurate.

In conclusion, pricing and exchange rate policies that discourage agricultural growth and promote import substitution encourage poor domestic resource use, and may inhibit economic growth and performance. The World Bank 1982 Development Report further substantiates this belief. This report suggests that economic growth is highly correlated with agricultural and/or export growth.

The policy prescriptions that merit examination stress that reform of the trade regime and internal pricing policies, in conjunction with exchange rate devaluation can ameliorate many of the distortions facing agricultural production. Such reforms however are only applicable in certain cases. Whilst there is a high correlation between agricultural growth and economic growth this may be because the industrial base is extremely small. Where the industrial base is broadening, and where industry output is dependent on imported intermediate inputs (displaying high import-price output elasticities), exchange rate devaluation can indeed impact negatively on economic growth. Devaluation may contribute to domestic inflation forcing the prices of industrial outputs to rise, industry may be starved of vital inputs further undermining industrial growth and development.

Policy prescriptions need to be very country specific. There can be no general rule that encompasses all developing countries. Policies must take account of incentives, supply and demand elasticities, internal market failures, the extent of the industrial and agricultural base and the rates and magnitudes of adjustment. The literature advocates the highly circumscribed use of exchange rate devaluation, and reform of the price and trading regimes focused wherever possible on the removal of artificially induced distortions. Devaluations should operate in conjunction with the appropriate monetary and fiscal policies, constraining internal inflation to be no higher than that experienced amongst the country's direct trading partners. It is possible to ensure that the terms of trade will shift in favour of exports and agriculture and against import substitution. Where inherent comparative advantage exists in agriculture and agro-industry production will expand. However where such industries are supported solely by protective and distortionary pricing output will decline. It is here that the speed and magnitudes of adjustment are crucial. If agriculture respond slowly to such policy reform, whilst the manufacturing sector contracts at a faster rate then the short term fall in GDP can be substantial. The reforms in agricultural pricing are also vulnerable to international agricultural product price movements. If world agricultural prices are falling, the benefits of such reforms may be offset, distortionary pricing is therefore measured relative to the prevailing international prices. This is particularly pertinent in the African experience.

7.11 **POSSIBLE POLICY REFORMS** [15]

(a) Non-Export Producer Prices

Producer prices for non-exported agricultural products should be freely adjusting. Measures should be taken to remove domestic marketing and distributional monopolies or collusive oligopolies. If such monopoly power exists, producer prices should be set by governments to promote agricultural investment, and stimulate production. These prices should reflect long-term world price levels for similar products to minimise the effects of internal price distortion. Official transaction should occur at the prevailing market price, this can be facilitated by bringing private marketing boards into competition with the parastatals. Internal agricultural trade should be carefully monitored, information should be rapidly exchanged facilitating decentralisation, bureaucracy should be limited.

(b) Export Producer Prices

Producer prices for exportables should be flexible and able to adjust quickly in response to international price movements. There is an argument for providing short-term producer price support, shielding exporters and producers from short-term market instabilities. This should be achieved through the use of stabilisation funds. In general prices should be set equivalent to the projected forecast of long-term average world prices. If world prices remain above these long-term world averages the additional revenues should be channeled into stabilisation fund reserves.

(c) Input Prices

Where farm inputs subsidies are used, they should prevail for limited time periods. In general such subsidies should be discouraged, as should the use of consumer food subsidies. Direct food transfers are best employed to overcome temporary food shortages, and can be more carefully restricted to the needy and impoverished.

(d) Export Taxes

Export taxes should be used infrequently and kept at a minimum. Trading quotas and tariffs should be employed rarely and only as short term measures. Where import taxes are used, they should be set at a uniform level to minimise their distortionary impact. Protective policies are best pursued through the operation of the stabilisation funds.

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[15] K. M. Cleaver

(e) Long Term Tax Profile

In the long-term, income taxes, expenditure taxes, or value added taxes should be instituted, replacing import and export duties as sources of revenue. Land taxes should also be employed where feasible. Whilst this may be initially distortionary, it involves a "once and for all" change in the tax regime which minimises the subsequent disincentives. Land taxes will not alter cropping and planting decisions, since they are levied irrespective of crop choice.

(f) Exchange Rate Regimes

Fixed exchange rates should be managed to ensure purchasing and export price parity with that of major trading partners. One recommendation is to abandon fixed or pegged exchange rate regimes and switch to freely floating currencies, where adjustment is automatic. Some African currencies are pegged to the French franc (is this still true?), these nations should be encouraged to pursue fiscal policy and credit expansion at a rate which contains domestic inflation at less than that experienced in France. Where the exchange rates are over-valued in the franc zone as the result of domestic inflation rates exceeding that of international inflation, the judicial use of subsidies to exports and import duties may offset the effects of over-valuation.

(g) Non-Price Variables

Pricing policies and exchange rate regimes are not the single most important factors determining agricultural performance. Other factors gain dominance particularly in the long-run. Non-price variables such as transport and marketing infrastructures, climatic variations, soil qualities, tenurial regimes, informational exchange, exert a powerful influence on the rate and pace of agricultural growth. Pricing and trading reforms must also be accompanied by the appropriate changes in these factors to ensure that such reforms are effective. Freeing up the price mechanism alone will have minimal impact if private markets face such operational impediments.

> " The long-term solution to stagnating agricultural production is the development of suitable new technology or the effective spread of available unadopted technology. the use of the price mechanism alone as a stimulant to agricultural production assumes unused capacity in the production system, that is, either the ability to expand areas under cultivation or to apply inputs more intensively. Increasing productivity (instead of marketed production) enables farmers to increase output and maintain income levels even in the light of falling

commodity prices. falling prices would, in turn, entail important gains to consumers and make policy more politically acceptable." [16].

[16] M. Fones-Sundell (1987)

COMPENDIUM OF PUBLICATIONS

A.Alicbusan (1987)
A Preliminary Survey of Evidence on Input Demand and Output Responses to Changes in Input Prices

World Bank,
Washington DC

This survey reviews agricultural input demands and output elasticities for various developing countries and contrasts these elasticities with those of the U.S. and the U.K. Alicbusan examines the differing cases of input complementarity, employing cross price elasticities, she also considers the effects of subsidised inputs and their indirect effects on rural employment.

E.B.Barbier (1990)
'Natural Resource Degradation, Policy, Economics and Management'
Paper for the ODI Conference **The Environment, Development and Economic Research**

This paper reviews recent developments in economic research on natural resource degradation in developing countries. It summarises the current gaps in our understanding of this problem and outlines future research needs. The discussion focuses on national and sectoral policy issues, the management of key natural resources - tropical forests, water resources, wetlands, drylands and arable soils. Barbier highlights the complex incentive structures that have developed over time through policy acretion, and highlights how these determine resource use. He emphasises that there is very little empirical understanding of the linkages between price changes, agricultural supply and demand responses, and natural resource usage.

E.B.Barbier (1988)
The Economics of Farm-Level Adoption of Soil Conservation Measures in the Uplands of Java

World Bank, Environment Department Working Paper No. 11
Washington DC

Barbier examines the incentives for an upland farmer on Java to invest in soil conservation packages, he captures this in a simple model relating profitability to erodibility on privately owned land. The model is used to examine how this relationship is in turn influenced by changes in relative prices, the farmer's discount rate, different soil qualities, slopes and depths, input prices and population, including migration for off-farm

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employment. Although the result of the analysis is relatively straightforward - upland farmers will not modify their land management practices and farming systems unless it is in their direct economic interest to do so - the incentives for farming households to adopt conservation packages vary significantly. For example, in some cases, such as growing horticultural crops on volcanic soils in the steep uplands, there is little incentive for farmers to invest in conservation as soil erosion appears to have negligible effects on farm profitability. Other incentive effects can be traced directly to government policies, such as maintaining high relative prices for cassava and vegetables, high subsidies for fertilisers and the general poor availability of rural credit at affordable rates. More complex incentive effects arise from the relationship among the availability of off-farm employment, population p[ressure and land management in the uplands.

S.Barrett and C.Heady (1988)*
'Agricultural Prices and Desertification in the Sahel'

Department of Economics, University College London. Prepared for: International Union for the Conservation of nature and Natural resources, **Sahel Special Status Report**

Barrett and Heady discuss price distortions brought about by the operation of certain types of producer price guarantees interacting with border controls such as import duties, taxes, and quotas. They discuss what policies are employed to encourage export base diversification, and what would constitute an efficient price mechanism. They then examine the environmental implications of increased agricultural prices, showing how these impacts depend crucially upon the rates of agricultural adjustment, and the prevailing incentive structure. Their is a brief discussion of common property resources and the introduction of an alternative to price management in the form of the conferral of property rights. Mismanagement is cited as one of the major causes of negative economy-environment impacts. The authors then propose hypothetical scenarios in which the raising or lowering of farmgate prices, or agricultural input prices affects environmental degradation. They conclude that whilst pricing policies provide an important management tool for manipulating resource use and agricultural growth it is not the only instrument available. In the case of open access resources they advocate the conferral of property rights and the development of a supportive legislative infrastructure.

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S.Barrett (1989)
Optimal Soil Conservation and the Reform of Agricultural Pricing Policies

IIED/UCL London Environmental Economics Centre, LEEC paper 89-08 London

Barrett attempts to evaluate the effects of mismanaged incentives and poor pricing policies on the extent and optimality of soil conservation. He concludes that the effects of rises in agricultural output prices on soil conservation measures are likely to be small. Barrett supports the view that whilst there are many valid reasons for allowing crop prices to reflect their true opportunity costs, if inadequate soil conservation is a major determinant of poor agricultural performance, then pricing policy reforms will have minimal effect on agricultural output.

K.M.Cleaver (1985)
The Impact of Price and Exchange Rate Policies on Agriculture in Sub-Saharan Africa

World Bank Staff Working Papers No 728
Washington DC

In this paper Cleaver explores the impacts that price and exchange rate policies have on rates of agricultural growth. He gives a detailed breakdown of various pricing policies and then examines their economic and social costs. In drawing attention to the dispersion of agricultural growth rates throughout Africa, Cleaver highlights problems of coherent statistical analysis. He examines two regression equations which separately assess the relative contributions that pricing policies and exchange rate overvaluations have made to depressing agricultural growth. Cleaver provides the reader with a meticulous methodological review describing the measurement of policy distortions, of comparative advantage and nominal protection. he concludes with a summary of appropriate policy reforms, correcting incentives and discouraging complex trading regimes.

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K.M.Cleaver (1988)
The Use of Price Policy to Stimulate Agricultural Growth in Sub-Saharan Africa

Agricultural Policies Division, Agriculture and Rural development Department
World Bank
Washington DC

This paper examines the responsiveness of farmers' investments to production and price signals. Cleaver identifies the determinants of agricultural production and the effects of policy regimes upon agricultural growth. He examines the constraints faced by agriculturalists in developing countries, input constraints spanning labour supply, quotas, the imposition of subsideis, and output constraints such as the existence of parallel markets where official prices bear minimal importance. He emphasises the weakness of private institutions, the lack of available technology and information. The response of the private sector to market and price liberalisation has been poos in Sub-Saharan Africa, but this can be ameliorated by appropriate policy reforms and the creation of favourable institutional and legislational conditions. Cleaver considers the structural constraints to have had a greater impact on agricultural growth, the removal investment constraints, improved marketing and processing linkages, the more rapid exchange of information and technological innovations, measures to promote land tenure etc. Such reforms will impact significantly on agricultural growth rates and ensure export base diversification.

M.Fones-Sundell (1987)
Role of Price Policy in Stimulating Agricultural Production in Africa

Swedish University of Agricultural Sciences, International Rural development Centre, RD Analysis Section.
where

Fones-Sundell examines the problem of poor agricultural performance in African nations, paying particular reference to the inadequate data base. He focuses on the supply elasticities and considers the role of non-price variables, access to marketing and transport infrastructure, access to technology, and tenure structures as determinants of agricultural growth. He supports the view that whilst low agricultural prices can act as a production disincentive, prices are only one factor that determines performance. Other factors that depress agricultural growth such as non-price infrastructural issues, climatic variation, and labour markets, must also be restructured if the freeing-up of the price mechanism is to have beneficial effects.

J.Kadyampakeni (1988)
'Pricing Policies in Africa with Special Reference to Agricultural Development in Malawi'

<u>**World Development**</u>, Vol. 16. No. 11. pp 1299-1315

This paper surveys recent agricultural policies in Sub-saharan Africa, considering the effects of pricing policies, exchange rate and trading regimes, marketing infrastructure and incentives that overdetermine agricultural growth. Kadyampakeni examines the case of Malawi as an example of successful agricultural development, concluding that the what has contributed to this success was the maintenance of a balance between urban wages and the prices paid to rural farmers for export and food crops. He stresses that in most African countries the domestic terms of trade have moved against rural smallholders promoting rural-urban migration or the retreat into subsistence agriculture. Kadyampakeni emphasises the equalising role played by the Malawian marketing agency ADMARC in minimising world price fluctuations and their impact on the scale and distribution of agriculture.

R.Lopez and M.Nicklitschek (1988)
<u>**Notes for A Research Proposal on the Interactions of Natural Resources and Agricultural Growth in Sub-Saharan Africa: Trade Policy Implications**</u>

World Bank,
Washington DC

Lopez and Nicklitschek develop a model which attempts to address the determinants of agricultural production. The problem is conceived in a dynamic framework, with an exogenous labour supply, a given biomass stock and production technology. They work through the consequences of a change in the relative price of land intensive commodities, the effect of relative price changes in the absence of investment in the resource stock, population growth, labour mobility and agricultural intensification. The authors decompose the long and short-run comparative statics, and give an intuitive yet technical exposition of the determinants of agricultural growth and how policy can interact with supply conditions to constrain agricultural growth.

E.Lutz and Y.Saadat (1987)
'Issues Relating to Agricultural Pricing Policies and their Analysis in Developing Countries'
Agricultural Economics, 01

Agricultural pricing policies in developing countries are often the result of complex interactions between producer, consumer and merchant groups and their relative effectiveness in influencing government decision-making. Many analyses of agricultural pricing policies have used the standard partial equilibrium analysis where no linkages between commodity markets were considered. In this paper the authors consider the cross-price effects, the overvaluation of currencies, input price distortions, the differences in the degree of distortions between producers and consumers, and the variability of border prices. they consider the large welfare losses, efficiency losses, and highlight the importance of correcting distorted prices that adversely affect the poorest sections of society.

R.Repetto (1988)
Economic Policy Reform for Natural Resource Conservation

World Bank, Environment Department Working Paper No.4
Washington DC

Repetto summarises policy failure and outlines the need for incentive reforms. He considers various types of agricultural pricing scenarios and describes the consequent loss of forest cover and biodiversity, the effects on rates of soil degradation and erosion. He emphasises the linkages between input subsidy mismanagement and ecological destruction with respect to irrigation, the use of pesticides, fertilisers, and mechanised inputs.

ENVIRONMENTAL ECONOMICS IN
THE DEVELOPING WORLD

VOLUME EIGHT

INTERNATIONAL ENVIRONMENTAL POLICY

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REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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VOLUME 8

INTERNATIONAL ENVIRONMENTAL POLICY

8.1 INTRODUCTION

"Environmental problems do not respect political frontiers. Waste emissions in one country can impact on other countries, as with acid rain, or the pollution of a sea or international lake.....Clearly, international environmental problems require some form of international environmental policy."[1]

International environmental problems can be classified in terms of the type of externality generated, the number of perpetrators and sufferers, and the direction of externality exchange. Table 8.1 shows the relationship between these factors and subsequently categorises current environmental problems.

Table 8.1

	NUMBER OF COUNTRIES		CHARACTERISTICS
	Externality Generator	Externality Sufferer	
Uni-directional	One	One	Classic textbook case
	One	Few	
	Few	One	Toxic waste transport in the Baltic, North Sea; Deforestation, Acid rain, Whaling, Antartica.
	Few	Few	
	Few	Many	
	Many	Few	
Reciprocal	One	One	Acid rain; Mediterranean Global Commons; Climate change; Ozone depletion; biodiversity loss
	Few	Few	
	Many	Many	

[1] Pearce and Warford (1990) ch 17.

Taxonomy

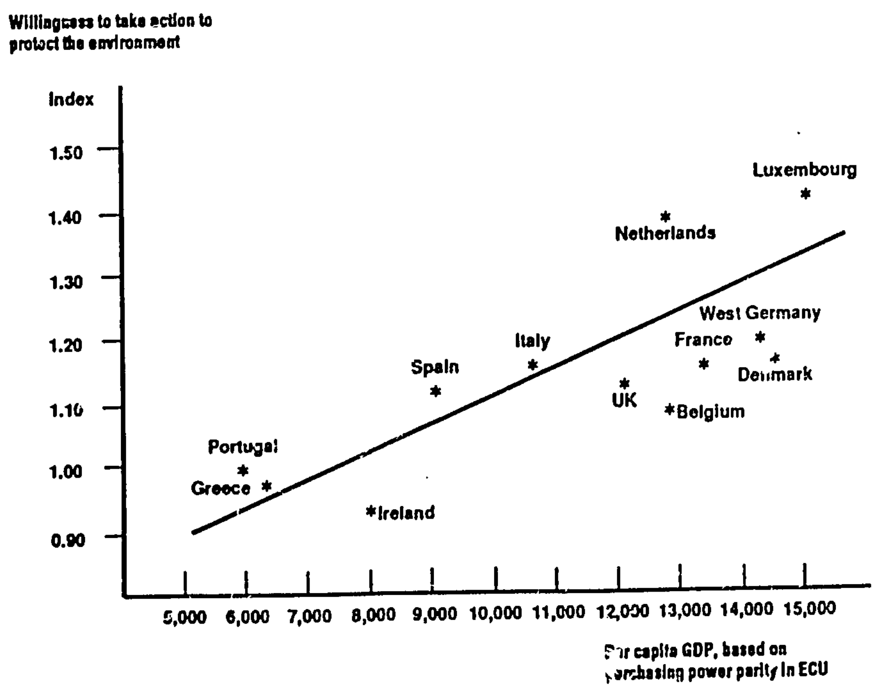
An externality exists when one economic agent imposes a cost or benefit on another agent and fails to compensate for this cost, or to appropriate the benefit. Two basic forms of interaction exist: unidirectional, where damage is caused by one agent and imposed on another; or reciprocal, damage is caused mutually because of a shared resource such as the atmosphere or an ocean.
Often an international externality can be a mix of unidirectional and recip[rocal interactions, as is exemplified in table .

The International Transfer Issue
A further complication is that at the early stages of development the perceived value of natural environments appears to be very low. In terms of policy decisions and enactment it appears that a low weight is assigned to environmental systems in developing countries. Development regardless of the ecosystem-economy interaction takes precedence.

By contrast, the weight assigned to environmental concerns in developed nations reflects their comparatively high rank on the political agenda, irrespective of party politics.

Figure 8.1

Willingness to Take Action to Protect the Environment



One salient feature of international environmental issues is their reciprocity. Environmental degradation in any one country may impact negatively on the welfare of another country. In the developed-developing context this can best be illustrated by tropical deforestation in a two country world. The deforesting country (P) may assess the benefits of deforesting to be (B_D, P) which is greater than the assessed costs of deforesting (C_D, P). This may be seen as a private justification on cost benefit grounds for undertaking the project. However this may rest on a weak notion of the horizon of the cost benefit study. Consider a richer country (R) which gains no benefit from the deforestation in (P) and suffers costs (C_D, R) in the form of climatic changes, and concern over the loss of biodiversity. These costs are clearly not included in the costs and benefits assessed. As long as the decision to deforest is made solely within country (P), deforestation will occur conditional upon:

$$B_D,\ P > C_D,\ P$$

However if global welfare is the objective we wish to maximise, the deforestation would not be deemed efficient unless:

$$B_D,\ P > \{C_D,\ P + C\ D,\ R\}$$

(a) <u>Transfer Payments</u>
This example highlights the importance of <u>transfer payments</u>, particularly in the case of international environmental degradation. However the direction of transfer is a complex issue. In this example country P imposes an external cost on country R by deforesting. If we were to employ the Polluter Pays Principle (PPP), this would suggest that P is obliged to compensate R for the damage caused. Yet the forest belongs to P, and the benefits of not deforesting in P accrue directly to R. This would appear to support the Victim Pays Principle (VPP), where R should pay P not to deforest.

The PPP and VPP can be easily applied in the case of a unidirectional externality where the damage is reciprocal. The principles are less easy to apply however in a scenario where ther are several countries and the damage inflicted is less attributable. What is obvious is that there are potential mutual gains from bargaining. It is the assumption that parties may gain from bargaining that underlies international environmental cooperation.

There are many ways in which international transfers can be applied for the mutual gain of bargaining parties.

(i) A direct transfer or lump sum payment can be employed to "compensate" for the non-development of a certain asset. These are termed <u>side-payments</u>.

(ii) Transfers can also be in the form of compensatory resources, a means of avoiding resource degradation by developing in an alternative environmentally less destructive manner. The transfer may take the form of technical assistance, or hypothecated loans specific to environmentally benign projects. Examples of such transfers are structural adjustment loans where some environmental "conditionality" is imposed, or proposals for international funds to be used to sponsor environmentally neutral projects.

(iii) Other contingent transfers may be used to reduce financial obligation by developing nations to developed ones in return for reduced environmental destruction and sustainable management of natural resources. Debt for Nature swaps are among these types of transfers. Here some of the debt to be serviced by the developing country may be "written off" conditional upon committment to certain environment enhancing projects.

(b) International Conservation Finance

A recent study[2], has suggested that there are four channels for developing "conservation financing" which should be persued further.

(i) The establishment of an International Environmental Facility (IEF) dedicated to funding conservation projects which are not currently funded by existing agencies. This body would specialise in conservation, an area in which the development of expertise would yield substantial returns. It would assemble projects for support by existing lending agencies, whilst playing a coordinative role. It has been suggested that lending should occur at below market rates to counter the apparent low economic rates of return in conservation projects.

(ii) Ecovests.
Measures must be taken to encourage private investment. This would involve informing markets of the potential for private investment and compensating for the information failures that currently predominate. This may take the form of an 'Ecovest' which would be designed to demonstrate the private profitability of environmentally benign investments such as wildlife utilisation and eco-tourism.

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[2] World Resources Institute, (1989)

(iii) Debt for Nature Swaps
Debt for Nature swaps occur with the purchase of developing country debt at a discounted value in the secondary debt market. The debt is then cancelled in return for environment related action on the part of the debtor nation.[3] Thus indebted countries reduce their debt, and the conservationists secure increased environmental safeguards.

(iv) Global Environmental trust Fund
A Global Environment Trust Fund (GETF) should be established by securing a levy or tax on global pollutants such as carbon dioxide. The proceeds of the levy could then be redistributed to countries facing difficulties in reducing carbon emissions, funding energy conservation and afforestation, thus increasing the level of carbon "sinks".

(c) Structural Adjustment and Environmental Quality

Early experience with project finance has revealed that projects often fail because of the distortions within the economy due to government failure, e.g. the excessive protection of certain industries, exchange rate controls, subsidies etc.

The flow of funds from official lending sources to developing countries has increasingly made use of structural adjustment and sectoral adjustment, as a means of avoiding these pitfalls. The aim of adjustment lending is to secure desirable adjustments in the borrowing economy and to mitigate the effects of the adjustment particularly on the balance of payments. When an adjustment programme is agreed upon, lending is dependent on the achievements of the adjustment programme which is closely monitored. The loans have "conditionality", the flow of finance is contingent on the achievement of agreed objectives.

Critics of Structural Adjustment Loans (SALs) argue that they have in fact contributed to environmental degradation. It was thought that since SALs promoted shifts in economic activity within the borrowing country, this may contribute to environmental destruction. An example of this phenomenon would include the encouragement of export-oriented crops through price and credit incentives. However such evidence as exists does not tend to support this thesis in its general form. Where incentive structures have been considered in the design of the SAL, this has not exacerbated environmental decline.

Table 8.2 reviews the impact of the World Bank SALs over the period 1979 to 1987.

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[3] Stein Hansen (1988)

Table 8.2

The Impact of World Bank SALs

ADJUSTMENT LENDING POLICIES WITH EFFECTS ON THE SYSTEM OF INCENTIVES IN THE ECONOMY

	ASIA	%	LAC	%	EMENA	%	AFRICA	%	TOTAL	%
Countries Reviewed	6		11		4		22		43	
Relative Price Changes										
Adjustments in agricultural producer prices	1	17	4	36	3	75	15	68	23	54
Subsidy removal/reduction on prices of agricultural inputs	3	50	5	46	4	100	16	73	28	65
Tax adjustments on agricultural exports	1	17	5	46	0	0	6	27	12	28
Improve terms of trade on agricultural products	0	0	5	46	3	75	8	36	16	37
Adjustments in energy prices	3	50	3	27	2	50	7	32	15	35
Trade and Industry Policy Reforms	6	100	8	73	4	100	11	50	29	67
Public Expenditure Program Changes										
Agriculture/Forestry	2	33	2	18	4	100	11	50	19	44
Energy	2	33	1	9	2	50	3	14	8	19
Industry	3	50	0	0	3	75	2	9	8	19
Institutional Reforms										
Agriculture/Forestry	3	50	7	64	3	75	16	73	29	67
Energy	3	50	3	27	2	50	5	23	13	30
Industry	5	83	5	46	3	75	9	41	22	51

Source Environment Department, World Bank
Notes: LAC = Latin America, Central America
EMENA = Europe, Middle East, North Africa

General Conclusions

(i) Table 8.2 reveals that in 23 of the 43 cases reviewed did the adjustment policies involve a raise in agricultural prices. In the particular countries studied the raised prices almost exclusively affected perennial crops which provided continuous root structure and canopy cover. Such crops enhance soil stability, particularly on sloping ground, and tend to be non-erosive. In general the SALs have encouraged the expansion of crops such as tea, coffee, cocoa, palm oil, bananas and rubber, which are environmentally benign. SALs have also lowered the prices of some of those food crops that are potentially damaging, in the case of Panama rice, maize and sorghum, and in Turkey foodgrains, cotton and tobacco.

(ii) 28% of the SAL's examined involved beneficial adjustments in agricultural export taxes. Export taxes levied on certain agricultural products effectively lower farmgate prices, since in the absence of the tax farmers would receive higher prices. In Haiti SAL's have incorporated efforts to remove export taxes on coffee consequently reducing incentives to grow erosive grain crops on the hillsides. This contrasts with the experience of Malawi where export taxes levied on tea have increased under the operation of a SAL. Whilst tea is often an environmentally beneficial perennial contributing to soil cohesion, in Malawi tea is cured using fuelwood obtained through deforestation. The net effect of the increased taxes, was thus considered to be beneficial to the environment. 35% of the SAL's studied did however reduce export taxes on erosive crops such as maize, sorghum and tobacco. Yet the overall impact on the environment is sensitive to the mix of policies. Higher foodgrain production need not be environmentally damaging if production methods are carefully managed. It is also interesting to note that in many cases increased foodgrain production incentives have been associated with reductions in price sup[ports for other comparatively more erosive crops such as sugercane.

(iii) Currency devaluations were undertaken in 37% of the cases reviewed. This effectively raises farmgate prices, with the net effect on the environment being dependent upon which crops are encouraged.

(iv) It has been the case that agricultural subsidies are often concentrated on environmentally damaging inputs such as fertilisers, pesticides, irrigation water, mechanisation and credit. In 65% of the cases studied, the SAL's incorporated a reduction in such subsidies. Table 8.3 summarises the experience of these SAL's with input price adjustments.

Table 8.3

Changes in the Price of Agricultural Inputs: Distribution by Type of Inputs and Country

Input	Number of Countries: Reduction/Removal Of Input Subsidies	Reduction In Import Duties	Countries a/
Fertilizers	20	2	Zambia, Guinea, Madagascar, Central African Republic, Sierra Leone, Togo, Ivory Coast, Niger, Malawi, Nigeria, Tunisia, Pakistan, Morocco, Turkey, Ecuador, Colombia, Costa Rica, Korea, Nepal, Philippines, (Colombia, Argentina)
Pesticides	5	1	Madagascar, Gambia, Pakistan, Ecuador, Turkey, (Colombia)
Insecticides	3	1	Ghana, Central African Republic, Turkey, (Argentina)
Herbicides	2	1	Tunisia, Turkey, (Argentina)
Agricultural equipment, spare parts, and implements	3	3	Sierra Leone, Ivory Coast, Niger, (Tunisia, Colombia, Central African Republic)
Machinery/tractor hire services	4		Zambia, Kenya, Somalia, Sudan
Interests on agricultural credit	10		Somalia, Sierra Leone, Zaire, Tunisia, Turkey, Ecuador, Colombia, Costa Rica, Panama, Philippines
Seeds and planting materials	9		Guinea, Kenya, Gambia, Sierra Leone, Ivory Coast, Tunisia, Morocco, Ecuador, Jamaica
Land rental rates	1		Sudan
Animal feeds/livestock services	3		Tunisia, Morocco, Kenya

a/ Enclosed in parenthesis are the countries in which policies are to reduce the import duties on agricultural inputs.

Source: World Bank Reports.

These subsidy reductions encourage the less profligate use of pesticides. Clearly there are limits to the potential environmental gains if the reduced usage of pesticides inhibits optimal pest control. Reduced fertiliser subsidies encourage substitution by organic manures and the development of an integrated crop and livestock system. Again, price increases may encourage environmental damage where application rates are suboptimal. Often, reduced farm machinery subsidies avoid encouraging inappropriate land use, as occurs with some forms of mechanised agriculture and forest clearance. In the Sudan the advent of subsidised farm machinery caused the overuse of types of equipment that contribute to soil compaction and consequently to soil erosion. Credit subsidies can also be particularly damaging to the environment, an example of this is the cattle ranching subsidies in Brazil, which has contributed to the widespread deforestatioon of the Amazonian basin. The net effect of the credit subsidy reductions, shown for the 10 countries represented in Table 8.3, cannot however be evaluated without detailed examination of the individual cases.

(v) SALs often involve reductions in energy subsidies to producers and consumers, this curtails inefficient consumption and overuse, and promotes energy conservation. Institutional reforms are often embedded in SAL's, measures which encourage conservation and the use of less environmentally destructive sources of energy. Production cost increases occured in 8 of the countries in Table 8.3; consumer prices rose in 15 of the countries; and institutional reform was implemented in 13 of the countries. The net effect on the environment is sensitive to the mix of inputs and the relevant income and substitution effects. This underscores the need for the detailed evaluation of the incentive structures within each economy.

(vi) In many cases trade liberalisation policies have been incorporated within the SALs. These have involved changing the relative prices of manufactured goods, removing barriers to external trade, and encouraging exports. In 67% of the cases represented in Table 8.3 trade liberalisation occured. Where environmental protection, legislation and enforcement is weak there is potential for such policies to encourage pollution, by the manufacturing sector and environmental degradation in the agricultural sector. However the evidence does not provide much support for the belief in "pollution havens".

(vii) A significant number of the SALs have resulted in reductions in public expenditure. Where this has occured, these SALs have diverted expenditure to forestry, extension, and rural road construction, such programmes tend to be environmentally beneficial. A welfare analysis would conclude that the burden of the reduction in public expenditure falls disproportionately on the poor increasing pressure on "free" natural resources. Many critics feel that SALs have focussed too narrowly on short to medium term macroeconomic adjustment, at the cost of increasing poverty. This is a serious indictment of SALs, since poverty is closely linked to environmental degradation.

(viii) Institutional reform appears central to most SALs. Reforms to agriculture, industry and energy occured in 80% of the sample in Table 8.3. These reforms have concentrated on privatisation, encouraging foreign investment, increased research and extension, improved marketing and land tenure reform. In general these reforms have had a favourable impact on the environment.

Summary

The general review of SALs is that their environmental impacts are varied. However certain measures can be taken to reduce the risks of associated environmental degradation:

(a) ensuring that all SALs are continually monitored and reassessed in respect of their environmental impacts;

(b) designing SALs with specific environmental aims held paramount.

Debt-for-Nature Swaps

At the end of 1987 the outstanding international debt held by the developing countries exceeded $1300 billion. This figure was roughly 50% of the total GDP for these developing nations. Approximately $600 billion of this debt was to "financial markets" , indebtedness to the private sector rather than official sources of lending such as governments, or multilateral organisations like the World Bank. Debt is highest in the upper-middle income countries, however lower income countries have some $330 billion of debt outstanding of which $67 billion is owed to financial markets. Expressed in terms of regional indebtedness, South and Central America owe some 63% of their debt to commercial sources, Asia 42% and Sub-Saharan Africa 20%. Much of this extensive indebtedness can be attributed to over-lending by the commercial sector in the 1970's when OPEC revenues were recycled to the banking world. Domestic economic mismanagement, world recession and the vagaries of international commodity markets, have promoted various "debt crises" during which borrowing countries have defaulted, or threatened default, on their loans. Mexico failed to meet its debt obligations in 1982 and other nations quickly followed this example. This initiated response in the form of debt rescheduling and alternative approaches to debt relief began to be considered.

One solution to the increasing risk of default was the resale of debt within the banking sector. In contrast to equity, debt service requires the payment of an agreed sum at regular intervals regardless of the ability to service that debt. Drawing on the theory of insurance, any one bank may spread its risks by selling high risk debt to another financier at a discount. The debt is discounted to reflect the potential for default. This discounted debt is termed <u>secondary debt</u>. In 1989, it was possible to purchase Yugoslavian debt at under 60% of its face value. Comparable percentages for other indebted nations were: under 30% for Brazil; under 20% for Argentina: 30% for Nigeria; and 5% for the Ivory Coast. Prices for secondary debt have fallen systematically during the 1980's, mirroring the growing risk of default.

The secondary debt market also handles <u>debt conversions</u>. Almost 50% of the secondary loan market is accounted for by debt conversions. Such a conversion involves undertaking the service on secondary debt in return for the ownership of an asset in the indebted country. If the swap is for equity, then it is a <u>debt-for-equity swap</u>. There are many forms of debt conversion: to local currency, to claims on exports etc. The lender thus gains direct access to creditors in the indebted country. The country itself is placed in a position where it may bargain over the debt payments and negotiate possible debt relief when the swap is made. Debt-for-equity swaps permit financiers to invest in the indebted country, providing a route of access not usually open to many investors. All debt conversions relate exclusively to commercial debt, and not to official debt obligations held with governments or multilateral agencies.

Of particular importance to environmentalists is the <u>debt-for-nature</u> swap. In this case the holder of discounted debt negotiates to undertake conservation of some natural resource in the indebted country. Various types of debt-for-nature swaps have been considered.[4]

(a) The conversion of debt by the central bank into localdebt (bonds) or local currency to be held by environmental organisations with specific conditions for investment in local environmental projects.

(b) The donation of debt to a local environmental organisation for investment in environmental projects.

(c) The purchase of debt by an environmental organisation and its discounted sale to a multinational corporation (MNC) which holds environmentalls "sound" corporate investments.

(d) Official debt relief conditional on the achievement of sustainably managed resources, <u>debt-for-sustainable development</u>.

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[4] Hansen (1988)

Case Studies of Debt-for-Nature Swaps

(i) Bolivia

Conservation International, a US-based environmental organisation, purchased $650,000 face value debt (0.01% of Bolivia's total debt) in 1987 for $100,000 from a Swiss bank. The debt was then swapped in return for the Bolivian government's commitment to establish and legislate the protection of three conservation areas. 3.7 million acres of land adjacent to the Beni Biosphere Reserve was guaranteed preservation as a result of this. The reserve is of particular environmental and cultural significance being home to the Chimane Indians, and also housing thirteen of Bolivia's endangered species. As part of the agreement the government redirected $250,000 in local currency towards the cost of managing the reserve, of which 60% was donated by US AID (the United States foreign aid agency). The effective cost of the aggreement was the initial $350,000 to protect the reserve, which translates to approximately 10 US cents per acre.

(ii) Costa Rica

In 1987 the WorldWide Fund for Nature (WWF) and several other agencies purchased $5.4 million face value Costa Rican debt for $1.35 million. Some of the debt was also financed with gifts from the private banking sector. The debt was subsequently converted into $1 million of local currency which was used to secure hold of "monetary stabilisation bonds". These bonds were then given to the Fundacion preservacion Natura which used the revenues to buy land for conservation.

In 1988 Fleet/Norstar Financial group of Rhode Island USA, donated its $250,000 Costa Rican loan to Nature Conservancy International to convert to Costa Rican bonds valued at $190,000. Principal and interest will be used to finance the acquisition of lans and part of the management costs in the Le Selva Protected Zone. The profile that this DNS received brought forth other donors, ensuring that Costa Rica met the $5.4 million target it had initially set.

Costa Rica has also experienced the government purchase of debt in a debt-for-sustainable development swap. In 1988 the Dutch Foreign Ministry purchased $30 million of debt at 15%, a cost of $4.5 million. This debt was then converted to $9 million of Costa rican bonds, 30% of its face value. The converted bonds yield revenues which, under the swap agreement, are to be used for agroforestry and reforestation.

(iii) Ecuador
In 1987 the WWF purchased $1 million of Ecuadorian debt for $300,000. This was then swapped for non-negotiable stabilisation bonds, the revenue from which was intended for the Fundacion Natura, a non-government organisation in Ecuador. This yield was for the protection and management of established reserves, the acquisition of new reserves, the training of conservationists and the advancement of environmental education programmes.

(iv) Madagascar
In 1989 WWF retired $2.1 million of Madagasy debt for $950,000, with an option to purchase up to $3 million of their debt. The US AID organisation donated a grant of $1 million towards the cost of this debt retirement. This swap took the form of a currency conversion, tying Madagascar to spending local currency on conservation project including the provision of 400 park rangers.

Are debt-for-nature swaps an effective means of achieving environmental aims?

Debt-for-nature swaps have provoked much discussion and debate amongst governments and international conservationists alike. The most salient criticisms are as follows:

(a) They retire too little debt. For these programmes to achieve specific environmental aims they are exclusively "local" in character. Since they are seldom large, they have a negligable impact on external indebtedness.

- This criticism is not of great importance, since the swaps were not devised for the sole purpose of diminishing debt. Their central focus is environmental.

(b) Such swaps interfere with national sovereignty, raising important questions about the real interests of the "investors".

- Host countries however do not appear to concur. Little evidence of this attitude has been gleaned from within the indebted country. Moreover, the Ecuadorian DFN swap was initiated from within the country. The Costa Rican government is known openly to favour DFN swaps. Much of the impetus for these agreements comes from vocal pressure groups within the host nations.

(c) The swaps are regarded as inflationary, contributing to demand pressure.

- Such a criticism might hold water if the amounts involved were indeed large and the conversion was to cash and not bonds. Even where there have been direct debt to currency conversions, there has been little evidence of greatly increased aggregated demand.

(d) They are seen as altering the allocation of resources. Many conversions displace smallholders and sedentary squatters. There is a substantial risk that such activities will fail to take account of the interests of these groups, who are typically under-represented and less vociferous.

- Whilst this is a very real criticism, the focus of DFN swaps is not narrowly set upon conservation in its strictest form. Many of these swaps have been designed to promote sustainable land use in certain protected areas. Often they operate using buffer-zones, a central circle is protected and a series of outer concentric circles of land are adapted for sustainable use. It is apparent that by careful design, such a criticism may be avoided.

(e) DFN swaps do not add funds to conservation, but merely displace existing funding already allocated to conservation issues.

- This is a curious criticism. For it to hold, it would mean that foreign conservation funds would have to be displaced. However the current examples of debt purchase have typically involved NGOs, largely recent entrants to the field of conservation. It seems clear that investment funds have not been displaced.

(f) Indebted countries may influence the exchange of debt itself. In advancing cash for conservation it is possible for donors to secure given rewards for a given sum of money. In the case of a DFN swap, the sum advanced for conservation depends crucially on the value of the debt in the market place. The value of debt can be readily influenced by the indebted country through its potential to manipulate the perception of default.

- Moral hazard[5] may indeed constitute a significant problem. However the costs of manipulating international perceptions are also significantly high. To artificially heighten the risk of default would impose certain exchange rate constraints upon the economy and currency movements would consequently occur. Not all these shifts may be seen as favourable by the host nation.

(g) Host governments may renege on the management agreements.

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[5] Moral Hazard - when individuals or groups can influence the probability of an event occuring, or the amount of remuneration conditional upon a given event taking place.

- The danger of this is quite high. One solution is to devise agreements whereby the flow of funds into the country is annual, and dependent upon the project achieving agreed objectives. Thus, if default occurs the payments can be stopped or reduced.

The real contribution of debt-for nature swaps lies in their ability to heighten environmental awareness. They expose governments, pressure groups and policy makers to the widespread practice of unsustainable environmental management. This raises environmental awareness within the host countries and creates channels for increased dialogue between local non-government organisations and local bureaucracy. The criticisms listed above are not extreme, however they might begin to "bite" with more effectiveness if the sums involved become significantly larger. This would increase the risk of demand push inflation, and might encourage debtor nations to influence secondary debt prices. Also if they were undertaken on a larger scale the swaps would risk being non-additional, they might begin to be at the expense of other loans or of debt-relief.

The Greenhouse Effect and the Implications of Global Warming[6]

The Greenhouse effect will probably dominate international environmental policy in the 21st century. Outgoing radiation absorbed by clouds, water vapour and carbon dioxide promotes the Greenhouse effect, contributing to global warming. Heat is consequently trapped internally leading to the gradual rise of the earths surface temperature. The emission of atmospheric trace gases which trap the outgoing long wave radiation such as sulphur dioxides, nitrous oxides, carbon dioxide, water vapour, chlorofluorocarbons and ozone, have been rising steadily over the last two centuries. The deflected long wave radiation fails to penetrate this protective layer resulting in the global rise in temperature, increased and more varied rainfall, and sea-level rise.

Whilst the concentration of these gases has been influenced by mans interaction with the environment, the residual components are natural. Much of this effect has been essential to evolution. Without this atmospheric insulation, the average earth surface temperature would be -18 C and not the 15 C that we observe.The 'greenhouse gases' are:

(i) Methane which is emitted by the natural process of organic decay was dispersed throughout the earths atmosphere during the carboniferous period.

[6] Pearce and Warford (1990)

(ii) Nitrous Oxides are the byproduct of microbial processes operating in soil and water. However these gases are also the byproducts of mans activities. Anthropogenic factors such as the cultivation of paddy rice significantly contributes to methane emissions, as does cattle farming. The use of nitrogen fertilisers and fuel combustion further contributes to the accumulation of atmospheric nitrous oxides.

(iii) Carbon Dioxide is released as the result of organic decomposition and from exchange processes that occur with the oceans and the atmosphere. The oceans play a crucial role in "storing" CO_2, holding 50 times as much carbon as does the atmosphere. Carbon is exchanged with the atmosphere, however figures suggest that they currently act as a net "sink" retaining carbon in excess of that which is emitted. As the global climate becomes warmer, it is possible that this accumulation process could be reversed. Much depends on the imperfectly understood mechanism by which the exchange takes place. Carbon dioxide is also released during the combustion of fossil fuels and because of deforestation as large tracts of forest are cleared and burnt. There is also the possibility of albedo, where cleared land reflects increased radiation. Carbon dioxide is absorbed by photosynthetic vegetation and subsequently rereleased to the atmosphere as oxygen. Forests therefore serve an important function, acting as carbon sinks, deforestation removes these potential carbon sinks.

As yet the implications of such changes in atmospheric gases are uncertain. The general scenario indicates that temperatures will rise, sea-levels will rise, and that weather systems will exhibit increased variability and instability. These effects are potentially devastating for much of the globe. However some countries may benefit. It is the unequal distribution of the costs and benefits of such climatic changes that greatly hampers international coordination. Not all countries stand to reap equivalent benefits from action against global warming. The incentives for international policy coordination are unevenly distributed throughout the world. In some cases acting now could be costly if warming turns out to be limited. However inaction could be catastrophic if warming is severe.

The Impacts of Global Warming

The impacts arising from the process of global warming can be broadly summarised as follows:

(a) average regional temperature and rainfall changes;

(b) average sea level rise;

(c) increased frequency and severity of weather events.

(a) Regional Temperature and Rainfall Changes

The following table reveals some of the potential impacts. The mid-latitude regions include most of the major world crop growing regions, including the USA, China, New zealand, Europe and Argentina. Some 65% of all the worlds cereal output comes from the 30-50 zone, 75% of all maize, 74% of all wheat, 86% of all barley and 38% of all rice. Just how these areas will be affected is uncertain. Summer soil moisture may be reduced and crops could be affected by summer droughts. One significant impact could be on water supplies, surface water and groundwater aquifers. Evapotranspiration can be expected to increase, but this may be offset by rainfall increases in certain areas. the main impact on agriculture is likely to be via changes in the hydrological cycle. The change in the distribution and intensity of rainfall across the growing season can be expected to greatly affect world agricultural output.

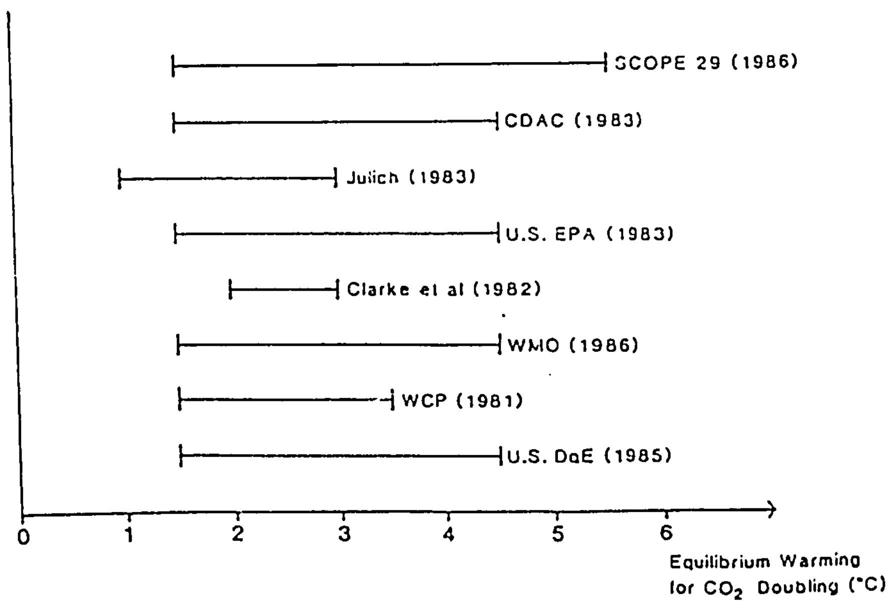
Greenhouse Gases and Their Man-Made Sources

	Carbon dioxide (CO_2)	Methane (CH_4)	Nitrous oxide (N_2O)	Chlorofluoro-carbons (CFCs)	Tropo-spheric Ozone
% contribution to "greenhouse effect" over period 1950-1985	56	14	7	23	*a*
Concentration of greenhouse gases – pre-industrial *b*	275ppmv	700ppbv	280ppbv	zero	15ppbv
Concentration in 1988 *b*	350ppmv	1700ppbv	310ppbv	0.26ppbv (CFC-11) 0.44ppbv (CFC-12)	335ppbv
Annual growth of concentrations in 1980s	0.5%	0.5%	0.25%	5 to 5.5%	1%
Sources of greenhouse gases	Fossil fuel burning Deforestation/land use changes	Rice paddy cultivation Rearing of ruminants (e.g. cows) Biomass burning Fossil fuel extraction and burning	Fertilizers Fossil fuel and biomass burning Land conversion for agriculture	Manufactured for: solvents; aerosol spray propellants; foam packaging	Product of sunshine and pollutants: carbon monoxide; methane; other hydrocarbons, nitrogen oxides

Source for percentage contribution, Wigley (1987); for growth, Mintzer (1987); for concentrations, Ramanathan et al (1985), UNEP/Beijer (1989).

Notes *a* contributions of ozone not estimated, perhaps around 8 per cent of total.
b ppmv is parts per million; ppbv is part per billion

THE EFFECTS OF DOUBLING CO2 ON GLOBAL WARMING: RESULTS OF VARIOUS MODELS



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Climate Change and Water Resources

Climatic Impact / Water Function	Annual Run-Off (Increase or Decrease)	Run-Off Frequency (Increase or Decrease)	Run-Off Seasonality (Less even)	Sediment Production (Greater)	Sea Level (Rising)
Water supply reservoirs	Increased yield in humid areas	Increased yield, more reliable in humid areas	Less even distribution, so reduced yield and reliability generally	Increased sediment, so loss of storage and reduced yield	Saline intrusion of aquifers
	Reduced yield in semi arid areas	Reduced yield and reliability due to more drought in semi arid areas			Flooding of reservoirs
Hydropower reservoirs	Increased generation in humid areas	Increased generation and firm load in humid areas	Reduced generation and firm load	Loss of storage and reduced generation from sediment	
	Reduced generation in semi arid areas	Reduced firm load in semi arid areas			
Flood protection	Increased protection required in humid areas	Greater flood frequency in humid areas, increasing flood hazard	More frequent floods in humid areas. Greater wet season run off in semi arid areas. Flood hazard	Loss of reservoir storage. Increased deposition. Increases flood hazard	Serious hazard in low lying areas. Sea flooding frequency and severity increased
	Protection in semi arid areas needs to cope with infrequent severe floods	Fewer wet years in semi arid areas but flood severity could be greater			
Environment resources and water quality	Quality improved in humid areas	Quality improved in humid areas	Dry season water quality affected in semi arid areas	Water quality impaired by sedimentation	Ground water contamination by salt water.
	Quality reduced in semi arid areas	Quality impaired in semi arid areas			Saline infiltration into sewerage system
Navigation	Improved river and lake navigation in humid areas	Reduced risk of drying up in humid areas	—	Sedimentation reduces navigation	Affects viability of low lying port installations

Source: (inter alia) Williams (1987)

2.6.0

(b) The Rise in Sea level

The global mean sea level rise is perhaps more certain than the temperature and rainfall predictions. Global warming will affect sea level by thermal expansion of the oceans, melting mid and high latitude glaciers and ice sheets, and by the melting of the Greenland and Antartic floating ice sheets. These sea level rises will vary regionally, not least because land masses change their levels, coastli8nes are subject to erosion and deposition and subsidence may occur extensively with the melting of sections of permafrost. This will result in the loss of low lying land adjacent to the sea, salt water intrusion into fresh water systems, and storm surges causing floods.

(c) Frequent and Severe Weather Ev nts

The frequency and severity of weather-related events is likely to increase, as global warming leads to increased systemic instability.

The Impact on Developing Countries

The impact on developing countries is likely to vary substantially by country, but for some the impact could be extreme.

(i) Developing economies are more dependent on their natural resource base. Such resources are highly sensitive to small climatic changes, soil quality is easily affected by changes in the hydrological regime and by temperature fluctuations, woody biomass, and water (both as a drinking reserve and a natural habitat) are similarly vulnerable.

(ii) In many developing countries agricultural systems are located on low lying deltaic land fed by rich silt from river systems. These will be increasingly prone to salt water intrusion and flooding.

(iii) Many agricultural systems are reliant on natural rainfall rather than irrigation systems. As already noted it is not merely the amount of rain that matters it is its timing and distribution across the growing seasons.

(iv) Many small developing countries are island communities at particular risk from severe weather events such as hurricanes and cyclones.

(v) The very poverty of the developing countries will preclude them from undertaking the defensive measures and adaptive policies that will be required, such as sea defences and hurricane barriers

The semi-arid tropical regions, Sub-Saharan Africa, North East Brazil, parts of India and Pakistan could be especially at risk from extended dry periods. Changes in the hydrological conditions in the humid tropics could affect rice growing, particularly in the marginal lands. Agriculture in the temperate zones may be also affected. One possible scenario is the loss of US cereal crops, but not on a significant scale; increased rice production in Japan; improved Soviet Union Wheat production, as the result of warming; and expanded cereal production in the more northern countries. However for developing countries the major impact will be on subsistence cropping which is concentrated on the more marginal and thus more climatically sensitive lands.[7]

Policies to Diminish the Greenhouse Effect

There are three broad policy responses that have been envisaged. In each case a country may consider acting alone or cooperatively. Acting alone is unlikely to have any significant impact on the damage suffered as a result of global warming. However there may be other reasons why a country would wish to demonstrate its desire to act.

(i) Inaction in the Expectation of Natural Adaption

Even if no specific actions are taken, populations will adapt to the impacts of climatic change. Much of the change will be relatively gradual, populations may respond by migration, changing their lifestyles, and by individually undertaking defensive expenditures, such as using increased fertilisers to offset crop productivity. Advantage may be taken of the innate lags in the systemic response to global warming. As the impact of global warming unfolds many of the uncertainties will begin to be clarified, action might then be more specific and effectively targeted. However this is an extremely optimistic representation. In such a scenario inevitably it will be the worlds poor who suffer disproportionately, and the developing countries who will bear much of the burden.

(ii) Coordinated Policy Response, Both Individually and Collectively

There is no possibility of preventing such global warming as we are already committed to. However global warming can be contained. Achieving consensus on an acceptabel level of containment is complex. An economic approach would be to compare the costs and benefits of control options. Yet we have seen that in this case the damage function and therefor the costs are uncertain and that the benefit function in the form of reduced warming is not known accurately. However as a framework within which to begin this containment, cost benefit analysis can yield some guidance.

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[7] See Pearce and Warford (1990), for particular developing country case studies.

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The main forms of prevention and containment so far considered have been:

(a) Reducing CO_2 emissions by reducing the use of fossil fuels. This would require substantial energy conservatiuon measures. Fuel mix changes in favour of non-carbon combustants, nuclear power, renewable energy sources, wave wind, tidal and solar power.

(b) Carbon sinks would need to be augmented and developed. Increased afforestation programmes, and reduced deforestaticn, especially of tropical forests.

The consensus of analysts is that energy conservation holds the highest potential for reducing Greenhouse effects. The most powerful influence on energy conservation in the developed world is the price of fuels. Increases in energy prices over the period 1978 to 1982, have been the most important single factor behind substantial improvements in energy efficiency over the last ten years. This suggests that effective energy conservation could be brought about by the imposition of a worldwide energy tax.

An energy tax designed to inhibit the amount of CO_2 emissions would be proportional to the potential CO_2 emissions content of the fuels. This would be consistent with the polluter pays principle. Coal and fuel oil would thus attract the highest tax, natural gas a lower tax, and gasoline woould also be subject to tax because of the important role that transport plays in the emission of CO_2. By raising prices to the users of such fuels, particularly the electric power sector, it would thus encourage the use of lower carbon fuels, and to reduce fuel usage. This last effect is of particular importance in the case of an economy which is locked into a given technology, and is unable to switch to the use of less damaging fuels until capital equipment becomes due for renewal.

Unless such a tax is part of worldwide coordinated policy, there may be a widespread reluctance to adopt the tax unilaterally for fear of imposing a cost disadvantage to international trade. Such fears are often overstated, because energy costs are a typically small proportion of the total costs of producing goods and services. But for some highly energy intensive industries these taxes may cause a sugnificant rise in product price. The scale of the energy tax required could be large if the acceptable level of global warming is deemed to be at the low end of the spectrum.

Long run international energy demand forecasts suggest that energy demand responds to energy price changes with an elasticity of about 0.5, thus a 10% rise in energy prices causes a 5% reduction in energy demand. Most of this demand response is through energy conservation.

If all developed economies agreed to tax fuels at a uniform rate, there should be no net effect on trade and international competitiveness. These taxes would give rise to revenues which could be used to support a global fund for energy conservation, fuel switching incentives, afforestation programmes and other environmental conservation projects in the developing world. The revenues from such a fund would be hypothecated to development, and the scale of the funds would be determined by the behavioural responses of energy users to the tax. There would therefore be a close link between the taxpayer, the emissions, and the use of the tax funds. The World Resources Institute advocated the establishment of such a Global Environmental Trust Fund (GETF), 1989. The developing world does not possess the resources to enable it to adopt higher cost energy sources, further it has a legitimate claim on internally welfare enhancing technologies such as refrigeration (which uses CFCs). The GETF revenues could be used to compensate for such activities. Indeed the 1988 International Conference on the Changing Atmosphere called for such an international fund, this call was renewed at the 1989 Helsinki conference which agreed to strengthen the Montreal protocol.

It appears that international agreement on greenhouse gas emissions may be secured, despite the complexities of the issue. Some countries have already imposed taxes on energy consumption and particularly legislated against increased environmental damage. The Netherlands has a general fuel tax levied on petroleum products, natural gas and coal. These revenues are used partly to fund the Netherlands environmental programme. The USA is contemplating the introduction of taxes on CFCs, with the intent of achieving the agreed Montreal protocol limits. A carbon tax is under consideration by several countries.

International cooperation has already been achieved in the case of CFCs and their damage to the Ozone layer. In 1985 the United Nations agreed a Convention on the protection of the Ozone layer, enabling the exchange of information between countries as to developments, internal measures, and research. In 1987 the Montreal Protocol on Substances that deplete the Ozone Layer was drawn up. This set targets for the amount of CFC emissions, requiring consumption changes and later production changes to accomplish this aim. The Montreal Protocol came into force on January 1st 1989, signatory countries are to achieve reductions by whatever means available to them. In May 1989 the Protocol was strengthened significantly at the Helsinki conference. CFCs are to be phased out completely no later than the year 2000. nonetheless the Helsinki agreement is still consistent with chlorine levels rising until around 2065, as the result of committed CFC decomposition in the atmosphere.

The possibilities of a worldwide carbon convention being achieved are less optimistic. Securing agreement on CFCs is relatively simple in comparison with the complexities of the carbon issue. The reasons for this lie in the game theoretic nature of international agreements. Game theory allows economists to model behavioural dynamics, the response of an agent is considered holding the response of all other parties as given. If country A takes action to reduce global warming, country A and all other parties benefit. There thus exists an incentive to be a "free rider" , an agent who benefits from the collective action of others without incuring the costs of action individually.[8] To oversimplify, the fewer players there are in the "game" the more likely it is that a cooperative solution will result. This fits the Montreal Protocol case because the number of CFC producers is limited and the consumers are mainly the developed nations. In the Carbon case however, the number of players is large, and inclusive of major developing nations. Cooperation is more likely to occur where the costs of participation are comparatively small. Finding substitutes for many uses of CFCs, notably their role in aerosols, is comparatively simple and inexpensive. This is not the case however in terms of reducing carbon dioxide emissions. Securing the necessary reductions in CO_2 emissions requires the use of significant tax disincentives, which may be reneged upon. The attributes of the game in this case make it much more difficult to enforce cooperation.

[8] Barrett (1989), Magrath (1989)

A COMPENDIUM OF PUBLICATIONS

S.Barrett (1989)
'The Problem of Global Environmental Protection'

<u>**Oxford Review of Economic Policy**</u>, Vol. 6, No.1

This paper considers the problems of the global commons and the impediments to global the coordination of policy. Barrett reconsiders the Demsetz view that users of a communally owned resource will fail to reach agreement, despite it being in their interests to cooperate, because of the "free-rider" problem. He refers to the non-cooperative and cooperative solutions to international "games". Employing the game theoretic analysis he examines the issue of cooperative environmental protection and international agreements. In many cases the problem collapses to one of enforcement and policing. Berrett endorses the use of international legislation and side-payments, which he feels can aid the management of global common property resources.

S.Barrett (1989)
'On the Nature and Significance of International Environmental Agreements'

London Business School

Barrett addresses the problems of international coordination and potential policy to provide a coherent framework for achieving international reductions in greenhouse gas emissions. He develops a game theoretic model which illustrates cooperative and non-cooperative solutions analysing the conditions required for a stable equilibrium to be reached.

I.G.Bertram, C.C.Wallace, and R.J.Stephens (1989)
'Economic Instruments and the Greenhouse Effect'

<u>**mimeo**</u>, Victoria University of Wellington, New Zealand

This paper considers the various instruments available for the control of greenhouse gas emissions. The authors suggest that any international anti-greenhouse policy regime should:

(i) recognise the importance of encouraging sinks as well as restricting sources for the targeted pollutants,

(ii) be designed such that the targets and the list of specified pollutants are able to be revised or adjusted continually as new information becomes available,

(iii) be constructed such that monitoring and enforcement costs are as low as possible, and that the burden falls directly on those responsible for the pollution or gaining from reduced emissions,

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(iv) ensure that the needs of the developing economies are adequately reflected,

(v) make resources available to promote technology transfer - both the promotion of energy-saving technologies in general and the installation of such technologies in the less developed countries.

The paper considers four regimes:

(i) a system of tradeable emission permitsissued by an international agency and exchanged through an international marketplace,

(ii) a system of country-specific quantitative emission permits enforceable in international law,

(iii) a system of taxes or levies targeted at emissions or at the consumption of specified fuels,

(iv) a convention setting ambient standards to be met on a country-by-country basis, and legitimating international sanctions against offending countries.

J.C.Burgess (1990)
'The Contribution of Efficient Energy Pricing to Reduce Carbon Dioxide Emissions'

Energy Policy, forthcoming

This paper is concerned with achieving that socially optimal level of energy production which is consistent with averting the greenhouse effect. The persuance of privately efficient pricing does not ensure this socially optimal level. Burgess considers changing the patterns of energy consumption in order to reduce carbon emissions, equating the price of each energy source to its marginal opportunity cost. Market prices, however, do not reflect private opportunity costs. This paper explores the possible reductions in emissions that could be achieved if energy prices were to become privately efficient, accepting that reductions wuld be greater were social cost pricing rules to be followed. Private opportunity cost pricing would remove many of the existing market distortions, forcing energy prices to reflect internal production costs and benefits. Yet were such policies to be followed, the potential savings from efficient energy pricing in the countries studied would be significant.

M.Grubb (1989)
The Greenhouse Effect: Negotiating Targets

Royal Institute of International Affairs, London

This paper examines the ensuing debate on international negotiations aimed at limiting greenhouse gas emissions, particularly carbon dioxide. Grubb considers carbon taxes, production quotas and permits and marketable carbon emission permits. There is a section addressing the issue of measurement with respect to monitoring biomass energy and deforestation, compliance incentives and enforcement - how to prevent international agreements from being reneged upon. Grubb concludes that a system of leasable permits for fossil carbon emission allocated on an adult per capita basis would provide the most effective means of control.

S.Hansen (1988)
Debt for Nature Swaps: Overview and Discussion of Key Issues

World Bank Environment Department Working Paper No.1

Hansen considers the effectiveness of debt-for-nature swaps, citing how they give investors direct access to the decision-making apparatus within developing countries. Such swaps can be made under terms that ensure sustainable resource policies are upheld. Whilst debt-for-nature swaps are unlikely to reduce the debt burden in the developing countries, they can have a major impact on the conservation and preservation of natural environments. Hansen explores the conditions that would need to be met to ensure that such swaps achieve their environmental aims. He also discusses the role that the World Bank can assume if it were to facilitate the sale of second hand debt for such purposes. As part of an integrated plan to ensure that sustainable policies are persued in the developing countries, debt-for-nature swapa can be usefully employed. However, they remain efficient only as long as the amounts at stake are marginal, since the opportunity cost of these freed funds is very low.

D.Hillel and C.Rosenzweig (1988)
Climate Change and its Potential Effects on Agriculture

World Bank, Environment Department Working Paper
World Bank,
Washington

The authors address the problem of global warming and the progressive accumulation of greenhouse gases. Whilst climatic predictions vary substantially, if the purported indications are partially correct, there could be profound effects on natural ecosystems. This report is a critical evaluation of the existing state of knowledge on the greenhouse effect and its impacts on agricultural productivity.

M.Hoel (1989)
'Efficient International Agreements for Reducing Emissions of CO_2'

mimeo, University of Oslo, Blindern

Hoel examines the possible policy responses for the international reduction in CO_2 emissions. The author notes that a uniform reduction in emissions worldwide will result in an inefficient outcome, with the marginal costs of emissions differing between sources. The efficient outcome, minimising deadweight loss, requires that the marginal costs of reducing emissions be equated across sources. Hoel discusses the possibility of developing an international CO_2 tax, contrasting this with an international system of tradeable quotas. The CO_2 tax has the advantage that it can be set such that the efficient outcome is ensured, with revenues being redistributed to compensate those countries facing higher costs of emissions reductions or smaller negative consequences of climatic change. Under a system of tradeable quotas, the efficient outcome is not assured, and emission reductions will be difficult to enforce. Hoel thus endorses the adoption of an international CO_2 tax.

M.Hoel (1989)
'Global Environmental Problems: The Effects of Unilateral Actions Taken by One Country'

mimeo, University of Oslo, Blindern

This paper provides an analysis of the consequences of unilateral reductions of harmful emissions. Hoel explores the cooperative game using a two country framework, studying the effects of one country persuing an altruistic strategy whilst the other's is dictated by self-interest. In the absenec of a negotiated agreement, the total emissions wil be lower than if both countries persued strategies of self-interest. However the existence of diverse stategies may well affect the outcome of international agreements. Hoel demonstrates that the outcome of international negotiations over reduced carbon emissions may well

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result in higher total emissions when one country persues an altruistic strategy in the absence of an agreement than if both countries act selfishly.

M.W.Holdgate, J.Bruce, N.Desai, O.Mascarenhas, H.Shihab, R.F. Camacho, F.Uddin Mahtab, W.J.Maunder, S.Tewungwa.
Climate Change, Meeting the Challenge (1989)

Commonwealth Secretariat,
Marlborough House,
London

This book gives a detailed overview of the causes of global warming, summarising the various perspectives on its potential impact. The authors present the scientific evidence and then consider the ecological, economic, and social impacts of climate change and sea level rise. They discuss at length the potential species loss, the implications for agriculture and the regional disparities, infrastructural changes and the vulnerability and importance of coastal ecosystems. Finally they examine the possible policy responses, the international exchange of research, monitoring, adaptive measures and protective designs to safeguard biological diversity, preventive measures and the possibility of international coordination over the issue of reducing CO_2 emissions. This text provides a fundamental basis for approaching the complexities of global warming.

D.Howarth, P.Nikitopoulos and G.Yohe (1989)
'On the Ability of Carbon Taxes to Fend Off Greenhouse Warming'

Wesleyan University
Middletown

This paper investigates the potential effectiveness of carbon restrictions designed to mitigate against carbon induced greenhouse warming and climate change. It concludes that even large carbon taxes, or their certainty equivalent consumption restrictions, are likely to be relatively ineffective unless they are preceded by succesful research into and development of alternative energy sources.

H.M.A.Jansen and J.W.Arntzen (1988)
'Debt for Sustainable Development'

Institute for Environmental Studies,
Amsterdam

This study aims at collecting and analysing experiences with existing debt-for-nature swaps. As few reports deal explicitly with the interdependence of debt and environmental problems, the authors briefly describe the essence of both problems and their interactions. Debt conversions are as yet limited to commercial loans; consequently, the study's emphasis lies on these loans, in particular on the secondary loan market.

K-G.Maler (1990)
'International Environmental Problems'
Oxford Review of Economic Policy Vol.6,No.1

Maler considers the problems of international environmental policy and the resolution of global externalities, reciprocal and uni-directional. He summarises the experience of international treaties, and examines the Polluter Pays, Mutual Compensation and Victim Pays principles. He develops a model designed to characterise the 'acid rain game', examining emmission reduction in both the short and long run.

W.Magrath (1989)
The Challenge of the Commons: The Allocation of Nonexclusive Resources

World Bank, Environment Department Working Paper No.14
Washington

This paper examines the forces that determine the allocation of resources which are not subject to completely private ownership. The paper develops the distinction between common property, in which collective action controls resource use, and open access where individual decision making prevails. It is shown that open access regimes are inefficient, but that, although potentially unstable, common property regimes can generate satisfactory outcomes. Policy interventions and socio-economic factors that influence the successful management of nonexclusive resources are reviewed from both theoretical and resource perspectives.

R.E.Marks, P.L.Swan, P.McLennan, R.Schodde, P.B.Dixon and D.T.Johnson (1990)
'The Cost of Australian Carbon Dioxide Abatement'
Special Issue on Economics of Global Warming, **Energy Journal**, Spring (1990)

The paper examines efficient means of abating the greenhouse effect by reducing the emissions of CO_2. It examines the generation of CO_2 emissions from fossil fuels in Australia, and analyses means to cut emissions from electricity generation and road transport. Finally it calculates the cost in terms of growth for one of measures to attain the Toronto targets for Australian electricity generation and road transport, using the ORANI multisectoral model.

D.W.Pearce (1990)
'Economics and the Global Challenge'
Henry Sidgwick Memorial lecture

Millenium, forthcoming

This paper summarises the current status of international agreements and the policies available for controlling the emmission of greenhouse gases. Pearce considers sulphur taxes, tradeable permits and the constraints to the operation of effective international agreements. This paper provides the reader with a concise overview of recent developments in both the theory and practice of providing an efficient and workable solution to the problems of global warming.

D.W.Pearce and J.Warford (1991)
'International Environment Policy'

Warford and Pearce, Environment and Economic development, Chapter 18

This chapter details the causes and impact of global warming, focussing on the potential for international agreements to provide a resolution to the problem of the global commons. Warford and Pearce summarise the potential environmental, and GNP losses for the developing nations as the result of climatic change. They discuss the case of international carbon taxes and tradeable permits, paying careful attention to the problems of international cooperation.

C.F.Runge (1990)
'Common Property Resources in a Global Context'

Ambio, forthcoming

Runge considers the global commons, paying particular attention to climate change and its relationship to biodiversity and the management of Antartic resources. In his discussion of common property resources and management in Nepal and deforestation in Ecuador he highlights the role played by the conferal of property rights in determining resource use.

G.E.Schuh (1990)
'International Economic Policies and Sustainable Development'
Workshop on the Economics of Sustainable Development

UNEP
Washington

Schuh identifies and discusses those international policies which have had an affect on the sustainability of economic development, highlighting the cases of international trade policies and international debt. This is followed by a brief summary of the need for reforms in international economic policies and institutional arrangements: monetary reform, trade policy reform concessional lending aid, agricultural research and the development of an international environmental code.

T.Sterner (1990)
'An International Tax on Pollution and Natural resource Depletion'
Energy Policy (1990)

Sterner reviews the choice of available policy instruments that can be employed to achieve international cooperation to reduce emissions. The paper emphasises the need for strengthening international cooperation to ensure that agreements are both effective and efficient.

G.W.Yohe (1990)
'The Cost of Not Holding Back the Sea', **mimeo**

Wesleyan University
Middletown

Yohe examines various responses to the inevitability of climate change: reducing emissions of greenhouse gases, innovation to ameliorate or mitigate its effects - protecting threatened shorelines, managing the migration of forests. Yohe considers ranking the various responses in terms of the expected present value of the net benefit that each response should achieve. This type of policy analysis requires:

(i) a subjective time distribution of future values for state variables such as sea level rise,

(ii) the derivation of an appropriate discount rate,

(iii) valuation of the potential cost of proposed policy,

(iv) the valuation of the potential benefit derived from policy response, which is usually based on the opportunity cost of anticipated climate change foregone by the introduction of policy.

This paper reports on the early steps of a process designed to produce a measure of economic vulnerability across the United States to greenhouse-induced sea-level rise. The first three sections outline a methodology by which site-specific vulnerability estimates can be devised. there follows the results of its application to Long Beach Island, New Jersey.

ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME NINE

POPULATION GROWTH AND ENVIRONMENT

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REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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POPULATION AND ENVIRONMENT

[This volume is a shortened version of Chapter 11 of D.W.Pearce and J.Warford, Environment and Development: Environmental Economics for the Developing World, forthcoming 1991. Its format differs from the other volumes in that salient publications are in footnotes.]

The Population Challenge

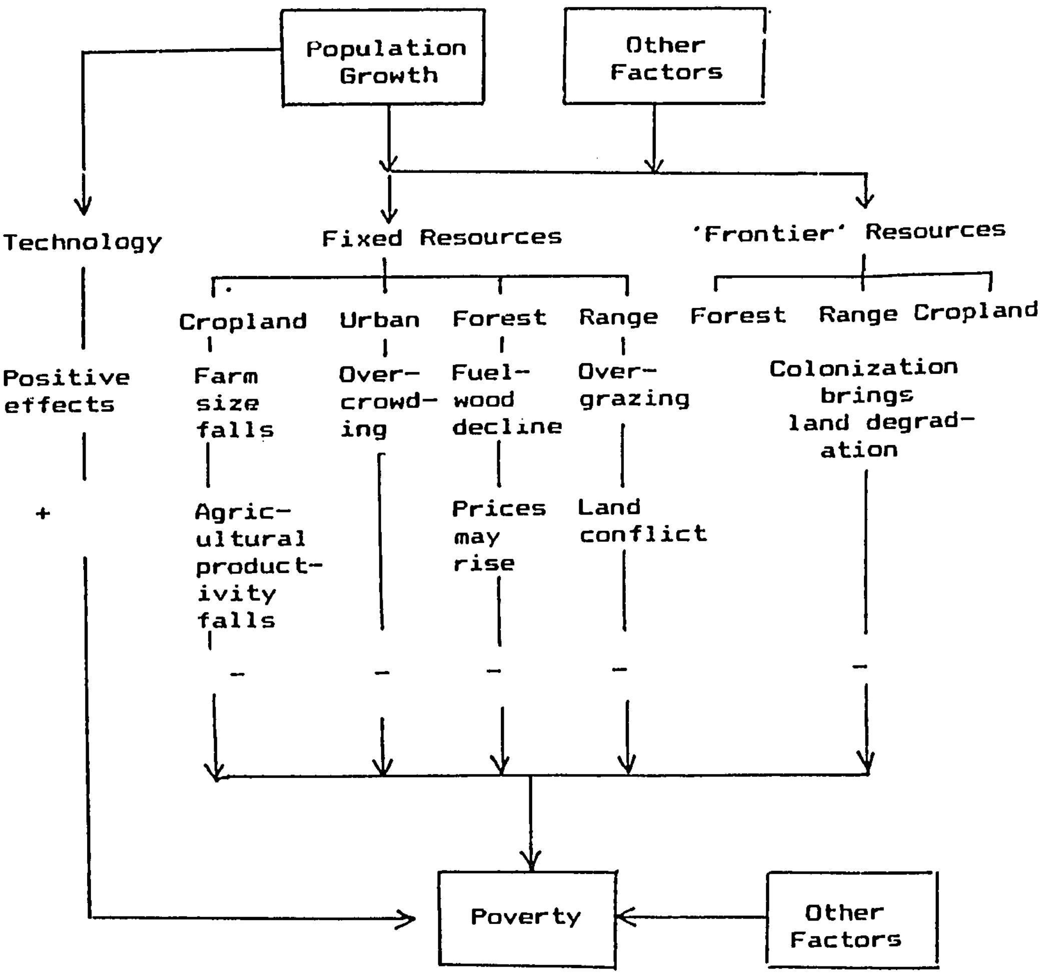
Population growth is widely regarded as the dominant cause of environmental deterioration and over-rapid resource use in the developing world, and globally. The links between population growth and poverty are more complex. If increases in population do cause environmental deterioration, which in turn is linked to poverty, then one linkage to poverty is established. But there are other factors giving rise to environmental change and other factors causing poverty. Citing population growth alone as the main cause of poverty is therefore likely to be a misstatement of the problem. Losses of environmental assets are also brought about by misguided government policies and by the failure of market systems to account for external effects and the interests of future generations. Poverty may similarly represent a manifestation of differences of political power within an economic system, differences that become self-perpetuating unless the power base is changed.

The generalised picture is depicted in Figure 1 which illustrates some of the possible intermediary effects of population change. A distinction is made between resources currently in use - existing cropland, urban land, forest resources and rangelands - and 'frontier' resource such as virgin forest, unused rangelands etc. Population growth tends to impact on both types of resources. Existing resources might be used more intensively, resulting in reduced fallow periods and non-recovery of soil productivity. Population pressure will also force further 'colonization' of previously unused resources: forests will be cleared, cattle will be put on to land previously used by wildlife, hillsides will be cultivated. Erosion and overuse tend to follow because the land is intrinsically unsuitable for cultivation, or because agricultural practices suited to intra-marginal land are not suited to sloped land. All these impacts contribute to soil erosion and lower soil productivity, and hence to a lowering of average yields. Incomes fall and poverty ensues. The induced poverty may itself then lead to further land degradation as the poor seek to cope by extending farming margins further, overgrazing livestock and so on.

But there could be positive feedbacks. Population growth may encourage agricultural intensification through the adoption of technological change. It is widely thought that population has in fact been the main stimulus to technological change in agriculture. The picture may not therefore be a wholly dismal one.

FIGURE 1

POPULATION – ENVIRONMENT – POVERTY LINKAGES



World Population Growth

World population currently stands at some 5 billion people. By 2000 there will be 6 billion people and by 2025 over 8 billion. The rate of increase will peak in the early 1990s at about 88 million per annum. Total population growth and its regional distribution is shown in Table 1. Asia (excluding Japan) has the largest share of the world's population (56% of the total), much of it in China, 1040 million people - and India, 765 million. The fastest rate of increase is in Africa.

Table 1

Population Trends 1900 - 2100

(millions)

	1900	1950	1985	2000	2025	2100
Africa	133	224	555	872	1617	2591
Asia(1)	867	1292	2697	3419	4403	4919
Latin America	70	165	405	546	779	1238
Total: Developing World	1070	1681	3657	4837	6799	8748
Europe, USSR, Japan, Oceania	478	669	917	987	1062	1055
North America	82	166	264	297	345	382
Total: Developed World	560	835	1181	1284	1407	1437
Total: World	1630	2516	4837	6122	8206	10,185

Source: T.W.Merrick, 'World Population in Transition', Population Bulletin, Vol.42, No.2, 1986.

Notes: (1) Excludes Japan.

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A long run historical perspective reveals that world population growth rates changed dramatically around the time of the industrial revolution in the developed world. In Europe the rate of change went from 0.5% per annum to 1.5% per annum. In North America the rate rose to 2% per annum in the early 19th Century due to high fertility, low mortality and substantial immigration. Yet these are low rates of increase compared to the experience of developing countries in the 20th Century. Rates of growth below 2 per cent per annum have been the exception, with annual rates being closer to 3 per cent per annum, twice that of the developed countries at a comparable stage of development. The marked contrast in historical experience is underlined by the fact that population growth and increases in material prosperity were correlated in the developed world transition, but population growth tends to be fastest the poorer the country in the current developing world. In short, there seems to be little by way of comparison between the historical experience of the currently developed countries and the recent experience of the developing world.

World population growth has resulted from marked reductions in mortality rates due to improved health care, education and sanitation, especially in the developing world. For example, a quarter of Sri Lanka's decline in mortality after 1945 has been attributed to malaria control[1]. While birth rates have also fallen they remain significantly above death rates in the developing world and only slightly above in the developed world. It is this factor which provides the proximate explanation for the difference between the developed and developing world experience. In the developed world reductions in mortality rates were generally accompanied by reductions in birth rates. Reductions in birth rates in the developing world have lagged behind reduced mortality rates, and in a number of cases the birth rate has hardly fallen at all.

Why, then, should there be an historical difference between developed and developing world in the time profile of birth rates ? The reasons are complex and there appears to be no universally valid explanation for all countries. In Korea fertility rates[2] fell by 44% between 1965 and 1982 as women married later and later. The 1982 level has continued to fall but at a much slower rate because the average age of women at marriage is tending towards a limit. The potential for further fertility decline is

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[1]. See World Bank, World Development Report 1984, World Bank, Washington DC, 1985, p. 69.

[2]. The fertility rate is a measure of the number of births per individual (or a group or a population). Broadly speaking, therefore, it is the number of children actually born to a woman of child-bearing age.

thus constrained. In Costa Rica fertility rates fell by 48% between 1965 and 1987, and are expected to fall by a further 25% by 2000. But there are signs that there is some lower limit to the desired family size. This suggests that fertility rates will not decline continuously as they did in the developed world. The experience with family planning varies markedly. In India the total fertility rate has fallen continuously but contraceptive practice varies according to female literacy and the vigour with which policy is pursued.

Some insight into the reasons for the slower than expected decline in fertility in the developing world can be obtained by looking at the underlying factors involved in the African experience.

Population Growth in Africa

The special problem of population growth in Sub-Saharan Africa[3] is revealed in Figure 2. Whereas population growth rates are broadly constant or declining in all other regions of the world, growth rates in Sub-Saharan Africa (SSA) have increased steadily from 2.5 per cent per annum in 1960 to 3 per cent per annum in 1983. This is the outcome of significant reductions in death rates and very little change in birth rates (indeed, some countries have experienced increased birth rates). Ivory Coast, Zimbabwe and Kenya have growth rates in excess of 4 per cent per annum which, if sustained, would double their populations in less than 18 years[4]. For Sub-Saharan Africa as a whole, the 1985 population of 485 million would be doubled in just 22 years if current rates of growth are sustained.

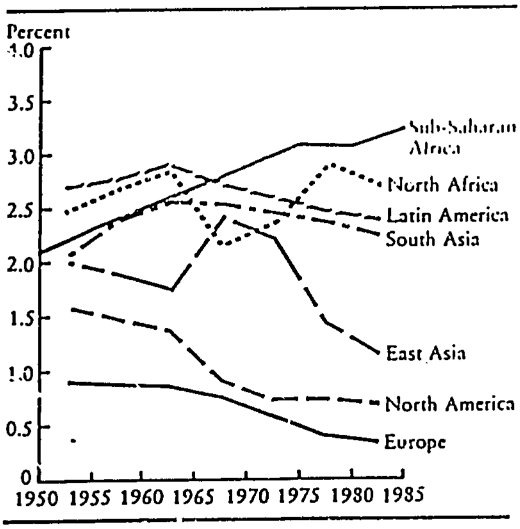
Mortality rates have fallen dramatically in SSA from just under 30 per 1000 in 1950 to some 16 per 1000 in the early 1980s. This decline reflects the general increase in living standards, education and public health programmes. The reasons for the constancy in the birth rate lie in underlying cultural attitudes to the bearing of children and in economic factors. As health improves so does natural fecundity (the physiological ability to bear children). Age at marriage for girls in Africa has not declined significantly. there is some evidence that breastfeeding and post-natal sexual abstinence have declined, and there is an extremely low use rate for contraceptives. The factors underlying

[3]. Sub-Saharan Africa relates to Africa other than Morocco, Tunisia, Libya, Algeria, Western Sahara, Egypt and South Africa.

[4]. A population's 'doubling time', t, is given by the equation $e^{xt} = 2$, where x is the growth rate.

Figure 2

World Regional Variations in Population Growth Rates 1950 to 1985



Source: World Bank, Population Growth and Policies in Sub-Saharan Africa, Washington DC, 1986, p.8.

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these proximate reasons for the continued high birth rate appear to be as follows[5]:

(i) the continuing agricultural bias in African economies. This provides incentives to 'invest' in children as labour on the farm, assisting with fuelwood and water collection, caring for children, looking after livestock, etc. Moreover, the amount of land that can be cultivated often depends on family size, creating further incentives for large families. The private benefics from increasing family size thus tend to outweigh the private costs, and this determine family size decisions. The net private benefits will tend to diminish, and eventually become negative above

[5]. See World Bank, Population Growth and Policies in Sub-Saharan Africa, Washington DC, 1986.

a limited family size, as education opportunities expand, as off-farm employment opportunities increase, and as land tenure and ownership patterns change. State provided education incurs private costs in the form of uniforms, books and travel, making larger families more costly. Urban work opportunities reduce the need for on-farm labour, and tenurial change reduces the incentive to claim resource and land rights on the basis of family size.

(ii) larger families act as a form of social security through the extended family. Being a child frequently involves many obligations to other members of the family. Once again, 'investing in children' becomes a way of ensuring care in old age. More generally, larger families mean wealth and influence. As state - provided social security systems are introduced so this motive for larger families will weaken.

(iii) as long as women have an inferior social role to men any preferences they might have for smaller families will be under-represented in the private cost-benefit decision about family size. Often, however, a woman's own status depends on childbearing so that they appear to share the preference for large families. As education expands and other forms of emancipation increase, so some women might be expected to change their preferences for large families, while others, with a prevailing but overruled preference for smaller families, might be expected to exert more influence.

(iv) many cultures simply favour large families. Women are afforded more respect if they have more children, while barrenness may be regarded as a legitimate reason for divorce.

(v) having few children and investing in their education is a high risk strategy if infant mortality is high and employment prospects poor. Once again, this 'risk aversion' influences the private cost-benefit decision in favour of large families. As employment prospects improve and infant mortality declines, the benefit - cost ratio can be expected to change to favour smaller families.

Clearly, the social, economic and cultural factors underlying decisions about family size are complex. They are also likely to vary from society to society. In general, however, the picture is as shown in Figure 3. The private benefit - cost ratio favours large families at low levels of education, high levels of rural dependence and low levels of state provided social security. As

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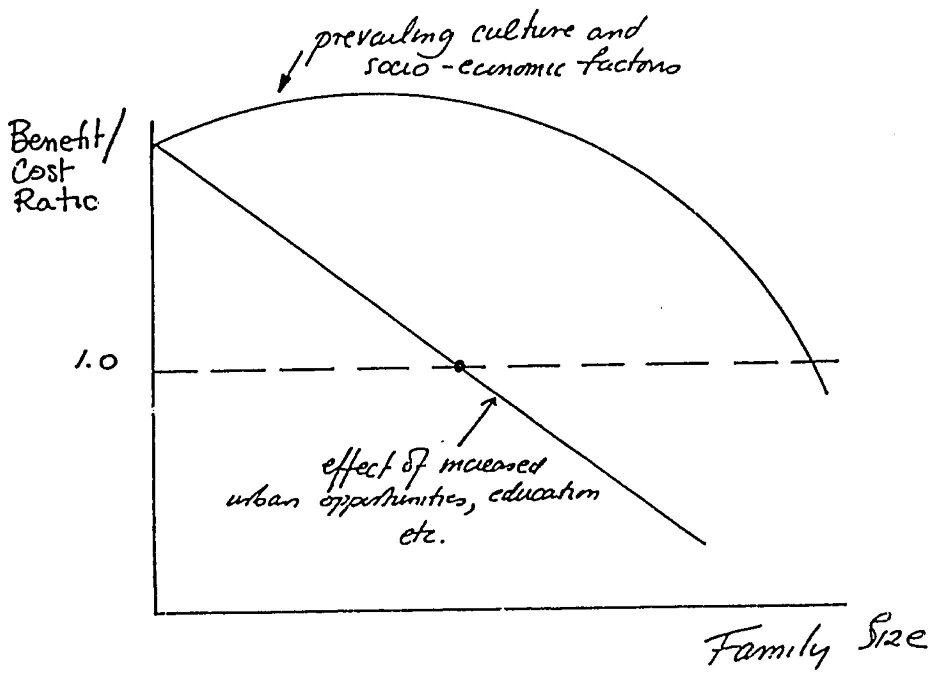
these change, the ratio falls and favours smaller families. The obvious problem in SSA is that these factors are changing all too slowly relative to the factors reducing the death rate.

Figure 3

Private Costs and Benefits and Family Size



As education increases, infant mortality declines, rural dependence is lessened and state social security advanced, so the net private benefits to increased family size decline.

<u>Population - Environment Linkages: the Carrying Capacity Approach</u>

One way of assessing the ultimate limits of population growth is to look at the <u>carrying capacity</u> of natural resources and land. Simply put, the carrying capacity of a given area is the maximum number of people that can be sustained by the resources on that land. The carrying capacity of a region is categorically not the <u>desirable</u> level of population unless the level of wellbeing at which the population is sustained is itself desirable. Usually, however, carrying capacity is defined as relating to the maximum sustainable population at the minimum standard of living necessary for survival.

The most extensive analysis of the carrying capacity of the world was carried out by the Food and Agriculture Organisation (FAO) of the United Nations[*]. The FAO approach involved looking at the potential food production of each of 117 countries. Obviously, potential food production depends on the level of technology applied to agriculture. FAO categorised these as:

> low level: corresponding to no fertilisers, pesticides or herbicides, with traditional crop varieties and no long-term conservation measures;
>
> intermediate level: corresponding to use of basic fertilisers and biocides, use of some improved crop varieties and some basic conservation measures;
>
> high level: corresponding to full use of fertilisers and biocides, use of improved crop varieties, conservation measures and the best crop mixes.

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

Table 2 summarises the results in a convenient form. It shows the ratio of potential sustainable population in 2000 to the expected population in 2000 for various regions of the world, and at the three different levels of technology. For example, for the developing world as a whole, if all cultivable land was devoted to food crops, at the lowest level of technology those lands could support 1.6 times the number of people expected in the year 2000. In south-west Asia the actual expected population will exceed the carrying capacity at both low and intermediate technology levels. As the technological assumptions improve so, dramatically, does the carrying capacity of the regions.

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[*]. See Food and Agriculture Organisation, Potential Population Supporting Capacities of Lands in the Developing World, FAO, Rome, Report FPA/INT/513, 1982. For a popular version see FAO, Land, Food and People, FAO Economic and Social Development Series No.30, Rome, 1984.

Table 2

Carrying Capacities for World Regions: 2000

(Potentially supportable population divided by expected population).

Input Level	Africa	SW Asia	S.America	C.America	SE Asia	Average
Low	1.6	0.7	3.5	1.4	1.3	1.6
Interm	5.8	0.9	13.3	2.6	2.3	4.2
High	16.5	1.2	31.5	6.0	3.3	9.3

Source: FAO, Land, Food and People, Rome, 1986, p.16.

Table 2 might appear to suggest a fairly optimistic picture. Certainly, it highlights the role which technological improvement can play in vastly increasing carrying capacity. However, it is important to understand why the picture is far from an optimistic one. First, carrying capacity relates to the maximum number of people that can be sustained with the given resource, not to the desirable level. Second, the carrying capacity figures relate to a minimum calorie intake, so that even for a single person the approach makes no allowance for increasing nutritional levels. Third, the time horizon of 2000 does not permit much change to take place in levels of applied technology so that at least the high technology input scenario is of limited relevance to what will actually be the case. Fourth, the approach assumes all cultivable land will come under food production or livestock pasture, which is a clear exaggeration of what is feasible. Allowing for non-food crops, the ratio of 1.6 in Table 2 becomes 1.07, i.e. at low technology the carrying capacity of the developing countries is only 7% more than the actual population.

In fact the situation may be worse still than is suggested in Table 2. The FAO study was concerned with carrying capacity in terms of food. But other resource scarcities may begin to exert an influence before cultivable land. A notable example is the availability of fuelwood. In a study of the Sahelian and Sudanian zones of West Africa Steeds computed the carrying capacity of various zones according to the limits set by crops, livestock and

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fuelwood[7]. The results are shown in Table 3. It will be observed that the carrying capacity of natural forest cover - the main source of fuelwood - is very much lower than that of crops using traditional technologies. Moreover, in five of the six regions (underlined) fuelwood carrying capacity is already exceeded, compared to two regions where food and livestock carrying capacity is exceeded. The general picture in Table 2 on world zone carrying capacities may therefore understate the problem of resource carrying capacity generally. What matters is which resource scarcity 'bites' first.

Carrying capacity calculations of the kind shown in Tables 2 and 3 are helpful up to a point. They can be used to indicate the broad-scale seriousness of a problem, but there are considerable dangers in deriving too many conclusions from them. The main drawbacks are as follows:

(i) at the country or small region level, carrying capacity can be readily increased by trade. If we calculated the carrying capacity of, say, South Korea it would show up adversely. Yet by trading on the basis of its comparative advantage in technology and industry, Korea can import food and so sustain a larger population.

(ii) as population grows so there is a 'forcing' effect on technology. It may, for example, lead to changes in the way in which agriculture is practised. Population growth generally explains the transition from shifting cultivation with long fallow periods, to short fallow farming and cropping rotations with organic manuring, to modern intensive monocultures based on high yield crops, irrigation, fertilisers and chemicals. Carrying capacity tends to be a 'static' concept and thus cannot capture these dynamic, interactive effects.

Despite these drawbacks, a casual glance at the level of population - resource imbalance and the rate of agricultural growth suggests that the greater is the pressure on natural resources the slower is agricultural growth. Table 4 shows

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[7]. D.Steeds, Desertification in the Sahelian and Sudanian Zones of West Africa, World Bank, Washington DC, 1985.

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Table 3

Carrying Capacities in Sahelian/Sudanian Zones of West Africa
(people / km²)

Zone	Sustainable Population: Crops	Sustainable Population: Livestock	Sustainable Population: Sum	Actual Rural Popn.	Sustainable Population: Fuelwood	Actual Total Popn.
Saharan	-	0.3	0.3	0.3	-	0.3
Sahelo-Saharan	-	0.3	0.3	2	-	2
Sahelian	5	2	7	7	1	7
Sahelo-Sudanian	10	5	15	20	10	23
Sudanian	15	7	22	17	20	21
Sudano-Guinean	25	10	35	9	20	10

Source: D.Steeds, Desertification in the Sahelian and Sudanian Zones of West Africa, World Bank, Washington DC, 1985, p.13.

this relationship for four groups of countries in Sub-Saharan Africa. Group 1 relates to countries where actual population exceeded the sustainable population in 1982; Group 2 relates to countries where this occurs in 2000; group 3 to countries where it will happen in 2030; and group 4 to the remaining countries, i.e. those whose carrying capacities will not be exceeded by 2030. In all cases the measure of carrying capacity is that of the FAO. The table suggests that the closer a country is to its carrying capacity the slower is its agricultural growth rate. In turn this suggests that the relationship between population growth and food output might reduce to the balance between two forces working in opposite directions: the role of population pressure in inducing technological inducement to higher productivity, and its role in wider resource degradation that reduces agricultural growth. The next section looks at these linkages.

Table 4

Resource Pressure and Agricultural Growth

in Sub-Saharan Africa

Group	Agricultural Growth
1	1.1
2	2.2
3	3.5
4	1.5

Source: T.Ho, 'Population Growth and Agricultural Productivity in Sub-Saharan Africa', in T.Davis (ed), Proceedings of the Fifth Agriculture Sector Symposium: Population and Food, World Bank, Washington DC, 1985.

Population Growth, Soil Degradation and Technological Change

The evolution of agricultural systems is closely linked to changes in population density*. Given the extensive forest cover of land in the earliest stages of man's development, primitive hunter-gatherer societies gave way to forest fallow systems based on forest clearance, use of the cleared land for a few years and then relocating elsewhere in new forest land. As population grew, so fallow periods shortened and forest cover declined in density, giving way to bush and shrub cover and then to grassland cover. Further population growth led to the abandonment of the fallow period altogether, necessitating the search for methods of restoring soil fertility which the fallow period had previously achieved naturally. For soil fertility to be sustained or improved, therefore, the soil's natural regenerative capacity obtained from the fallow period has to be substituted for by other inputs and by technology. One immediate reaction to

*. Important works establishing this linkage are E.Boserup, Population and Technology, Blackwell, Oxford, 1981, and P.L.Pingali and H.Binswanger, 'Population Density and Agricultural Intensification: a Study of the Evolution of Technologies in Tropical Agriculture', Report ARU 22, Agriculture and Rural Development Department, World bank, 1984.

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declining fertility was, and is, increased labour inputs. Similar substitutions occur with organic manuring and, subsequently, artificial fertilisers, the use of animal draught power and, later still, mechanical power.

While this process describes the general transition from 'extensive' to 'intensive' agriculture, it is important to recognise that some agro-ecosystems cannot support intensive farming technologies. Some soils are quickly eroded by mechanical tillage, for example. Thus the picture of agricultural development as a competing process between soil degradation brought on by the loss of natural regeneration (due to declining fallow periods) and technological advance has to be tempered by consideration of the types of soil and ecosystem in place. Moreover, empirical tests of the various linkages involved are not conclusive. There does appear to be a close correlation between population density and farming intensity, as Table 5 shows. The other linkage is between declining fallows and agricultural productivity. Various studies establish this relationship, although data for Sub-Saharan Africa, where the advance of technology to compensate for declining fertility has been conspicuously slow, tend to be sparse[9].

The process therefore seems to be that population growth leads to reduced fallow periods and increased farming intensity. This, in turn, reduces soil productivity. Farmers react by introducing technological change. The relative speed at which technology changes compared to the decline in soil productivity and the increase in population growth determines the rate of change in agricultural productivity. In terms of the carrying capacity arguments, technological change shifts the carrying capacity by enabling the land to support ever larger population levels.

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[9]. Some of the evidence is assembled in Ho, op.cit. See also H.Ruthenberg, Farming Systems in the Tropics, 3rd edition, Oxford University Press, Oxford, 19880, especially Section 4.5.

Table 5

Population Density and Farming Intensity

Farming System	Farming Intensity[1]	Pop.Density[2]	Climate
Hunter/Gatherer	0	0 - 4	
Forest Fallow	0 - 10	0 - 4	Humid
Bush Fallow	10 - 40	4 - 64	Humid/ Semi-Humid
Short fallow	40 - 80	16 - 64	Semi-Humid Semi-Arid High Alt.
Annual Cropping	80 -120	64 -256	Semi-Humid Semi-Arid High Alt.

Notes:

1. (Years of Cultivation/Years of Cultivation plus Fallow) x 100

2. Persons/km^2.

Source: Pingali and Binswanger, op.cit.

Population growth may thus 'force' technological change and increase agricultural productivity and hence food supplies. It may also cause declining productivity if, for any number of reasons, technological change does not take place. One reason why technological change may not occur is if the soils in question cannot support such changes. If there are such 'limits to technology' it then matters a great deal that the final farming system established has the capability of trading with other areas. For example, areas with soils suited only to rangelands may trade livestock with areas suited to arable crops and more intensive farming.

Population growth may also benefit a given area through an economies of scale effect. Essentially, fallow farming involves significant population movement. As fallow periods reduce the movement slows down and there is a tendency towards sedentary farming and settlement. This, in turn, makes it worthwhile to introduce permanent infrastructure, thus making the transport and marketing of produce easier. Moreover, as these changes occur so it is possible for specialisation in production to occur, with different areas trading with each other.

What are the policy implications of these probable linkages between population growth, technology and soil fertility ? It is tempting to draw a 'laissez faire' conclusion: there is no need to intervene to reduce population growth rates because they will generate feedback effects which will ultimately increase food production. This is a dangerous conclusion. As we have seen, there is nothing in the argument to prove that rates of technological change will be <u>sufficient</u> to outweigh the deleterious effects of population growth on soil productivity. To observe that they have had this effect in the past carries no particular implication for what will happen in the future, not least because the 'agricultural revolution' required has to take place in different climatic conditions. Second, even where technology does achieve marked increases, as with the 'green revolution', the technology itself can have significant negative environmental consequences as with the effects of fertiliser runoff on water systems, pesticides on human health, and monocultural cropping on the resilience of ecosystems to shock and stress. Third, and perhaps most significant, if the technological change can be secured <u>without</u> rapid population growth, this is surely better than technological change with population growth. The fallacy in the optimistic interpretation of the population - agriculture linkage is in seeing population growth as a <u>necessary condition</u> for improved agricultural productivity.

For these reasons at least, policy has to continue to be directed towards <u>both</u> improving the application of technology <u>and</u> to reducing population growth rates.

<u>Population Growth and Resource Scarcity</u>

(a) <u>Net Primary Product</u>

The previous discussion concentrated on the relationship between population growth and soil fertility. Implicit in the analysis was a linkage between population growth and use of the total land area available for different uses. As population grows and fallow periods decline so any existing plot of land is 'occupied' on an increasingly continuous basis. If efforts are made to colonise hitherto uncultivated land, so the land available for other uses declines. The 'other uses' here include land for recreational use, wildlife habitat and general environmental protective functions. One consequence of population growth, then, is that resources other than agricultural land fertility disappear. Ecologists characterise this effect in terms of competing uses for 'net primary production' (NPP) in the world's ecosystems. NPP is the change in the world's biomass due to the fixing of solar energy by the photosynthetic conversion of CO_2 into usable carbon compounds. Approximate calculations suggest that the standing stock of biomass in the world is about $1,800 \times 10^{15}$ grammes, and that NPP is around 175×10^{15} grammes per annum[10]. A crude estimate puts the amount of NPP used for food for people at between 84 and 102 x 10 grammes per annum, i.e. around 48-58% of NPP. The significance of this ecological view is that population growth is increasing this proportion by (a) increasing the amount of NPP need to support food production, and (b) reducing NPP through forest clearance and conversion to agriculture. Note that (b) occurs because agricultural land contributes less NPP than forested land, i.e. a reduction in forest is not compensated wholly by its conversion to agriculture.

(b) Non-Renewable Resources

As population expands so we can expect the demand for non-renewable resources, such as coal, oil and metal ores, to rise. But consumption per capita is also likely to rise as living standards improve. Table 6 illustrates the relative contributions of population growth and rising per capita consumption levels on the demand for commercial energy[11]. The relative contributions are computed by taking the per capita energy consumption level for 1960 and multiplying it by the 1984 population level. This shows what the energy consumption level would have been had per capita consumption remained unchanged with population growth. This change in the total energy consumed is then expressed as a percentage of the total actual change in energy consumption between 1960 and 1984[12]. Table 6 also shows the per capita energy consumption levels for 1960 and 1984. As an illustration, for the world as a whole, energy consumption would have risen 46% between 1960 and 1984 had the world's population in 1984 consumed energy at the 1960 per capita level. Thus 46% of the growth in energy consumption was 'due to' population growth, and 54%, the remainder, to rising per capita consumption levels. Asia shows a marked increase because of rising standards of living, and this is revealed also in the per capita consumption levels. Overall, then, population growth certainly impacts significantly on non-

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10. The estimates here are taken from G.Woodwell, 'On the Limits of Nature', in R.Repetto (ed), The Global Possible, Yale University Press, New Haven, 1985, 47 - 65.

11, Commercial energy excludes woodfuels and other biomass.

12. That is, we compute $e_0/p_0 . p_1$ and subtract from it e_0. The result is then expressed as a percentage of $e_1 - e_0$, where e is total energy consumption, p is population and the subscripts 1 and 0 are 1984 and 1960 respectively.

renewable resources, typified here by energy. But rising income levels account for slightly more of the growing world energy consumption than does population growth. Rising income levels are seen to be especially important in explaining energy consumption growth in Asia and Europe.

Table 6

Population Growth and Energy Consumption
1960 - 1984

Region	% of Increased Energy Consumption due to: Population	Living Standards		Energy Consumption per capita[1] : 1960	1984
World	46	54		38	55
Africa	33	67		6	12
N.America	51	49	USA	236	281
			Canada	164	286
S.America	37	63		16	28
Asia	18	82		8	20
Europe	16	84		72	124

Notes: 1. 10^9 joules per person

Source: computed from data in United Nations Environment Programme, <u>Environmental Data Report</u>, Blackwell, Oxford, 1987.

The term 'non-renewable' implies a fixed stock of resources. In a literal sense this must be true. Actual recorded <u>reserves</u> of energy and minerals tend to increase over time because reserves simply record what has been proven to exist on a commercially exploitable basis. Reserves are therefore a subset of the total of resources available. One way of finding out if population pressure is contributing to the exhaustion of resources would be to estimate total resources on the basis of known geological formations and guesses at their mineral content. One could then estimate the world's future population at some point in time, multiply it by an estimated per capita consumption of resources and divide the resulting total into the figure for the total stock of resources. This would provide a very rough estimate of the number of years before the exhaustion of that resource takes place[13]. But such exercises are seriously misleading because they fail to account for any of the adaptive and feedback mechanisms which tend to operate as a resource becomes physically scarcer. Such mechanisms include technological change to reduce the amount of the resource used per unit of economic activity and substitution between resources. A major inducement to such adaptations is price. As a resource becomes scarce we might expect its price to rise, inducing conservation, substitution and technological change.

Trends in real prices of natural resources traded in the USA have been analysed in a number of publications. One recent study by Darwin and Jane Hall[14] suggests the results shown in Table 7. Using two measures of scarcity - one based on costs of extraction and production, the other on real prices - the study concludes that energy resources were generally scarcer in the 1970s, whereas non-ferrous metals appeared to become more plentiful. Up to the 1970s the evidence is unambiguously in favour of the hypothesis that resources generally became less scarce.

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[13]. This is very much what the celebrated publication Limits to Growth did in 1972. See, D.Meadows et al., Limits to Growth, Earth Island, London, 1972.

[14]. D and J.Hall, 'Concepts and Measures of Natural Resource Scarcity, with a Summary of Recent Trends', Journal of Environmental Economics and Management, September 1984. The classic work, which argued that price and cost trends failed to support a hypothesis of increasing resource scarcity, is H Barnett and C Morse, Scarcity and Growth: the Economics of Natural Resource Availability, Johns Hopkins University Press, Baltimore, 1963.

Table 7

Cost and Price Measures of Resource Scarcity: USA

Resource	Unit Cost Test	Relative Price Test
Coal	1960s: down 1970s: up	Not significant
Oil and gas	1960s: down 1970s: up	1960s: down 1970s: up
Electricity	1960s: down 1970s: up ?	1960s: down 1970s: up
Non-ferrous Metals	1960s: up 1970s: down	? ?

Notes: 'up' means increasing scarcity; 'down' means decreasing scarcity. The unit cost approach uses a measure of the cost of inputs in the extractive process. Relative prices are real final prices. ? signifies no real statistical trend.

Source: adapted from Hall and Hall, op.cit.

Results of this kind need to be interpreted with caution. Resource markets may not necessarily reflect anticipated scarcity well. Indeed, a great many government interventions in markets have taken place precisely because governments do not believe that free markets correctly anticipate future scarcity. On the other hand, the price and cost indicators of scarcity are to be preferred to simple resource availability measures since, as we have seen, these do not account for the various feedback mechanisms which ultimately determine the true scarcity of resources.

(c) Renewable Resources

Population growth has unquestionably impacted upon renewable resource availability. Up until the Second World War, agricultural output expansion was mainly met from expanding the area under cultivation. Table 8 shows broad estimates of changes in land use for the world's major regions between 1850 and 1980.

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Table 8

World Land Use Changes by Region

% change in area 1850 - 1980

	Forests	Grassland	Cropland
All Regions:	-15	-1	+ 179
Tropical Africa:	-20	+9	+ 288
Latin America	-19	-23	+ 677
North America	- 3	-22	+ 309
China	-39	- 3	+ 79
S.Asia	-43	- 1	+ 196
S.E.Asia	- 7	-25	+ 670
Europe	+ 4	+ 8	- 4
USSR	-12	- 1	+ 147

Source: IIED and World Resources Institute, World Resources 1987, Basic Books, New York, 1987 p.272.

The picture is systematic. Only in Europe has cropland area remained static (and will in fact decline as agricultural price support schemes are phased out). This expansion has been at the cost of losses in forest land, wetlands and grassland.

The links between deforestation and population growth have been investigated by several writers. Palo, Mery and Salmi[15] produced an extensive statistical test of the factors influencing deforestation in 72 tropical countries. They regressed a measure of deforestation in a given year on indicators of soil erosion sensitivity, climate, accessibility of the forest area, extent of shifting cultivation and grazing, extent of fuelwood collection, various indicators of economic development, land tenure and population pressure. Forest coverage was found to be very closely

[15]. M.Palo, G.Mery and J.Salmi, 'Deforestation in the Tropics: Pilot Scenarios Based on Quantitative Analysis', in M.Palo and J.Salmi, Deforestation or Development in the Third World ?, Finnish Forest Research Institute, Helsinki, 1987, 53-106.

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correlated with population density and with population growth rates in all countries other than eight arid African countries. Food production was also correlated with deforestation indicating that increased food output has been secured by forest clearance for agricultural land use. To a limited extent, GNP per capita was also correlated with deforestation. Using the regression relationships, the authors project levels of deforestation up to the year 2025 under various assumptions. The general result is that very large scale deforestation can be expected in the future, particularly in Latin America.

Deforestation is, however, a complex process caused by many interacting factors. Southgate has analysed the factors at work in one particular country, Ecuador[16]. A simple Malthusian hypothesis linking deforestation with population pressure was rejected because the areas under study exhibited no secular increase in population density between 1974 and 1982, the period covered by the study. Land and resource tenure arrangements contribute strongly since land claims can only be adjudicated if at least half of any settled land is cleared of vegetation. Fallow lands can also be claimed by agricultural colonists, deterring existing fallow arrangements which maintained much of the land under forest cover. Logging concessions were banned in 1982, placing the burden of supplying timber on colonists who deplete the forests inefficiently. The growth in their activity is revealed by the rapid increase in the import of chainsaws. The Ecuadorian government has also banned log exports, which has had the effect of keeping timber prices low, in turn discouraging any afforestation effort. Forest protection is also severely limited by the lack of forest rangers and low expenditure on research and extension. The studies link the extent of deforestation to the extent of agricultural colonisation and an index of the extent to which formal land tenure is held. Land clearance was found to be affected by both population pressure and tenurial arrangements[17].

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[16]. D.Southgate 'How to Promote Tropical Deforestation: the Case of Ecuador', Department of Agricultural Economics and Rural Sociology, Ohio State University, mimeo, June 1989; and D.Southgate, R.Sierra and L.Brown, 'A Statistical Analysis of the Causes of Deforestation in Eastern Ecuador', Ohio State University, mimeo, June 1989.

[17]. More formally, the model has two equations. The first regresses the size of a canton's agricultural labour force on its non-agricultural labour force, the agricultural productivity of the soil and the extent of a canton's all-weather road network. This equation then 'explains' the extent of agricultural colonisation. The second equation regresses deforestation on this measure of colonisation and on land tenure. Southgate's findings are consistent with other work which explains deforestation in terms of inefficient government interventions such as tax

Simple relationships between population growth and renewable resource loss therefore tend to conceal the myriad factors contributing to resource degradation. Nonetheless, the evidence is sufficient to show that population pressure plays a major part in renewable resource losses.

(d) Common Property

Population growth contributes to the overuse of common property, be it rangelands, the world's oceans or the atmosphere. Atmospheric trace gases contributing to the 'greenhouse effect' are strongly linked to energy consumption which, in turn, is linked partly to population growth, as we have seen.

In the oceans it is now widely recognised that most fisheries are fully exploited, and a number are seriously overfished. Table 9 shows total catches by the major fishing nations between 1962 and 1982. The data are not totally reliable due to under-reporting of catches in a number of countries, but the trends are clear: fish catches increased dramatically to about 1970 after which the growth rate slowed, partly because of overfishing which, in turn, is due to demand induced by population growth rather than income growth. The figures for Norway and the United Kingdom illustrate the decline in the Atlantic herring and cod industry. Total catches of Atlantic cod have fallen from around 1.5 million tonnes in 1965 to about 600,000 tonnes in the 1980s. The haddock catch has fallen from 250,000 tonnes to just over 50,000 tonnes. The decline of the Peruvian anchovy fishery is reflected in the declining catch figures for Peru.

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concessions for land clearance, tenure through clearance, log export bans designed to capture rents for the domestic wood processing industry etc. See, notably, R.Repetto and M.Gillis, Public Policies and the Misuse of Forest resources, Cambridge University Press, Cambridge, 1988; R.Repetto, The Forest for the Trees?: Government Policies and the Misuse of Forest Resources, World Resources Institute, Washington DC, 1988; H.Binswanger, Brazilian Policies That Encourage Deforestation in the Amazon, Environment Department, World Bank, Working Paper 16, Washington DC, April 1989; and D.Mahar, Government Policies and Deforestation in Brazil's Amazon Region, Environment Department, World Bank, Working Paper 7, Washington DC, June 1988. For further discussion see Chapter 9.

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Table 9

Fish Catches 1962 - 1982

(million tonnes: freshwater plus marine)

	1962	1972	1982
World	45.7	62.3	76.5
USA	2.9	2.8	4.1
Canada	1.2	1.1	1.4
Japan	6.8	9.9	11.0
China	4.1	3.7	5.1
India	1.0	1.8	2.4
Indonesia	0.9	1.3	2.1
Korea	0.5	1.3	2.3
Thailand	0.4	1.7	2.2
Norway	1.4	3.0	2.7
UK	1.0	1.1	0.9
USSR	3.8	8.2	9.9
Chile	0.7	0.7	3.8
Peru	7.1	3.5	2.5

Source: United Nations Environment Programme, Environmental Data Report, Blackwell, Oxford, 1987.

(e) Urban Pollution and Congestion

The rapid growth of urban populations clearly results in squalour, slums and ill-health. Unable to afford land in the town or city, poor households occupy the urban margins, invariably without sanitation or clean water supplies. Around 4 billion people are expected to be crowded into the world's urban centres by 2025. Each year adds 50 million extra urban dwellers[18]. The extent of overcrowding can be partially gauged by comparing population densities for major cities in the developing world with those for the developed world. Chicago has around 2500 people per square kilometre, Philadelphia has some 3000. London has 4000 and Milan has about 9000. Cairo has 24,000, Casablanca 12,000, Buenos Aires 15,000, Santiago 17,000, Lima 29,000. But top of the league are Mexico City with 34,000 people per square kilometre, Manila with 43,000, and Calcutta with 88,000. Despite

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[18]. See United Nations Centre for Human Settlements, Global Report on Human Settlements 1986, Oxford University Press, Oxford, 1987, p.51.

these concentrations, progress is being made with connections to water supply and sanitation. Air pollution has increased dramatically in many urban congested areas, although data for the developing world are very limited. Sao Paulo has shown an increase in sulphur oxides concentration but a decrease in particulate (smoke) concentration, reflecting a policy of trying to combat the more visible pollutant. Manila, on the other hand, has reduced sulphur oxides but increased particulates[19]. Clearly, trends in air pollution are determined as much by policy measures and the nature of the urban economy as much as by population density.

Policy on Population and Environment

The evidence of this volume indicates that population growth has two broadly counteracting impacts on environment and development. By 'forcing' adaptive and technological change, population growth may actually increase the prospects for development in the traditional sense of rising GNP per capita. By contributing to the depletion of natural resources, primarily the renewable and common property natural resources, population growth impedes development in the traditional sense and certainly reduces environmental quality. The balance of these two broad impacts probably favours the view that population growth, at least on the scale now being witnessed, is detrimental to future human welfare[20]. Such growth threatens both the quantity and the quality of natural resources, including the waste assimilative capacities of the environment. Moreover, to argue that population growth can be associated with advances in technology does not mean that technological advance will not occur without population change. Such a view overlooks the extent to which conscious decisions to invest in new technology can be made for reasons unassociated with the need to feed, house and supply with energy an increasing number of people.

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[19]. See World Health Organisation, Urban Air Pollution 1973 - 1980, WHO, Geneva, 1984.

[20]. For a strongly optimistic view which argues that population growth is almost systematically beneficial see J.Simon, Theory of Population and Economic Growth, Blackwell, Oxford, 1986. Simon's views are partly an extension of the population - technological progress argument presented in this chapter. He also argues that the greater the supply of people the more chance there is of finding inventors and scientists whose discoveries will increase long run human welfare. He omits to note that the same argument could be applied to the supply of individuals whose actions materially diminish human welfare- e.g. a Hitler or a Stalin.

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But reducing population growth rates will contribute only partly to solving environmental problems. Many other factors generate resource degradation, especially misdirected policies concerning land tenure and prices. Major advances can be made by reforming government policy which directly or indirectly affects environmental quality. China, for example, has increased agricultural output dramatically by improving farmers' incentives and placing land under household management[21]. Malawi has increased agricultural output by 7 per cent per annum since 1973 despite having the third highest rural population density in Africa. The potential for energy conservation is substantial in the developed and developing world alike. Proper pricing and proper incentives offer the scope for substantial resource conservation. These issues are discussed at length in Chapter 9.

To argue that policies other than constraining population growth are important is not to downplay the importance of population control. Policies have to be advanced on many fronts and these must include major additional efforts to control birth rates, especially in Sub-Saharan Africa where the traditional model of population control appears not to be working. Population policy in turn requires not just investment in information about the benefits of reduced family size, and about contraception, but also a major effort to understand and modify the underlying cultural factors which continue to favour the large family. Ultimately, development will stabilise populations, but in many case development itself is threatened by over-rapid population growth.

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[21]. For a general discussion see R. Repetto, 'Population, Resources, Environment: an Uncertain Future', <u>Population Bulletin</u>, Vol.42, No.2, 1987.

ENVIRONMENTAL ECONOMICS IN THE DEVELOPING WORLD

VOLUME TEN

POVERTY AND THE ENVIRONMENT

S. GAMMAGE

REPORT TO THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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VOLUME 10

POVERTY AND THE ENVIRONMENT

10.1 INTRODUCTION

The conventional analysis of the relationship between poverty and environmental degradation characterises it as a reciprocal one: degraded environments can be seen as one of the major causes of poverty, and poverty often promotes environmental degradation. However the causality is often misrepresented. Poverty is cited as one of the "push" factors that forces subsistence populations onto marginal lands, necessitating their unsustainable use as a result of the high private discount rates faced by such populations. This in turn contributes to their impoverishment and furthers environmental degradation. Yet very little is known about the dynamics between poverty and environmental degradation. What is known is that the causality is not solely unidimensional. Poverty is only one of the contributory factors that accelerate ecosystem destruction.

Recent studies have concluded that the linkages between poverty and the environment are determined by economic, institutional and social structures. These structures shape the prevailing incentives, the social and physical infrastructure, and consequently affect resource usage. The complex nature of forces that govern resource use serves to highlight the conceptual difficulties central to modelling linkages between poverty and the environment. Further, the absence of adequate and reliable developing country data on poverty and environmental characteristics greatly impedes the exposition of these linkages.

10.2 POVERTY-ENVIRONMENT LINKAGES

(a) Scale

Scale addresses the physical dimensions of the economy relative to the ecosystem.[1] It is measured by population times the per capita resource use which equals the flow of resources through the economic subsystem. Scale is therefore measured relative to the ecosystem and not relative to prevailing prices or rates of interest. Environmental problems may be caused by an excessive physical resource load undermining the regenerative capacities of renewable resources. Prolonged population growth will place pressure on the scale of total resource use resulting in the environmental degradation of natural capital even if allocation is efficient and distribution is equitable. Physical and biological determinants of resource use stipulate that, at any point in time, there is a maximum sustainable scale of human resource use which the environment can withstand without

[1] G. Foy and H. Daly (1989)

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extensive degradation. This maximum scale is dynamic, it will change as the underlying capital, technological and environmental relations change. The ultimate determinant of sustainability is the relation between the total physical scale of the economy and the physical capacities of the environmental capital. Optimal scale can be located at that point where the marginal benefit from expansion equates with the marginal cost incurred because of that expansion.

Traditionally, high rates of population growth and problems of scale have been cited as generating poverty-environment interactions. In poor economies population pressure has led to greatly extensive and intensive agricultural systems, resulted in the over-use of marginal lands and the exploitation of renewable resources. Rapid population expansion per se does not automatically imply that environments will be degraded,but the association is obviously a forceful one. The linkages between poverty and environmental degradation are not just governed by the physical limits of ecosystems.

(b) Unequal Access to Productive Resources

Poverty often manifests itself as an unequal access to land and capital. Asset ownership in developing countries is markedly inequitable. Monetisation appreciates land and water values, and in the face of this common property resources begin to be nationalised or privatised. The poor often lose rights of access to common property and open access resources as a result of changing tenurial relations, regulation, and legislation. This has led to the poor being displaced onto marginally productive tracts of land. In this case it is not poverty per se that causes environmental degradation, rather it is the interaction between the state of being poor and the loss of property rights combined with misdirected legislation.

(c) Income Strategies

As developing countries have become "monetised", production and exchange have been altered. Apart from those experiencing extreme poverty, many individuals have responded to monetisation by seeking income security in addition to food security. Cash has become a prerequisite for the purchase of non-traditional food and consumption items, as well as agricultural inputs. The desire to maintain income security has led to the widespread development of highly divisible, labour intensive, low skill employment in rural and urban markets. The development of tertiary sector employment has also decreased dependence on natural environments as a source of vital foodstuffs and shelter inputs.

(d) Government Failure or Misallocation

Efficient allocation requires that the discounted flow of monetary returns are equal across all sectors at the margin. Market failure and government failure distort this efficient outcome, perpetuating or entrenching environmental degradation. The solution is to promote policies that encourage full cost

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pricing and competition, where this is possible, rather than distorting incentives and initiating rent-seeking. Further, institutions must be provided that define and guarantee property rights in public goods settings.

The aims of government may be briefly summarised under three headings:

(i) Equity. Inequality manifests itself in various ways: inequality of access to the resource base, and to productive and consumptive goods. Where the prevailing income distribution is skewed, governments may seek to perform transfers, ensuring that the least advantaged have sufficient purchasing power or sufficient consumption goods to meet their basic needs. Transfers may be "in kind" or "monetary". Governments typically employ taxation, transfer and legislative methods to compensate for inequality of access to the resource base and to productive and consumptive goods.

(ii) Efficiency. Governments may seek to ensure that there is efficiency in both the consumption mix and the product mix. Prices should reflect the true opportunity cost of the good or service, all externalities must therefore be internalised, this requires the removal of market imperfections and corrective intervention in the case of market failures.

(iii) Sustainability. Broadly speaking this requires that exhaustible resources are depleted in a sustainable manner and that renewable resources are managed sustainably. Where it is not possible to correctly value a resource or the cost of its depletion, governments may follow the sustainability criterion which requires either constancy of the natural capital stock, or of the overall stock of capital.

The satisfaction of these aims imposes conflicting demands on the administration. There is a necessary trade-off between efficiency, equity and sustainability which impedes the simultaneous persuit of all three disparate goals.

Poverty has been cited as a fundamental cause of environmental degradation. But it is important to identify other causes - the prevailing incentive structures, misallocation, the inequitable distribution of income and rights of access to productive and consumptive resources. Institutional and legislative policies define the parameters for resource use for both the poor and non-poor alike.

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(e) The Divergence Between Private and Social Discount Rates

Discounting[2] presents the economist with the means of reflecting the value of a resource or asset in terms of the flow of income deriving from that asset over a specific time horizon. It is also a useful tool of analysis enabling consumption today to be measured against consumption tomorrow. The discount rate can be made to embody a rate of time preference, whereby current consumption is valued at a higher rate than future consumption. Discount rates reflect this trade-off between current and future consumption. As the discount rate increases, the meaningful time horizon contracts. If the social discount rate is high, and if the regenerative capacity of the resource is low in comparison, then it may be socially efficient and economically profitable to exhaust that resource, investing the proceeds in other assets which yield a higher return.

Private and social discount rates often diverge. This partly reflects the fact that the lifetime of an individual is much shorter than the relevant time horizon for society. If individuals overconsume in the present, rather than following a sustainable consumption path, then the private rate of time preference is presumed to be in excess of the social rate of time preference. The exhaustion of a resource may in fact be privately efficient whilst being socially inefficient. Furthermore, the poor have a much shorter lifespan and are subject to greater instability than the non-poor. The poor subsequently weight consumption today more heavily against consumption tomorrow. Facing such high private discount rates it becomes internally consistent and indeed privately efficient for such individuals not to manage their lands and agricultural production sustainably. It is this scenario that has fostered many of the conventional theories of poverty-environment linkages.

However it is not only the poor who face private discount rates in excess of the social discount rate. The rich and the elite often choose to speculate on land values and on agricultural production, in the face of rising land and farmgate prices. As a form of intertemporal profit maximisation, it might again be privately efficient to degrade a resource, extracting its full present value, without regard to its sustained management. High prices, credit subsidies, and tax concessions promote rent-seeking activities which can lead to environmental degradation. Such rent-seeking activities are typically open to the non-poor who have greater access to credit markets and to resource rights.Whilst the private discount rates faced by the rich are more likely to converge towards the social discount rate, their observed behaviour might belie this fact. Rent-seeking may motivate a higher level of resource degradation than is efficient given their private discount rate.

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2 see Gammage and Pearce Vol.4

10.3 POVERTY, A POSITIVE OR NORMATIVE MEASURE

The debate over the definition of poverty has raised questions as to the relevance and applicability of an absolute, or positive measure. Poverty embodies a subjective notion of deprivation, one that is culturally and ethnically unique. In seeking to uncover the linkages between poverty and environmental quality, we should be mindful of the subjective nature of the terms which we are using. Both poverty and environmental quality are descriptive allusions to states of nature. Such states have no absolute definition that can effectively encompass all societies, cultures, and environments.

(a) Absolute Poverty

Rowntree [3], developed a concept of primary poverty, which has been employed as the closest approximation to a positive measure of poverty. Primary poverty applies to those whose income, in monetary or commodity units, is insufficient to obtain the minimum necessities for the maintenance of "purely physical efficiency". However such a definition cannot be easily reduced to an optimal calorific or nutritional intake. An individual's nutritional needs depend on his or her level of activity, the environment and climatic regime inhabited, age, sex, and state of health. Thus no definitive measure of poverty can be arrived at. In response to the absence of positive definitions of poverty, theorists began to explore and legitimise more subjective or normative definitions of poverty.

(b) Relative Poverty

Townsend [4] sought to incorporate contemporary living standards into his definition of poverty. He described the state of being poor as occurring when individuals were unable to command the opportunities, comforts, and self-respect regarded as customary in the community that they inhabit. Such a measure would track a continuously moving average, being revised as cultural norms and expectations changed.

In defining environmental quality, similar difficulties occur. More generally, a definition of environmental degradation is easier to produce. Environmental degradation occurs when environments are not managed sustainably. In certain cases it might indeed be optimal to exploit resources to the point of extinction. This occurs when the present value of the flow of benefits from resource exploitation exceeds the corresponding

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[3] Rowntree (1901) 'Poverty a Study of Town Life'(1922 ed) Macmillan,London

[4] Townsend (1962) 'The Meaning of Poverty' British Journal Of Sociology, Vol.13

present value derived from its preservation. This depends exclusively on the rate of time preference, that is the applicable discount rate.

Poverty can be seen as a complex array of characteristics. Per capita income frequently appears in definitions of poverty as a means of summarising reduced access to productive and consumptive goods. However the most widely used measures of poverty are based on the extent and incidence of energy-deficient diets. This may also provide a crucial link between resource use and the state of being poor.

A further link between poverty and environmental degradation emerges from a spatial approach to the incidence of poverty. The geographical distribution of the poor reveals much about the nature of resource use and the management regimes under which these resources are employed. The poor are disproportionately concentrated on ecologically fragile rural lands and upon marginal lands at urban peripheries. These areas are vulnerable to stress or shocks such as climatic variation and population pressure.[5]

In order to characterise the linkages between environmental degradation and poverty an appropriate methodology must be established. Jagannathan [6] has undertaken three studies attempting to describe the dynamic relationship between poverty and qualitative changes in environments.

10.4 METHODOLOGY

Most economic, social, political and natural resource data are spatially expressed. Macroeconomic data are usually expressed in terms of country boundaries, one type of spatial unit. Equally a country unit can be differentiated by region and sub-region, forming alternative spatial units. Economic data such as GNP, population, land values, can all be represented as attributes associated with particular areas. Physical investments in infrastructure, demographic movements can all be spatially referenced. Prices may vary regionally, since the coherence of markets depends crucially on the extent of communication and mobility, and the exchange of information. Natural resource databases are conventionally compiled over bio-physical features, forests, mountains, seas. Socio-economic data bases tend to be aggregated by political and administrative units. All such data sets might be expressed in terms of common bases and scales. Particularly three sectors of analysis can be diffracted into such spatial units.

(a) The economic sector. Data can be disaggregated from the national accounts into regions. Statistics

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[5] D.W.Pearce and J.Warford (1991)

[6] Jagannathan (1989)

referencing production, investment, prices, wage rates, and employment can be regionally classified.

(b) The demographic sector. National census data on population growth rates, migration patterns, birth rates, morbidity and death rates can be similarly spatially referenced.

(c) The natural resource sector. Data for soil erosion rates, soil productivity, climate, land use, forest cover, aquifers and bodies of water are frequently expressed in spatial terms.

Disaggregating areas of study into such spatial units and employing satellite imagery, or remote sensing, enabled Jagannathan to monitor resource degradation. He then employed socio-economic data searching for economic and demographic explanations for resource use. The ideal would be to design continuous monitoring systems collecting data on flow variables such as soil erosion rates, soil nutrient levels, the extent of deforestation. However such environmental data are not currently available in most developing countries. The case studies of West Java in Indonesia, Gombe, and Ekiti-Akoko in Nigeria, employed satellite imagery to asses aggregate changes in the stocks of natural resources and environmental attributes.

(i) Land areas ranging from 4,000 to 10,000 square kilometers were identified primarily on the basis of the availability of supplementary data on natural resource attributes for each region.

(ii) LANDSAT images for two time periods (one from the mid 70s and another from the mid 80s) were used to visually identify quantitative changes in natural resource use. These images reveal the extent of land cleared of vegetative cover and are often able to indicate what type of crops and trees are in use. They are also particularly useful for identifying the growth of human settlements, areal farming changes, and infrastructure development such as road and dam construction.

(iii) The potential causal factors in these regions were analysed using socio-economic data. Information about farm-nonfarm-urban informal sector linkages, data on rural-rural and rural-urban migration, public investments, incentive structures, credit facilities, tax concessions, legislation and institutional aspects were all considered.

10.5 CASE STUDY OF KABUPATEN SUKABUMI, WEST JAVA

(a) Changes in Land Use

The use of remote sensing, or satellite images, revealed the extent to which land use had changed over the ten year period studied. The study indicated that forest cover had been reduced by approximately 27%, with the current forest cover being almost half the official estimates. Official forest statistics estimated cover at 98,000 hectares of forest in 1986, remote sensing revealed it as 53,000 hectares.

Table 10.1

Changes in Forest Cover in Kabupaten Sukabumi (1976-1986)

Change from forest to:	Hectares	Percentage Change
(a) Shrubland	19,864	38%
(b) Mixed garden	7,133	14%
(c) Estate	5,014	10%
(d) Uncovered	1,999	4%
(e) Built-up area	13,000	25%
(f) Miscellaneous	5,230	9%

Source N.V.Jagannathan (1989)

Subdividing the area into ten districts, it was found that the most severely deforested areas were those having:

(i) relatively low population densities;

(ii) improved road connections to the provincial highway system.

In half of the deforested areas land use has been given over to mixed gardens, estates, and built-up environments. These uses appear to be market-driven, satisfying production and consumption requirements, and are sustainable with the appropriate management regimes and institutional policies. The remaining area of deforestation was confined to sparsely populated districts, where the conversion from forest to shrubland appears to have occurred to satisfy the consumption demand for wood. Changes in land use can also be partitioned into the northern section, above the river Cimandiri, and the southern section below the river. North of the river population densities exceed 900 persons per square kilometer, making this area one of the most densely populated in Java. The two remote sensing images reveal the systematic replacement of shrublands by rubber, tea, coconuts, and clove estates, or the mixed garden farming of such products. These crops provide an important source of foreign exchange, and reflect the success of policies designed to diversify Java's export base. Many of these gardens and estates are on hill slopes with gradients of between 2% and 15%, such areas are prone to soil creep and erosion, with vital nutrients being easily leached. With adequate extension support, these estates and mixed gardens could significantly reduce soil erosion, whilst simultaneously providing income for the rural poor. South of the Cimandiri river the spread of estates and mixed gardens has been less concentrated. The southern regions have a lower population density, and the lands are less productive. Finally, the remote sensing images showed a distinct increase in water bodies as the result of private and public investments in irrigation, and an increase in areas classified as bare lands, particularly areas adjacent to river beds.

(b) The Process of Environmental Change

The examination of these satellite images at the two points in time, made it possible for the land use changes to be charted. The conversion of forest to economic use appeared to follow a defined sequence, applicable in most cases of land use change.

			ESTATES	→	BUILT UP AREAS
FOREST	→	SHRUBLANDS		→	ESTATES
			MIXED GARDENS	→	BARE LANDS

Forest is first converted to shrubland prior to its being given over to estates and mixed gardens. The 1976 satellite image reveals that areas of land officially classified as forest, north of the Cimandiri river, have already been converted to shrubland. This suggests that shrubland is the initial stage in this sequence of change.

These shrubland plots are then given over to economic uses, generating income from the sale and exchange of mixed garden and estate products. Theoretically such a change can be environmentally sustainable in addition to augmenting agricultural incomes. In support of this, the study identified only 6% of the area which had fallen into poverty related and unsustainable farming practices. These activities were concentrated on areas of marginal land, abandoned and non-productive estates which had been taken over by displaced farmers and landless shifting cultivators. The farming methods were noticeably ecologically destructive, slash and burn techniques of cropping being favoured.

Areas classified as bare lands have emerged where:

(i) farming was concentrated on steep hillsides, exposed to soil erosion, leaching and subsidence;

(ii) land had been previously mined for clay, gravel and limestone;

(iii) estates had been abandoned, and were being illegally farmed by landless and shifting cultivators.

Comparison of the 1976 and 1986 satellite images also reveals that the most significant areas of deforestation have occurred adjacent to major highways. Heavy investment in communication infrastructure has ensured that no district is more than 20 kilometers from good roads. This exposes much of the remaining areas of forest to illegal tree-felling, mining or quarrying. The spread of human settlements into adjacent shrubland, forest and farmland, has been rapid. However, in aggregate terms there has been no decline in the area under vegetative cover in the more densely populated sub-districts. This could be because mixed gardens and estates extend vegetative cover on what was already deforested land.

Deforestation is not the major cause of environmental degradation if environmental degradation is defined as the unsustainable use of land. The unregulated mining of natural resources, clay, gravel, and minerals, coupled with the overexploitation of groundwater in the Sukabumi aquifer is by far the single most important cause of environmental degradation. This study reveals that the primary determinants of environmental degradation are:

(i) the prevailing incentive structure;

(ii) public investments in infrastructure, roads, highways, etc;

(iii) and macroeconomic, institutional and legislative policies;

(c) Rural Economic Change

The ten year study period saw a marked rise in commercialisation: increases in paddy production as the result of yield intensification, the spread of tree crop cultivation, investments in agricultural capital, and the increase in cash flows between farms and market centers. The growth of a commercialised rural economy resulted in greater rural-urban integration. Labour and capital became increasingly mobile leading to a greater exchange between rural and urban communities. This led to several alterations in the traditional social and economic framework.

(i) The growth of a tertiary sector, providing income earning opportunities. Farmers receiving higher cash incomes altered their consumption patterns, generating small multiplier effects. This led to the development of a tertiary employment sector offering non-farm, labour-intensive occupations, absorbing many of the landless workers and marginal farmers. Household budget surveys indicate that the change in earning opportunities has significantly altered the profile of consumption expenditures amongst the poor. Food consumption expenditure has declined in favour of non-food expenditures, contributing to the further development of the tertiary sector.

(ii) The development of urban markets for fish, meat and poultry has increased their production, changing traditional land uses.

(iii) The <u>relative decline in poverty levels</u> has released many of the rural poor from their acute dependency on the natural resource base for primary production and subsistence farming. There was an overall improvement in the poverty profile of West Java as a direct result of the increased earning potential provided by non-traditional employment. Rietveld's study [7] shows that landless farmworkers derived 64% of their incomes from non-agricultural activities.

(d) <u>Role of Public Policies</u>

The role of public policies and investments in "enabling" infrastructure, roads, education, and health services overdetermine land use. Poverty appears not to be the major causal factor that influences environmental degradation.

(i) The Indonesian government has employed a combination of credit programmes, taxes and subsidies, producer support prices and infrastructural investments to achieve increased rice and tree-crop production. The activities provide a valuable source of foreign exchange, and have diversified Indonesia's export base. The expansion in agricultural production with its associated rise in agricultural incomes can be attributed to three factors: technological innovation, favourable relative price movements for both crops and inputs, and increased access to critical inputs such as fertilisers and adequate water supplies. In the short term it appears that such policies have led to the persuance of sustainable farming practices. Whilst deforestation has occurred, cleared land has for the most part been given over to estates and mixed gardens, ensuring that vegetative cover has not decreased significantly.

(ii) The improvement in educational and health facilities has increased the level of literacy and prolonged life expectancy. Consequently work force participation rates have risen promoting increased rural-urban migration. The increase in population mobility, and the integration of rural and urban areas, has provided a natural "valve" decreasing pressure on the natural resource base.

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[7] Rietveld (1986) referenced in N.V.Jagannathan (1989)

(e) Poverty and Environmental Degradation

(i) The Jagannathan study of Java indicates that in this case the poor have largely turned to the market system in order to augment their incomes. Most of the consequent changes in natural resource use can be attributed to economic and policy variables. Where a clear poverty-environmental degradation linkage was identified, this too could be attributed to policy design and mismanaged incentives. Poverty was concentrated most heavily in the densely populated settlements, manifesting itself in terms of sub-standard housing, congestion, and exposure to pollution and untreated wastes. When the rural poor migrate to the cities, they search for "free" goods from the surrounding open access resources in order to minimise their cash expenditures. A World Bank study [8] identifies the continual increase in the price of kerosene relative to fuelwood prices as being a major factor contributing to the illegal felling of trees on urban peripheries. Thus unfavourable relative prices can lead to unsustainable resource use. Corrective policies if carefully applied could overcome this unsustainable resource use.

(ii) The poor or inadequate policing and regulation of resources has also contributed to their over-exploitation.

(iii) Extremely high population densities in erosion-sensitive watersheds for important rivers has also exacerbated environmental decline. Eight district towns were located in environmentally fragile areas. Little has been done to contain the spread of urbanisation in these areas. Government policy and legislative action could be effectively employed to protect vulnerable ecosystems, and prevent urban agglomeration.

(iv) The role of poverty in environmental degradation has been predominantly indirect. Those factors which exert direct effects on the environment can be subject to control through corrective policy and legislative actions. The increased pollution levels in rivers have come about through the mismanagement of industrial and municipal discharges. The intensification of mining has undermined valuable ecosystems since the government has failed to introduce restrictive legislation and effective policing.

[8] World Bank (1989) referenced in N.V.Jagannathan (1989)

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10.6 CONCLUSIONS

In the three areas studied sampling Indonesia and Nigeria, Jagannathan came to the following conclusions.

(a) That it was possible to relate spatial changes in land and water use to specific economic decisions taken by both individuals and the state. Public policies and institutions play a critical role shaping the incentive structures faced by both the poor and non-poor alike, and setting the parameters of resource use.

(b) Investments in infrastructure, particularly road construction, have increased the unpoliced access to fragile ecosystems. Roads have also increased areas under commercial agriculture, and increased population mobility which has necessarily impacted on the environment.

(c) The extent of rural urban integration also determines resource use. Where both rural and urban markets have been found to be highly integrated the urban peripheries tend not to be as degraded. The urban poor thus have a decreased dependency on their immediate environment, open access marginal lands are not subject to prolonged unsustainable use.

A COMPENDIUM OF PUBLICATIONS

E.B.Barbier (1988)
Sustainable Agriculture and the Resource Poor: Policy Issues and Options

LEEC paper 88-02
IIED/UCL London Environmental Economics Centre
London

This paper summarises the case of the rural poor and the linkages between poverty and environmental degradation. Barbier concentrates on the prevailing policy framework which is biased against the interests of the marginal poor in rural areas. He also draws attention to climatic factors, low and erratic rainfall; the lack of affordable low-input technology; and factors that lead to the increased concentation of the rural poor on marginal lands, accelerating resource degradation. Barbier extends the discussion of international constraints, debt servicing requirements, and the long term decline in world commodity prices. He appeals to the conferral of property rights, and changes in tenurial relations, trade-offs over inter-regional equity and a long-term commitment to sustainable rural development.

G. Foy and H. Daly (1989)
Allocation, Distribution and Scale as Determinants of Environmental Degradation: Case Studies of Haiti, El Salvador and Costa Rica

World Bank Environment Working Paper No. 19
Washington DC

This study analyses environmental degradation in three small Latin American countries (Haiti, El Salvador, and Costa Rica) in terms of three categories of cause: allocation, distrinution and scale. The general conclusion is that excessive scale (population times per capita resource use) and maldistribution (concentrated land ownership) are in all three cases more basic causes of environmental degradation than is misallocation (distorted prices), although the latter remains very important as a proximate cause. The policy implication is that more emphasis be given to scale reduction (especially population control) and redistribution (especially land reform). These are not novel policy recommendations, but they are different from the policies actually being followed in the countries studied. Moreover, past advocacy of these policies has been based less on environmental considerations than on general economic development arguments. Convergence of environmental and development arguments toward the same policy recommendations is a hopeful sign.

N. V. Jagannathan (1989)
Poverty, Public Policies and the Environment

World Bank Environment Working Paper No. 24
Washington DC

In the developing countries poverty and environmental deterioration are often visible in proximity to each other, and have led many to infer that a two-way causality exists between human and environmental degradation. The apparent association, however, draws away the attention of policy makers from more substantive causal factors. This paper suggests that the real factors causing environmental degradation may lie elsewhere, such as: in specific acts of public policy, through the expansion of consumption demand for natural resources by growing populations, and by the spread of urbanisation. The poor are merely one of several actors who respond to changing incentive structures by altering their usage of renewable natural resources. The links between poverty and renewable natural resource degradation, the paper argues, require evaluating the role of economic and institutional policies in altering labour and capital flows between and within regions. As economic and spatial integration of markets occur, several new marginal income earning opportunities become available in the informal sector of the economy, and the dependence of the poor on the natural resource base for livelihoods may actually get reduced. Three case studies from West Java (Indonesia), Ekiti-Akoko (S.Nigeria), and Gombe (N.Nigeria) are used to illustrate the linkages between poverty, public policies and renewable natural resource use. In all three, remote sensing imagery over two points of time provides basic data on land areas where vegetative cover appear to have undergone significant changes. A diagnosis of the causal factors has then been undertaken, and the paper demonstrates that the linkages between poverty and the environment have been largely influenced by conomic and institutional policies. These policies have (a) shaped incentive structures and (b) improved social and physical infrastructure, through which natural resource usage has been affected. The poor, like the non-poor, have utilised opportunities brought about by the spatial integration of economic activities, sometimes to the detriment, and other times to the benefit of long-term renewable natural resource usage.

N. V. Jagannathan (1989)
The Use of Geographic Information in Natural Resource Management A Research Proposal

World Bank
Washington DC

Over the past years widespread degradation of the renewable natural resource base has taken place in most developing countries, and there are indications that this threatens the sustainability of economic growth. It is increasingly recognised that public policies at the Central Government level, may, often unwittingly, encourage such degradation. Understanding the relationships between various government policies, other socio-economic variables and physical manifestations of environmental degradation is necessary if appropriate remedial measures are to be taken, and environmentally sustainable economic and other social policies are to be identified. This research proposal outlines the methodology for investigating poverty-environment linkages. Jagannathan outlines the objectives of his research, reviews the literature, and discusses the expected outputs from the research. He also includes case studies from Uganda, West Java and Nigeria.

H.J.Leonard and contributors (1989)
Environment and the Poor:Development Strategies for a Common Agenda

Overseas Development Council,
Washington

This book examines the complex interrelationships between several equally desirable policy goals: eliminating poverty, slowing population growth, and safeguarding the environment. Leonard addresses the methodological issues central to the categorisation of poverty and attempts to develop a 'common agenda' for tackling poverty and environmental destruction. The various contributors consider the sustainable and equitable development of irrigated environments, technology, scale and ecology in the arid and semi-arid tropics, development alternatives for tropical rain forests, hillside agricultural development, urban development and fragile ecosystems. Poverty is analysed as a spatial phenomenon and related directly to location-specific factors and socio-economic variables. Poverty-environment linkages are emphasised, and policy recommendations are focused on dual solutions.

D.W.Pearce and J.Warford (1991)
Environment and Economic Development

Chapter 12 examines poverty, income distribution and the environment. The authors stress that no clear picture emerges from what data there are on inequality and that the links between inequality and environmental degradation are comparatively harder to explore than those between absolute income levels and the environment. They discuss the nature of poverty and its definition and the extent to which poverty is localised - being concentrated in ecologically fragile rural areas and upon urban peripheries. Poverty is seen as a disabling factor rather than an underlying 'cause' of environmental degradation.

H.J.Ruitenbeek (1989)
A Model for Nature Conservation: The Integrated Development and Conservation Initiative

This article reviews conservation practices in the wider context of the prevailing incentive structures. Ruitenbeek stresses that in West African tropical rainforest areas, evidence suggests that increased incomes in themselves lead to increased pressures on forest resources. Higher incomes drive up the price for hunted bushmeat. Higher incomes also allow individuals to invest in equipment - such as guns for hunting and chainsaws for forest clearance - which enables the rural poor to derive additional income from the forest reserves and not necessarily in a sustainable manner. Further, higher rural incomes in certain regions generate heightened incentives for migration to that area, contributing to problems of scale and resource degradation. Ruitenbeek examines conservation promotion proposals in Nigeria, disputing the traditional belief that mere income or 'in kind' transfers wil suffice to alleviate the problems of resource degradation brought about by poverty.