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Environmental Economics and Valuation in Development Decisionmaking

Mohan Munasinghe

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ABSTRACT

One essential step towards achieving sustainable development is the economically efficient management of natural resources. This paper explains the key role of environmental economics in facilitating the more effective incorporation of environmental concerns into development decisionmaking. Traditionally, the economic analysis of projects and policies (including the techniques of shadow pricing), has been developed to help a country make more efficient use of scarce resources. However, "externalities", mainly those arising from adverse environmental consequences, often have been neglected in the past.

This paper reviews concepts and techniques for valuation of environmental impacts that enable such environmental considerations to be explicitly considered in the conventional cost-benefit calculus used in economic decisionmaking. Key related aspects including environmental impacts of economywide policies, discount rate issues, and multi- criteria analysis are reviewed. The process of internalizing environmental externalities may be facilitated by making even rough qualitative assessments early on in the project evaluation cycle. The advantages of such an approach include: the early exclusion of options that are not sound environmentally; more effective in-depth consideration of those alternatives that are preferable from the environmental viewpoint; and better opportunities for redesigning projects and policies to achieve sustainable development goals.

There are an increasing number of attempts to both improve and make use of economic techniques to value environmental assets in developing countries. This paper seeks to help practitioners in the field, whose main concern is to keep up with, and make use of the advances most relevant to their own areas of application. To facilitate this, a range of publications is included in the bibliography section.

A number of developing country case studies which cover a wide range of practical valuation methods, are reviewed. We may conclude generally, that further application to practical problems in developing countries is required (rather than further theoretical development), of the environmental valuation concepts and techniques presented in the paper. Such case study work can be most effective when carried out as part of project preparation. A major purpose in this endeavor is at least to indicate orders of magnitude, if it is not possible to provide more accurate numbers. Some alternatives can be ruled out, and gross environmental errors avoided in this fashion. Also, one can often identify the key environmental indicators to which the decision is sensitive and focus attention on them.

The evidence presented suggests that the valuation techniques for determining "use values" may be applied successfully in appropriate cases. However, examples involving the estimation of "non-use values" are virtually non-existent in the developing world, and rather scarce even in the industrialized nations. The use of multiobjective decision methods also needs to be explored, where economic valuation is not feasible.

ENVIRONMENTAL ECONOMICS AND VALUATION IN DEVELOPMENT DECISIONMAKING

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1. INTRODUCTION

In recent times, the environment has emerged as a major area of concern worldwide. Pollution in particular is perceived as a serious threat in the industrialized countries, where the quality of life had hitherto been measured mainly in terms of growth in material output. Meanwhile, natural resource degradation is becoming a serious impediment to economic development and the alleviation of poverty in the developing world.

Mankind's relationship with the environment has gone through several stages, starting with primitive times in which human beings lived in a state of symbiosis with nature, followed by a period of increasing mastery over nature up to the industrial age, culminating in the rapid material-intensive growth pattern of the twentieth century which resulted in many adverse impacts on natural resources. The initial reaction to such environmental damage was a reactive approach characterized by increased clean-up activities. In recent decades, mankind's attitude towards the environment has evolved to encompass the more proactive design of projects and policies that help anticipate and avoid environmental degradation. The world is currently exploring the concept of sustainable development -- an approach that will permit continuing improvements in the present quality of life with a lower intensity of resource use, thereby leaving behind for future generations an undiminished or even enhanced stock of natural resources and other assets.[1/]

It is useful to recall here that the environmental assets that we seek to protect, provide three main types of services to human society -- and the consequences of the degradation of all these functions must be incorporated into the decisionmaking process. First, the environment is a source of essential raw materials and inputs that support human activities. Second, the environment serves as a sink which absorbs and recycles (normally at little or no cost to society) the waste products of economic activity. Finally, the environment provides irreplaceable life support functions (like the stratospheric ozone layer that filters out harmful ultraviolet rays), without which living organisms would cease to exist, at least in their present condition.

This paper reviews how environmental economics facilitates the efficient use of natural resources (both mineral and biological), as well as manmade capital and human resources -- an objective which is a vital prerequisite for sustainable development. Special attention is paid to the key role of environmental economics in helping value environmental and natural resources more precisely, and in internalizing the costs and benefits of using such resources into the conventional calculus of economic decisionmaking. More generally, the identification of sustainable development options requires:

1/. This broad definition is based on the World Commission on Environment and Development, *Our Common Future*, Oxford University Press, Oxford, 1987. For a recent review of alternative definitions of sustainable development, see J. Pezzey, "Economic Analysis of Sustainable Growth and Sustainable Development", World Bank Technical Paper - Environment Series, World Bank, Washington D.C., 1992, forthcoming.

1. Good understanding of the physical, biological and social impacts of human activities;
2. Improved estimates of the economic value of damage to the environment, to improve the design of policies and projects, and to arrive at environmentally sound investment decisions; and
3. Development of policy tools and strengthening of human resources and institutions to implement viable strategies and manage natural resources on a sustainable basis.

2. LINKING ECONOMICS AND THE ENVIRONMENT

2.1 The Role of Environmental Economics

Environmental economics plays a key role in identifying efficient natural resource management options that facilitate sustainable development. It is an essential bridge between the traditional techniques of decisionmaking and the emerging more environmentally sensitive approach. Environmental economics helps us incorporate ecological concerns into the conventional framework of human society, as shown in Figure 2.1.

The right-hand side of the diagram indicates the hierarchical nature of modern society. The global and transnational level consists of sovereign nation states. In the next level are individual countries, each having a multisectoral macroeconomic structure. Various economic sectors (such as energy, industry, agriculture, transport, etc.) exist within each country. Finally, each sector consists of different subsectors, projects and local schemes.

Unfortunately, the analysis of the environment cannot be carried out readily using the above socioeconomic structuring. As shown on the left side of Figure 2.1, one convenient breakdown recognizes environmental issues that are -- (1) global and transnational (e.g., climate change, ozone layer depletion); (2) natural habitat (e.g., forests and other ecosystems); (3) land (e.g., agricultural zone); (4) water resource (e.g., river basin, aquifer, watershed); and (5) urban-industrial (e.g., metropolitan area, airshed) -- related. In each case, a holistic environmental analysis would seek to study a physical or ecological system in its entirety. Complications arise because such natural systems tend to cut across the decisionmaking structure of human society. For example, a forest ecosystem (like the Amazon) could span several countries, and also interact with many different economic sectors within each country.

The causes of environmental degradation arise from human activity (ignoring natural disasters and other events of non-human origin), and therefore, we begin on the right side of Figure 2.1. The physical (including biological and social) effects of socioeconomic decisions on the environment must then be traced through to the left side. The techniques of environmental assessment (EA) have been developed to facilitate this difficult analysis. For example, deforestation of a primary moist tropical forest may be caused by hydroelectric dams (energy sector policy), roads (transport sector policy), slash and burn farming (agriculture sector policy), mining of minerals (industrial sector policy), land clearing encouraged by land-tax incentives (fiscal policy), and so on. Disentangling and prioritizing these multiple causes (right side) and their impacts (left side) will involve a complex EA exercise.

Meanwhile, the usual decisionmaking process on the right side of Figure 2.1 relies on techno-engineering, financial and economic analyses of projects and policies. In particular, we note that conventional economic analysis has been well developed over the past several decades, and uses techniques including project evaluation/cost-benefit analysis (CBA), sectoral/regional studies, multisectoral macroeconomic analysis, and international economic analysis (finance, trade, etc.) at the various hierarchic levels.

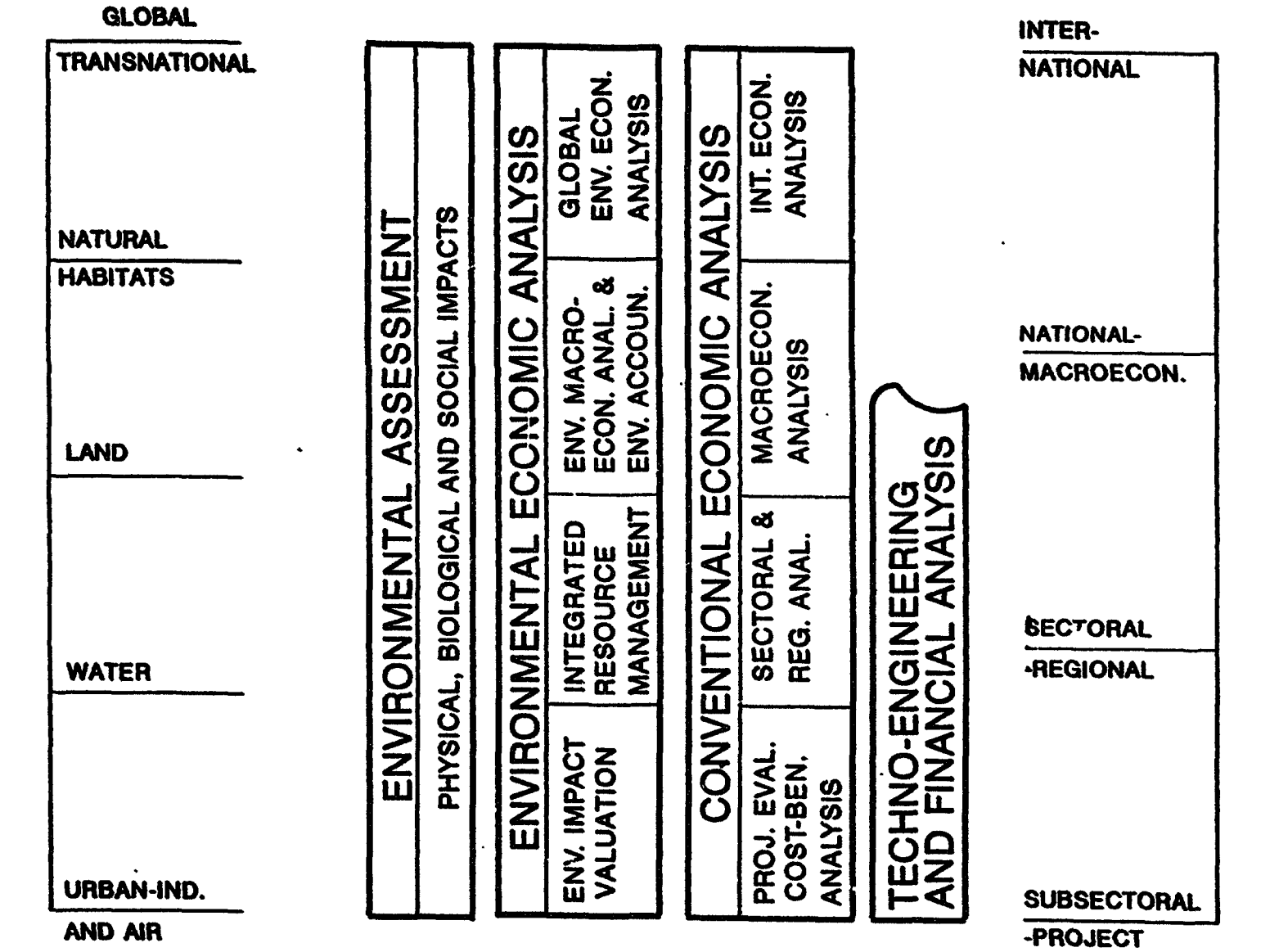

FIGURE 2.1. Incorporating Environmental Concerns Into Decisionmaking

Figure 2.1 also shows how environmental economics plays its bridging role, by mapping the EA results onto the framework of conventional economic analysis. Once again, a variety of environmental economic techniques including economic valuation of environmental impacts (at the local/project level), integrated resource management (at the sector/regional level), environmental macroeconomic analysis and environmental accounting (at the economywide, multisector level), and global/transnational environmental economic analysis (at the international level), facilitate this process of incorporating environmental issues into traditional decisionmaking. We note that there is considerable overlap among the analytical techniques described above, and therefore this conceptual categorization should not be interpreted too rigidly.

Once the foregoing steps are completed, projects and policies must be redesigned to reduce their environmental impacts and shift the development process towards a more sustainable path. Clearly, the formulation and implementation of such policies is itself a difficult task. In the deforestation example described earlier, the decisionmakers who wish to protect this single ecosystem are likely to face problems in coordinating policies in a large number of disparate and (usually) non-cooperating ministries and line institutions (i.e., energy, transport, agriculture, industry, finance, forestry, etc.).

2.2 Recent Developments

While the consolidation of environmental economic theory and its application to empirical issues spread throughout the developed world in the 1970s, the incorporation of environmental issues into development planning is a relatively recent phenomenon. A review of the literature in the field reveals the paucity of writings touching upon the environment. Academic development economics barely acknowledged the field until recently (Dasgupta and Maler 1990). Much of the literature on the environmental economics of developing countries has emerged since the mid-1980s. This is largely as a result of the increasing emphasis being placed on environmental issues by major aid-giving institutions.

The Brundtland Report recognized the role of economics in sustainable development -- both in assessing costs of environmental degradation in developing countries, and in designing relevant incentives to limit such degradation (World Commission on Environment and Development, 1987). The recent worldwide concern regarding the environment has strengthened the emphasis placed on environmental sustainability as an important criterion for sound natural resource management. Another facet of this concern is reflected in the increased attention paid to intergenerational equity and the role of discount rates in economic calculations.

In recent years, most governments have adjusted their policy objectives to include the proper management of natural resources alongside economic growth and income distribution/poverty alleviation. There may be some complementarities in these objectives, but it is accepted that trade-offs are required, at least in the short term. Given the existing scarcities of financial and human resources in developing countries and the emerging pressure on environmental resources, it is particularly important to use these limited resources sustainably and in such a way as to have the maximum benefit in terms of the country's objectives. Sound economic analysis of projects and policies is an important means of making the allocation process more efficient, and thereby, more sustainable. However, economic efficiency does not necessarily guarantee sustainability.

The growing attention to environmental issues in the work of the Bank over the past decades culminated in November 1989 in the issuing of the environmental impact assessment mandatory for all Bank projects.[2/] Thus environmental analysis has been elevated to the same level of importance as the three traditional aspects of project evaluation: financial, economic and technical analyses. The valuation of environmental impacts takes on added urgency in this context, to permit environmental concerns to be incorporated effectively into the normal process of decisionmaking in all Bank operations.

2.3 Conventional Project Evaluation

The successful completion of a development project usually involves several well defined steps. The systematic approach used by the World Bank in a typical project cycle includes: identification, preparation, appraisal, negotiations and financing, implementation and supervision, and evaluation.

2.3.1 The Project Cycle

Project identification involves preliminary selection (by the borrowing country and the Bank) of potential projects that appear to be feasible and conform to national and sectoral development goals. In the preparation phase which may last one year or more, the borrower studies the engineering-technical, environmental, institutional, economic and financial aspects of a proposed project. Project appraisal consists of a comprehensive and systematic review of all aspects of the project, culminating in an appraisal report that discusses comprehensively, the national and sectoral strategies, as well as the engineering-technical, environmental, institutional, economic and financial issues.

The appraisal report is the basis for justifying the investment, as well as the negotiations at which the borrower and financier (i.e., the Bank) discuss the measures required to ensure the success of the project, and the conditions for funding. The resulting agreements are included in loan agreements which together with the appraisal report are considered and accepted by the Bank's Board of Executive Directors and the borrowing government. The borrower is responsible for implementing the project according to conditions mutually agreed on with the Bank. Supervision of the implementation process is carried out by the Bank through periodic field visits and progress reports from the borrower. Evaluation is the final stage of the project cycle, following disbursement of the loan. Project performance audits are carried out by an independent Bank department involving review of previous project documents and field visits, where appropriate. This analysis yields valuable experience that helps improve the work at all stages of the project cycle, for future projects.

2.3.2 Economic Analysis and Cost-Benefit Criteria

Cost-benefit analysis (CBA) is the key element in the appraisal stage of the project cycle. CBA seeks to assess project costs and benefits using a common yardstick. Benefits are defined relative to their effects on the improvements in human well-being. Costs are defined in terms of their opportunity costs, which is the benefit foregone by not using these resources in the best available alternative application.

2/ For details, see World Bank, Operational Manual Statement No. 4.00, Annex A.

In addition to this economic test, it was mentioned that a number of other aspects (including technical, environmental, institutional, and financial criteria), also need to be considered in project appraisal. In particular, the economic analysis of projects differs from financial analysis. The latter focuses on the money profits accruing to the project enterprise or firm, based on market or financial costs. The economic analysis of a project, on the other hand, measures the effect on the efficiency objectives in relation to the whole economy. Rather than financial prices, shadow prices are used that reflect opportunity cost, including valuation of externalities wherever practical (as described below). We summarize next some criteria commonly used in the cost-benefit test of a project, with the emphasis on economic rather than financial evaluation.

The most basic criterion for accepting a project, compares costs and benefits to ensure that the net present value (NPV) of benefits is positive:

$$NPV = \sum_{t=0}^{T} (B_t - C_t)/(1+r)^t$$

where B_t and C_t are the benefits and costs in year t, r is the discount rate, and T is the time horizon.

Both benefits and costs are defined as the difference between what would occur *with and without* the project being implemented. As described later, for the economic testing, B, C, and r are defined in economic terms and appropriately shadow priced using efficiency border prices (see the following discussion on discount rate). However, for the financial analysis of projects, B, C and r may be defined in financial terms.

If projects are to be compared or ranked, the one with the highest (and positive) NPV would be the preferred one, i.e., if $NPV_I > NPV_{II}$ (where NPV_i = net present value for project i), then project I is preferred to project II, provided also that the scale of the alternatives is roughly the same. More accurately, the scale and scope of each of the projects under review must be altered so that, at the margin, the last increment of investment yields net benefits that are equal (and greater than zero) for all the projects. Complexities may arise in the analysis of interdependent projects.

The internal rate of return (IRR) is also used as a project criterion. It may be defined by:

$$\sum_{t=0}^{T} (B_t - C_t)/(1+IRR)^t = 0 .$$

Thus, the IRR is the discount rate which reduces the NPV to zero. The project is acceptable if IRR > ARI (Accounting Rate of Interest), which in most normal cases implies NPV > 0 (i.e., ignoring cases in which multiple roots could occur -- this may happen if the annual net benefit stream changes sign several times). Problems of interpretation occur if alternative projects have widely differing lifetimes, so that the discount rate plays a critical role.

Another frequently used criterion is the benefit-cost ratio (BCR):

$$BCR = \left[\sum_{t=0}^{T} B_t/(1+r)^t\right] / \left[\sum_{t=0}^{T} C_t/(1+r)^t\right] .$$

If BCR > 1, then NPV > 0 and the project is acceptable.

Each of these criteria has its strengths and weaknesses, but NPV is probably the most useful. The NPV test may be used to derive the least-cost rule. In certain cases, the benefits of two alternative projects may be equal (i.e., they both serve the same need or demand). Then the comparison of alternatives is simplified. Thus:

$$NPV_I - NPV_{II} = \sum_{t=0}^{T} [C_{II,t} - C_{I,t}]/(1+r)^t ;$$

since the benefit streams cancel out. Therefore, if

$$\sum_{t=0}^{T} C_{II,t}/(1+r)^t > \sum_{t=0}^{T} C_{I,t}/(1+r)^t ;$$

this implies that $NPV_I > NPV_{II}$.

In other words the project which has the lower present value of costs is preferred. This is called the least-cost alternative (when benefits are equal). However, even after selecting the least-cost alternative, it would still be necessary to ensure that this project would provide a positive NPV.

2.3.3 Shadow Pricing[3/]

In the idealized world of perfect competition, the interaction of atomistic profit-maximizing producers and utility-maximizing consumers gives rise to a situation that is called Pareto-optimal. In this state, prices reflect the true marginal social costs, scarce resources are efficiently allocated and, for a given income distribution, no one person can be made better off without making someone else worse off (Bator 1957).

However, conditions are likely to be far from ideal in the real world. Distortions due to monopoly practices, external economies and diseconomies (such as environmental impacts which are not internalized in the private market), interventions in the market process through taxes, import duties and subsidies, all result in market (or financial) prices for goods and services which may diverge substantially from their shadow prices or true economic values. Furthermore, the reliance on strict efficiency criteria for determining economic welfare implies the passive acceptance of the existing (skewed) income distribution -- this may be socially and politically unacceptable, especially if there are large income disparities. Such considerations necessitate the use of appropriate shadow prices (instead of market prices) of project inputs and outputs, to determine the optimal investment decisions and policies, especially in the developing countries where market distortions are more prevalent than in the industrialized countries.

3/ Further details concerning the summarized material in this section may be found in: P. Dasgupta, S. Marglin and A.K. Sen, *Guidelines for Project Evaluation*, UNIDO, New York, 1972; I.M.D. Little and J. Mirrlees, *Project Appraisal and Planning for Developing Countries*, Basic Books, New York, 1974; M. Munasinghe, *Energy Analysis and Policy*, Butterworths Press, London, 1990b; A. Ray, *Cost Benefit Analysis*, Johns Hopkins University Press, Baltimore, 1984; and L. Squire and H. Van der Tak, *Economic Analysis of Projects*, Johns Hopkins University Press, Baltimore, 1975.

Consider a general equilibrium model of the economy in which the national goal is embodied in an acceptable objective function such as aggregate consumption. This consumption is to be maximized subject to constraints that might include limits on resource availabilities, distortions in the economy, and so on. Then, the shadow price of a given scarce economic resource represents the change in value of the objective function, caused by a marginal change in the availability of that resource. In the more specific context of a mathematical programming macroeconomic model, the optimal values of the dual variables (that correspond to the binding resource availability constraints in the primal problem) have dimensions of price, and could be interpreted as shadow prices (Luenberger 1973 and Sassone 1977). While the general equilibrium approach is conceptually important, it is too cumbersome and data-intensive to use in most cases. Therefore in practice, partial equilibrium techniques may be used that evaluate the impact of the change in the availability of a given resource on a few key areas, rather than throughout the economy (see the following sections on environmental accounting and environmental impacts of economywide policies).

Two basic types of shadow prices exist. These involve whether or not society is indifferent to income distributional considerations. To illustrate this point, consider the simple national goal of maximizing the present value of aggregate consumption over a given time horizon. If the consumption of different individuals is added directly regardless of their income levels, then the shadow prices derived from such a model are termed efficiency prices because they reflect the pure efficiency of resource allocation. Alternatively, when increasing the consumption of the lower income groups becomes an important objective, this consideration is given a greater weight in evaluating aggregate consumption. Then, the resultant shadow prices are called social prices.

The goal of shadow pricing is, therefore, either efficiency- or socially-oriented. In brief, efficiency shadow prices try to establish the actual economic values of inputs and outputs, while socially-oriented shadow prices take account of the fact that the income distribution between different societal groups or regions may be distorted in terms of overall national objectives. This may call for special adjustments, for example, by giving greater weight to benefits and costs accruing to the poor relative to the rich. In practice, such formal weighting schemes are seldom used in project evaluation -- instead, income distributional and other social issues are addressed through direct targeting of beneficiaries and similar ad hoc approaches. In our analysis, we will place primary emphasis on efficiency shadow pricing.

Nonpriced inputs and outputs must be shadow-priced to reflect their economic opportunity costs (see Annex 1 for details of border shadow prices and conversion factors). Major categories of such nonpriced inputs and outputs are public goods and externalities (especially environmental impacts). Public goods are defined as those goods and services that are free to all without payments once they have been made available, such as transportation and navigation facilities, and police protection. Externalities are defined as beneficial or adverse effects imposed on others, for which the originator of these effects cannot charge or be charged (as the case may be).

Unfortunately, many externalities are not only difficult to measure in physical terms, but even more difficult to convert into monetary equivalents (i.e., to measure the "willingness to pay" of the parties affected by the externalities). Quite often therefore, the approach taken is to impose regulations and standards, expressed in physical measurements only, that try to eliminate the perceived external damages. However, this approach may not be effective, because no attempt is made to compare the costs of compliance with the real benefits provided (i.e., damages avoided). Basic concepts and techniques for economic valuation of environmental impacts are discussed later in the text.

2.3.4 Numeraire

To derive a consistent set of economic shadow prices for goods and services, a common yardstick or numeraire to measure value is necessary. The choice of the numeraire, like the choice of a currency unit, should not influence the economic criteria for decisionmaking, provided the same consistent framework and assumptions are used in the analysis.

The same nominal unit of currency may have a different value depending on the economic circumstances in which it is used. For example, a rupee-worth of a certain good purchased in a duty free shop is likely to be more than the physical quantity of the same good obtained for one rupee from a retail store, after import duties and taxes have been levied. Therefore, it is possible to distinguish intuitively between the border-priced rupee, which is used in international markets free of import tariffs, and a domestic-priced rupee, which is used in the domestic market subject to various distortions. A more sophisticated example of the value differences of a currency unit in various uses arises in countries where investment for future economic growth is considered inadequate. In these instances, a rupee-worth of savings that could be invested to increase the level of future consumption, may be considered more valuable than a rupee devoted to current consumption.

A most appropriate numeraire in many instances is a unit of uncommitted public income at border shadow prices (Little and Mirrlees, 1974). Essentially, this unit is the same as freely disposable foreign exchange available to the government, but expressed in terms of units of local currency converted at the official exchange rate. The discussion in Annex 1 is developed in relation to this particular yardstick of value. The border-priced numeraire is particularly relevant for the foreign exchange - scarce developing countries. It represents the set of opportunities available to a country to purchase goods and services on the international market.

2.4 The National Income Accounts and Macroeconomic Performance

In order to accurately recognize and include environmental concerns in economic analyses, standard income accounting techniques must be re-examined. Performance is currently measured by the growth in GDP, and policy reforms are justified routinely on the basis of their short-, medium-, or long-term contribution to such growth. While GDP measures market activity reasonably well, it has been criticized for its neglect of non-market value added. More importantly, since GDP does not consider depreciation of man-made capital and also leaves out the degradation of "natural capital", it is an inaccurate measure of true, sustainable income. In terms of the environment, there are three specific shortcomings in the current national accounting framework:

- Natural and environmental resources are not included in balance sheets; therefore, national accounts represent limited indicators of national well-being, since they are a poor, or even "perverse", measure of changes in environmental and resource conditions;

- Conventional national accounts fail to record the depreciation of natural capital, such as a nation's stock of water, soil, air, nonrenewable resources, and wilderness areas, which are essential for human existence. Dasgupta and Maler (1991) make the case that resource-based goods are underpriced in the market -- the lower the value added, the larger is the extent of underpricing of the final product. It follows that countries which export primary products do so by subsidizing them, usually with disproportionately large adverse impacts on the poorest members of society (who are less able to protect themselves) -- the small cultivator, the forest dweller, the landless peasant, and so on. Currently, there are no estimates of such hidden costs or "subsidies". If there were, the GDP of many

countries could well be significantly lower. In addition, natural resource depletion raises intergenerational equity issues, to the extent that the productive assets available to future generations would be unfairly diminished (see the discussion on discount rate in the next section).

- Cleanup costs (e.g., expenditures incurred to restore environmental assets) are often included in national income, while environmental damages are not considered. For private firms, defensive environmental expenditures (i.e., measures to reduce or avoid environmental damage) are netted out of final value added. In contrast, such cleanup costs are considered as productive contributions to national output if they are incurred by the public sector or by households. The calculation of GDP is distorted in two ways -- undesirable outputs (e.g., pollution) are overlooked while beneficial environment-related inputs related to environmental needs are often implicitly valued at zero.[4/]

The deficiencies in the accounting techniques employed at present point to the need for a system of national accounts (SNA) which permits the computation of an Environmentally-adjusted Net Domestic Product (EDP) and an Environmentally-adjusted Net Income (EDI). Such measures would help to better capture environmental services, account for the depreciation of both man-made and natural capital, exclude relevant categories of defensive environmental expenditures, and/or estimate damages as a result of economic activities. To the extent that national level decisionmakers and macroeconomic planners (typically, in a Ministry of Finance or National Planning) rely on the conventional SNA to formulate economic policies, a supplementary environmentally-adjusted SNA and corresponding performance indicators would encourage policymakers to reassess the macroeconomic situation in light of environmental concerns, and trace the links between economywide policies and natural resource management (Muzondo et al. 1990).

Based on ongoing work since 1983, the Bank has actively encouraged the consideration of environmental issues during the ongoing revision of the SNA by the United Nations, and proposed as an interim measure, that a satellite system for integrated environmental and economic accounting (SEAA) be created. This approach represents a compromise that does not change the core of the SNA, its production boundary, and the relevant time series -- but at the same time, the satellite accounts will encourage the collection of relevant information and compilation in the area of natural resources and the environment. The satellite accounts are an interim step that will permit further progress towards the computation of an EDP and an EDI. The World Bank, together with the UN Statistical Office, has recently completed a case study in Mexico (van Tongeren et al. 1991), and is currently carrying out another in Papua New Guinea, to determine how such accounts can be prepared.

The "UNSO Framework" (Bartelmus, Stahmer, and van Tongeren 1989) was used as a basis for the above studies. This framework is a System for Environmentally-adjusted Economic Accounts (SEAA), which represents one approach to deriving EDP and ENI. It tries to integrate environmental data sets with existing national accounts information, while maintaining SNA concepts and principles as far as possible. Environmental costs, benefits, and natural resource assets, as well as expenditures for environmental protection are presented in flow accounts and balance sheets in a consistent manner, while maintaining the accounting identities of the SNA.

On the basis of the UNSO framework, a draft Handbook for Environmental Accounting has been developed (UNSO 1990) which outlines in detail the possibilities for computing an EDP. Until the

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4/ Dasgupta and Maler (1991) suggest that in order to avoid doublecounting, expenditures which go to enhance resource bases, such as forests, should not be included in national income computations, as they are already reflected in the value of changes in the resource stocks.

EDP concept becomes more widely accepted and used, decisionmakers and policy analysts should keep in mind the limitations of current national accounts information. Ultimately, the most desirable policy reforms are the ones that would focus on increasing EDP rather than GDP, since EDP more accurately measures "sustainable" income (see also Peskin 1990 and Repetto et al. 1989 for related research).

2.5 Economywide Policies and the Environment

Economywide policies (both macroeconomic and sectoral) play a significant role in the rate of depletion of natural resources and the level of environmental degradation. Fiscal and monetary policies, structural adjustment programs, and stabilization measures all have an effect on the natural resource base. Unfortunately, interactions between the economy and the environment are complex and our understanding of them limited. Ideally one would wish to trace the effects of economywide policy reforms (both macroeconomic and sectoral) through the economic and ecological systems. Time and data limitations generally preclude the use of such comprehensive approaches in developing countries. Practical policy analysis is usually limited to a more "partial equilibrium" approach that seeks to trace the most important impacts of specific economywide policies, at least qualitatively, and wherever possible, quantitatively.

2.5.1 Macroeconomic Policies

In the 1980s, debtor countries adopted emergency stabilization programs which necessitated currency devaluations, controls on capital, and interest rate increases. When income levels dropped, tax revenues decreased accordingly. As unemployment increased, governments fell back upon expansionary financing policies, which led to increases in consumer prices. The effect of such policies on the poorest population groups often drove them onto marginal lands, resulting in soil erosion and desertification. Fuel price increases and lowered incomes combined to cause deforestation and reductions in soil fertility, as the poor were forced to use fuelwood and animal dung for heating, lighting, and cooking.

Real currency devaluations have the effect of increasing international competitiveness, and raising production of internationally tradable goods (e.g., forestry and agricultural products). If the agricultural response occurs through crop substitution, environmental impact would depend on whether the higher priced crop had environmental benefits (e.g., tea, cocoa, rubber) or was environmentally damaging (e.g., tobacco, sugarcane, corn). Environmental impacts would also depend on whether increased production led to farming on new land (which could result in increased deforestation) or resulted in more efficient use of existing farmland. By increasing the competitiveness of world exports, it has been demonstrated by Capistrano and Kiker (1990) that the opportunity cost of keeping timber unharvested increases as a result. This could lead to forest depletion that significantly exceeds natural regenerative capacity.

Overvaluation of the exchange rate results in negative terms of trade, encouraging the production of subsistence crops at the expense of internationally tradable products. If these subsistence crops are environmentally harmful, then currency overvaluation leads to environmental degradation. In addition, decreased competitiveness of products and lower farmgate prices push small cultivators onto marginal lands in an attempt to absorb the effects of the price changes. Since an overvalued exchange rate is often associated with poor export performance and foreign exchange shortages, devaluation may provide a double saving in foreign exchange -- more export earnings from forestry products, as

well as foreign exchange saved through import substitution from agricultural crops planted on deforested land.

In a recent review of the links between growth, trade policy and the environment, Lopez (1991) argues that the output from a natural resource like a forest or fishery (where the production depends critically on the stock) also will be affected by other factors like property rights. Thus, if trade policy increased the value of output (e.g., timber or fish exports), then the degree of ownership would influence how production and resource stocks were managed -- reactions might range from more investment in and maintenance of assets (if environmental costs were internalized by owner-users), to rapid depletion (when the users had no stake in the resource stock).

2.5.2 Structural Adjustment

The conditionality clause embodied in structural adjustment loans (SALs) implemented by the World Bank covers many of the elements discussed above: increases in agricultural prices, currency devaluations, and removal of agricultural subsidies (Sebastian and Alicbusan, 1989). Export taxes are often one of the policies included. Such taxes, which are a means of generating public revenues, result in lower agricultural prices. Again, environmental impacts depend on the nature of the crops.

SALs often call for reductions in energy subsidies, to decrease pollution and encourage energy conservation. However, such policies may force poor consumers to substitute fuelwood and animal dung for liquid fuels, thereby increasing deforestation and decreasing soil fertility.

SALs usually entail the adoption of policies designed to:
(a) promote trade liberalization -- by removing barriers to external trade, and encouraging exports; and
(b) implement institutional reform -- through privatization, encouraging foreign investment, better training and marketing, and reform of land ownership.

The benefits and costs of such projects are highly country-specific. There is some concern that encouraging foreign investment and privatization might lead to the growth of "pollution havens", given the weakness of environmental regulations in most developing countries. Trade liberalization also could encourage the growth of energy-intensive and/or highly polluting industry. However, pollution caused by industrialization could be offset by afforestation (although this does not necessarily compensate residents of polluted areas), and limited by appropriate taxation policies that encouraged the use of pollution abatement technologies. In a recent review of the Latin American experience, Birdsall and Wheeler (1991) conclude that there is no evidence to show that open economies are more prone to pollution. They argue that the inflow of foreign technology and capital would tend to bring in better pollution standards. At the same time, it is the pollution-intensive heavy industries sector that has generally benefited from protective industrial and trade policies.

2.5.3 Public Investment/Expenditure Reviews (PI/ERs)

Reductions in public expenditure are an integral part of many SALs, and usually emerge from recommendations on spending priorities made in Public Investment/Expenditure Reviews (PI/ERs). The main purpose of PI/ERs is to provide recommendations to governments on the size and composition of their spending programs and on ways to strengthen local institutions to enhance country capabilities to design and implement such programs. They have also been used to carry out basic sector work and to identify projects appropriate for World Bank support. PI/ERs can form the

heart of the Bank's country dialogue, as expenditure decisions by the core planning and finance agencies are central to the key objectives of structural adjustment, poverty alleviation and sound management of natural resources.

In the past, public investment programs in most countries may not have given adequate weight to environmental objectives as compared to efficiency and poverty alleviation. The potential clearly exists for investment reviews to appropriately elevate environmental concerns and thereby help to avoid making investments with some of the serious long-term environmental consequences. The expenditure reviews are perhaps less crucial; nevertheless, these could be used to ensure, for example, that conservation-oriented agencies and extension programs get a fair share of current government expenditures.

2.5.4 Sectoral Policies

Several studies contain practical examples of the effects such policies have on the environment.[3/] Some countries subsidize urban consumers by placing price ceilings on food. In such cases, the environmental consequences will be the same as for currency overvaluation, as both result in lowered incentives to increase production of internationally tradable crops.

Lutz and Young (1990) traced the effects of agricultural policies on the natural resource base. They found that where the removal of a fertilizer or pesticide subsidy is being considered in an adjustment program, government expenditures will decrease, farmers' use of these inputs will decrease, and adverse environmental side effects will tend to diminish as well.

In the case of Brazil, Binswanger (1989) showed that general tax policies, special tax incentives, the rules of land allocation, and the agricultural credit system all accelerate deforestation in the Amazon. These policies also increase the size of landholdings and reduce the land available to the poor.

Through a systematic historical analysis of government policies and programs, also in Brazil, Mahar (1989) traced many of today's problems in the Amazon to the decision in the mid-1960s to provide overland access to Amazonia. This decision was made before enough was known about the region's natural resource base and how to develop it in a sustainable manner. The initial error was compounded by subsequent decisions to provide generous incentives to investors willing to undertake environmentally questionable livestock projects, and more recently, smelting projects in the greater

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3/ See for example: H. Binswanger, "Brazilian Policies That Encourage Deforestation in the Amazon", Environment Department Working Paper No. 16, April 1989; D. Mahar, "Government Policies and Deforestation in Brazil's Amazon Region", A World Bank publication in cooperation with the World Wildlife Fund and the Conservation Foundation, Washington, D.C., 1989; R. Repetto, "Economic Policy Reform for Natural Resource Conservation", Environment Department Working Paper No. 4, May 1988; I. Sebastian and A. Alicbusan, "Sustainable Development: Issues in Adjustment Lending Policies", ENVPR Divisional Working Paper No. 1989-6, October 1989; and E. Lutz and M. Young, "Agricultural Policies in Industrial Countries and their Environmental Impacts: Applicability to and Comparisons with Developing Nations", Environment Department Working Paper No. 25, February 1990.

Carajas areas. Official settlement projects have also contributed to deforestation, although it would be wrong to place all of the blame on the settlers. Pushed by poverty and skewed land distribution in their regions of origin, the settlers have merely responded to incentives created by the government in the form of access roads, title to public lands, various public services, and, in the case of the Transamazon scheme, subsistence allowances.

3. INCORPORATING ENVIRONMENTAL COSTS AND BENEFITS INTO ECONOMIC DECISIONMAKING

Recently, Little and Mirrlees (1990) noted that from the mid-1970s to 1990, there had been a "rise and decline of project appraisal in the World Bank and elsewhere", and they concluded that currently the incentives were inadequate for project analysts to undertake thorough, in-depth evaluations of projects.

Given the existing discrepancy between what ought to or could be done and what is actually being done in practice, the question arises whether it is realistic to expect a more thorough treatment of environmental issues. Our view is that even in situations where analysts have limited resources at their disposal, natural resource and environmental issues may be critical ones that can make a difference between success and failure of a project or policy. Therefore, depending on the nature of the project or policy reform package, a significant share of available resources should be devoted to environmentally-oriented economic analysis, preferably early on in the project cycle. Even in cases where the physical impact on the environment cannot be easily valued in economic terms, techniques of multiobjective analysis may be used to improve the quality of the investment decision (see below).

The following section contains a summary of "best practice" that can be pursued to better integrate natural resource and environmental issues into economic analyses of projects and policies. Four key aspects are discussed: (a) determining the physical impacts and valuing the impacts in monetary terms; (b) multi-objective decisionmaking; (c) discounting; and (d) risk and uncertainty. The main emphasis is given to methods and approaches for valuing environmental effects.

3.1 Valuation of Environmental Costs and Benefits

The first step in doing environmentally sound economic analyses is to determine the environmental and natural resource impacts of the project or policies in question. These physical impacts (broadly defined to include also biological and social effects) are determined by comparing the "with project" and the "without project" scenarios. For determining such impacts, the economist will have to rely on the expertise of engineers, ecologists, agronomists, social scientists, and other experts. An important issue, outside the scope of this paper, is that such physical impacts are complex and often poorly understood.

The second step in considering environmental effects involves valuing the physical impacts and relationships. An environmental impact can result in a measurable change in production and/or change in environmental quality. A number of concepts of value, and practical valuation techniques have been developed to trace the welfare impacts of these changes.

3.1.1 Basic Concepts of Economic Value and Classification of Valuation Techniques

Conceptually, the total economic value (TEV) of a resource consists of its (i) use value (UV) and (ii) non-use value (NUV). Use values may be broken down further into the direct use value (DUV), the indirect use value (IUV) and the option value (OV) (potential use value). One needs to be careful not to double-count both the value of indirect supporting functions and the value of the resulting direct use.[6] The categories of non-use value are existence value (EV) and bequest value (BV). Therefore, we may write:

$$TEV = UV + NUV$$

$$\text{or} \quad TEV = [DUV + IUV + OV] + [EV + BV]^{7}$$

Figure 3.1 shows this disaggregation of TEV in schematic form. Below each valuation concept, a short description of its meaning and a few typical examples of the environmental resources underlying the perceived value, are provided. Option values, bequest values and existence values are shaded, to caution the analyst concerning some of the ambiguities associated with defining these concepts -- as shown in the examples, they can spring from similar or identical resources, while their estimation could be interlinked also. However, these concepts of value are generally quite distinct. Option value is based on how much individuals are willing to pay today for the option of preserving the asset for future (personal) direct and indirect use. Bequest value, while excluding individuals' own use values, is the value that people derive from knowing that others (perhaps their own offspring), will be able to benefit from the resource in the future. Finally, existence value is the perceived value of the environmental asset unrelated either to current or optional use, i.e., simply because it exists.[8]

A variety of valuation techniques may be used to quantify the above concepts of value. The basic concept of economic valuation underlying all these techniques is the willingness to pay (WTP) of individuals for an environmental service or resource, i.e., the area under the compensated or Hicksian demand curve.[9] As shown in Table 3.1, valuation methods can be categorized, on the one hand, according to which type of market they rely on, and on the other hand, by considering how they make use of actual or potential behavior.

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[6] For a discussion and example of this see B. Aylward, and E. Barbier, "Valuing Environmental Functions in Developing Countries", forthcoming in *Biodiversity and Conservation.*

[7] The various terms in the equation for TEV may be grouped in somewhat different ways, for convenience -- see for example R.G. Walsh, J.B. Loomis, and R.A. Gillman, "Valuing Option Existence and Bequest Demands for Wilderness", *Land Economics*, Vol. 60, No. 1, February 1984. In order to measure willingness to pay for wilderness protection, they sought to separate (a future-oriented) preservation value from recreational use value (in current use). Accordingly, these authors defined preservation value (PV) as option value plus existence value plus bequest value, i.e., PV = [OV + EV + BV].

[8] See for example Randall and Stoll, "Existence Value in a Total Valuation Framework," in *Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas*, Westview Press, Boulder, CO, 1983.

[9] For an up-to-date exposition, see: J.B. Braden and C.D. Kolstad (eds.), *Measuring the Demand for Environmental Quality*, Elsevier, New York, 1991, Chap. 2.

Figure 3.1 Categories of Economic Values Attributed to Environmental Assets

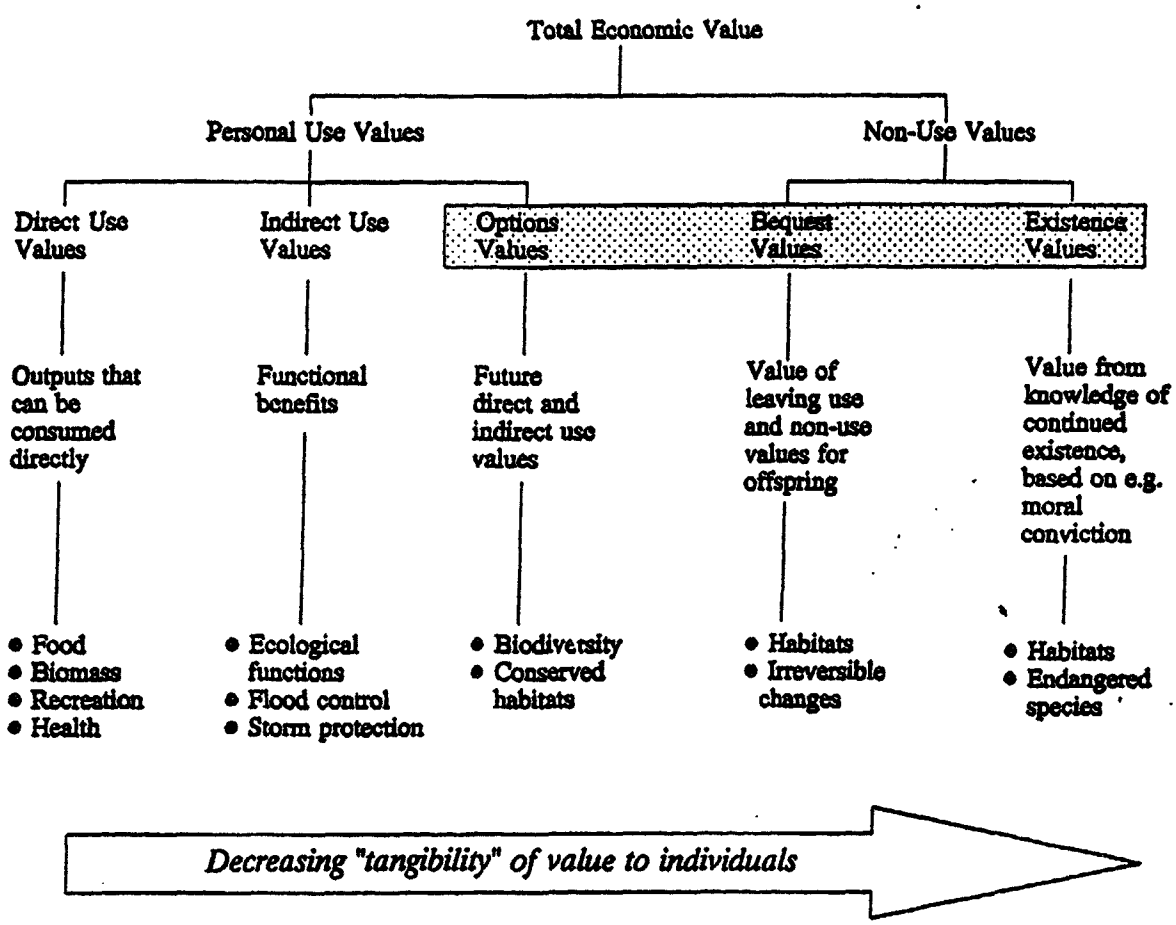

Table 3.1. Taxonomy of relevant valuation techniques

	Conventional market	Implicit market	Constructed market
Based on actual behavior	• Change of Productivity • Loss of Earnings • Defensive Expenditure	• Travel Cost • Wage Differences • Property values	• Artificial market
Based on potential behavior	• Replacement Cost • Shadow project		• Contingent valuation

Next, we group the valuation techniques in Table 3.1 according to analytical method and provide some general comments, before discussing each technique in greater detail.

Under specific conditions, such as when the environmental impact leads to a marginal change in the supply of a good or service that is bought on a competitive market, the WTP can be estimated directly in terms of changes valued at prevailing market prices. If the market is not fully competitive, then the market valuation will be a partial measure, and shadow price corrections may need to be made. The foregoing comments apply to:

- Change of productivity

Often, the result of the impact cannot be directly related to a market activity. In some of these cases, the WTP could be estimated at conventional market value by using a closely related proxy. Care should be exercised on the following points: (1) the relevant attributes affected by the environmental impact might, in the case of the proxy measure, be mixed with other attributes -- thereby affecting the value of proxy; and (2) if the proxy attributes are identical to the ones lost by the impact, then the value given by the proxy is only a lower bound for the true WTP. This approach applies to the following techniques:

- Loss of earnings
- Defensive expenditure
- Replacement cost
- Shadow project

In certain cases the WTP can be estimated through derivation of a demand function for the environmental asset through analysis of actual behavior. Examples of this approach (also called surrogate market techniques) include:

- Travel cost
- Wage differential
- Property valuation

The WTP can also be elicited through a controlled experiment or direct interviews, using the following methods:

- Artificial market
- Contingent valuation

3.1.2 Direct Effects Valued on Conventional Markets

The primary feature of the methods considered in this section is that they are directly based on market prices or productivity. This is possible where a change in environmental quality affects actual production or productive capability.

Change-in-Productivity. Development projects can affect production and productivity positively or negatively. The incremental output can be valued by using standard economic prices. There are examples of this in the following case studies. In the study on soil conservation in Lesotho (Section 4.1.1) the increased production from conserved land is estimated. In the valuation of one hectare of Peruvian rainforest (Section 4.1.2) the values of different production schemes are compared. Other examples include impacts on tropical wetlands (Barbier et al. 1991) and the effects of sedimentation on coral diversity and ultimately on fish production (Hodgson and Dixon, 1988).

Loss-of-Earnings. Changes in environmental quality can have significant effects on human health. Ideally, the monetary value of health impacts should be determined by the willingness to pay, of individuals, for improved health. In practice, one may have to resort to "second best" techniques such as using foregone earnings through premature death, sickness or absenteeism (and increased medical expenditures, which can be considered a type of replacement cost). This approach may be relevant, for example, when considering road and industrial plant safety, and projects that affect air pollution in major cities of developing countries.

The "value-of-life" approach is often questioned on ethical grounds. It is argued that it dehumanizes life, which is considered to have infinite value. In practice, however, society implicitly places finite values on human life and health in policy and project decisions that affect environmental quality, workers' safety or health. If this was not so, we would be justified in spending all of GDP on health improvements.

In the case of an increase or a reduction in the numbers of deaths, an approximate estimate of value is the loss in estimated future earnings of the individuals involved (also called the human capital approach). An increase or reduction in sicknesses can be approximated by the sum of medical costs and the loss in earnings. Both these approaches are exemplified in the case study on the costs and benefits of tobacco growing (Section 4.2.1).

Actual Defensive or Preventive Expenditures. Individuals, firms, and governments undertake a variety of "defensive expenditures" in order to avoid or reduce unwanted environmental effects. Environmental damages are often difficult to assess, but information on defensive expenditures may be available or can be obtained at lesser cost than direct valuations of the environmental good in question. Such actual expenditures indicate that individuals, firms or governments judge the resultant benefits to be greater than the costs. The defensive expenditures can then be interpreted as a minimum valuation of benefits.[10/] However, caution is advisable with this approach, especially in

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10/ As mentioned in the section on national income accounts, work is ongoing to identify defensive expenditures. Such expenditures by firms are treated in the current System of National Accounts (SNA) as intermediate costs and are therefore not part of value added or final output. Defensive expenditures by households and governments, on the other hand, are treated as final expenditures and included in GDP. Present research seeks to address this and other issues and inconsistencies in the SNA (see E. Lutz and M. Munasinghe, "Accounting for the Environment," *Finance and Development*, Vol. 28, March 1991, pp. 19-21).

cases where defensive expenditures are arbitrarily mandated by governments, having little or no relationship to market forces or free choices by informed economic agents.

3.1.3 Potential Expenditure Valued on Conventional Markets

Replacement Cost. Under this approach, the costs that would have to be incurred in order to replace a damaged asset are estimated. The estimate is not a measure of benefit of avoiding the damage in the first place, since the damage costs may be higher or lower than the replacement cost. However, it is an appropriate technique if there is some compelling reason as to why the damage should be restored, or certainty that this will occur.

The replacement cost approach has been applied to protecting groundwater resources in the Philippines, by determining the cost of developing alternative water sources (Munasinghe, 1990c). A second type of application involves estimating erosion prevention benefits by calculating the value of fertilizer needed to replace the nutrients lost through soil erosion. The method is only relevant if, in the absence of erosion control measures, the fertilizer would actually be applied. Another example would be the cost of an artificial fish nursery to estimate the value of wetlands that might be impaired by a project. The same technique of estimating potential ex-post mitigation expenditures represented by the increased costs of health care, is used in the tobacco case study (Section 4.2.1).

Shadow Project. When evaluating projects that have negative environmental impacts, this approach involves the design and costing of one or more "shadow projects" that provide for substitute environmental services to compensate for the loss of environmental assets under the ongoing projects. This approach is essentially an institutional judgment of the replacement cost, and is increasingly being mentioned as a possible way of operationalizing the concept of sustainability at the project level. It assumes that there is a constraint to maintain environmental capital intact, and therefore could be most relevant when "critical" environmental assets are at risk.

3.1.4 Valuation Using Implicit (or Surrogate) Markets

The methods and techniques described in this section use market information indirectly. The approaches discussed are the travel cost method, the property value approach, the wage differential approach, and uses of marketed goods as surrogates for non-marketed goods. Each technique has its particular advantages and disadvantages, as well as requirements for data and resources. The task of the analyst is to determine which of the techniques might be applicable to a particular situation.

Travel Cost. This approach is most often connected with recreational analysis in industrial countries, where it can serve to measure the benefits produced by recreation sites (parks, lakes, forests, wilderness). Essentially the same approach can also be used to value "travel time" in projects dealing with fuelwood and water collection.[11/]

The surrounding area of a site is divided into concentric zones of increasing distance. (Visits from the various zones involve different travel costs). A survey of users, conducted at the site, determines the zone of origin, visitation rates, travel costs, and various socio-economic characteristics. Users close to the site would be expected to make more use of it, because its implicit price, as measured

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11/ For a recent example, see N.D. Hanley, "Valuing Rural Recreation Benefits: An Empirical Comparison of Two Approaches", *Journal of Agricultural Economics*, Vol. 40(3), 1989, p. 361-374.

by travel costs, is lower than for the more distant users. The analysis of the questionnaires enables a demand curve to be constructed [based on the willingness to pay for (a) entry to the site; (b) costs of getting to the site; and (c) foregone earnings or opportunity cost of time spent] and an associated consumers' surplus to be determined. This surplus represents an estimate of the value of the environmental good in question.

Two of the case studies summarized below use the travel cost method. In one study, the travel cost for domestic trips to a forest reserve in Costa Rica is used (Section 4.3.1). In the other study on the value of elephants in Kenya (Section 4.3.2), the travel cost of tourists from Europe and North America is used as one estimate of consumer surplus.

Property Value. This valuation method is also referred to as a hedonic price technique, and it is based on the general land value approach. The objective here is to determine the implicit prices of certain characteristics of properties. In the environmental area, the aim of the method is to place a value on the benefits of environmental quality improvements or to estimate the costs of a deterioration.

The property value approach has been used to analyze the effects of air pollution in certain areas. Where pollution is localized, the method compares prices of houses in affected areas with houses of equal size and similar neighborhood characteristics elsewhere in the same metropolitan area. The approach is based on the assumption of a competitive real estate market, and its demands on information and statistical analysis are significant; therefore, applicability to developing countries is limited.

Wage Differential. This approach is based on the theory that in a competitive market the demand for labor equals the value of the marginal product, and that the supply of labor varies with working and living conditions in an area. A higher wage is therefore necessary to attract workers to locate in polluted areas or to undertake more risky occupations. Again, as in the case of the property value approach, the wage differential approach can only be followed if the labor market is very competitive (see earlier discussion on shadow pricing). Also, the approach reflects private valuation of health risks, but not necessarily social ones. In this context, the level of information concerning occupational hazards must be high, for private individuals to make meaningful tradeoffs between health-risk and remuneration. Finally, the effects of all factors other than environment (e.g., skill level, job responsibility, etc.) that might influence wages must be eliminated, to isolate the impacts of environment.

Marketed Goods as Proxies for Non-Marketed Goods. There are situations where environmental goods have close substitutes which are marketed, and where therefore the value of the environmental good in question can be approximated by the observed market price. For example, the value of a non-marketed fish variety can be valued at the price of the most similar fish being sold in local markets (Barbier et al. 1991).

3.1.5 Valuation Using Constructed Markets

Contingent Valuation. In the absence of people's preferences as revealed in markets, the contingent valuation method tries to obtain information on consumers' preferences by posing direct questions about willingness to pay. It basically asks people what they are willing to pay for a benefit, and/or what they are willing to accept by way of compensation to tolerate a cost. This process of "asking" may be either through a direct questionnaire/survey, or by experimental techniques in which subjects respond to various stimuli in "laboratory" conditions. What is sought are personal valuations

of the respondent for increases or decreases in the quantity of some good, contingent upon a hypothetical market. Willingness to pay is constrained by the income level of the respondent, whereas willingness to accept payment for a loss is not constrained. Estimates of willingness to accept tend to be significantly higher than willingness-to-pay estimates.

Pearce and Markandya (1989) compared the contingent valuation method with other, more market-based methods and found that in seven studies done in industrial countries the overlap of estimates is complete, if accuracy is expressed as plus or minus 60 percent of the estimates computed. This result provides some reassurance that a rigorously applied contingent valuation method, while not being very precise, nevertheless can produce valuations that are of the right order of magnitude. This may be sufficient to rule out certain alternative projects or favor others, which can be valuable in decisionmaking.

The contingent valuation method has certain shortcomings, including problems of designing, implementing and interpreting questionnaires.[12/] While its applicability may be limited, there is now considerable experience in applying this survey-based approach in developing countries, e.g., to evaluate the quality of supply of potable water and electricity services.[13/]

In certain circumstances, the contingent valuation method may be the only available technique for benefit estimation, which can and has been applied to common property resources, amenity resources with scenic, ecological or other characteristics, or to other situations where market information is not available (Mitchell and Carson, 1989). Caution should be exercised in seeking to pursue some of the more abstract benefits of environmental assets such as existence value (of an asset, which may never be used, but promises psychic satisfaction merely because it exists)[14/].

Two examples of contingent valuation surveys are given in the case studies. The use of the contingent valuation method for estimating the value of viewing elephants in Kenya (Section 4.3.2) shows that it is possiole to achieve an understanding of the order of magnitude of the benefits with only small means. The study on willingness to pay for water services in southern Haiti (Section 4.3.3) tests the methodology for different biases, proving its reliability.

Artificial Market. Such markets could be constructed for experimental purposes, to determine consumer willingness to pay for a good or service. For example, a home water purification kit might be marketed at various price levels, or access to a game reserve may be offered on the basis of different admission fees, thereby facilitating the estimation of values placed by individuals on water purity or on the use of a recreational facility, respectively.

12/ See for example several papers appearing in: *The Energy Journal*, Special Issue on Electricity Reliability, Vol. 9, December 1988.

13/ For examples of contingent valuation studies, see the case studies on Haiti and Kenya in this paper, and M. Munasinghe, *Electric Power Economics*, Butterworths Press, London, 1990, chapters 2,7,8, and 9.

14/ See for example Randall and Stoll, "Existence Value in a Total Valuation Framework", in *Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas*, Westview Press, Boulder CO, 1983.

3.2 Multi-Objective Decisionmaking

The methods described above seek to estimate costs and benefits of a given project in monetary terms. When projects/policies and their impacts are to be embedded in a system of broader (national) objectives, some of which cannot be easily quantified in monetary terms, multi-objective decisionmaking offers an alternative approach which may facilitate the optimal choice among investment options or policies available.

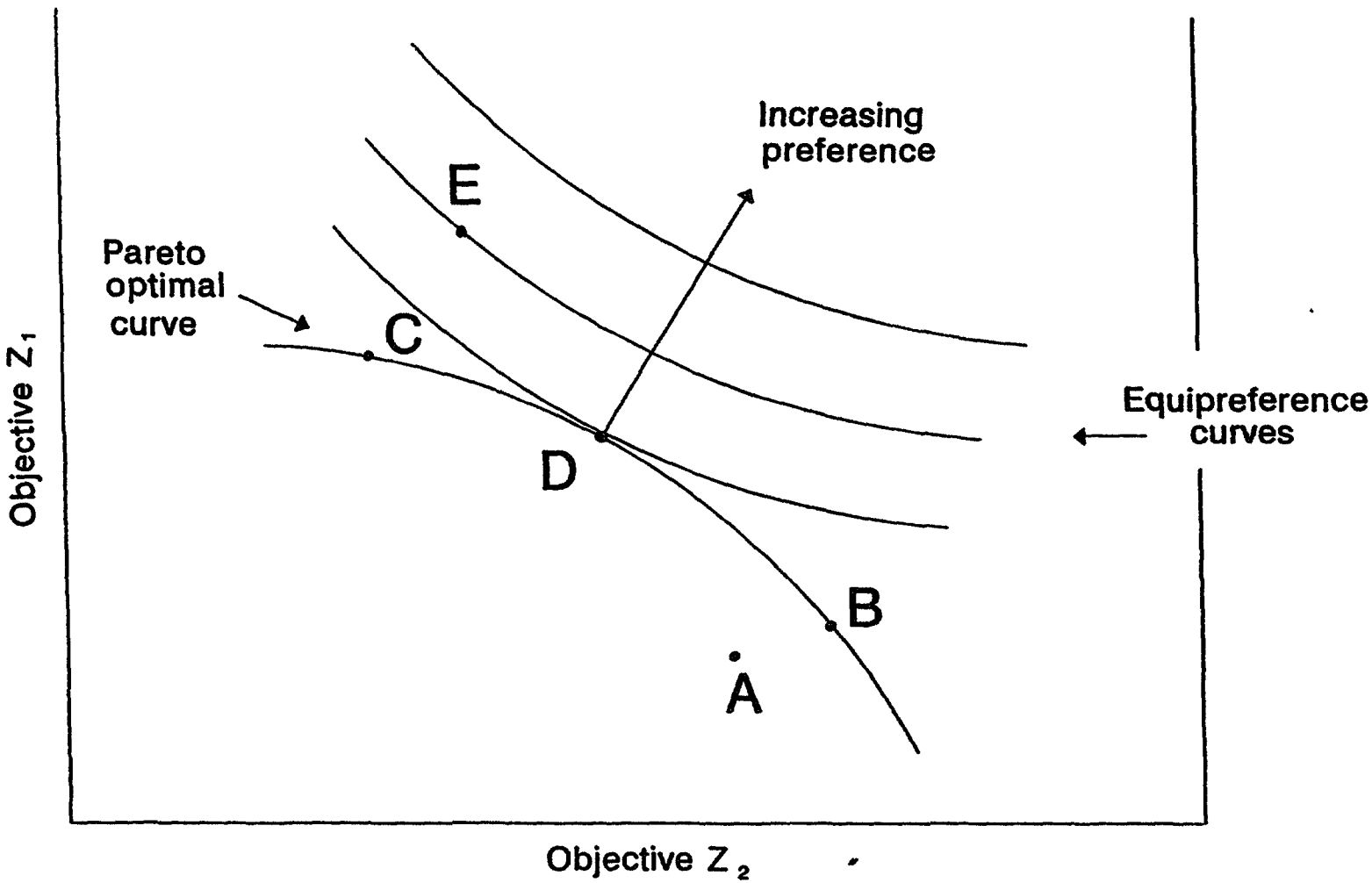
Desirable objectives need to be specified. These often exhibit a hierarchical structure. The highest level represents the broad overall objectives (e.g., improving the quality of life), often vaguely stated and, hence, not very operational. Some of these, however, can be broken down into more operational lower level objectives (e.g., increase income) so that the extent to which the latter are met may be practically assessed. Sometimes only proxies are available (e.g., if the objective is "to enhance recreation opportunities", the attribute "number of recreation days" can be used). Although value judgements may be required to choose the proper attribute (especially if proxies are involved), in contrast to the single-criterion methodologies used in economic cost-benefit analysis, measurement does not have to be in monetary terms. More explicit recognition is given to the fact that a variety of concerns may be associated with planning decisions.

An intuitive understanding of the fundamentals of multi-objective decisionmaking can be provided by a two-dimensional graphical exposition such as in Figure 3.2. Assume that a project has two non-commensurable and conflicting objectives, Z_1 and Z_2. Assume further that alternative projects or solutions to the problem (A, B and C) have been identified. Clearly, point B is superior (or dominates) to A in terms of both Z_1 and Z_2. Thus, alternative A may be discarded. However, we cannot make such a simple choice between solutions B and C since the former is better than the latter with respect to objective Z_2, but worse with respect to Z_1. In general, more points (or solutions) such as B and C may be identified to define the set of all non-dominated feasible solution points that form a Pareto optimal curve (or curve of best options). This line is also called a transformation curve or efficient frontier.

For an unconstrained problem, further ranking of alternatives cannot be conducted without the introduction of value judgements. Specific information has to be elicited from the decisionmaker to determine the most preferred solution. In its most complete form such information may be summarized by a family of equi-preference curves that indicate the way in which the decisionmaker trades off one objective against the other, as illustrated in Figure 3.2. The preferred alternative is that which results in the greatest utility -- which occurs (for continuous decision variables as shown here) at the point of tangency D of the highest equi-preference curve, with the Pareto optimal curve. In this case, point E (on an even higher equi-preference curve) is not attainable.

Figure 3.2

PARETO OPTIMAL CURVE AND ISOPREFERENCE CURVES



Several multi-criteria methods have been developed.[15] Which practical method in particular is suitable to determine the "best" alternative available, depends upon the nature of the decision situation. For instance, interactive involvement of the decisionmaker has proved useful in the case of problems characterized by a large number of decision variables and complex causal interrelationships. Some objectives can be dealt with through direct optimization, while others require the satisfaction of a certain standard (e.g., level of biological oxygen demand (BOD) not below 5 mg/liter).

The major accomplishment of multi-objective decision models is that they allow for more accurate representation of decision problems, in the sense that several objectives can be accounted for. However, a key question concerns whose preferences are to be considered. The model only aids a single decisionmaker (or a homogeneous group). Various interested groups will often assign different priorities to the respective objectives, and normally it may not be possible to determine a "single" best solution via the multi-objective model. Also, the mathematical framework imposes constraints upon the ability to effectively represent the planning problem. Non-linear, stochastic and dynamic formulations can assist in better defining the problem, but impose costs in terms of complexity in formulation and solving the model (Cocklin, 1989).

Nevertheless, in constructing the model the analyst communicates information about the nature of the problem. He specifies why factors are important and how they interact. Liebman (1976) observes that "modelling is thinking made public", and considers the transfer of knowledge to represent perhaps the most important contribution of modelling. With respect to the second point of criticism (i.e., diverse preferences), Liebman suggests that there is value to be gained in constructing models from differing perspectives and comparing the results.

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[15] For an introductory overview relevant to natural resource analysis, see M. Munasinghe, *Water Supply and Environmental Management*, Westview Press, Boulder CO, 1992. An extensive survey including references to about 150 applications has been done by C. Romero and T. Rehman:"Natural Resource Management and the Use of Multiple Criteria Decision-making Techniques:A Review", *European Journal of Agricultural Economics*, Vol. 14, 1987, pp. 61-89. A shorter, but more recent, survey was done by F. Petry:"Who is Afraid of Choices? A Proposal for Multi-Criteria Analysis as a Tool for Decision-making Support in Development Planning", *Journal of International Development*, Vol. 2, 1990, pp. 209-231.

3.3 The Discount Rate

As introduced in Section 2, discounting is the process by which costs and benefits that occur in different time periods may be compared. The discount rate to be used has been a general problem in cost-benefit analysis[16], but it is particularly important with regard to environmental issues, since at least some of the associated costs and benefits are long-term in nature.

In standard analysis, past costs and benefits are treated as "sunk" and are ignored in decisions about the present and future. Future costs and benefits are discounted to their equivalent present value and then compared. In theory, in a perfect market, the interest rate reflects both the subjective rate of time preference (of private individuals) and the rate of productivity of capital. These rates are equated at the margin by the market, so that the rate at which individuals are willing to trade present for future values is just equal at the margin to the rate at which they are able to transform present goods (in the form of foregone consumption) into future goods (through capital investment).

Often, the rate of time preference and the rate of capital productivity are not equal, because of imperfect financial markets and government distortions introduced by taxation. Also, individual decisions differ from social decisions in that individuals are relatively short-lived, whereas societies persist for much longer periods. Thus one strong reason for individual preference for the present (i.e., the certainty of death coupled with the uncertainty of when it will occur), is absent from the viewpoint of society. Therefore, the community has reason to discount the future less than individuals.

The rate of capital productivity is often very high in developing countries, because of the scarcity of capital. In the poorer countries, the rate of time preference also is elevated in many cases, because of the urgency of satisfying immediate food needs rather than ensuring long term food security (Pearce and Turner, 1990).

Higher discount rates may discriminate against future generations. This is because projects with social costs occurring in the long term and net social benefits occurring in the near term, will be favored by higher discount rates. Projects with benefits accruing in the long run will be less likely to be undertaken under high discount rates. It is therefore a logical conclusion that future generations will suffer from market discount rates determined by high rates of current generation time preference and/or productivity of capital.

Based on the foregoing, it is often argued that discount rates should be lowered to reflect environmental concerns and issues of intergenerational equity. However, this would have the drawback that not only would ecologically sound activities pass the cost-benefit test more frequently, but also a larger number of projects would generally pass the test and the resulting increase in investment would lead to additional environmental stress. Norgaard (1991) argues that lowering discount rates can in fact worsen environmental degradation -- by lowering the cost of capital and thereby lowering the cost of production such that more is consumed in the near-term relative to the case where discount rates were higher.

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[16] For more details, see P. Dasgupta, S. Marglin, and A. Sen, *Guidelines for Project Evaluation*, UNIDO, New York, 1972; A.C. Harberger, *Project Evaluation: Collected Papers*, University of Chicago Press, 1976; I. Little and J. Mirrlees, *Project Appraisal and Planning for Developing Countries*, Basic Books, New York, 1974; S.A. Marglin, "The Opportunity Costs of Public Investment", *Quarterly Journal of Economics*, vol. 77, no. 2, 1963; and A.K. Sen, "Isolation, Assurance, and the Social Rate of Discount", *Quarterly Journal of Economics*, vol. 81, no. 1, 1967.

Many environmentalists believe that a zero discount rate should be employed to protect future generations. However, employing a zero discount rate is inequitable, since it would imply a policy of total current sacrifice, which runs counter to the proposed aim of eliminating discrimination between time periods -- especially when the present contained widespread poverty (Pearce, 1991).

Norgaard makes the case that manipulating discount rates to reflect sustainability concerns results in an inefficient use of capital, and instead suggests direct income transfers to compensate for environmental degradation. He utilizes a general equilibrium model to demonstrate that income transfers to future generations, through the efficient allocation of resources, results in new levels of savings and investment, a shift in the types of investments, and a different interest (or discount) rate. The rate of interest may increase or decrease, but this is irrelevant, since it merely serves as an equilibrating price.

In order to facilitate such intergenerational transfers, one alternative might be to impose a sustainability constraint, whereby current well-being is maximized without reducing the welfare of future generations below that of the current generation. In practice, this would entail monitoring and measurement of capital stocks (man-made, human and natural), and an overarching investment policy which sought to ensure that compensating investments offset depreciation of existing assets (Pearce, 1991). The aim would be to ensure that the overall stock of capital (broadly defined) is preserved or enhanced for future generations. Apart from the previously detailed attempts to include depreciation of natural resource stock in national income accounting, little has been accomplished in this area to date.

In the case of projects leading to irreversible damage (e.g., destruction of natural habitats, etc.), the benefits of preservation may be incorporated into standard cost-benefit methodology using the Krutilla-Fisher approach (Markandya and Pearce, 1988). Benefits of preservation will grow over time as the supply of scarce environmental resources decreases, demand (fueled by population growth) increases, and possibly, existence value increases. The Krutilla-Fisher approach incorporates these increasing benefits of preservation by including preservation benefits foregone within project costs. The benefits are shown to increase through time by the use of a rate of annual growth. While this approach has the same effect on the overall CBA as lowering discount rates, it avoids the problem of distorted resource allocations caused by arbitrarily manipulating discount rates.

In summary, the following conclusions may be reached, within the context of environmental cost-benefit analysis:

a) The standard opportunity cost of capital (e.g., 6-12 percent) should be used as for NPV calculations, and as the comparator when the IRR is computed;

b) Efforts should be made to ensure that compensating investments offset capital stock degradation within a framework of policy and project decisions; and

c) In the case of projects leading to irreversible damage, CBA should be adapted to the extent possible, to include a measurement of the foregone benefits of preservation in the computation of costs.

3.4 Risk and Uncertainty

All projects and policies entail some element of risk and uncertainty. Risks are measured usually by the probabilities that can be assigned to the likelihood of occurrence of an undesirable event (e.g.,

an industrial accident). Uncertainty describes a situation where little is known about future impacts. Therefore, no probabilities can be assigned to definite outcomes, or even the outcomes are so novel that they cannot be anticipated.

Risk can be treated probabilistically on the basis of known or estimated data, and therefore insured against and treated like any other project cost. However, uncertainty defies actuarial principles because of undefinable outcomes. For example, stratospheric ozone layer depletion was an unknown outcome of the introduction of CFCs and could not have been costed as a risk when they were first used. Uncertainty is especially important in environmental issues. As projects grow larger in scale and introduce new substances into the environment, the category of uncertainty looms much larger than risk. The proper response to risk is to count it as a cost in expected value computations. However, the use of a single number (or expected value of risk) does not indicate the degree of variability or the range of values that might be expected. Additionally, it does not allow for individual perceptions of risk. The proper response to uncertainty is to proceed with caution -- if the future cannot be perceived clearly, then the speed of advance should be tailored to the distance over which the clarity of vision is acceptable.

In practice, the way risk and uncertainty are included in project appraisal work is through sensitivity analyses, which determine how the IRR is dependent on different variables. Using optimistic and pessimistic values for different variables can indicate which variables will have the most pronounced effects on benefits and costs. We note that while sensitivity analysis need not reflect the probability of occurrence of the upper or lower values, it is useful for determining which variables are most important to the success or failure of a project (Dixon et al. 1988). Much work has been done on the subject of risk and uncertainty in project appraisal (for a recent treatment, see Anderson and Quiggin, 1990).

The issue of uncertainty plays an important role in environmental valuation and policy formulation. Option values and quasi-option values are based on the existence of uncertainty. Option value (OV) is essentially the "premium" that consumers are willing to pay to avoid the risk of not having something available in the future (see the study on the valuation of elephants in Kenya.) The sign of option value depends upon the presence of supply and/or demand uncertainty, and on whether the consumer is risk averse or risk loving.

Sign of Option Value (OV)

	Risk loving	Risk neutral	Risk averse
Demand uncertainty			
- Income	positive	none	negative
- Preferences	pos./neg.	none	pos./neg.
Supply uncertainty	negative	none	positive

Source: Pearce and Turner, 1990.

Quasi-option value (QOV) is the value of preserving options for future use in the expectation that knowledge will grow over time. If a development takes place that causes irreversible environmental damage, the opportunity to expand knowledge through scientific study of flora and fauna is lost. Uncertainty about the benefits of preservation to be derived through future knowledge expansion (which is independent of development) leads to a positive QOV. This suggests that the development should be postponed until increased knowledge facilitates a more informed decision. If information growth is contingent upon the development taking place, which is unlikely in an environmental context, then QOV is positive when the uncertainty regards the benefits of preservation, and negative when the uncertainty is about the benefits of the development[17].

Environmental policy formulation is complicated by the presence of numerous forms of uncertainty. As an illustration, Bromley (1989) identified six different aspects of uncertainty in the matter of air pollution resulting from acid deposition.

1. The identification of the sources of particular pollutants.
2. The ultimate destination of particular emissions.
3. The actual physical impacts at the point of destination.
4. Human valuation of the realized impacts at the point of destination of the emissions.
5. The extent to which a particular policy response will have an impact on the abovementioned factors.
6. The actual cost level and the incidence of those costs that are the result of policy choice.

Bromley suggests that the way in which policymakers address these uncertainties depends on their perception of the existing entitlement structure. The interests of the future are only protected by an entitlement structure that imposes a duty on current generations to consider the rights of future generations (or, as he terms them, "missing markets" because "future generations are unable to enter bids to protect their interests"). In the absence of such a structure, decisionmakers may tend to follow a policy that ignores costs to future generations, and minimizes costs to current generations at the expense of the future. If the entitlement structure is adjusted, the policymaker can then examine three policy instruments to ensure that future generations are not made worse off:

(1) mandated pollution abatement;
(2) full compensation for future damages (e.g., by taxation); and
(3) an annuity that will compensate the future for costs imposed in the present.
In the face of uncertainty, the first option would appear to be the most efficient.

Other important sources of uncertainty linked with environmental issues include uncertainty over land tenure (which leads to deforestation and unsustainable agricultural practices), and uncertainty of resource rights (which can accelerate the rate of depletion of a nonrenewable resource). Policymakers can address these issues by instituting land reforms, and by designing appropriate taxation policies that return rents to public sources rather than to private agents.

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17. See Pearce and Turner (1990); A.C. Fisher and M. Hanemann, "Quasi Option Value: Some Misconceptions Dispelled", *Journal of Environmental Economics and Management*, 14, 1987, pp.183-190.

4. CASE STUDIES OF VALUATION OF ENVIRONMENTAL IMPACTS

In this section, a number of developing country case studies are outlined briefly, to illustrate the implementation of some of the techniques of environmental impact valuation discussed earlier. Further details of these case studies are provided in Annex 2. These illustrations apply primarily to the direct and indirect use value categories shown in Figure 3.1. In view of the rarity of developing country examples describing attempts to estimate option, existence and bequest values, the last part of this section summarizes several studies in this area, but applied to the industrialized countries.

4.1 Change in Productivity Method

4.1.1 Cost-Benefit Analysis of Land Improvement in Lesotho[18/]

The Farm Improvement with Soil Conservation (FISC) project was initiated in Southern Lesotho in 1985, with the overriding aim of raising agricultural production among smallholder farming households through soil conservation measures, subsidized inputs, and afforestation. In pursuit of this goal the project has rehabilitated old terrace structures, constructed new ones and added other structures for conservation. It has promoted the use of hybrid maize and sorghum, the planting of fodder grasses, and tree planting. It has also promoted rotational grazing on communal rangeland. "Conservation", in this study, is defined as "the promotion of optimum use of land in accordance with its capability so as to assure its maintenance and improvement".

A financial analysis is carried out, comparing a "high input" alternative implying the use of commercial fertilizer and hybrid seed, with the "traditional" alternative implying no use of fertilizer and locally saved seeds as opposed to hybrids. The calculation, which is valid for one year only, does not take into consideration the impacts on soil conservation. Calculations for maize and sorghum show a negative real marginal IRR of 21 and 30 percent, respectively.

An economic cost-benefit analysis is performed, distinguishing between productivity impacts due to increased use of commercial inputs, and impacts due to increased soil conservation. Costs are primarily labor and material input costs. Primary benefit categories include increased production of sorghum and maize (in terms of the incremental yield due to conservation, relative to future decline in yield due to erosion), fruit, fuelwood, and fodder. Given various assumptions regarding the rate of growth of project implementation factors (see Section III of case study), the results of the base case are an NPV of -M 7.0 million at a discount rate of 10 percent and -M 5.6 million at 1 percent. Table A2.1.2 demonstrates that conservation crop benefits are more significant at a lower discount rate, as they are slow to materialize.

The qualitative interpretation is that the project makes a loss that is significant in comparison to the resources invested. In terms of the overriding target of the project - to raise agricultural production among smallholder farming households - the project cannot be termed successful. However, the benefits of soil conservation may have been underestimated in the desire to improve crop yields (FISC has a "production", as opposed to a "preservation" orientation). Given demand uncertainty arising from lack of information on future population, food habits, agricultural technology, and capacity to import food; and supply uncertainty about the possibility of droughts leading to soil

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18/ Derived from J. Bojö, *The Economics of Land Degradation: Theory and Applications to Lesotho*, Dissertation for the Doctor's Degree in Economics, Stockholm School of Economics, 1991, pp. 259-350.

losses, it may be advisable to ascribe a positive option value to soil conservation efforts, to be incorporated into the stream of costs and benefits. Again, if long-term protection of the land base is assigned a higher priority relative to immediate productivity increases, there would be a basis for more substantial subsidization of cover crops such as fodder grasses at the expense of traditional cropping.

Aside from the debatable benefits of its "production" as opposed to "conservation" oriented approach, FISC serves as an important model in terms of its emphasis on consultation and community participation, and its reliance on low-cost, labor-intensive field techniques.

4.1.2 Valuation of an Amazonian Rainforest[19/]

Most financial appraisals of tropical forests have focused exclusively on timber resources and have ignored the market benefits of non-wood products. This has provided a strong market incentive for destructive logging and widespread forest clearing. In an effort to illustrate the values of non-wood forest products, the authors present data concerning inventory, production and current market value for all the commercial tree species occurring in one hectare of Amazonian forest. They arrive at a combined NPV of $5820 for a fruit and latex production and selective cutting project, with logging contributing just 7% of the total. This compares favorably with an estimated NPV of $3184 for timber and pulpwood obtained from a 1 hectare plantation in Brazilian Amazonia, and an NPV of $2960 for fully stocked cattle pastures in Brazil.

In order to extrapolate the value of the project, which is based on the value of 1 hectare, it would be useful if attempts were made to incorporate elasticities of demand for the products. (This approach is being followed for a World Bank study of a similar nature in India).

Another methodological concern is the use of returns per hectare as the unit of comparison between different uses. A recent World Bank study concludes that an appropriate analysis would compare returns per productive unit, including land, labor and capital valued at their opportunity cost. Since land in the Amazon is generally abundant relative to labor, an analysis based on the returns to labor would better predict the market outcome than one which focused on the returns to land. This deduction is confirmed by behavior in the market, where forest extractivism has tended to vanish wherever labor has had reasonable alternatives.[20/]

19/ Derived from C.M. Peters, A.H. Gentry, and R.O. Mendelsohn, "Valuation of an Amazonian Rainforest", *Nature*, Vol. 339, 29 June 1989, pp. 655-656.

20/ World Bank, "Brazil: An Analysis of Environmental Problems in the Amazon", Vol. 2, Annex 5, p.5.

4.2 Loss of Earnings Method

4.2.1 Valuing Health: The Economic Costs and Benefits of World Bank Tobacco Projects[21/]

This study analyzes the net impact, from a global perspective, of existing World Bank tobacco-related projects appraised from 1974 to 1991. The aim is to indicate the order of magnitude of the net benefits as a guide in formulating a Bank policy on lending for tobacco. The analysis begins by calculating incremental effects on world output and prices. It is estimated that the added global supply results in lowering the price per metric ton by $20.5. Social benefits and costs are then estimated from a global standpoint.

Benefits and costs identified are:
1. the benefit from added consumer's surplus, the benefit from added producer's surplus;
2. the value of life lost from premature death;
3. the indirect cost of added morbidity; and
4. the direct cost of added morbidity.

Summing across the net benefits and costs above gives an annual net benefit as of 1991 of -$612,000,000. It is estimated that an additional ton of tobacco produced by a new project in 1991 will have net annual global benefits of -$7,500.

However, several key assumptions in the analysis must be questioned. It is estimated that there are 0.65 deaths from all tobacco related causes per metric ton of tobacco consumed, based on an average ratio of total smoking mortality to tobacco caused lung cancer mortality in the United States from 1965 to 1985 of 4.0. Such a statement requires further analysis. In addition, on a global level, U.S. figures do not necessarily apply, as there is little documentation of tobacco caused lung cancer (as opposed to, say, industrial pollution caused lung cancer) in developing countries.

Another questionable assumption is that only 10 percent of tobacco starts are made by well informed consumers. It does not necessarily hold true that the information gap for tobacco is the same as for alcohol, as claimed by the author.

Finally, the study does not consider the costs of passive smoking, which may be as great or even greater than the costs of direct tobacco consumption. Markandya and Pearce (1989) discuss this issue in a study of the social costs of tobacco smoking.

21/ Derived from H.N. Barnum, "A Note on the Economic Costs and Benefits of Bank Tobacco Projects". Dated 5/10/91.

4.3 Travel Cost and Contingent Valuation Methods

4.3.1 The Domestic Consumer Surplus From Visits to a Rainforest Reserve in Costa Rica[22/]

This study measures the value of ecotourism at a tropical rainforest site in Costa Rica using the travel cost method. By observing travel behavior, the authors reveal that Costa Rican visitors are willing to pay $35 per household to visit the site. The study finds that visitation is highly correlated with education (and therefore probably income), and that households in areas with high population densities make more trips.

The paper only considers domestic visits, although foreign visitors to the site outnumbered domestic visitors by four to one in 1988. Foreign visitation is likely to be worth far more than domestic, as foreign visitors have higher travel costs, and a greater value of travel time because of higher earnings. Additionally, they provide foreign exchange. Nevertheless, if we use the same value of $35 per visit for all visitors, this would result in an NPV of $1250 per hectare. This figure is one to two times the magnitude of the purchase price currently paid by the reserve for the acquisition of new lands.

A linear demand function is utilized, as opposed to the more popular semi-log functional form, as visitation rates from many zones were zero. In a similar study, Willis and Garrod (1991) made the case for the superiority of the semi-log functional form over the linear for the Clawson-Knetsch Zonal Travel Cost Method. They also found that the zonal travel cost method probably overestimated the consumer surplus for their sample of travel cost studies. The individual travel cost method comes closer to contingent valuation results.

It is unclear whether the Costa Rican case study assesses the cost (in foregone earnings) of time spent at site. It does mention the "cost of travel time". It would have been useful to have a clearer definition of this element.

As in this Costa Rican example, most travel cost studies look at single-purpose, single destination trips. A more general methodological problem is how to deal with multiple destination trips. In most cases of international tourism to developing countries the travel cost would need to be attributed to many activities at a number of sites. The problem then becomes to elicit the specific value given to a certain site. An ongoing World Bank study on environmental valuation of a forestry development and conservation project in Madagascar is attempting to do this.[23/] Their model utilizes a household production framework in which the household examines cost functions for specific activities within the potential destination countries to compare the expected satisfaction and cost of trips of various bundles of activities. However, this demands much from the empirical data. A survey of tourists is being used to collect travel cost data as well as itinerary data that includes the distribution of time between activities for each individual, the costs of pursuing the activities, and the features of the various activities that lead to differences across individuals in their ability to undertake them.

22/ Derived from D. Tobias, and R. Mendelsohn, "Valuing Ecotourism in a Tropical Rain-Forest Reserve", *Ambio*, Vol. 20, No. 2, April 1991.

23/ R.A. Kramer, M. Munasinghe, N. Sharma, E. Mercer, and P. Shyamsunder, "Valuing and Protecting Tropical Forests: A Case Study of Madagascar", paper presented at the IUCN World Parks Congress, Caracas, February 1992.

4.3.2 The Value of Viewing Elephants on Safaris in Kenya[24/]

The travel cost method was utilized to estimate a demand function for safaris in Kenya. The analysis is based on the 80% of tourists who come to Kenya from Europe and North America. Surveys of tour operators and visitors provided data for the estimation of land costs, air fare and travel time costs. Travel time costs were weighted at 30% to reflect the fact that vacation time is valued at lower than the gross wage rate. A weighted average consumers' surplus of 725 dollars is estimated. This gives a total consumer surplus for those on safari in the range of 182 - 218 million dollars annually, depending on the assumed level of visitation.

To identify the contribution elephants make to the value of a safari, tourists were asked to allocate the pleasure and enjoyment of their trip over various categories of experience. Elephants represented 12.6% of total enjoyment. Therefore, the estimated economic value of a safari yields a viewing value for elephants of 23 to 27 million dollars per year.

In order to assess consumers' willingness to pay to maintain the elephant population at current levels through increased enforcement activity, a survey was designed, utilizing the contingent valuation approach. Attempts were made to adjust for biases. The average value was 89 dollars while the median was 100 dollars. This yields an annual viewing value of 22 to 27 million dollars, and 25 to 30 million dollars respectively, based on an estimate of 250,000 to 300,000 adult safaris per year. (This is an example of option value -- the premium consumers are willing to pay to avoid the risk of supply uncertainty.)

Note that both methods produced annual viewing values for elephants of around 25 million dollars. Although these estimates are rough, they are a useful guide to the order of magnitude of value.

4.3.3 The Willingness to Pay for Water Services in Haiti[25/]

The contingent valuation method was used in this study to estimate consumers' willingness to pay for an improved water system in a village in southern Haiti. The project was executed by CARE. The research team devised tests in an attempt to correct biases that could threaten the validity of the survey results, such as strategic bias, starting point bias, and hypothetical bias. The results of the survey, utilizing an ordered probit model as opposed to a linear model, demonstrated that willingness to pay for a new water system (whether for a public standpost or for a private connection) was positively correlated to income, the cost of obtaining water from existing sources, and the education of household members. It was negatively correlated with the individual's perception of the quality of water at the traditional source used before the construction of the improved water supply system. The sex of the respondent was statistically significant in the model for public standposts, but not in the model for private connections.

24/ Derived from G. Brown Jr, and W. Henry, *The Economic Value of Elephants*, London Environmental Economics Centre, Discussion Paper 89-12, London, 1989.

25/ Derived from D. Whittington, J. Briscoe, X. Mu, and W. Barron, "Estimating the Willingness to Pay for Water Services in Developing Countries: A Case Study of the Use of Contingent Valuation Surveys in Southern Haiti", *Economic Development and Cultural Change*, Vol. 38, No. 2, January 1990.

The mean of WTP bids for public standposts represented 1.7% of household income, while the mean WTP bid for private connections was 2.1% of household incomes. These bids are significantly lower than the 5% rule-of-thumb often used in rural water-supply planning for maximum "ability to pay" for private connections. However, the bids are based on the assumption that the public standposts are already in place.

The results of this study show that it is possible to do a contingent valuation survey among a very poor, illiterate population and obtain reasonable, consistent answers. Contingent valuation has the potential to become a viable method in developing countries: both for collecting information on individuals' willingness to pay for a wide range of public infrastructure projects, and for environmental protection services (such as the treatment of industrial wastewater flowing through residential areas).

4.4 Contingent Valuation Method Used to Estimate Option, Existence and Bequest Values

Since hardly any developing country examples are available in this category, four U.S. examples are provided below. An ongoing World Bank study seeks to determine non-use values of tropical forests in Madagascar (Kramer et al. 1992).

The following studies all used the contingent valuation approach to obtain actual measures for option, existence, and/or bequest values. Case 4.4.1 was quite possibly the first survey that developed a methodology to attempt to determine existence value. Both Studies 4.4.1 and 4.4.2, while revealing the significance of existence values, examine them as an adjunct to their main focus, which is recreational use value. Case 4.4.3 is perhaps the first study that undertook to examine total preservation value in depth, broken down into its three separate components of option, existence, and bequest value. Case 4.4.4 is basically an attempt to measure the effects of information disclosure (endangered status and physical appearance) on existence values for endangered species.

4.4.1 The Existence Value of Preserving Visibility[26]

The survey attempts to measure annual household willingness to pay (WTP) to preserve visibility in the Grand Canyon -- both WTP if visibility preservation were to be extended to the entire southwestern parklands region, and WTP to prevent plume blight seen from Grand Canyon National Park. For the purpose of the study, only the major source of air pollution in the region, coal-fired power plants, was focused on. Over 600 households in Denver, Los Angeles, Albuquerque and Chicago participated in the survey. One-third of the respondents were asked a pure user value question: how much would they be willing to pay in higher entrance fees per day for visibility protection at the Grand Canyon or other parks? The other two-thirds of the respondents were asked how much they would be willing to pay, in the form of a higher monthly electric power bill, to preserve visibility in the parklands, a measurement of total preservation value (defined by the authors as the sum of existence plus user value). The authors interpreted existence value as the difference between total preservation value and user value.

The preservation value bids are substantially higher than the user value bids, apparently signifying that existence value is an important component of total economic value. The authors are careful to point out that visitation plans were not an overwhelming factor in determining preservation value bids, and that knowledge acquired through previous visits was also considered relatively unimportant in the determination of bids. Moreover, preservation bids did not decline with distance, which seems to indicate that non-use value was an important component in the respondents' bids.

4.4.2 The Option Price and Existence Value of Wildlife[27]

This study measures the option price (option value plus expected consumer surplus) and existence value of grizzly bears and bighorn sheep in Wyoming -- both of these species being endangered by

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[26] Derived from W.D. Schulze, D.S. Brookshire, E.G. Walther, K. Kelley MacFarland, M.A. Thayer, R.L. Whitworth, S. Ben-David, W. Malm and J. Molenar, "The Economic Benefits of Preserving Visibility in the National Parklands of the Southwest", *Natural Resources Journal*, Vol. 23, January 1983.

[27] Derived from D.S. Brookshire, L.S. Eubanks, and A. Randall, "Estimating Option Values and Existence Values for Wildlife Resources", *Land Economics*, Vol. 59, No. 1, February 1983.

human activity in the area. A mail survey was sent out, with questions being directed towards hunters and non-hunters. Hunters were asked their WTP to pay for a grizzly bear, or bighorn sheep, "stamp", that would allow them to hunt in new hunting areas in either five or fifteen years (an individual respondent was only confronted with one time horizon). The probability of supply was variable. Non-hunters were asked to specify their WTP for the existence of the animals, or for the opportunity to observe them in the future.

As expected, the overall option price increased as the probability of supply increased. Contrary to expectations, no systematic relationship could be determined showing that bids based on certain demand exceeded those based on uncertain demand. Existence values and observer option prices were significant. The mean bids for observer option prices were in the range of $20 for both grizzly bear and bighorn sheep, regardless of the time element. This is on a par with option bids for hunters at high levels of supply certainty. Existence values are high for grizzly bear ($24 at five years, $15.20 at fifteen years), but are significantly lower for bighorn sheep ($7.40 and $6.90 respectively).

4.4.3 Option, Existence and Bequest Values of Wilderness[28/]

The key question posed here is the amount of wilderness to be protected in Colorado. A sample of 218 resident Colorado households participated in a mail survey. Respondents were asked to report their willingness to pay into a special fund to be used exclusively for the purpose of protecting wilderness. This payment vehicle is recognizable to Colorado residents, being similar to the state income tax form's checkoff for nongame wildlife preservation. Respondents were asked to write down the maximum amount of money they would be willing to pay annually for protection of current wilderness, and for hypothetical increases in wilderness depicted on four maps. Once this budget allocation was completed, respondents were asked to allocate the highest amount reported among four categories of value: recreation use, option, existence, and bequest demands. Total preservation benefits are estimated as the residual after recreation use benefits have been subtracted from total WTP for wilderness protection. Preservation values were estimated by developing an appropriate econometric model of willingness to pay by households included in the survey and aggregating values across households in the state.

Results indicate that as the quantity of wilderness increases, annual household preservation values increase at a decreasing rate, except for bequest value which is linear. Option value had a strong positive association with income, and it was found that in-state wilderness users had a much higher option value than nonusers, indicating that recreation use is an important element in the determination of option value. Existence value was positively related to the importance of preservation of natural scenery, ecosystems, and genetic strains. Existence value increased with frequency of wilderness trips undertaken. All income groups valued existence of wilderness about equally. Interestingly, workers (skilled, unskilled, salesperson, clerical) would pay $1.50 more for existence demands than would persons in other occupations. Bequest value was not influenced by number of children at home. This seems to indicate that bequest value is correctly defined as the satisfaction from interpersonal transfers of wilderness to indefinite future generations rather than specifically to the children of the respondent. Retired persons were willing to pay $6.15 more for bequest demand than were other respondents. All income groups valued bequest demands about equally.

28/ Derived from R.G. Walsh, J.B. Loomis, and R.A. Gillman, "Valuing Option, Existence and Bequest Demands for Wilderness", *Land Economics, Vol. 60, No. 1, February 1984.*

The authors conclude that, even without taking into account the preservation estimates of nonresidents of the state, adding preservation value to the consumer surplus of recreational value had a substantial effect on the benefit function for wilderness.

4.4.4 The Existence Value of Endangered Species[29]

This study tests the hypothesis that an individual's WTP to preserve a particular animal is significantly influenced by information provided about the animal's physical and behavioral characteristics and about its endangered status. Public awareness about endangered species and preservation alternatives plays an important part in determining the replicability and usefulness of existence valuation results.

The experiment was conducted using isolated experimental and control groups of paid university-level student subjects in the U.S. CVM was used to measure preservation bids for a humpback whale preservation fund. The experimental group was then provided with more information about the whales (through the screening of a film), and both groups were then questioned again. The experimental group increased their bids by 32% from their original values, and the control group increased their bids by 20%. This may be attributable to the fact that all respondents had more time to reconsider their bids, and perhaps demonstrates how preferences are learned through the interview process itself, even in the absence of new information.

As a final survey procedure, a series of questions were posed to all control and experimental subjects in which each was asked to fully allocate a lump-sum windfall gain of $30 among preservation funds for three animal species, given four scenarios, each containing different levels of information about physical appearance and endangered status.

The effects of information disclosure on responses was more evident here. Faced with zero information distinguishing species, it appears that subjects were willing to pay to preserve each species nearly equally. Given information on physical appearance, subjects gave larger allocations to the monkey-like animal as compared with the rabbit-like or rat-like animal, reflecting a strong anthropomorphic tendency. Given information on endangered status, respondents allocated significantly more funds to the animal that was endangered but savable as compared with ubiquitous or extremely rare animals. When information was provided on both physical appearance and endangered status, the endangered but savable species received the highest allocation followed by the rare and abundant species. These results suggest that information about endangered status may be relatively more important to respondents than information about physical characteristics in formulating preservation bids.

In conclusion, it appears that information disclosure can influence perceived marginal efficiency of investment in a preservation fund, and thereby result in changes of an individual's budget allocation strategy.

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[29] Derived from K.C. Samples, J.A. Dixon, and M.M. Gowen, "Information Disclosure and Endangered Species Valuation", *Land Economics*, Vol. 62, No. 3, August 1986.

5. CONCLUSIONS

One essential step towards achieving economically efficient management of natural resources and formulating a practical strategy for sustainable development, is the effective incorporation of environmental concerns into decisionmaking. Traditionally, the economic analysis of projects and policies (including the techniques of shadow pricing), has been developed to help a country make more efficient use of scarce resources. "External effects", especially those arising from adverse environmental consequences, often have been neglected in the past.

This report has reviewed concepts and techniques for valuation of environmental impacts that enable such environmental considerations to be explicitly considered in the conventional cost-benefit calculus used in economic decisionmaking. The process of internalizing these environmental externalities may be facilitated by making even rough qualitative assessments early on in the project evaluation cycle -- the advantages include:

1. early exclusion of alternatives that are not sound from an environmental point of view;

2. more effective in-depth consideration of those alternatives that are preferable from the environmental viewpoint; and

3. better opportunities for redesigning projects and policies to achieve sustainable development goals.

There are an increasing number of attempts to both improve and make use of economic techniques to value environmental assets in developing countries. While the academic literature usually focuses mainly on the development of the techniques, there are also sector or topic related approaches.[29] For practitioners, the important concern is to keep up with, and make use of the advances most relevant to their own areas of application. To facilitate this, a range of publications is included in the following bibliography.

Certain specific shortcomings and difficulties associated with the case studies were discussed earlier. More generally, we may conclude that greater application to practical problems in a developing country is required (rather than further theoretical development), of the environmental valuation concepts and techniques presented in this paper. Such case study work can be most effective when carried out as part of project preparation. A major purpose in this endeavor is not to provide fine-tuned numbers but to indicate orders of magnitude. Some alternatives can be ruled out, and gross environmental errors avoided in this fashion. Also, one can often identify the key environmental indicators to which the decision is sensitive and focus attention on them.

Some modest evidence exists that the valuation techniques for determining use values may be applied successfully in appropriate cases. However, examples involving the estimation of non-use values are virtually non-existent in the developing world, and rather scarce even in the industrialized

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[29] See for example J.S. Dixon, *The Economics of Dryland Management*, Earthscan, London, 1989. J.S. Dixon, *Economics of Protected Areas*, Island Press, Washington D.C., 1990. D.W. Pearce, *An Economic Approach to Saving the Tropical Forest*, LEEC Paper 90-06. R.K. Turner, "Wetland Conservation: Economics and Ethics," in *Economics, Growth and Sustainable Environments: Essays in Memory of Richard Lecomber*, D. Collard, D.W. Pearce and D. Ulph, eds., 121-159. Macmillan, London, 1988.

nations. The use of multiobjective decision methods also needs to be explored, where valuation is not feasible.[21/]

21/ A recently completed World Bank case study involving energy-environmental issues in Sri Lanka, uses this approach: P. Meier and M. Munasinghe, *Incorporating Environmental Concerns into Energy Sector Decisionmaking*, Environment Department, World Bank, Washington, D.C., February 1992.

ANNEX 1: USING SHADOW PRICES

The estimation and use of shadow prices is facilitated by dividing economic resources into tradeable and nontradeable items. Tradeables and nontradeables are treated differently. The values of directly imported or exported goods and services are already known in border prices, that is, their foreign exchange costs converted at the official exchange rate. However, locally purchased items whose values are known only in terms of domestic market prices, must be converted to border prices, by multiplying the former prices by appropriate conversion factors (CF).

Border(Shadow) Price = Conversion Factor x Domestic(Market) Price

$$BP = CF \times DP$$

For those tradeables with infinite elasticities -- of world supply for imports, and of world demand for exports -- the cost, insurance, and freight (C.I.F.) border price for imports and the free-on-board (F.O.B.) border price for exports may be used (with a suitable adjustment for the marketing margin). If the relevant elasticities are finite, then the change in import costs or export revenues, as well as any shifts in other domestic consumption or production levels or in income transfers, should be considered. The free trade assumption is not required to justify the use of border prices since domestic price distortions are adjusted by netting out all taxes, duties, and subsidies.

A nontradeable is conventionally defined as a commodity whose domestic supply price lies between the F.O.B. export price and C.I.F. import price. Items that are not traded at the margin because of prohibitive trade barriers, such as bans or rigid quotas, are also included within this category. If the increased demand for a given nontradeable good or service is met by the expansion of domestic supply or imports, the associated border-priced marginal social cost (MSC) of this increased supply is the relevant resource cost. If the incremental demand for the nontradeable results in decreased consumption of other domestic or foreign users, the border-priced marginal social benefit (MSB) of this foregone domestic consumption or of reduced export earnings, would be a more appropriate measure of social costs.

The socially optimal level of total consumption for the given input (Q_{opt}) would lie at the point where the curves of MSC and MSB intersect. Price and non-price distortions lead to nonoptimal levels of consumption $Q \neq Q_{opt}$ characterized by differences between MSB and MSC. More generally, if both effects are present, a weighted average of MSC and MSB should be used. The MSB would tend to dominate in a short-run, supply constrained situation; the MSC would be more important in the longer run, when expansion of output is possible.

The MSC of nontradeable goods and services from many sectors can be determined through appropriate decomposition. For example, suppose one peso-worth, of the output of the construction sector (valued in domestic prices), may be broken down successively into components. This would include capital, labor, materials, and so on, which are valued at pesos C_1, C_2,... C_n in border prices. Since the conversion factor of any good is defined as the ratio of the border price to the domestic price, the construction conversion factor equals:

$$CCF = \sum_{i=1}^{n} C_i$$

The standard conversion factor (SCF) may be used with nontradeables that are not important enough to merit individual attention, or lack sufficient data. The SCF is equal to the official exchange rate (OER) divided by the more familiar shadow exchange rate (SER), appropriately defined. Using

the SCF to convert domestic priced values into border price equivalents, is conceptually the inverse of the traditional practice of multiplying foreign currency costs by the SER (instead of the OER), to convert foreign exchange to the domestic price equivalent. The standard conversion factor may be approximated by the ratio of the official exchange rate to the free trade exchange rate (FTER), when the country is moving toward a freer trade regime:

$$SCF = \frac{OER}{FTER} = \frac{eX + nM}{eX(1-t_x) + nM(1+t_m)}$$

where X = F.O.B. value of exports, M = C.I.F. value of imports, e = elasticity of domestic supply of exports, n = elasticity of domestic demand for imports, t_x = average tax rate on exports (negative for subsidy), and t_m = average tax rate on imports.

As illustrative examples of important tradeable inputs used in many development projects, consider capital goods and petroleum-based fuels. Some countries may have other fuels available, such as natural gas or coal deposits. If no clear-cut export market exists for these indigenous energy resources, then they cannot be treated like tradeables. If there is no alternative use for such fuels, an appropriate economic value is the MSC of production or of extracting gas or coal, plus a markup for the discounted value of future consumption foregone (or "user cost"). If another high value use exists for these fuels, the opportunity costs of not using the resources in alternative uses should be considered as their economic value.

Two important nontradeable primary factor inputs are labor and land, the next subjects for discussion. The foregone output of workers used in the energy sector is the dominant component of the shadow wage rate (SWR). Consider a typical case of unskilled labor in a labor surplus country -- for example, rural workers employed for dam construction. Complications arise in estimating the opportunity cost of labor, because the original rural income earned may not reflect the marginal product of agricultural labor. Furthermore, for every new job created, more than one rural worker may give up former employment. Allowance must also be made for seasonal activities such as harvesting, and overhead costs like transport expenses. Based on the foregoing, the efficiency shadow wage rate (ESWR) is given by:

$$ESWR = a.m + c.u,$$

where m and u are the foregone marginal output and overhead costs of labor in domestic prices, and a and c are corresponding conversion factors to convert these values into border prices.

If we are interested only in efficiency pricing, then we may stop here. However, if social pricing is important, consider the effect of these changes on consumption patterns. Suppose a worker receives a wage W_n in a new job, and that the income foregone is W_o, both in domestic prices; note that W_n may not necessarily be equal to the marginal product foregone m. It could be assumed, quite plausibly, that low-income workers consume the entire increase in income (W_n - W_o). Then this increase in consumption will result in a resource cost to the economy of $b(W_n - W_o)$. The increased consumption also provides a benefit given by $w(W_n - W_o)$, where w represents the MSB, in border prices, of increasing domestic-priced private sector consumption by one unit. Therefore,

$$SWR = a.m + c.u + (b - w)(W_n - W_o)$$

The symbol b represents the MSC to the economy, resulting from the use of the increased income. For example, if all the new income is consumed, then b is the relevant consumption conversion factor or resource cost (in units of the numeraire) of making available to consumers one unit worth (in domestic prices) of the marginal basket of n goods that they would purchase. In this case

$$b = \sum_{i=1}^{n} g_i.CF_i$$

where g_i is the proportion or share of the i the good in the marginal consumption basket, and CF_i is the corresponding conversion factor.

The corresponding MSB of increased consumption may be decomposed further; w = d/v, where 1/v is the value (in units of the numeraire) of a one-unit increase in domestic-priced consumption accruing to someone at the average level of consumption (c_a). Therefore, v may be roughly thought of as the premium attached to public savings, compared to "average" private consumption. Under certain simplifying assumptions, b = 1/v. If MU(c) denotes the marginal utility of consumption at some level c, then d = MU(c)/MU(c_a). Assuming that the marginal utility of consumption is diminishing, d would be greater than unity for "poor" consumers with $c < c_a$, and vice versa.

A simple form of marginal utility function could be:

$$MU(c) = c^{-n}.$$

Thus, $$d = MU(c)/MU(c_a) = (c_a/c)n .$$

Making the further assumption that the distribution parameter n = 1, gives:

$$d = c_a/c = i_a/i$$

where i_a/i is the ratio of net incomes, which may be used as a proxy for the corresponding consumption ratio.

The consumption term (b-w) in the expression for SWR disappears if, at the margin: (a) society is indifferent as to the distribution of income (or consumption), so that everyone's consumption has equivalent value (d=1); and (b) private consumption is considered to be as socially valuable as the uncommitted public savings (b=1/v).

The appropriate shadow value placed on land depends on its location. Usually, the market price of urban land is a useful indicator of its economic value in domestic prices, and the application of an appropriate conversion factor (such as the SCF) to this domestic price, will yield the border-priced cost of urban land inputs. Rural land that can be used in agriculture may be valued at its opportunity costs -- the net benefit of foregone agricultural output. The marginal social cost of both urban and rural land should reflect the value of associated environmental assets (see main text). Examples might be the flooding of virgin jungle because of a hydroelectric dam that would involve the loss of valuable timber, or spoilage of a recreational area that has commercial potential.

The shadow price of capital is usually reflected in the discount rate or accounting rate of interest (ARI), which is defined as the rate of decline in the value of the numeraire over time. Although there has been much discussion concerning the choice of an appropriate discount rate, in practice the

opportunity cost of capital (OCC) may be used as a proxy for the ARI, in the pure efficiency price regime. The OCC is defined as the expected value of the annual stream of consumption, in border prices net of replacement, which is yielded by the investment of one unit of public income at the margin.

A simple formula for the social-priced ARI, which also includes consumption effects, is given by:

$$ARI = OCC\ [s + (1 - s)w/b],$$

where s is the fraction of the yield from the original investment that will be saved and reinvested.

Usually, the rigorous estimation of shadow prices is a long and complex task. Therefore, the energy sector analyst is best advised to use whatever shadow prices have already been calculated. Alternatively, the analyst would estimate a few important items such as the standard conversion factor, opportunity cost of capital, and shadow wage rate. When the data are not precise enough, sensitivity studies may be made over a range of values of such key national parameters.

ANNEX 2: SUMMARIES OF ENVIRONMENTAL VALUATION CASE STUDIES[32/]

A2.1 Change in Productivity Method

A2.1.1 Cost-Benefit Analysis of Land Improvement in Lesotho[33/]

I. Background

The Farm Improvement with Soil Conservation (FISC) project was initiated in 1985 in Mohale's Hoek District in southern Lesotho, and is gradually being expanded. The project is now used as a model for a national training program in soil conservation. Other soil conservation projects are already using FISC as a model. The choice of the FISC project as an object of study is further justified by its features coinciding with the modern approach to deal with land degradation: production orientation, labor intensive techniques and popular participation. Furthermore, low-cost access to information could be assured from a research point of view. The project area is fairly typical for Lowland Lesotho, where most of the crop production takes place. With some adjustments, the calculations could be used for other areas in Lesotho, or even for other areas with similar geographic and socio-economic features in other countries.

The overriding aim of the FISC project is to raise agricultural production. In pursuit of this goal, the project has rehabilitated old terrace structures, constructed new ones and added other structures for conservation. It has promoted hybrid maize and sorghum, fodder grasses and planted thousands of tree seedlings. It has also promoted rotational grazing on communal rangeland. The project area covers almost 26,000 ha and reaches out to about 22,000 people.

II. Financial Analysis

The financial analysis was done from a household perspective, using market prices. Two management options for cultivation of maize and sorghum have been compared in financial terms. The "high input" alternative implies the use of commercial fertilizer and hybrid seed. The "traditional" alternative implies no use of fertilizer and locally saved seeds instead of hybrids. The less immediate impact of soil conservation measures is left out of this calculation, which is valid for one year only.

Crop sampling was carried out in cooperation with the FISC staff during five seasons, 1986-1990. The results show that farmers using a "high input" management do receive higher yields on average, but that very substantial variations of yields make this a risky investment.

Financial calculations for maize and sorghum show that the yield must increase by 125% and 144%, respectively, in order to achieve a real rate of return of 10 percent. The demands are significantly higher than the average achieved under high input management as sampled, which give a **negative** real marginal IRR of 21 and 30 percent, respectively.

32/ Based on original version prepared by Gunnar Kohlin.

33/ Derived from J. Bojö, *The Economics of Land Degradation: Theory and Applications to Lesotho*, Dissertation for the Doctor's Degree in Economics, Stockholm School of Economics, 1991, pp. 259-350.

Maintained participation in the project appears limited after the initial boost when conservation efforts result in in-kind payments. Most likely, project sales are merely replacing alternative, less accessible sources of supply. There are no convincing signs of a major transformation of the crop management regime. The long-term impact of physical conservation works may be the only net impact, as far as the major grain crops are concerned. However, financial budgets for fruit and fuelwood trees show more promising returns, and have also met with greater interest among local people.

Possible explanations for the lack of farmer response to the promotion of "high input" management are discussed, including inter alia, land tenure, credit for agricultural investments and risk pertaining to agricultural investments. Most serious is the problem of risk. Crop yields are very unreliable in Lesotho. The farmers are quite aware of this and will (informally) calculate the chances of losing invested resources. Demands for yield increases for maize and sorghum have been shown to be considerable in order to reach an "acceptable" level of financial return (10 percent real rate). It is certainly not "irrational" of the farmer to adopt a careful approach in the face of these risks.

III. The Economic Analysis

Overall project performance has been recorded for the period March 1985 to December 1990. Current, firm plans for work until mid-1992 have been incorporated, and extrapolations have been made from past performance in relation to the availability of future financial means.

The analysis distinguishes between productivity impacts due to increased use of commercial inputs, and impacts due to improved soil conservation. The distribution, sales and use of commercial fertilizer and hybrid seed in the project areas has been monitored. While there is some short-term increase in distribution of these inputs as they are used as in-kind payments for conservation work on individually controlled land, there are no convincing signs of a lasting impact in terms of commercial sales or their use. Farmers are known to save project distributed inputs for several years, and the level of use in the project areas is not significantly different from use in non-project areas. Therefore, the project cannot be credited with a rise in productivity due to increased use of inputs.

Identification of Costs and Benefits. Financial costs are identified through project and donor accounts. There are also costs of soil conservation works. These are borne by the farmers, and have to be estimated separately. However, financial costs have to be adjusted in several ways to arrive at real economic costs. Below is a list of potential benefits that have been examined. The project aims at increasing production of:

(1) Maize, sorghum and crop residues due to the use of fertilizer, hybrid seed and conservation of soil and nutrients;

(2) Fruits: peaches and apples;

(3) Fuelwood from pine and other tree species;

(4) Fodder grasses such as Eragrostis and Bana grass;

(5) Vegetables from communal gardens sponsored by the project;

(6) Livestock products by promoting improved grazing management.

Additional benefit items to consider are:

(7) Training of personnel, and the introduction of improved communal management, with potential extra-project impacts;

(8) Off-site physical impacts, such as less siltation of dams, less maintenance costs for roads and bridges, improved water quality, etc;

(9) Secondary benefits for the community at large as a result of the increase in income from agriculture.

Quantification of Costs and Benefits. Not all costs are readily available in monetary terms. Examples are the temporary loss of soil from new, ungrassed terraces, "loss" of land to terraces and other structures and increased maintenance for roads due to greater use. Labor cost for soil conservation is not included since it was reported to be negligible. This view is, however, contentious. Monetary cost data were taken from project accounts and complemented by the executing company's data for costs paid by the donor agency directly to the company.

The crop benefits due to hybrid seeds and fertilizer use is assumed to be negligible. Only small quantities of the inputs have been distributed through the project and the financial analysis showed their use to be questionable. For those that wanted the inputs they were available through other channels.

To determine the benefits from soil conservation a number of factors need to be considered. Firstly, we need to consider whether soil loss actually affects crop production at all in this particular area. Secondly, if it does, to what extent soil loss occurs, and thirdly, how this rate affects productivity.

There is reason to believe that soil loss immediately affects the average crop production area since the average topsoil depth is estimated to 25 cm, a level at which the water retention capacity is reduced. Research in the area indicates that the annual soil loss is roughly 15 t/ha on poorly managed soils and 5 t/ha for the areas under project influenced conservation management. Through comparisons with other studies on loss of productivity due to soil loss, a 1% annual decline in yield on non-conserved land was assumed.

The impact of soil conservation on crop production can be expressed as follows:

$$IQ_{it} = dY_{it} \times AYi \times \Sigma AC_t \times PI \times CS_i$$

where

IQ = incremental production (kg);

dY = relative crop decline avoided due to conservation;

AY = the base level of average (14-year) yield for the district (kg/ha);

ΣAC = accumulated area under the conservation management (ha);

PI = project impact: the share of AH affected by the project's actions (%);

CS = the share of maize and sorghum respectively of the cultivated land (%);

t = time index (year 1 ... T);

i = crop index.

The assumption here is that PI (project impact) = 1.0, as conservation activities are assumed to be nil in the absence of the project.[34]

Up to 1992, more than 18,000 seedlings of apple and peach trees will be delivered to farmers in the project area. The survival rate was estimated to 50%. The number of survived fuelwood trees by 1992 is estimated at roughly 130,000. The fodder benefits are rather small due to the small areas planted and the opportunity cost of the land used.

Maintenance of roads and bridges in the area will not be significantly affected by the improved land management and soil retention. There are no major dams for hydropower and/or irrigation in the project areas that will be affected.

Valuation in Economic Prices. The Loti (pl. Maloti) is fixed on a par with the internationally convertible South African Rand. There is no black market for Rands or Loti. This indicates that the distorting impact of foreign exchange restrictions is not significant. The official exchange rates have therefore been used, based on IMF data. In 1990 the exchange rate was set to SEK 2.3 per Loti (roughly 3 Loti per US$).

Since there is a transfer of income to Lesotho of about 20 percent of the import value, inclusive of duties, the value of **imported** components is multiplied by a factor of 0.8 when going from financial to economic prices.

Skilled and semi-skilled labor has access to the large South African labor market and is priced at the financial wage. The project payment of M 3.5 per day for unskilled labor is shadow priced at M 2.5 which is the generally accepted local wage for daily laborers.

Local financial prices were used for the crops. Based on a comparison of the protein and energy content of maize residues as compared to five substitutes, the approximate price of M 60 per ton of maize crop residues was derived. The same figure will be applied to sorghum residues.

The value of fuelwood is based on the values and calorific content of its substitutes, displayed in Table A2.1.1.

Table A2.1.1 Economic Value of Fuelwood Substitutes per m^3

	MJ/kg	Eq. kg	M/kg(1987)	M(1990)
Brushwood	16.0	550	0.03	24.33
Dung	12.9	682	0.10	100.61
Crop residues	14.0	629	0.02	18.54

The actual substitution value will vary depending on the household's situation. A rough, weighted average could be calculated as follows:

a) 25% will substitute dung 0.25 * M 100.61

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[34] This is supported by observations during field work in the area before project initiation.

b) 75% will substitute brushwood 0.75 * M 24.33
Weighted average: M 43.40

As for the period after 1992, the following assumptions have been made:

The level of costs is assumed to remain as the average for 1985-1992, but with all costs associated with expatriate (non-domestic) services, such as consultant fees, back-stopping by the executing company, external evaluation missions, etc. taken out. This implies a level of 54 percent of the previous average.

As for benefits, it is assumed that the project continues to add newly conserved crop land at a performance rate of 50 percent of the previous level. However, from the accumulated area under conservation management reached the previous year, a decline rate of 2 percent per year is applied. Another assumption is that there will be no lasting impact on the level of use of fertilizer and hybrid seed. Furthermore, it is assumed that distribution of fruit trees continues, but declines to a level of 50 percent of project maximum. For fuelwood it is assumed that tree planting declines to a level of 50 percent of project average achievement in 1986-1991. For fodder grasses, the assumption in the base case will be that fodder growing stabilizes on 50 percent of the level achieved in 1986-1991.

IV. Results and Sensitivity Analyses

Given these assumptions, the results of the base case are an NPV of - M 7.0 million at a discount rate of 10 percent and - M 5.6 million at 1 percent. The internal rate of return is -0.8 percent.

The qualitative interpretation is that the project makes a loss that is significant in comparison to the resources invested. The present value of costs is only M 9.9 million at 10 percent and M 33.6 million at 1 percent. In terms of the overriding target for the project as defined by the donor - to raise agricultural production among smallholder farming households - the project cannot be shown to be successful, when the benefits are related to the costs. The table below summarizes the benefit categories, which provide some overview of the relative importance of various benefit items. Each benefit category has been discounted by 1 and 10 percent respectively.

Table A2.1.2. Discounted Share of Total Benefit

Item	Benefit Shares	
	1%	10%
Sorghum	30	25
Maize	28	23
Fruit	29	38
Fuelwood	11	12
Fodder	1	2
Total	100	100

Table A2.1.2 shows that fruit is a significant benefit item that deserves more thorough monitoring in the future. This, and conservation benefits, make up the bulk of benefits, and deserve closer scrutiny in terms of sensitivity testing.

The robustness of this base case result is tested using sensitivity analysis of alternative assumptions with regard to:

(1) discount rate
(2) post-1992 project performance
(3) fruit income
(4) erosion impact on crop yields
(5) future grain prices
(6) distributional weights

The qualitative impression of the sensitivity analysis is that, if the rate of 10 percent is used, the base case result remains robust, although the size of the deficit is changed. However, if the lower rate of 1 percent is considered acceptable as a standard, the base case result could be qualitatively altered by several factors making the project perform better than expected. With the lower rate, the project could also be justified using a heavy distributional weight reflecting the higher marginal utilities of the recipients as a group as opposed to the donors as a group. However, this weight should then be consistently applied to alternative projects.

V. Discussion

In the quantification of costs, the labor requirement for maintenance of conservation structures was omitted. However, if a higher cost estimate is accepted, the size of conservation benefits change drastically. It can be shown that the break-even point for maize is 15 person-days, given a time horizon of 50 years and a discount rate of 10 percent. Given a discount rate of 1 percent, the maximum labor input is raised to 34 days, before the net present value of conservation benefits approximate zero. Thus, it is possible that this benefit item has been considerably overestimated. Only empirical measurement in project areas could resolve this issue.

An additional point is option value. Lesotho is extremely dependent upon migrant labor remittances. A high price scenario is designed to build into the calculation the possibility of a substantial increase in relative prices, as a proxy for the somewhat unlikely, but not impossible event, that a mass of migrant workers are forced to return to Lesotho. While the nominal price level in fact may not be changed considerably due to the extent of the market, the real price would increase for Basotho farmers, as incomes would fall. The value of the project is thus correlated to the size of the GNP of Lesotho. From both a macro and a micro perspective, the soil conservation program is an "insurance" against hard times. This leaves the decisionmakers with a partially quantified problem: is the present value of the options higher than the negative NPV of the stream of costs and benefits that have been valued?

However, soil conservation is not the only possible "insurance" against declines in migrant labor incomes. Lesotho needs **food security**, not necessarily more domestic production of grain. If an economic capacity to buy grain on the world market can be established through other development projects, this may be a more efficient alternative. Lesotho has a comparative advantage in inexpensive labor, not in good agricultural land and a beneficial climate. Screening available development project options for their profitability is therefore a useful exercise. Furthermore, the capacity to ensure food security is dependent on the size of the population, a neglected matter which needs urgent attention in Lesotho.

While non-agricultural investments may be more efficient from a macroeconomic point of view, the majority of the population, and the poorest part, live in the rural areas. If the primary value of a project like FISC is not so much immediate production raising, but to a significant degree long-term protection of the land base, there could be a basis for more substantial subsidizing of cover crops such as fodder grasses at the expense of traditional cropping. Even if fodder could not be commercially sold, the grower would provide an "insurance service" while protecting the land for future, potential need. The economics of this option need to be worked out.

This study cannot conclusively provide an answer to the future value of the FISC approach, but has given some reasons why massive, full-scale replication involving a substantial number of expatriate personnel should be avoided. Continued efforts should be subject to close monitoring of their efficiency in order to justify any further funding. The original report also contains a discussion of the income distributional impacts of the project, which is not analyzed here due to lack of space and direct relevance to the topic of environmental valuation.

A2.1.2 Valuation of an Amazonian Rainforest[35/]

I. Background

Most financial appraisals of tropical forests have focused exclusively on timber resources and have ignored the market benefits of non-wood products. This has given a strong incentive for destructive logging and widespread forest clearing.

This valuation was based on a systematic botanical inventory of 1 ha of Peruvian rainforest along the Rio Nanay near the small village of Mishana, 30 km south-west of the city of Iquitos. Annual precipitation in the region averages 3,700 mm; soils are predominantly infertile white sands. The inhabitants of Mishana are detribalized indigenous people who make their living practicing shifting cultivation, fishing and collecting a wide variety of forest products to sell in the Iquitos market.

II. Method and Data

The inventory showed 50 families, 275 species and 842 trees of at least 10.0 cm in diameter. Of the total number of trees on the site, 72 species (26.2%) and 350 individuals (41.6%) yield products with an actual market value in Iquitos. Annual production rates for fruit trees and palms were either measured from sub-samples or estimated from interviews with collectors. Latex yields were taken from the literature. The merchantable volume of each timber tree was calculated using published regression equations relating diameter to commercial height.

Average retail prices for forest fruits were collected in monthly market surveys. The officially controlled rubber prices were used. Four independent sawmill operators were interviewed to determine the mill price of each timber species.

The labor investment associated with fruit collection and latex tapping was estimated in man days per year based on interviews and direct observation of local collecting techniques. The harvest cost was based on the minimum wage rate, US$ 2.50 per day.[36/] Based on earlier studies the transport cost for fruit and latex was estimated at 30% of total market value while extraction cost for timber was set at 40% of total value.

III. Results

The market value of the fruit production in the sample area was almost US$ 650 per year. Annual rubber yields amount to about US$ 50. Deducting collection and transportation costs gives net annual revenues from fruits and latex of US$ 400 and US$ 22, respectively. The net present value (NPV) of this production, at 5% discount rate and assuming that 25% of the fruit crop is left in the forest for regeneration, is estimated at US$ 6330.

The hectare of forest also contains 93.8 m^3 of merchantable timber. If liquidated in one felling, this sawtimber would generate a net revenue of US$ 1,000 on delivery to the sawmill. A logging operation of this intensity, however, would damage much of the residual stand and greatly

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35/ Derived from C.M. Peters, A.H. Gentry, and R.O. Mendelsohn, "Valuation of an Amazonian Rainforest", *Nature*, Vol. 339, 29 June 1989, pp. 655-656.

36/ All prices given in 1987 US$ using an exchange rate of 20 intis to the dollar.

reduce, if not eliminate, future revenues from fruit and latex trees. The net financial gains from timber extraction would be reduced to zero if as few as 18 trees were damaged by logging.

Periodic selective cutting would yield a maximum of about 30 m^3/ha every 20 years. With a weighted average price of US$ 17.21 per m^3 and deducting harvest and transport costs this gives a net revenue of about US$ 310 at each cutting cycle. The net present value would be US$ 490.

The combined NPV of fruit, latex and selective cutting would be about US$ 6820, with logging contributing to about 7% of the total. Timber management appears to be a marginal financial option in this forest, especially considering the possible impact of logging on fruit and latex trees.

IV. Comparisons

The NPV of this piece of rainforest compares well with other uses of rainforests. Using the same discount rate, 5%, the NPV of the timber and pulpwood obtained from a 1.0 ha plantation of *Gmelina arborea* in Brazilian Amazonia is estimated at US$ 3184 or less than half that of the forest. Similarly, gross revenues from fully-stocked cattle pastures in Brazil are reported to be US$ 148 per ha and year. This gives a present value of US$ 2960. Deducting the costs of weeding, fencing and animal care would lower this figure significantly. Both these estimates are based on the optimistic assumption that plantation forestry and grazing lands are sustainable land-use practices in the tropics.

Tropical forests perform vital ecological services, they are the repository for an incredible diversity of germplasm, and their scientific value is immeasurable. The results from this study indicate that tropical forests can also generate substantial market benefits if the appropriate resources are exploited and properly managed.

A2.2 Loss of Earnings Method

A2.2.1 Valuing Health: The Economic Costs and Benefits of World Bank Tobacco Projects[37]

I. Introduction

This study provides an outline of the costs and benefits of Bank tobacco related projects. The analysis is intended to indicate the order of magnitude of the net benefits as a guide in formulating a Bank policy on lending for tobacco. Some of the parameters underlying the analysis are approximate (but conservative) and could be refined with effort. The analysis concludes, however, that the net global impact of Bank tobacco projects is decidedly negative, and it is doubtful that a more refined analysis would provide the order of magnitude changes needed to reverse this conclusion.

Cost/Benefit analysis must be done from the point of view of a particular constituency. To determine appropriate Bank policy for tobacco, the analysis should be done from a global point of view. A starting point for an analysis is the calculation of the incremental effect on world output and prices. According to project documents, Bank loans have added 80,000 metric tons annually to world output as of 1990. The actual incremental effect of this additional productive capacity is less, however, because of market responses.

II. Incremental World Output

The global market effects of Bank tobacco projects can be discussed with the aid of Figure A2.2.1. S is current world supply. S' would be current world supply if the Bank had not funded tobacco projects from 1974 to 1990. dX is the increment to supply (calculated from project documents) before taking market effects into account. dQ is the actual increment in world supply after taking the demand and supply responses into account. To isolate the stream of net effects from the tobacco projects it is necessary to calculate dQ/dX. By differentiating a reduced form of the supply and demand equations for tobacco we receive the net change in output expressed as price elasticities for supply and demand.

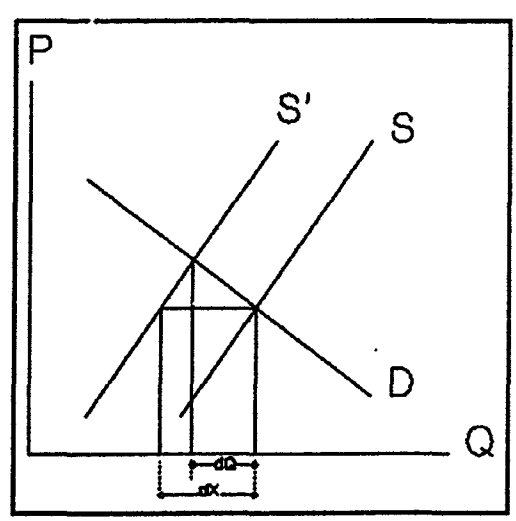

Figure A2.2.1

$$(1) \qquad dQ/dX = (1-S_P/D_P)^{-1} = (1-\eta_{SP}/\eta_{DP})^{-1}$$

where η_{SP} is elasticity of S with respect to P,
and η_{DP} is elasticity of D with respect to P.

From Bank estimates, $\eta_{SP} \approx 0.6$ (Actually, 0.7 for developed countries with market economies and 0.6 for less developed countries (LDCs)). Price elasticities of demand for developed and developing countries are also similar and confirm an elasticity of about $\eta_{DP} \approx -0.6$.

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[37] Derived from H.N. Barnum, "A Note on the Economic Costs and Benefits of Bank Tobacco Projects". Dated 5/10/91.

Inserting these values into (1): $dQ/dX = (1-(0.6/-0.6))^{-1} = 0.5$.

The cumulative direct annual production effect of Bank tobacco projects from 1974 to 1990 is 80,000 metric tons. That is, $dX = 80,000$. Thus the annual global increment in production after market adjustments is

$dQ = (0.5)(80,000) = 40,000$ metric tons.

The net price effect is found by differentiating the demand equation:

$dP = D_Q dQ$ or, (2) $dP = (1/\eta_{DP})(P/Q)dQ$

For 1990 $Q \approx 6,500,000$ metric tons, $P \approx$ US$2,000 per metric ton, dQ (as calculated above) is 40,000 metric tons. Inserting all of this into (2) gives

$dP = (1/-0.6)(2000/6500000)(40000) = -US\$20.5$

An estimate of the added global supply of tobacco is 40,000 metric tons annually. This added global supply results in lowering the market price per metric ton by US$20.5.

III. Valuation of Costs and Benefits

Given the above estimate of the incremental effect on world output and price, we can estimate the social benefits and costs from a global standpoint. Five benefits or costs are identified.[39/]

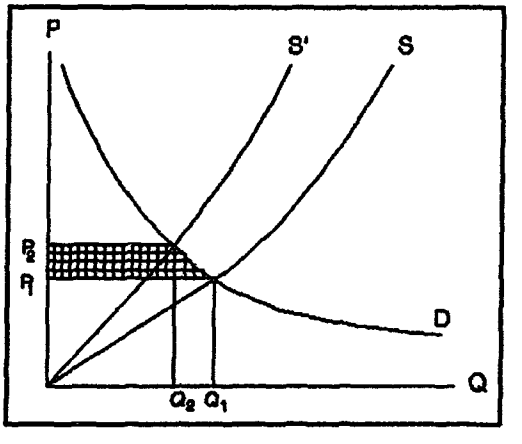

Figure A2.2.2

Benefit from Added Consumer's Surplus

This is the added value to consumers of the incremental annual tobacco production as well as the lower market price. It represents the difference between the price that consumers would be willing to pay and the market price for the added world output resulting from Bank projects. It also includes the gain to consumers from a lower market price for the rest of world output. This benefit incorporates the immediate welfare gain to world tobacco consumers. The estimated annual value of this benefit is +US$133,000,000. This is represented graphically by the cross hatched area in Figure A2.2.2.

Benefit From Added Producer's Surplus

This is the net gain to producers in the form of quasi-rents (profits) that equals the difference between the market price and the incremental cost of production. An explanation of the loss in producer's surplus becomes clear from examination of Figure A2.2.3 which depicts the change in producer's surplus in two parts. The first part is the loss in producer's surplus that results from the

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39/. The environmental costs of tobacco production, including soil degradation and fuelwood depletion, have not been included.

lowered market price. This loss in producer's surplus is represented by the cross hatched area in Figure A2.2.3. A second part of the change in producer's surplus results from the shift of the supply curve (the sum of producer marginal cost curves) to the right by the addition of the Bank project output. This gain in producer's surplus is represented by the diagonally hatched area in Figure A2.2.3. Given the estimated elasticities of supply and demand, the loss resulting from the lowered price more than offsets the gain from the shifting supply function. The net change in producer's surplus as a result of the incremental output from Bank projects is an annual loss of -US$33,000,000.

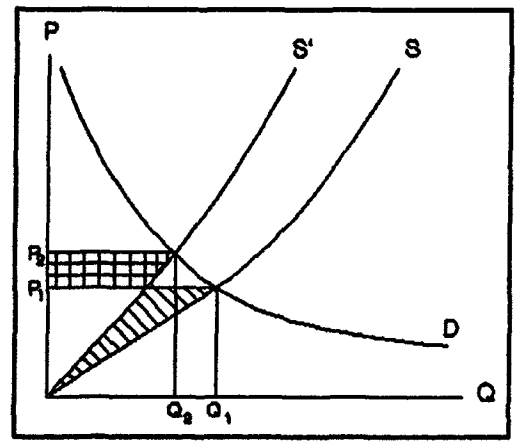

Figure A2.2.3

Value of Life Lost From Premature Death

The cost of premature death caused by added tobacco production is obtained as the product of 1) the value of life lost per death, 2) deaths per metric ton of tobacco consumed, and 3) the incremental output of tobacco.

Value of Life Lost per Death. A profile of the average tobacco death is as follows:

(a) smoking starts at age 22
(b) with an average world life expectancy (at age 22) extending to age 69, approximately ten years of life are lost
(c) assigning time t=0 to age 22, the value of the years of life lost is

$$V_{LIFE} = \sum_{t=37}^{47} \frac{Y_t}{(1-r)^t} = \bar{Y}\int_{37}^{47} e^{-rt}dt = -\frac{\bar{Y}}{r}[e^{-2.35}-e^{-1.85}]$$

where $\bar{Y}$ is a measure of the value of one year of life.

Willingness to pay is the appropriate measure of the value of life to the individual. Willingness to pay has been estimated by implication from revealed preference studies examining earnings premiums for risky jobs or safety expenditures by consumers. Such studies produce consistently greater estimates of the value of life than the discounted present value of the stream of per capita income. Thus, lacking results from revealed preference studies that can be applied globally, the discounted flow of per capita income of tobacco users provides a conservative estimate. In 1990 the average per capita income of tobacco using countries, weighted by the quantity of tobacco consumed, was US$7,750. Using this as an estimate of $\bar{Y}$ and a discount rate of 0.05 (the real rate of interest has remained at 1-5 percent or so for decades), a conservative estimate of the value of a life lost from a tobacco caused death is

$$V_{LIFE} = \text{US\$ } 10{,}800$$

Deaths per Metric Ton. One estimate of deaths per metric ton (δ) can be obtained by regressing smoking attributed lung cancer deaths on a distributed lag function of metric tons of tobacco consumed. The lag weights were obtained from information on the relation between duration of smoking and probability of lung cancer. Using time series of lung cancer mortality and tobacco consumption for the United States from 1930 to 1987 the estimated number of lung cancer deaths per metric ton of tobacco is 0.162. Based on an average ratio of total smoking mortality to

tobacco caused lung cancer mortality in the United States from 1965 to 1985 of 4.0, it is estimated (4 * 0.162 = 0.65) that there are 0.65 deaths from all tobacco related causes per metric ton of tobacco consumed.

Given the value of life lost per tobacco caused death and the number of tobacco deaths per ton of tobacco consumed, the total annual value of life lost to premature deaths from incremental world tobacco output attributable to bank projects is

$$TC_{DEATH} = V_{LIFE} \cdot dQ \cdot \delta = (10800)(40000)\ (0.65) = \text{US\$ } 282{,}000{,}000.$$

It can be argued that the cost to smokers themselves, including the loss of their life, should not be part of the cost-benefit computation because smokers are informed and have made a choice that reflects their preferences. However, most smokers start young, become addicted, and then lose much of the power of choice after addiction. The real choice comes when they are young and have difficulty estimating the consequences accurately. Surveys on alcohol, for example, show that despite extensive public information campaigns in developed countries, young people underestimate the total cost of alcohol consumption by 92 percent.[39] In most of the world, public information campaigns for tobacco are not well developed, and even in the United States and Europe, the information gap for tobacco is likely to be much the same as for alcohol. Assuming that only 10 percent of tobacco starts are made by well informed consumers, the cost of death not included in smoker's consumption decisions is

$$C_{DEATH} = 0.9 \cdot TC_{DEATH} = \text{US\$ } 254{,}000{,}000.$$

Indirect Cost of Added Morbidity

Estimates of the number of deaths and cases attributable to Bank tobacco projects by disease are given in columns 1 and 2 of Table A2.2.1. A computer program was used to calculate the years of productive life lost (see column 3) per case from immediate illness and from temporary and chronic disability. Adjustments have been made for partial disability, discounting from age of onset and changes in productivity over time[40]. Total years lost were then calculated, as shown in column 4, from the product of cases times years/case. These years were then valued at a per capita GNP of $7,750 as shown in column 5. The total value of morbid years for all diseases is the column sum, $V_{MORBIDITY}$, US$1,365,000,000. This represents the present value, at age of onset of the disease, of productive life lost to morbidity. As was done above for mortality, this must be discounted back to the age at which smoking starts. Thus, the present value of lost productivity from morbidity is

$$C_{MORBIDITY} = V_{MORBIDITY} e^{-rT} = (1365000000)e^{-(0.05)(32)} = \text{US\$ } 276{,}000{,}000$$

where T=32 is the number of years between the start of smoking and average age of onset of disease. (This is conservative for several reasons, but the alternative is a complex model.)

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39. C.E. Phelps, "Death and Taxes: An Opportunity for Substitution", *Journal of Health Economics*, Vol. 7, 1988, pp 1-24.

40. The procedure is explained in H. N. Barnum (1987).

Table A2.2.1 Value of Lost Productivity from Added Morbidity

Tobacco Induced Disease	Annual Mortality by Cause[a] (Col 1)	Annual Morbidity by Cause[b] (Col 2)	Years Lost per Case[c] (Col 3)	Years Lost per Disease (Col 4)	Value of Morbid Years Lost[d] (Col 5)
Cancer	8320	9244	1.8	16640	128960000
Cardiovascular	13260	17680	5.3	93704	726206000
Cerebrovascular	1820	5200	4.8	24960	193440000
COPD	2600	7429	5.5	40857	316649000
Total	26000	39553	5.0	176161	1365000000

[a]Out of a total of 26,000 tobacco induced deaths from Bank projects. The proportions of total mortality by cause are 0.32, 0.51, 0.07 and 0.10 for cancer, cardiovascular, cerebrovascular and COPD, respectively. These proportions are estimated from data given in the United States Surgeon General's Report (1989) and International Association for Research on Cancer (1986).

[b]This column was obtained from mortality using case fatality rates of 0.9, 0.75, 0.35, and 0.35 for cancer, cardiovascular, cerebrovascular and COPD, respectively.

[c]See H. N. Barnum, "Evaluating Healthy Days of Life Gained from Health Projects", *Social Science & Medicine*, vol. 24, no 10, 1987, pp 833-41.

[d]Evaluated at a per capita income of US$7750, discounted back to time of onset of disease.

Direct Cost of Added Morbidity

In most of the world, the diseases caused by tobacco go largely untreated. Therefore, unlike the other components of the analysis in this note, a part of this component does not represent a cost of tobacco consumption actually incurred. Instead, we calculate the cost that would be incurred if all tobacco caused diseases were to be treated according to Part I country standards. This is an important calculation because the Bank is engaged in projects with the objective of improving the level of health care, ultimately to Part I country levels.

Because labor and other local costs are an important proportion of health care costs (over 75 percent in many countries) we have calculated the cost of treatment as a percent of GNP per capita. A detailed calculation of the cost of lung cancer treatment, over the lifetime of the disease, indicates that a level of treatment about equal to that of the U.S. in 1980 costs about 600 percent of per capita GNP in a lower middle income country (Barnum and Greenberg, 1991). Estimates (based on Hartunian et al. 1981) of the cost of treating cardiovascular and cerebrovascular disease are 440 and 500 percent of per capita GNP, respectively. Finally, a rough estimate for chronic obstructive pulmonary disease (COPD) is 200. To obtain a value in monetary terms, the treatment costs are evaluated at an average per capita GNP of US$ 7750. Multiplying the treatment costs times the annual mortality by cause gives a total cost of treatment,

$$V_{DIRECT} = \text{US\$ } 950{,}000{,}000.$$

This is the cost of treatment during the year of onset of disease. Discounting back to the average age of starting smoking gives the present value of the total direct cost of treatment,

$$TC_{DIRECT} = V_{Direct}e^{-rT} = (950000000)e^{-(0.05)(32)} = \text{US\$ } 192{,}000{,}000$$

As was the case with the cost of death, the estimate of the total cost has been modified to account for the proportion of private costs that are included as part of a smoker's consumption decision. We have assumed that roughly 50 percent of total medical costs are borne by the private sector and that of these only 10 percent are estimated by smokers at the time they start smoking. The modified estimate of the direct cost of morbidity is

$$C_{DIRECT} = (0.5 + 0.45)\bullet TC_{DEATH} = 182{,}000{,}000$$

IV. Conclusion

Summing across the benefits and costs above gives an annual net benefit as of 1991 of -US$612,000,000. In other words **the net effect of the stream of benefits and costs from the aggregate of all Bank tobacco projects from 1974 to 1991 is a world loss amounting to one-half billion US dollars per annum.** This conclusion is sufficiently robust that it remains qualitatively valid even with the exclusion of the mortality cost of tobacco or the cost of treatment in the private sector.

V. The Net Benefit of New Tobacco Projects

The preceding analysis is given in terms of the net impact of existing Bank projects appraised from 1974 to 1991. As an alternative, the analysis can be used to examine the net benefits of a new project. For this purpose the results can be given in terms of the expected annual net benefit of an incremental project output of 1 ton. An additional ton of tobacco produced by a new project in 1991 will have net annual global benefits of -US$7,500. In other words **the net effect of an additional ton**

of tobacco produced by a new project is an annual global loss equal to several times the current market price of the product. At a 5 percent discount rate the net present value of the sustained global loss from the flow of tobacco produced by the project over time is over -US$100,000 per ton of new productive capacity. Clearly, tobacco is not a good investment if the object is to enhance the future welfare of the globe.

VI. Optimal Taxes

One possible policy to mitigate the net negative effect of the tobacco market is to impose a tax to reduce consumption. The effect of such a tax would be to provide benefits in the form of reduced mortality and morbidity, but the tax would also have costs in the form of reduced consumer's and producer's surplus. An interesting question is the size of the optimum tax that would equate the marginal tax benefits and costs. Based on the supply and demand elasticities and other parameters that underlie the analysis above, the optimal tax would be over 3000 percent of the producer price including the cost of mortality, and 1500 percent excluding mortality and private treatment costs. The taxation capacity of many lower income countries is notoriously weak and taxes of the scale identified here are obviously an impractical policy. The optimal taxes do, however, illustrate the magnitude of the fiscal burden caused by tobacco and underline the importance of programs to combat tobacco consumption and the cessation of lending for tobacco production or processing.

VII. Sensitivity to Discount Rate

Because of the lag between the short-term benefits from consumer surplus and the long-term costs associated with consumption, the net benefits of tobacco projects are sensitive to the discount rate. At discount rates above 11 percent the net short-term benefits from consumers surplus exceed the discounted value of the long-term health costs. (This analysis excludes the actual project development costs.)

To adjust for project implementation risk, the Bank commonly uses a discount rate of 8-12% for project analysis, which may exceed the real rate of interest. However, the risk attached to the policy changes discussed in these guidelines is considerably less than for project implementation, and the 5% discount rate used for the analysis provides a more accurate assessment of the real returns to the policy. After correcting nominal rates of interest for inflation, the real rate of interest has been in the vicinity of 1 to 5% for decades.

A2.3 Travel Cost and Contingent Valuation Methods

A2.3.1 The Domestic Consumer Surplus From Visits to a Rainforest Reserve in Costa Rica[41/]

I. Background

This study measures the value of domestic eco-tourism to the privately owned Monteverde Cloud Forest Biological Reserve (MCFR). The MCFR straddles the continental divide in Costa Rica and consists of 10 000 ha^2 of rugged terrain, the vast majority of which is virgin rainforest. Tourism to the reserve has increased markedly over the 18 years of its existence, both in terms of domestic and foreign visitation rates, despite the relatively remote locality and difficulty of accessing the site.

II. Data, Method and Results

In 1988, 755 out of approximately 3000 domestic visitors left their addresses at the Reserve for the opportunity to win wildlife photographs. The sample showed a similar geographical distribution as a control sample and is assumed to be representative of the true domestic visitor population.

Costa Rica is divided into 81 cantóns. Each canton is treated as an observation.[42/] Visitation rates (number of visits per 100,000 residents) were calculated for each cantón by dividing observed numbers of trips by census populations. Populations, densities, and illiteracy rates for each cantón were taken from a 1986 census. Distances were measured along the most likely roads between the major population center of each cantón and MCFR. The travel cost was estimated at US$ 0.15 per km. This includes out-of-pocket costs, a fraction of fixed costs, and the value of travel time.

The demand function for visits (VISITATION RATE) was assumed to be linear and to depend on the travel cost (DISTANCE), the population density (DENSITY) and the illiteracy rate (ILLITERACY).

$$\text{(I)} \qquad \text{VISITATION RATE} = a_0 + a_1\text{DISTANCE} + a_2\text{DENSITY} + a_3\text{ILLITERACY} + e$$

where e is an error term assumed to be independent and normally distributed. The model was estimated using multiple regressions. The semilog functional form could not be used on this data because the visitation rate from many cantóns was zero.[43/] Two specifications were estimated; with and without illiteracy rates. The results are presented in Table A2.3.1.

41/ Derived from D. Tobias, and R. Mendelsohn, "Valuing Ecotourism in a Tropical Rain-Forest Reserve", *Ambio*, Vol. 20, No. 2, April 1991.

42/ This is used instead of the concentric zones mentioned in Section 3.1.

43/ For a discussion on functional forms see discussions of case studies.

Table A2.3.1. The domestic demand for visits to Monteverde

VISITATION RATE = 36.17 -0.121 DISTANCE +0.008 DENSITY
(4.20) (2.77) (2.76)

Adjusted R^2 = 0.145

VISITATION RATE = 44.42 -0.107 DISTANCE +0.006 DENSITY -0.001 ILLITERACY
(4.28) (2.40) (1.82) (1.40)

Adjusted R^2 = 0.156

The t-statistics are in parentheses.

The number of observations (cantóns) are 81.

Note: The low R^2 values are probably due to the lack of additional data. For example, information is unavailable on socioeconomic variables which might better explain differences in visitor travel behavior.

All coefficients have the expected sign. The coefficient on price is negative and statistically significant. Higher population densities result in more trips, which is expected since people living in less dense cantóns probably have nearby rainforests to visit. The higher the illiteracy rate the lower the visitation rate, which indicates that visitation is positively correlated with education, and probably permanent income.

The visitation rates predicted in Table A2.3.1 are lower than actual rates, since they only predict the visitation observed in the sample. Adjusting this for the whole sample (3000/755) yields an accurate per capita visitation rate. The linear demand functions estimated in Table A2.3.1 suggests that visitation would drop to zero only at distances of 328 km and 347 km, respectively, for the two regressions. At the presumed US$ 0.15 per km, this implies a maximum price per visit of US$ 49 and US$ 52, respectively.

The consumer surplus for each cantón is the integral under the demand function (I) between the actual price for this cantón and the maximum price. The results are summed across all cantóns yielding an annual consumer surplus estimate of US$ 97,500 and US$ 116,200, respectively. Given that there are about 3000 Costa Rican visitors per year, the site is worth about US$ 35 per domestic visit. Assuming the real value of this recreational flow remains the same over time and using a real interest rate of 4%, the present value of domestic recreation at this site is between US$ 2.4 and US$ 2.9 million.

III. Discussion

This US$ 100,000 per year estimate does not include foreign visitors. Foreign visitors outnumbered domestic visitors by four to one in 1988. Foreign visitation is likely to be worth far more than domestic since foreign tourists probably value the site more than domestic visitors due to their higher income and lack of nearby substitutes. The present value estimate is probably too low when considered that visitation has been growing at 15% a year for the last five years. Still, if we use the same US$ 35 for all visitors and also for the future, that would mean a net present value of US$ 1250 per ha. The price that the reserve currently pays to acquire new land is between US$ 30 and

US$ 100 per ha. This suggests expansion of protected areas near this reserve is a well-justified investment.

Finally, it should be noted that the recreational value of standing forests is but one of its potential benefits. The total value of the forest includes benefits from renewable harvests of many commodities, biological diversity, ecological services, and sites for scientific research.

A2.3.2 The Value of Viewing Elephants on Safaris in Kenya[44]

I. Travel Cost Approach

The travel cost method can be used to estimate a demand function for going on safari in Kenya. The consumer surplus (CS) is the difference between what people pay for this and the maximum they would be willing to pay. This net economic benefit from a safari does not show up in market observations but would be lost to the international society if safaris were prohibited.

About 80% of the tourists to Kenya came either from North America or Europe and the analysis is based on these. The other 20% of the tourists were assumed to have the same average consumers' surplus as the included 80% have.

In 1988 there were 63,000 visitors from North America and 350,000 from Europe. Normalizing for population differences gave 0.2316 and 0.9826 visitors per 1,000 population for North America and Europe, respectively.

The price of safari is defined as the sum of land costs, air fare and travel time costs. These are summarized in Table A2.3.2. Land costs were estimated by creating a quality weighted price index from the tour operators' surveys. The air fare and travel time were estimated from visitors' surveys.[45] Average income was US$ 45,000 which gives an estimated hourly wage of US$ 22.50 which is weighted at 30% to reflect that vacation time is less valued than gross wage rate.

Table A2.3.2 Price data (US$)

Region	Land cost	Air fare	Travel time	Hourly wage	Weight	Time cost	Total price
North America	1,465	1,900	40 Hrs	22.50	0.30	270	3,635
Europe	957	1,300	18 Hrs	22.50	0.30	121	2,378

We now have the minimum requirement to estimate a demand curve -- two observations of price-quantity. Expecting demand to be a linear function we have:

$$P = 4{,}023 - 1{,}674\,Q$$

where P is the sum of land and air travel time costs, and Q is holiday visits per 1,000 population. Note that we have yet to address the problem of the percentage of visitors on holiday to Kenya that actually goes on safari.

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44. Derived from G. Brown Jr, and W. Henry, *The Economic Value of Elephants*, London Environmental Economics Centre, Discussion Paper 89-12, London, 1989.

45. The survey contained 17 questions and was distributed at some lodges and given to tourists during parts of May and June, 1988. There were 53 respondents.

Given a linear demand curve, per person consumer surplus for North America is[46]

$$C.S. = 0.5 * (4{,}023 - 3{,}635) = 194 \text{ dollars}$$

For Europe it is

$$C.S. = 0.5 * (4{,}023 - 2{,}378) = 822.50 \text{ dollars}$$

It seems reasonable that a safari, a once-in-a-lifetime adventure for most North Americans, most of whom had a very satisfactory experience, would be worth 5% more than it cost. It seems plausible that a similar experience at less cost would be worth 35% more than the cost for a European.

II. Results From Travel Cost Approach

The weighted average consumers' surplus is about 725 dollars. Based on discussions with tour operators and with personnel in the economic section of the U.S. Embassy in Kenya, the number of adults going on safari each year was estimated at between 250,000 and 300,000. This gives a total consumer surplus for those on safari in the range of 182 - 218 million dollars annually, depending on the assumed level of visitation.

To identify the contribution elephants make to the value of a safari, tourists on safari were asked in the tourist survey to allocate the pleasure and enjoyment of their trip over four stipulated categories of experience. "Seeing, photographing and learning about the wildlife" made up 50% of the pleasure according to the answers. In a follow-up question concerning only the enjoyment of the wildlife, the interviewees attributed 25% of their wildlife pleasure to "seeing African elephants". Applying the share of 12.6%, attributed by the visitors to elephants, to the estimated economic value of a safari yields a viewing value for elephants of 23 to 27 million dollars per year.

III. Contingent Valuation Approach

The tourists' survey contains a series of contingent valuation questions. One of the questions (see box) asks people to pay in the form of a special annual permit (or increased safari cost) of 100 dollars which would maintain the elephant population at current levels through increased enforcement activity. Sixty-five percent of the respondents said they would pay 100 dollars. The average was 89 dollars while the median was 100 dollars.

46/ Note that 4,023 dollars is the price at which demand is driven to zero.

Question 10 in survey: Special Fees and Permits

Suppose that the current population of elephants can be maintained if additional foot, vehicle and aerial patrols are operated on a sustained and regular basis in the parks. If these patrols can be supported by a special 100 dollar annual permit (or included in each visitor's safari cost), are you willing to support this permit fee?

[18] NO, I am not willing to pay $100 for this permit.

[34] YES, I am willing to pay $100 for this permit.

[ ] I am willing to pay a maximum of _____ for this permit.

Some respondents dislike translating important qualitative experiences into a dollar metric and respond with a zero response. There were a substantial number of zero responses. However, to maintain a short questionnaire no follow-up questions were asked to distinguish "protesting" respondents from "genuine" zero respondents. To diminish the importance of the zeros, the median value, 100 dollars, has been used instead of the average.

There could be a strategic bias among respondents to give large values if they think the result will lead to policy decisions which they like, but will not have to pay for. Respondents may also put in large values if they regard the question as a sort of referendum in which they vote, as it were, for a broader, perhaps moral issue. However, the largest response to this question was 500 dollars, less than 1% of the respondent's income and about 3% of the cost of his safari. There was therefore no "trimming" of data.

Starting point bias was not tested for due to inadequate sample size. As to the credibility of the median value, 100 dollars, it seems modest inasmuch as it is 3% of the total cost of a safari. If one thinks introspectively about the value over and above the cost of a very satisfying moderately expensive experience, 100 dollars does not appear to be a suspiciously high number and some think it somewhat low.

IV. Results From Contingent Valuation Method

Combining the median value of willingness-to-pay of 100 dollars with the estimate of 250,000 to 300,000 adult safaris per year, yields an annual viewing value of elephants of between 25 to 30 million dollars. If the mean value of 89 dollars per person is accepted, the viewing value is decreased to between 22 to 27 million dollars.

Note that both methods produce annual values of around 25 million dollars for viewing elephants. Although the estimates are rough, they are almost certainly a good guide to the order of magnitude of value. The viewing value of elephants is probably more like 25 million dollars annually, than 2.5 or 250 million dollars. It does not seem prudent for Kenya's 1988 Wildlife Management and Conservation budget to be under 200,000 dollars when tens of millions of dollars in viewing value of elephants alone are at stake.

A2.3.3 The Willingness to Pay for Water Services in Southern Haiti[47/]

I. Background

In rural areas many of those who are "served" by new water supply systems have chosen to continue with their traditional practices. If rural water projects are to be both sustainable and replicable, an improved planning methodology is required that includes a procedure for eliciting information on the value placed on different levels of service, and tariffs must be designed so that at least operation and maintenance costs (and preferably capital costs) can be recovered. A key concept in such an improved planning methodology is that of "Willingness to Pay" (WTP).

Two basic theoretical approaches are available for making reliable estimates of households' WTP. The first, "indirect" approach, uses data on observed water use behavior (such as quantities used, travel times to collection points, perceptions of water quality) to assess the response of consumers to different characteristics of an improved water system. The second "direct" approach, is simply to ask an individual how much he or she would be willing to pay for the improved water service. This survey approach is termed the "contingent valuation method" and is the focus of the case study.

II. The Study Area

In August 1986 the research team conducted a contingent valuation survey and source observations in Laurent, a village in southern Haiti. At the time USAID was funding a rural water supply project designed to provide services to about 160,000 individuals in 40 towns and villages. The project was executed by CARE. The affiliation with CARE provided access to villages and justified the presence of the team to the local population.

Haiti, with two-thirds of the population at an annual per capita income of less than US$ 155 in 1980, provides a field setting similar to the situation in much of Africa and some parts of Asia. In such poor areas an accurate understanding of the willingness of the population to pay for rural water services is likely to be particularly important for sound investment decisions.

The population of Laurent is about 1,500, predominantly small farmers with a few people having regular wage employment. Remittances from relatives and friends are common. More than 80% of the population is illiterate and malnourishment among children is widespread.

There are seven sources of fresh water within approximately 2 km of most of the population: one protected well and six springs in dry river beds. The springs provide only modest amounts of water, and individuals often wait more than an hour to draw supplies. The average 3 km round trip to a water source can sometimes take several hours. The preference for clean drinking water is strong, and people sometimes will walk considerable distances past alternative sources to collect drinking water that is considered pure.

47/ Derived from D. Whittington, J. Briscoe, X. Mu, and W. Barron, "Estimating the Willingness to Pay for Water Services in Developing Countries:A Case Study of the Use of Contingent Valuation Surveys in Southern Haiti", *Economic Development and Cultural Change*, Vol. 38, No. 2, January 1990.

III. Research Design

Economic theory suggests that an individual's demand for a good is a function of the price of the good, prices of substitute and complementary goods, the individual's income, and the individual's tastes. Maximum WTP for a new water system will vary from household to household and should be positively related to income, the cost of obtaining water from existing sources, and the education of household members, and negatively correlated with the individual's perception of the quality of water at the traditional source used before the construction of the improved water supply system. The authors hypothesize that the WTP bids of women respondents would be higher than those of men because women carry most of the water, but alternative interpretations are certainly possible.

The research design attempted to test whether WTP bids are systematically related to the variables suggested by economic theory. Different ways of posing the questions were tried. The bidding-game format worked better than direct, open-ended questions. The bidding-game was very familiar and easily understood because it was similar to the ordinary kind of bargaining that goes on in local markets of rural Haiti. Tests were also included for the existence and magnitude of several types of threats to the validity of the survey results, such as strategic bias, starting point bias and hypothetical bias.

Strategic bias may arise when an individual thinks he may influence an investment or policy decision by not answering the interviewer's questions truthfully. Such strategic behavior may influence an individual's answers in either of two ways. Suppose the individual is asked how much he would be willing to pay to have a public standpost near his house. If he thinks the water agency or donor will provide the service if the responses of individuals in the village are positive, but that someone else will ultimately pay for the service, he will have an incentive to overstate his actual WTP. On the other hand, if he believes the water agency has already made the decision to install public standposts in the village, and the purpose of the survey is for the water agency to determine the amount people will pay for the service in order to assess charges, the individual will have an incentive to understate his true WTP.

An attempt to estimate the magnitude of the bias was made by dividing the study population in two groups. One group was read an opening statement that was intended to minimize strategic bias. It was clarified that CARE had already decided to build the new system and that people would neither have to pay CARE for the system, nor to pay money at the public fountains. The second group was read another statement that was accurate but left more questions about the purpose of the study unanswered, especially concerning the role of the interview in designing a water fee.

The hypothesis was that if individuals acted strategically, then bids from those who received the second statement would be lower than bids from those who received the first, because the former would fear that a high bid would result in a higher charge by the community water committee.

Starting-point bias exists if the initial price in a bidding-game affects the individual's final WTP. This could, for example, be the case if the respondent wants to please the interviewer and interprets the initial price as a clue to the "correct" bid. To test for starting-point bias three different versions of the questionnaire were randomly distributed, each with different initial prices in the bidding game.

Hypothetical bias may arise from two kinds of reasons. First, the respondents may not understand or correctly perceive the characteristics of the good being described by the interviewer. This has been a particular problem when the contingent valuation method has been used to measure

individuals' WTP for changes in environmental quality, because it may be difficult for people to perceive what a change, for example, in sulfur dioxide or dissolved oxygen means in terms of air or water quality. This bias is not likely in the present case. The respondents were familiar with public water fountains and private water connections and photos of public standposts built in nearby villages were shown as part of the interview.

The second source of hypothetical bias is the possibility that the respondents do not take the questions seriously and will respond by giving whatever answer first comes to mind. The test for this is the same as for the applicability of consumer demand theory: were bids systematically related to the variables suggested by economic theory?

IV. Field Procedure

Fieldwork in the village consisted of two parts: household surveys and source observation. The majority of households in Laurent were interviewed (170 questionnaires completed out of approximately 225 households). The household interview consisted of four sections. The first dealt with basic occupational and demographic data for the family. The second consisted of a number of specific water related questions. In the third section the enumerator read one of the statements used to test for strategic bias and showed the photographs of public standposts in other villages. The respondent was then asked to present bid per month for (*a*) public standposts (assuming no private connection) and (*b*) for a private connection (assuming public standposts were already installed). The fourth section was a series of questions on the health and education of family members and the household's assets (such as radios or kerosene lamps). The latter was used, along with observations about the quality of the house itself, as a substitute for expenditure questions, to form a household wealth index.

The second part of the fieldwork consisted of observing the quantities of water collected by individuals at all the sources used by the population of the village. The objective of these observations was to verify the information individuals provided in household interviews on the sources they used and the quantities of water collected. All sources were observed on the same day from sunrise to sunset. The analysis of the source observation data for Laurent increased the confidence in the quality of the water-use data obtained from the household interviews. Out of 119 observations of trips to water sources, the interview responses were consistent with the source observation for 101 households (85%).

V. Analysis of Contingent Valuation Bids

Fourteen percent of the households gave an answer of "I don't know" in response to WTP question for public standposts; there was a 25% non-response rate for the WTP question for private connections. The mean for the bids for the standposts, 5.7 gourdes per month, (US$ 1.14) seemed realistic.

The test for strategic bias showed the anticipated higher bids for those who had received the neutral statement, but the difference was not statistically significant (*t*-statistics of 1.1 and 0.5, respectively, for bids on standposts and private connections). On the basis of this test, the hypothesis that respondents were not acting strategically when they answered the WTP questions cannot be rejected.

The test for starting-point bias showed that the bids did not vary systematically with the starting-point. The null hypothesis that the three samples are from the same population cannot be rejected, although the confidence intervals are wide.

On the basis of these results, there was no reason to attempt to adjust the WTP bids for strategic or starting-point bias. The mean of WTP bids for the public standposts was 5.7 gourdes per household per month. Assuming an average annual income in Laurent of 4,000 gourdes (US$ 800), the mean bid is about 1.7% of household income and is significantly lower than the 5% rule of thumb often used in rural water supply planning for maximum "ability to pay" for public standposts. The mean of WTP bids for private connections, 7.1 gourdes, was not much higher (2.1% of household income), but these bids are based on the assumption that the public standposts are already in place.

The variations in the bids for public standposts and private connections were modeled as a function of the identified explanatory variables. The dependent variable obtained from the bidding game is probably not the maximum amount the household would be willing to pay but rather an interval within which the "true" willingness to pay falls. Linear regression is not an appropriate procedure for dealing with such an ordinal dependent variable because the assumptions regarding the specification of the error term in the linear model will be violated. An ordered probit model was instead used to explain the variations in WTP bids.

The results of the estimations can be seen in Table A2.3.3. The coefficients for all the independent variables are in the direction expected. The *t*-statistics indicate that the variables for household wealth, household education, distance of the household from the existing water source, and water quality are all significant at the 0.05 level in both models. The sex of the respondent was statistically significant in the model for public standposts, but not in the model for private connections. The results clearly indicate that the WTP bids are not random numbers but are systematically related to the variables suggested by economic theory.

The ordered probit model can be used to predict the number of households in a community which will use a new source if various prices were charged. Such demand schedules are precisely the kind of information needed by planners and engineers to make sound investment decisions.

VI. Conclusions

The results of this study suggest that it is possible to do a contingent valuation survey among a very poor, illiterate population and obtain reasonable, consistent answers. The results strongly suggest that contingent valuation surveys are a feasible method for estimating individuals' willingness to pay for improved water services in rural Haiti. It may also prove to be a viable method for collecting information on individuals' willingness to pay for a wide range of public infrastructure projects and public services in developing countries.

Table A2.3.3 Willingness-to-pay bids for public standpost and private connections

Dependent variable: Probability that a household's WTP falls within a specified interval						
	for a public standpost			for a private connection		
Independent variables:	Co-efficient		*t*-ratio	Co-efficient		*t*-ratio
Intercept	.841		1.350	-.896		-1.344
Household wealth index	.126		2.939	.217		4.166
Household with foreign income (1 if yes)	.064		.232	.046		.194
Occupation index (1 if farmer)	-.209		-.848	-.597		-2.541
Household education level	.157		2.113	.090		1.818
Distance from existing water source	.001		5.716	.000		1.949
Quality index of existing source	-.072		-2.163	-.099		-2.526
Sex of respondent (1 if male)	-.104		-5.41	-.045		-.207
Log-likelihood		-206.01			-173.56	
Restricted log-likelihood		-231.95			-202.48	
Chi-square (freedom=7)		51.88			57.83	
Adjusted likelihood ratio		.142			.177	
Degrees of freedom		137			120	

BIBLIOGRAPHY

Anderson, D., *The Economics of Afforestation - A Case Study in Africa*, The World Bank Occasional Paper No. 1/New Series, (Baltimore, Md: The Johns Hopkins University Press), 1987.

Attaviroj, P., "Soil Erosion and Land Degradation in the Northern Thai Uplands", in J.A. Dixon, D.E. James and P.B. Sherman (Eds.), *Dryland Management: Economic Case Studies*, Earthscan Publications Ltd., London, 1990.

Aylward, B., *The Economic Value of Ecosystems: 3 - Biological Diversity*, LEEC Gatekeeper Series No. GK91-03, IIED/UCL London Environmental Economics Centre, June 1991.

Aylward, B., and E.B. Barbier, "Valuing Environmental Functions in Developing Countries", forthcoming in *Biodiversity and Conservation.*

Barbier, E.B., *The Economic Value of Ecosystems: 1 - Tropical Wetlands*, LEEC Gatekeeper Series No. GK89-02, August 1989.

Barbier, E.B., *The Economic Value of Ecosystems: 2 - Tropical Forests*, LEEC Gatekeeper Series No. GK91-01, January 1991.

Barbier, E.B., *The Economics of Controlling Degradation: Rehabilitating Gum Arabic Systems in Sudan*, LEEC Discussion Paper No. DP90-03, IIED/UCL London Environmental Economics Centre, June 1990.

Barbier, E.B., W. M. Adams and K. Kimmage, *Economic Valuation of Wetland Benefits: The Hadejia-Jama'are Floodplain, Nigeria*, LEEC Discussion Paper No. DP91-02, April 1991.

I ..rde, J.P., and D. W. Pearce (eds.) *Valuing the Environment: Six Case Studies*, Earthscan Pub. Ltd., London, June 1991.

Barnum, H.N., "A Note on the Economic Costs and Benefits of Bank Tobacco Projects". Dated 5/10/91.

Barnum, H.N., "Evaluating Healthy Days of Life Gained from Health Projects",*Social Science & Medicine,* vol. 24, no. 10, 1987, pp. 833-41.

Bartelmus, P., C. Stahmer, and J. van Tongeren, "Integrated Environmental and Economic Accounting -- Framework for an SNA Satellite System", *Review of Income and Wealth*, 1989.

Bator, F.J., "General Equilibrium, Welfare and Allocation", *American Economic Review*, March 1957, pp. 22-59.

Binswanger, H., "Brazilian Policies that Encourage Deforestaton in the Amazon", ENV Department Working Paper No. 16, World Bank, Washington, D.C., April 1989.

Birdsall, N. and D. Wheeler, "Openness Reduces Industrial Pollution in Latin America: The Missing Pollution Haven Effect", paper presented at the Symposium on International Trade and the Environment, International Economics Department, World Bank, Washington D.C., November 1991.

Bojö, J., *The Economics of Land Degradation: Theory and Applications to Lesotho*, Dissertation for the Doctor's Degree in Economics, Stockholm School of Economics, 1991, pp. 259 - 350.

Bojo, J., "Benefit-Cost Analysis of the Farm Improvement with Soil Conservation Project in Maphutseng, Mohale's Hoek District, Lesotho", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Bojo, J., *Economic Analysis of Agricultural Development Projects. A Case Study from Lesotho*, EFI Research Report, Stockholm School of Economics, 1990.

Braat, L.C. and J.B. Opschoor, "Risks in the Botswana Range-Cattle System", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Braden, J.B. and C.D. Kolstad (eds.), *Measuring the Demand for Environmental Quality*, Elsevier, New York, 1991, Chap. 2.

Bromley, D. W., "Entitlements, Missing Markets, and Environmental Uncertainty", *Journal of Environmental Economics and Management*, vol. 17, 1181 - 194, 1989.

Brookshire, D.S., L.S. Eubanks and A. Randall, "Estimating Option Prices and Existence Values for Wildlife Resources", *Land Economics*, Vol. 59, No. 1, February 1983.

Brown Jr., G. and W. Henry, *The Economic Value of Elephants*, London Environmental Economics Centre, Discussion Paper 89-12, 1989.

Capistrano, D. and C. F. Kiker, "Global Economic Influences on Tropical Closed Broadleaved Forest Depletion, 1967 - 1985", paper presented at the International Society for Ecological Economics Conference, May 1990, World Bank, Washington D.C.

Cocklin, C., "Mathematical Programming and Resources Planning I: The Limitations of Traditional Optimization", *Journal of Environmental Management*, vol. 28, 1989, pp. 127-141.

Dasgupta, P. and K.G. Maler, "The Environment and Emerging Development Issues", paper presented to the Annual Conference on Development Economics, World Bank, 1990, p. 101 of Conference proceedings.

Dasgupta, P., S. Marglin and A. K. Sen, *Guidelines for Project Evaluation*, UNIDO, New York,1972.

Dixon, J., R. Carpenter, L. Fallon, P. Sherman, and S. Manipomoke, *Economic Analysis of the Environmental Impacts of Development Projects*, published by Earthscan in association with the Asian Development Bank, 1988.

Dixon, J.A., D.E. James and P.B. Sherman, *The Economics of Dryland Management*, Earthscan, London, 1989.

Dixon, J.A. and P.B. Sherman, *Economics of Protected Areas*, Island Press, Washington D.C., 1990.

Durojaiye, B.O., and A.E. Ikpi. "The Monetary Value of Recreational Facilities in a Developing Economy: A Case Study of Three Centers in Nigeria." *Natural Resources Journal* 28(2):315-328, 1988.

Energy Journal, Special Issue on Electricity Reliability, Vol. 9, December 1988.

Finney, C.E. and S. Western, "An Economic Analysis of Environmental Protection and Management: An Example from the Philippines", in *The Environmentalist*, Vol. 6, No. 1, 1986.

Fisher, A. C., and M. Hanemann, "Quasi Option Value: Some Misconceptions Dispelled", *Journal of Environmental Economics and Management*", 14, 1987, pp. 183 - 190.

Fleming, W.M., "Phewa Tal Catchment Management Programme: Benefits and Costs of Forestry and Soil Conservation in Nepal", in L.S. Hamilton (ed.), *Forest and Watershed Development and Conservation in Asia and the Pacific*, Westview Press, Boulder, Co, 1983.

Gigengack, A.R. et al., "Global Modelling of Dryland Degradation", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Gilbert, A., "Natural Resource Accounting: A Case Study of Botswana", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Grandstaff, S., and J.A. Dixon. "Evaluation of Lumpinee Park in Bangkok, Thailand." Chapter 7 in *Economic Valuation Techniques for the Environment: A Case Study Workbook*. John A. Dixon and M.M. Hufschmidt (eds.), Johns Hopkins University Press, Baltimore, Md., 1986.

Hanley, N.D.: "Valuing Rural Recreation Benefits: An Empirical Comparison of Two Approaches", *Journal of Agricultural Economics*, Vol. 40(3), 1989, p. 361-374.

Harberger, A.C., *Project Evaluation: Collected Papers*, University of Chicago Press, 1976.

Hartunian, N.S., C.N. Smart, and M.S. Thompson, *The Incidence and Economic Costs of Major Health Impairments*, D.C. Heath, Lexington, Mass, 1981.

Hodgson, G., and J.A. Dixon, *Logging Versus Fisheries and Tourism in Palawan*, Paper No. 7, East West Center, Honolulu, HI, 1988.

Holmberg, G., "An Economic Evaluation of Soil Conservation in Kitui District, Kenya", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Kim, S. and J.A. Dixon, "Economic Valuation of Environmental Quality Aspects of Upland Agricultural Projects in Korea", in J.A. Dixon and M.M. Hufschmidt (eds.), 1986, op. cit.

Kramer R.A., M. Munasinghe, N. Sharma, E. Mercer, and P. Shyamsundar, "Valuing and Protecting Tropical Forests: A Case Study of Madagascar", paper presented at the IUCN World Parks Congress, Caracas, February 1992.

Liebman, J., "Some Simple-Minded Observations on the Role of Optimization in Public Systems Decisionmaking", *Interfaces*, Vol. 6, 1976, pp. 102 - 108.

Little, I.M.D. and J.A. Mirrlees, *Project Appraisal and Planning for Developing Countries*, Basic Books, New York, 1974.

Little, I. M. D. and J. A. Mirrlees, "Project Appraisal and Planning Twenty Years On", paper presented at the Annual Conference on Development Economics, World Bank, April 26 and 27, 1990.

Lopez, R., "The Environment as a Factor of Production: The Economic Growth and Trade Policy Linkage", mimeo, Economics Department, University of Maryland, College Park, MD, December 1991.

Luenberger, D., *Introduction to Linear and Non-linear Programming*, Addison-Wesley, Reading MA, 1973.

Lutz, E. and M. Munasinghe, "Accounting for the Environment," *Finance and Development*, Vol. 28, March 1991, pp. 19-21.

Lutz, E. and M. Young, "Agricultural Policies in Industrial Countries and their Environmental Impacts: Applicability to and Comparisons with Developing Nations", ENV Working Paper No. 25, World Bank, Washington, D.C., February 1990.

MacRae, D., Jr., and D. Whittington, "Assessing Preferences in Cost-Benefit Analysis: Reflections on Rural Water Supply Evaluation in Haiti." *Journal of Policy Analysis and Management* 7(2):246-263,1988.

Mahar, D., "Government Policies and Deforestation in Brazil's Amazon Region", a World Bank publication in cooperation with the World Wildlife Fund and the Conservation Foundation, Washington, D.C., 1989.

Markandya, A. and D.W. Pearce, "Environmental Considerations and the Choice of the Discount Rate in Developing Countries", ENV Department Working Paper No. 3, Washington D.C., May 1988.

Markandya, A. and D.W. Pearce, "Social Costs of Tobacco Smoking", *British Journal of Addiction*, Vol. 84, No. 10, 1989, pp. 1139-1150.

McConnell, K.E., and J.H. Ducci, "Valuing Environmental Quality in Developing Countries: Two Case Studies." Prepared for session on "Contingent Valuation Surveys in Developing Countries," AEA/AERE Annual Meetings, Atlanta, Georgia, 1989.

Meier, P. and M. Munasinghe, "Incorporating Environmental Concerns into Energy Sector Decisionmaking", ENV Department, World Bank, Washington D.C., January 1992.

Mitchell, R.C., and R.T. Carson, *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Resources for the Future, Washington, D.C., 1989.

Munasinghe, M., *Electric Power Economics*, Butterworths Press, London, 1990a, chapters 2,7,8,9.

Munasinghe, M., *Energy Analysis and Policy*, Butterworths Press, London 1990b.

Munasinghe, M., "Managing Water Resources to Avoid Environmental Degradation", ENV Working Paper No. 41, World Bank, Washington, D.C. 1990c.

Munasinghe, M., *Water Supply and Environmental Management*, Westview press, Boulder, CO, 1992.

Munasinghe, M. and G. Kohlin, "Economic Evaluation of the Environment in Developing Countries: A Review of Methods and Case Studies", Draft Paper, Environmental Policy and Research Division, World Bank, Washington D.C., 1991.

Munasinghe, M., and E. Lutz, "Environmental-Economic Analysis of Projects and Policies for Sustainable Development", ENV Working Paper No. 42, World Bank, Washington, D.C., January, 1991.

Muzondo, T.R., K.M. Miranda, and A.L. Borenberg, "Public Policy and the Environment", IMF Working Paper, International Monetary Fund, Washington D.C., June 1990.

Norgaard, R. B., "Sustainability as Intergenerational Equity: The Challenge to Economic Thought and Practice", Internal Discussion paper, Asia Regional Series, Report No. IDP 97, World Bank, June 1991.

Pearce, D.W., *An Economic Approach to Saving the Tropical Forest*, LEEC Paper 90-06.

Pearce, D. W., "Economic Valuation and the Natural World", draft submitted for inclusion in *World Development Report 1992: Development and the Natural World*, World Bank, August, 1991.

Pearce, D.W., E.B. Barbier, A. Markandya, S. Barrett, R.K. Turner and T. Swanson, *Blueprint 2: Greening the World Economy*, Earthscan Publications Ltd., London, 1991.

Pearce, D.W., and A. Markandya, *Environmental Policy Benefits: Monetary Valuation*, OECD, Paris, 1989.

Pearce, D.W., and K. Turner, *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, 1990.

Peskin, H.M. with E. Lutz, "A Survey of Resource and Environmental Accounting in Industrialized Countries", Environment Working Paper No. 37, World Bank, Washington D.C., 1990.

Peters, C.M., A.H. Gentry, and R.O. Mendelsohn, "Valuation of an Amazonian Rainforest", *Nature*, Vol. 339, 29 June 1989, pp. 655-656.

Petry, F., "Who is Afraid of Choices? A Proposal for Multi - Criteria Analysis as a Tool for Decisionmaking Support in Development Planning", *Journal of International Development*, Vol. 2, 1990, pp. 209-231.

Pezzey, J., "Economic Analysis of Sustainable Growth and Sustainable Development", World Bank Technical Paper - Environment Series, World Bank, Washington D.C., 1992, forthcoming.

Phantumvanit, D., "A Case Study of Water Quality Management in Thailand", in Y.J. Ahmad (ed.), *Analysing the Options*, UNEP Studies, 5. Pergamon Press Ltd., Headington Hill Hall, Oxford, England. 1982.

Phelps, C.E., "Death and Taxes: An Opportunity for Substitution", *Journal of Health Economics*, Vol. 7, 1988, pp 1-24.

Randall, A. and J.R. Stoll, "Existence Value in a Total Valuation Framework", in *Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas*, Westview Press, 1983.

Ray, A., *Cost Benefit Analysis*, Johns Hopkins University Press, Baltimore MD, 1984.

Repetto, R., "Economic Policy Reform for Natural Resource Conservation", ENV Department Working Paper No. 4, World Bank, Washington D.C., May 1988.

Repetto, R., W. Magrath, M. Wells, C. Beer,and F. Rossini, *Wasting Assets: Natural Resources in the National Income Accounts*, World Resources Institute, Washington D.C., 1989.

Romero, C. and T. Rehman, "Natural Resource Management and the Use of Multiple Criteria Decisionmaking Techniques : A Review", *European Journal of Agricultural Economics*, Vol. 14, 1987, pp. 61 - 89.

Samples, K.C., J.A. Dixon, and M.M. Gowen, "Information Disclosure and Endangered Species Valuation", *Land Economics*, Vol. 62, No. 3, August 1986.

Sassone, P.G., "Shadow Pricing in CBA: Mathematical Programming and Economic Theory", *The Engineering Economist*, vol.22, Spring 1977, pp. 219-33.

Schulze, W.D., D.S. Brookshire, E.G. Walther, K. Kelley MacFarland, M.A. Thayer, R.L. Whitworth, S. Ben-David, W. Malm. and J. Molenar, "The Economic Benefits of Preserving Visibility in the National Parklands of the Southwest", *Natural Resources Journal*, Vol. 23, January 1983.

Sebastian, I., and Alicbusan, A., "Sustainable Development: Issues in Adjustment Lending Policies", ENVPR Working Paper No. 1989 - 6, October 1989, World Bank.

Society for Promotion of Wastelands Development, "Economic and Social Change in a Small Rural Community in the Degraded Lower Shivalik Hill Range in North India", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Society for Promotion of Wastelands Development, "Dryland Management Options in Wastelands Development: Jawaja Block, Rajasthan (India)", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op cit.

Squire, L. and H. van der Tak, *Economic Analysis of Projects*, Johns Hopkins University Press, Baltimore MD, 1975.

Statistical Office of the United Nations (UNSO), "SNA Handbook on Integrated Environmental and Economic Accounting", New York, preliminary draft, October 1990.

Thomas, V., "Evaluating Pollution Control: The Case of Sao Paulo." Chapter 13 in *The Economics of Urbanization and Urban Policies in Developing Countries*, G.S. Tolley and V. Thomas (eds.), The World Bank, Washington, D.C., 1987.

Tobias, D. and R. Mendelsohn, "Valuing Ecotourism in a Tropical Rain-Forest Reserve", *Ambio*, Vol. 20, No. 2, April 1991.

Turner, R.K., "Wetland Conservation: Economics and Ethics," in *Economics, Growth and Sustainable Environments: Essays in Memory of Richard Lecomber*, D. Collard, D.W. Pearce and D. Ulph, (eds.), 121-159. Macmillan, London, 1988.

van Tongeren, J., S. Schweinfest, E. Lutz, M. Gomez Luna, and F. Guillen Martin, "Integrated Environmental and Economic Accounting: A Case Study for Mexico", Environment Working Paper No. 50, World Bank, Washington D.C., December 1991.

Walsh, R. G., J.B. Loomis, and R.A. Gillman, "Valuing Option, Existence and Bequest Demands for Wilderness", *Land Economics*, Vol. 60, No. 1, February 1984.

Wang, G., W. Wu and F. Li, "Economic Evaluation of Land Levelling in Weibei Dry Upland, Shaanxi, China", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Wang, G. and L. Han, "Economic Evaluation of Dryland Peanut Growing with Perforated Plastic Mulch", in J.A. Dixon, D.E. James and P.B. Sherman (eds.), 1990, op. cit.

Whittington, D., J. Briscoe,, X. Mu, and W. Barron, "Estimating the Willingness to Pay for Water Services in Developing Countries: A Case Study of the Use of Contingent Valuation Surveys in Southern Haiti", *Economic Development and Cultural Change*, Vol. 38, No. 2, January 1990.

Whittington, D., A. Okorafor, A. Okore, and A. McPhail, "Strategy for Cost Recovery in the Rural Water Sector: A Case Study of Nsukka District, Anambra State, Nigeria." Draft. Infrastructure and Urban Development Department, The World Bank, Washington, D.C., 1989.

Willis, K.G. and G.D. Garrod, "An Individual Travel-Cost Method of Evaluating Forest Recreation", *Journal of Agricultural Economics*, Vol. 42, No. 1, pp. 33-42, January 1991.

World Commission on Environment and Development, *Our Common Future*, Oxford University Press, Oxford, 1987.

World Bank, "Brazil: An Analysis of Environmental Problems in the Amazon", Vol. 2, Annex 5.