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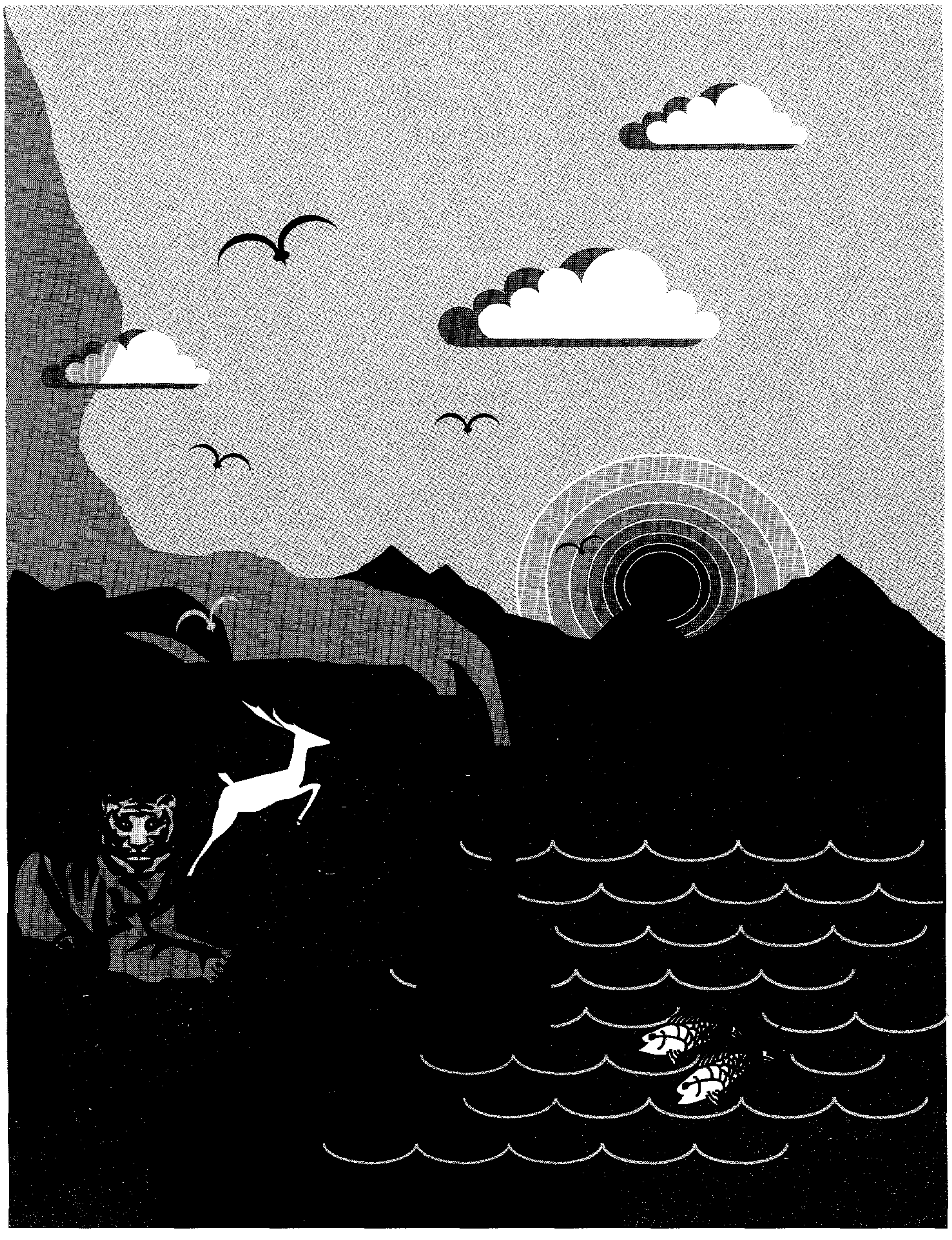
WORLD BANK ENVIRONMENT PAPER NUMBER 3

Environmental Economics and Sustainable Development

Mohan Munasinghe



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The World Bank
Washington, D.C.

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Mohan Munasinghe is chief, Policy and Research Division, in the Environment Department of the World Bank.

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Foreword

The decade of the 1980s has witnessed a fundamental change in the way governments and development agencies think about environment and development. The two are no longer regarded as mutually exclusive. It is now recognized that a healthy environment is essential to sustainable development and a healthy economy. Moreover, economists and planners are beginning to recognize that economic development which erodes natural capital is often not successful. In fact, development strategies and programs which do not take adequate account of the state of critical resources—forests, soils, grasslands, freshwater, coastal areas and fisheries—may degrade the resource base upon which future growth is dependent.

Since its creation, the Vice Presidency for Environmentally Sustainable Development (ESD) has placed the highest priority on the analysis of these important issues. Within ESD, the Environment Department's work, in particular, has focused on the links between environment and development, and the implications of these linkages for development policy in general. The objective of the Environment Paper Series is to make the results of our work available to the general public.

Increasing environmental awareness and concerns over sustainability have broadened the range of issues that need to be examined in the assessment of the potential impacts of proposed projects and programs. Three different concepts of sustainable development may be identified; based on economic, ecological, and socio-cultural criteria. Reconciling these concepts and operationalizing them will be a formidable task, which is only now getting underway. In the meantime those making decisions have to find ways of introducing such concerns into their analysis in a practical way.

The objectives of this paper recognize these needs. It seeks to help analysts, practitioners and policymakers in the field by reviewing the latest thinking on the concepts and techniques of sustainable development and the valuation of environmental impacts, so that they can be explicitly taken into account in development decisionmaking.

The application of environmental economic principles is examined, in order to not only extend conventional cost-benefit analysis but also make better use of other methods such as multi-criteria decisionmaking. This analytical discussion is further illustrated by a careful selection of the most recent empirical work. These case studies cover a range of projects and circumstances to be encountered in a variety of developing countries.

Ismail Serageldin
Vice President
Environmentally Sustainable Development

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Contents

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. It is also important to recognize the social and ecological objectives that are a part of sustainable development, and to reconcile these concepts and operationalize them within the economic framework.

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 economy-wide policies (both macroeconomic and sectoral), 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 environmentally preferable alternatives; 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 the advances most relevant to their own areas of application. To facilitate this, an extended bibliography is provided.

First, a number of shorter developing country case studies which cover a wide range of practical valuation methods, are reviewed. Next, two longer case studies describe the current state-of-the-art in application of a combination of valuation techniques in developing countries. The Madagascar example focuses on the use of methods such as contingent valuation and travel cost, to value forest resources and biodiversity. The Sri Lanka case study examines the scope for application of multicriteria techniques (in addition to economic valuation), to improve decisionmaking in the energy sector.

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 expanded, (as illustrated in the Sri Lanka case study), given the difficulties in using purely monetary methods of cost benefit analysis in many contexts.

PART I : ANALYTICAL FRAMEWORK

1. Introduction

The state of the environment is a major worldwide concern today. 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, environmental degradation has become 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, and culminating in the rapid material-intensive growth pattern of the twentieth century which adversely affected natural resources in many ways. The initial reaction to such environmental damage was a reactive approach characterized by increased clean-up activities. Most recently, mankind's attitude towards the environment has evolved to encompass the more proactive design of projects and policies that will help anticipate and minimize environmental degradation. In this context, the world is currently exploring the concept of sustainable development, an approach that will permit continuing improvements in the present quality of life at 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]

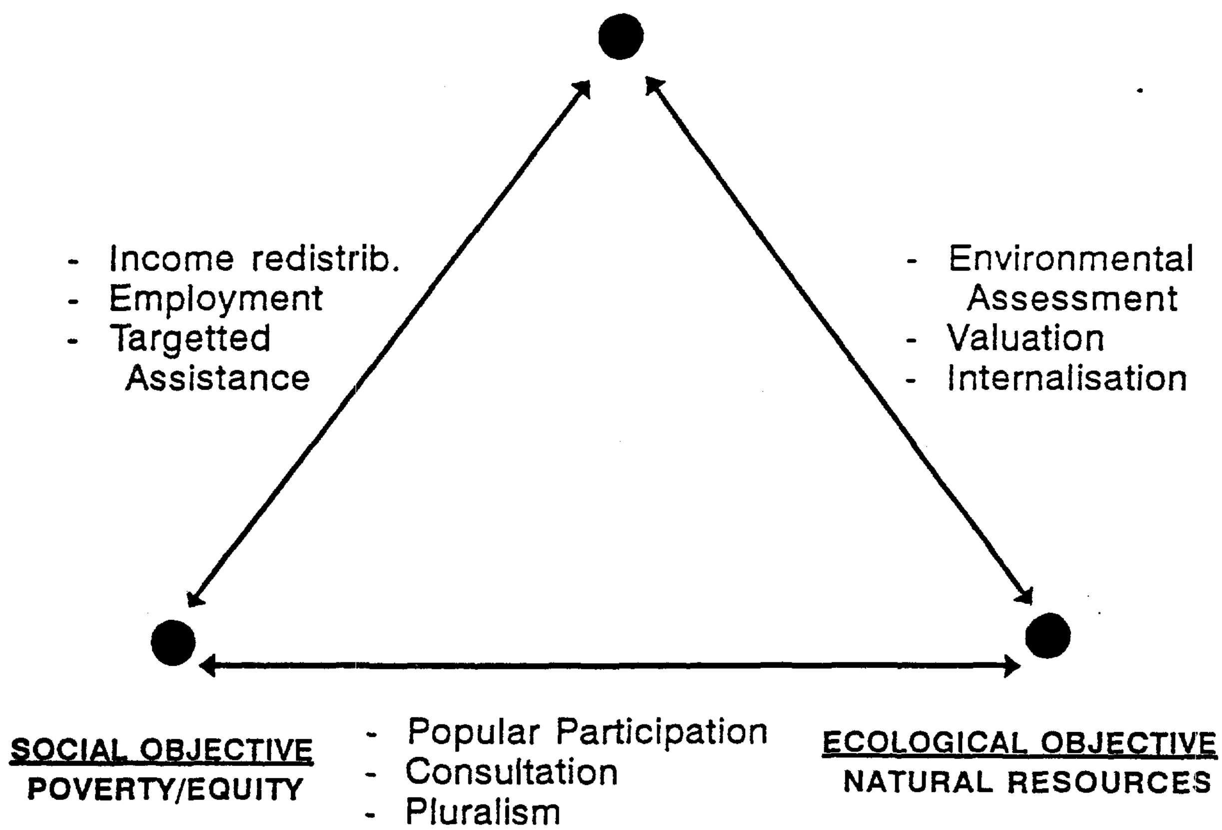
The environmental assets that we seek to protect provide three main types of services to human society, and the consequences of their degradation must be incorporated into the decisionmaking process. First, it has been known for centuries that the natural resource base provides essential raw materials and inputs which support human activities. Second, the environment serves as a sink to absorb and recycle (often at little or no cost to society) the waste products of economic activity. This function has received much greater attention in modern times, especially where overloading of the sink capacity has occurred. Finally, there has been increasing recognition, particularly in the last two decades, that the environment provides many other generalized services ranging from simple amenities to irreplaceable life support functions (e.g., stabilization of the global climate or filtering out of harmful ultraviolet rays by the stratospheric ozone layer). One complication is that these functions tend to interact negatively—for example, overloading the waste absorbing capability will generally reduce the supply of other productive environmental inputs as well as general life-support functions.

In this context, several authors have pointed out that human activities are part of an open dynamic socioeconomic subsystem which is embedded in the global ecosphere (examples of early writings are: Odum 1973, Odum 1975; while some recent ones include Costanza 1991, and Folke and Janssen 1992). The rapid growth of the socioeconomic subsystem in modern times has begun to overload some of the capabilities of the ecosystem (locally as well as globally). Many environmentalists argue that unbounded (and especially material-intensive) economic growth would not be sustainable in the long run, given that the ecosphere is finite (see, for example: Goodland, Daly and El-Serafy 1991).

Conceptual Basis of Sustainable Development

In addition to its environmental roots, the concept of sustainable development which emerged in the 1980s, draws also on the experience of several decades of development efforts. In the 1950s and 1960s, the focus of economic progress was on growth and increases in output, based mainly on the concepts of economic efficiency. By the early 1970s, the large and growing numbers of poor in the developing world, and the inadequacy of "trickle-down" benefits to these groups, led to greater efforts to directly improve income distribution. The development paradigm shifted towards equitable growth, where social (distributional) objectives were recognized as distinct from and as important as economic efficiency (see left side of Figure 1.1).

Figure 1.1 Tradeoffs among the Three Main Objectives of Sustainable Development



Early attempts were made to weight benefits (and costs) of development projects according to the income level of the beneficiaries, thereby incorporating social equity concerns directly into economic decisions. However, the lack of success with such approaches resulted in a more pragmatic procedure, whereby the economic and social objectives were kept separate, but reconciled through the pursuit of more efficient production coupled with targeted poverty-alleviating initiatives (e.g., employment generation, direct subsidies, etc.) to assist low income groups.

Protection of the environment has now become the third major objective of development. By the early 1980s, a large body of evidence had accumulated that environmental degradation was a major barrier to development. The concept of sustainable development has therefore evolved to encompass three major points of view: economic, social and ecological, as shown in Figure 1.1.

Attempts are continuing (as described later in this volume) to integrate environmental concerns into conventional economic decisionmaking—mainly by valuing environmental assets and impacts of development efforts and using them in procedures ranging from project level cost-benefit analysis to environmentally adjusted national accounts at the macroeconomic level (see the right side of Figure 1.1). However, to the extent that some functions of the environment cannot be valued in monetary terms (e.g., biodiversity), other techniques like multi-criteria analysis need to be used to trade off non-comparable objectives.

Finally, the interaction between the social and ecological objectives are probably the least well understood (see the base of Figure 1.1). The growing importance of topics like public participation in decisionmaking, consultation of affected groups, and pluralism, are manifestations of this awareness.

Three Approaches to Sustainable Development

It is possible to identify three different concepts of sustainable development that reflect the ideas presented above—i.e., the economic, the ecological and the socio-cultural (Munasinghe and McNealy 1992).

The *economic* approach to sustainability is based on the Hicks-Lindahl concept of the maximum flow of income that could be generated while at least maintaining the stock of assets (or capital) which yield these benefits (Solow 1986, Maler 1990). There is an underlying concept of optimality and economic efficiency applied to the use of scarce resources. Problems of interpretation arise in identifying the kinds of capital to be maintained (e.g., manufactured, natural, and human capital) and their substitutability, as well as in valuing these assets, particularly ecological resources. The issues of uncertainty, irreversibility and catastrophic collapse pose additional difficulties (Pearce and Turner 1990).

The *ecological* view of sustainable development focuses on the stability of biological and physical systems. Of particular importance is the viability of subsystems that are critical to the global stability of the overall ecosystem (Perrings 1991). Protection of biological diversity is a key aspect. Furthermore, "natural" systems may be interpreted to include all aspects of the biosphere, including man-made environments like cities. The emphasis is on preserving the resilience and dynamic ability of such systems to adapt to change, rather than conservation of some "ideal" static state.

The *socio-cultural* concept of sustainability seeks to maintain the stability of social and cultural systems, including the reduction of destructive conflicts (UNEP et al. 1991). Both intragenerational equity (especially elimination of poverty), and intergenerational equity (involving the rights of future generations) are important aspects of this approach. Preservation of cultural diversity across the globe, and the better use of knowledge concerning sustainable practices embedded in less dominant cultures, should be pursued. Modern society would need to encourage and harness pluralism and grass-roots participation into a more effective decisionmaking framework for socially sustainable development.

In comparing the concepts of ecological and economic sustainability, Githinji and Perrings (1992) point out that it may be more relevant to examine the maintenance of the set of opportunities, as opposed to the preservation of the value of the asset base. This is because preferences and technology are not held constant through successive generations, so preserving a constant value of the asset base could be redundant. By concentrating on the size of the opportunity set, the importance of the conservation of biodiversity becomes more evident, both in terms of ecological and economic approaches to sustainability. The preservation of biodiversity allows the system to retain resilience by protecting it from external shocks, in the same manner that preservation of the capital stock protects assets for future consumption. The difference between the two concepts lies in the consequences of a loss in ecological resilience. Under the Hicksian income measure, a society that consumes its fixed capital without replacement is not sustainable. Using an ecological approach, loss of resilience implies a reduction in the self-organization of the system, but not necessarily a loss in productivity. This depends to a certain extent on the capacity of human societies to adapt and continue functioning in the face of stress and shocks. The linkage between socio-cultural and ecological sustainability is thus demonstrated through the organizational similarities between human societies and ecological systems.

In a separate paper, Perrings (1992) points out that sustainable development is not necessarily synonymous with the maintenance of the status quo. Biodiversity conservation does not require the preservation of all species, nor the maintenance of current environmental conditions. An evolutionary system requires that a level of biodiversity be maintained that will guarantee the resilience of the ecosystems on which human consumption and production, and therefore human welfare, depend. Sustainable development demands compensation for the opportunities foregone by future generations, because today's economic activity changes the level or composition of biodiversity in a way that will affect the flow of vital future ecological services, and narrow the options available to unborn generations. This holds true even if positive rates of economic growth indicate an increase in the instrumental (or use) values of options currently available.

Reconciling these various concepts and operationalizing them as a means to achieve sustainable development is a formidable task. The diversity of short-term needs and concerns, as well as long-term goals throughout the world, suggests that there is no universally "right" or "wrong" sustainable development.

One practical approach that may be more useful to policy-makers and the public is the concept of maximization of net benefits of economic and social development, subject to maintaining the services from, and stock of natural resources over time. This implies that renewable resources, especially if they are scarce, should be utilized at rates less than or equal to the natural rate of regeneration. The efficiency with which non-renewable resources are used should be optimized subject to substitutability between these resources and technological progress. Waste should be generated at rates less than or equal to the assimilative capacity of the environment, and efforts should be made to protect intra- and intergenerational equity. Finally, the implementation of sustainable development will require a pluralistic and consultative social framework that, among other things, facilitates the exchange of information between dominant and hitherto disregarded groups in order to identify less material and pollution intensive paths for human progress.

Sustainability Constraint

In conventional economic analysis, biases exist against the adequate valuation of natural capital, and the costs of natural capital depletion. Often, there is an inbuilt lack of consideration for the rights of future generations in the traditional decisionmaking process. The original work of Hotelling which established the principle of a depletion premium or user cost for exhaustible resources, was a key step in beginning to place a value on current resource use based on future benefits foregone (for a good review, see Dasgupta and Heal 1979). More generally, if it is accepted that rents from natural capital depletion (both renewable and exhaustible) should be shared with future generations (as encompassed in the concept of sustainable development), and that a cautious approach must be adopted with regard to natural resource stock depletion, then shadow pricing ought to reflect a sustainability constraint (Pearce et al. 1991). One approach is to ensure that sufficient assets remain to ensure a non-decreasing flow of future per capita welfare or consumption (Pezzey 1992).

The emphasis on a sustainable supply ensures that natural capital is not regarded as a free good, and therefore preempts the biases mentioned earlier. If an appropriate rule was applied, differences in the relative scarcity of resources would be reflected in the sustainable price. However, certain practical considerations need to be addressed in determining such a rule. Lack of knowledge of the demand curve can cause difficulties in estimating the sustainable price of a resource. The institutional difficulties in the implementation of inter-generational compensation schemes would be significant. Despite such difficulties, the development of methodologies to reflect sustainability constraints in shadow pricing is important, if economic decisions are to consider the intergenerational effects of the depletion of natural resource stocks (see also the following section on discount rates).

Focus of the Paper

This volume reviews how environmental economics could facilitate the efficient use of natural resources (both mineral and biological), as well as manmade capital and human resources—an objective which is a vital step towards sustainable development. Part A describes the framework for analysis. 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:

- Good understanding of the physical, biological and social impacts of human activities.
- Better estimates of the economic value of damage to the environment that help to improve the design of policies and projects and lead to environmentally sound investment decisions.
- Development of policy tools and strengthening of human resources and institutions to implement viable strategies and manage natural resources on a sustainable basis.

Part B of the volume contains a number of shorter case studies grouped and presented according to the various techniques of environmental valuation discussed earlier. Two longer case studies that illustrate the combined use of several valuation techniques are described next. Finally, the conclusions are presented followed by the bibliography and annexes.

Note

1. This broad definition is based on the World Commission on Environment and Development, 1987. For a recent review of alternative definitions of sustainable development, see Pezzey, 1992.

2. Linking Economics and the Environment

The Role of Environmental Economics

Environmental economics plays a key role in identifying options for efficient natural resource management 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 Figures 2.1 and 2.2.

Figure 2.1 indicates the hierarchical nature of decisionmaking in 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.

The usual decisionmaking process that corresponds to this structure, 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 a variety of techniques including project evaluation/cost-benefit analysis (CBA), sectoral/subnational studies, multisectoral macroeconomic analysis, and international economic analysis (finance, trade, etc.), at the different hierarchic levels.

Unfortunately, the analysis of the environment cannot be carried out readily using the above socioeconomic structuring. As shown in Figure 2.2, one convenient breakdown recognizes environmental issues that are related to: (1) global and transnational concerns (for example, climate change, ozone layer depletion); (2) natural habitats (for example, forests and other ecosystems); (3) land (for example, agricultural); (4) water resources (for example, river basins, aquifers, watersheds); and (5) urban-industrial areas (for example, large cities, airsheds). 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 mentioned earlier. For example, a forest ecosystem (like the Amazon) could affect the global climate, span several countries, and also interact with many different economic sectors within each country.

Figure 2.1 The Socio-Economic Structure

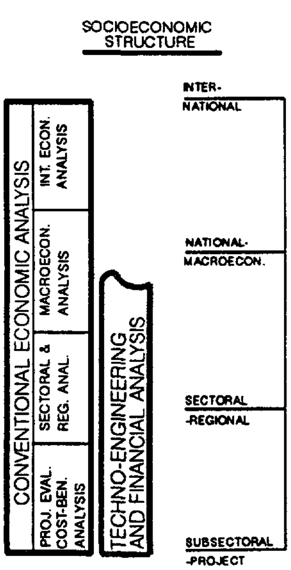
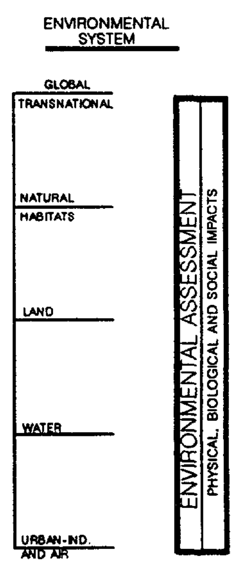


Figure 2.2 The Environmental System

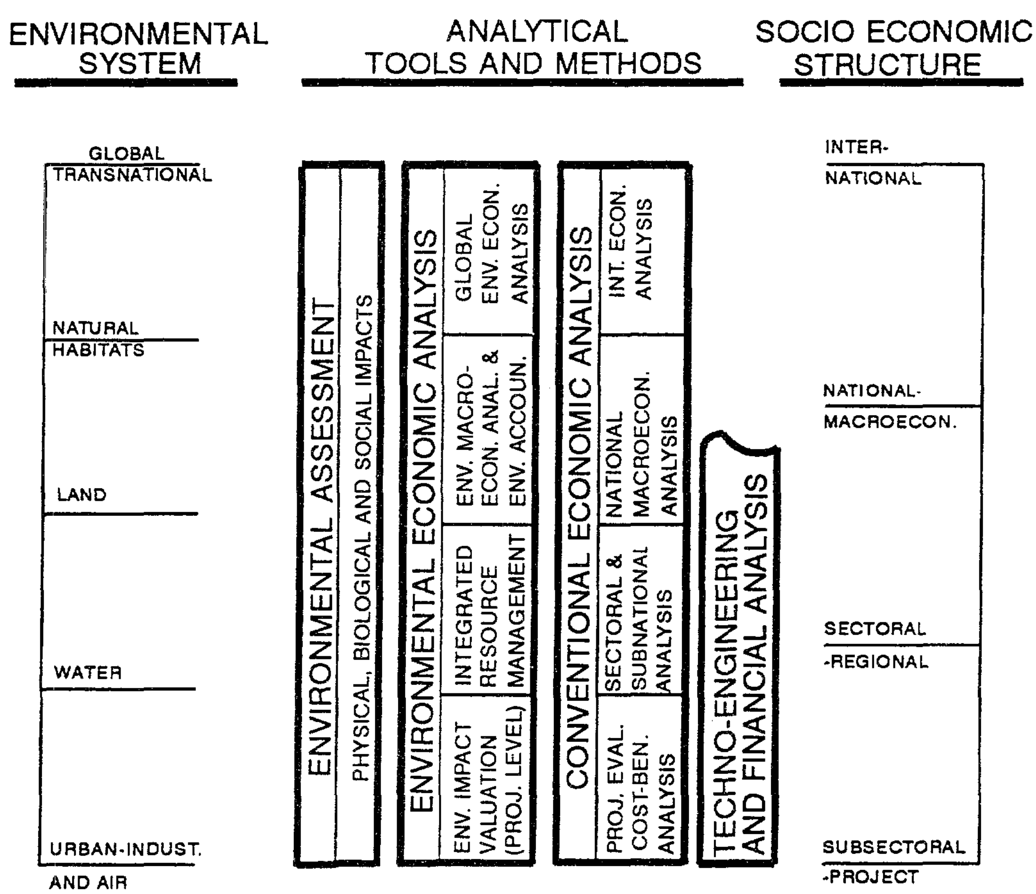


The causes of environmental degradation arise from human activity (ignoring natural disasters and other events of nonhuman origin), and therefore, we begin in the upper part of Figure 2.1. The physical (including biological and social) effects of socioeconomic decisions on the environment must then be traced through to the bottom half of the diagram, and 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 environmental assessment exercise.

The various elements in Figures 2.1 and 2.2 are combined in Figure 2.3, while the new analytical tool of environmental economics has also been added—the latter plays a key bridging role, by helping to map the EA results onto the framework of conventional economic analysis. Once again, a variety of environmental economic techniques facilitate this process of incorporating environmental issues into traditional decisionmaking. These methods include 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). The analytical techniques mentioned above overlap considerably, 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 to shift the development process towards a more sustainable path. Clearly, the

Figure 2.3 Incorporating Environmental Concerns Into Decisionmaking



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 (such as energy, transport, agriculture, industry, finance, and forestry).

Recent Developments

Although 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.

Decisionmakers in most developing countries now accept that poor management of the environment has become a significant barrier to development. Since sustainable development includes other long standing, high priority objectives like economic growth and poverty eradication, scarce resources (both natural and man-made) must be used as efficiently as possible. The conventional approach relied on the systematic analyses of economic decisions (in particular, investment and pricing policies) that influenced the production of goods and services. However, as discussed earlier, this focus on economic efficiency is a necessary but not sufficient condition for sustainable development.

In 1989, the World Bank issued its guidelines for environmental impact assessment of projects, as the natural culmination of many years of increasing concern about the environmental dimension of development.[1] Thus environmental analysis has been elevated to the same level of importance as the other traditional aspects of project evaluation: economic, financial, social, and technical analyses. The valuation of environmental impacts takes on added urgency in this context, since it would permit environmental concerns to be incorporated effectively into the normal decisionmaking process.

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.

The Project Cycle

Project identification involves preliminary selection (by the borrowing country and the World 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 (the World 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, and where appropriate, involve review of previous project documents and field visits. This analysis yields valuable experience that helps improve the work at all stages of the project cycle.

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 in relation to how a project improves human welfare. Costs of scarce resources used up by the project are measured by their opportunity costs—the benefit foregone by not using these inputs in the best alternative application.

In addition to this economic test, as previously mentioned, a number of other aspects (including technical, environmental, institutional, and financial criteria) also need to be considered in project appraisal. The *financial* and *economic* analyses of projects are different. The former uses market or financial costs to estimate the financial viability and profits of the project enterprise or firm. By contrast, the economic analysis seeks to capture economic effects on the whole economy, using shadow prices that reflect opportunity costs. Externalities are valued wherever possible (as described below). Some of the criteria commonly used in the cost-benefit test of a project are described next, 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, in economic testing B, C, and r are defined in economic terms and appropriately shadow priced using efficiency border prices (see Annex 1 for more details of shadow pricing). 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, that is, 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 > r, which in most normal cases implies NPV > 0 (ignoring cases in which multiple roots could occur, which 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):

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

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 (that is, they both serve the same need or demand). Then the comparison of alternatives is simplified. Thus:

$$NPV_1 - NPV_{II} = \sum_{t=0}^{T} [C_{II,t} - C_{I,t}]/(1+r)^t ;$$

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.

Shadow Pricing

In the economist's 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.[2] 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.

Given the complex nature of modern societies, it is often conceptually and empirically useful to attempt to capture all the key economic relationships in a comprehensive "General Equilibrium" model of the macroeconomy. In such a model, the overall national development goal might be embodied in an acceptable objective function such as aggregate consumption. Usually, one important task of the analyst is to maximize this consumption subject to constraints—including limits on the availability of resources (like capital, labor and environmental assets), structural 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.[3] While the general equilibrium approach is conceptually important, it is too cumbersome and data-intensive to use in many cases. 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 sectors or areas, rather than throughout the economy (see also, 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 distribution 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, 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 non-priced inputs and outputs are common property resources and externalities (especially those arising from environmental impacts). Access to common property resources is not restricted, and therefore exploitation tends to occur on a first come, first served basis, often resulting in overuse (beyond the sustainable level). In particular, public goods are a class of environmental resources (e.g., a beautiful view) that are freely accessible and indivisible (i.e., enjoyment by one individual does not preclude enjoyment by others). These properties lead to "free-riding"—a situation in which one consumer, either knowingly or unknowingly, uses the resource at a price less than the efficient cost of making that resource available, and in the process takes advantage of the greater contributions of others (this is the case when wastewater discharge taxes are paid by consumers using a transnational groundwater source in one nation, and the environmental benefits of cleaner water are shared by consumers in another country who draw from the same aquifer, but do not pay such taxes.)[4]

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).[5] If a (damaging)externality can be economically valued or shadow priced, then a charge or tax may be levied on the perpetrator, to compensate for and limit the damage. This is the so-called "Pigouvian" or "price-control" approach to environmental regulation. The basic concepts and techniques for economic valuation of environmental impacts underlying this approach are discussed later in Chapter 3.

Unfortunately, many externalities are not only difficult to measure in physical terms but even more difficult to convert into monetary equivalents (that is, to measure the "willingness to pay" of the parties affected by the externalities). Quite often therefore, the so-called "quantity-control" approach is taken, by imposing regulations and standards, expressed in physical measurements only (e.g., safe minimum standards for pollution), that try to eliminate the perceived external damages. Especially when environmental pollution is severe and obvious, setting standards could serve as a useful first step to raise consciousness about the problem and limit excessive environmental damage, until more accurate data and valuation studies can be carried out. In such cases, the initial emphasis is on cost effectiveness (i.e., achieving pollution targets at the lowest cost), rather than valuing the benefits of control measures. For example, quantity controls on air pollution that limit the aggregate emission level may be combined with an initial allocation of emission rights among existing and potential individual polluters (which collectively do not exceed the total emission limit). This is analogous to defining property rights to an open access resource—in this case, the airshed over a particular region. Next, it would be logical to encourage schemes like marketable pollution permits (which may be competitively traded among polluters), to achieve an economically efficient redistribution of "pollution rights" within the overall emission limit. However, specific minimum quantity controls may not be an efficient long-term solution, if no attempt is made to compare the marginal costs of compliance with the real benefits provided (i.e., marginal damages avoided)—especially as environmental conditions improve over time).

In practice, it is often prudent to use a variable mix of both price and quantity controls to protect the environment (Pearce and Turner 1990). A mixed system allows the various policy instruments to be flexibly adjusted depending on marginal cleanup costs. In this way, an optimal outcome can be approached even without full information concerning control costs (Baumol and Oates 1988).

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. Annex 1 contains a discussion of 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.

National Income Accounts and Macroeconomic Performance

In order to accurately recognize and include environmental concerns in macro-economic analyses, standard income accounting techniques must be re-examined. Gross domestic product (GDP) is the commonly used growth measure, based on transactions in markets. GDP is the basis on which many aspects of macroeconomic policy are determined. However, its shortcomings include neglect of income distributional concerns, non-market activities, and even more crucial—environmental degradation.

In terms of the environment, there are three weaknesses in the current national accounting framework (Lutz and Munasinghe 1991):

1. National accounts may not represent welfare accurately, because the balance sheets do not fully include environmental and natural resources, and therefore, important changes in the status of such resources are neglected.
2. The true costs of using natural resources in human activity are not recorded in conventional national accounts. The depletion or degradation of natural capital (such as the stock of water, soil, air, minerals, and wilderness areas), which occurs in the course of productive activity, is not included in terms of current costs or depreciation of natural wealth. Thus, resource-based goods are underpriced in the market—the lower the value added, the larger is the extent of underpricing of the final product (Dasgupta and Maler 1991). It follows that countries that export primary products do so by subsidizing them, often 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", but 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 are unfairly diminished (see the discussion on discount rate in the next section).
3. Abatement or cleanup activities (for example, those that result in expenditures incurred to restore the environment) often serve to inflate national income, but the offsetting environmental damages are not included. In the case of private firms, defensive environmental expenditures (that is, measures to reduce or avoid environmental damage) are dedected from final value added. However, if such cleanup costs are undertaken by the government or by households, they are added to national output.The resulting GDP estimate is incorrect because: (a) harmful outputs like pollution are ignored; and (b) beneficial inputs related to environmental needs are implicitly under valued.[6]

To overcome these deficiencies in presently used accounting techniques, it is necessary to develop a System of National Accounts (SNA) that is capable of yielding an Environmentally-adjusted net Domestic Product (EDP) and an Environmentally-adjusted net Domestic Income (EDI). National level decisionmakers and macroeconomic planners (typically, in a Ministry of Finance or National Planning) routinely rely on the conventional SNA to formulate economic policies. Thus, a supplementary environmentally-adjusted SNA and corresponding performance indicators would encourage such policymakers to reassess the macroeconomic situation in light of environmental concerns and to trace the links between economywide policies and natural resource management (Muzondo et al. 1990).

The World Bank has worked closely with the UN for the past decade, to better incorporate environmental concerns into the present round of revisions of the SNA framework. As an interim measure, the "UNSO Framework" (Bartelmus, Stahmer, and van Tongeren 1989, UNSO 1990) was created. This framework is referred to as the System for Environmentally-adjusted Economic Accounts (SEAA). Its objective is to integrate environmental data sets with existing national accounts information, while maintaining SNA concepts and principles insofar as possible. Environmental costs, benefits, and natural resource assets, as well as expenditures for environmental protection, are presented as satellite accounts in a manner consistent with the accounting framework of the SNA.

In brief, the SEAA seeks to maintain the essential integrity of the existing SNA; but at the same time, encourages (through the satellite accounts) the collection and compilation of relevant information on natural resources and the environment. An important element of the SEAA is its ability to utilize information that may be generated by other measurements such as physical resource accounting at the regional or sectoral level. The satellite accounts constitute an important step towards the eventual goal of computing an EDP and an EDI.

The World Bank, together with the UN Statistical Office (UNSO), has recently completed case studies in Mexico (van Tongeren et al. 1991), and Papua New Guinea (Bartelmus et al. 1992), to determine how such accounts can be prepared. The Papua New Guinea study demonstrates the feasibility of applying the SEAA framework in a country with relatively weak institutional capacities and limited data availability, (a scenario that would exist in many resource-rich developing countries). Depreciation of produced assets was calculated to be between 9 and 11 percent of Gross Domestic Product (GDP), resulting in a conventional Net Domestic Product (NDP) of between 89 and 91 percent of GDP. Environmental impacts were assessed for the agriculture, forestry, mining and energy sectors.

The authors estimated that these impacts amounted to 2.1 percent of NDP on average, for the 1986-1990 time period. First, the Environmentally—adjusted net Domestic Product 1 (EDP 1) was calculated, which incorporates the "economic" depletion costs of natural resource use, (but does not account for the degradation of environmental quality and corresponding losses of non-marketed environmental services that is reflected in EDP2). Next, EDP2 was estimated after subtracting the costs of degradation of environmental quality from EDP1. EDP2 was estimated to range from 90 to 97 percent of NDP. The final results showed that consumption exceeded net environmentally adjusted domestic production in most years. However, lack of physical data made it extremely difficult to obtain accurate estimates. Significant fluctuations in commodity prices also reflect the difficulties for governments in attempting to maintain sustainable development policies.

Additionally, contrary to findings, Papua New Guinea is not necessarily depleting its capital base, as the capital gain from erosion of external debt (caused by inflation reducing the value of the debt) is about 4% of GNP in real terms. The substitutability of capital is therefore an issue to be considered in the definition of "income".

Aside from these World Bank-supported studies, few examples exist of the application of environmental accounting in developing countries (and even less in the developed world). The UN Economic Commission for Latin America and the Environment (ECLAC) and the United Nations Environment Programme (UNEP) performed two case studies in Latin America that apply environmental accounting methodologies to limited areas within countries. The Argentina study valued a forest ecosystem by estimating the costs of improving productive functions and of maintaining ecosystem functions. Results gained were employed in modelling alternative management and exploitation scenarios. The Mexico study calculated adjustments to the gross product, due to a biological corridor, using market valuation of replacement cost in the agricultural and forestry sectors, and constructed physical balance sheets for individual resources (CIDIE 1992). The Hicksian concept of income was utilized to provide a revised measure of the region's income.

Gilbert performed a case study of Botswana using an environmental accounting framework within a larger modelling and information system. The framework consisted of stock accounts (describing natural resource stocks in physical units); resource user accounts (describing stocks in physical and monetary units); and socio-economic accounts (which focused more on demographics, environmental policy, and the use of resources). However, full implementation of the framework has not been possible because of severe constraints on information (CIDIE 1992).

An early application of environmental accounting in a developing country was performed by Repetto et al. (1989) for the World Resources Institute. The study collected data on petroleum, timber, and soil resources. The approach used is based upon physical stock and flow accounts of natural resources, and the valuation of these stocks. It has been suggested that the valuation method used in forestry overestimates the true resource depreciation (Peskin with Lutz 1990) but has nevertheless proved extremely useful as an indicator of the magnitudes involved in adjustments to GDP through environmental accounting (CIDIE 1992). A later study by the Tropical Science Center and the World Resources Institute (1991) utilized the same valuation methodology for forestry, but focused on providing detailed methods for the technical estimates of deforestation, soil erosion, and coastal fishery over-exploitation in Costa Rica. An example from Brazil is provided in Serôa da Motta and Young (1991). Lutz (1993) is a recent comprehensive volume on environmental accounting.

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 not well understood. The ideal approach is a "general equilibrium" analysis that traces both the economic and environmental effects of economywide policy reforms. However, such comprehensive methods are seldom feasible in developing countries where data and skills are more scarce. "Partial"approaches that help to identify the most important impacts of economywide policies may be more practical.

No simple generalizations are possible as to the likely environmental effects of broad policy measures. Nevertheless, opportunities have been missed often for combining poverty reduction- or efficiency-oriented reforms with the complementary goal of environmental protection. Indeed, a key message of the 1992 World Development Report is the need to identify and exploit such "win-win" policy reform opportunities. For example, addressing problems of land tenure as well as access to financial and social services not only yield economic gains but also are essential for promoting environmental stewardship. Similarly, reforms to improve the efficiency of industrial or energy related activities will reduce both economic waste and environmental pollution (World Bank 1992).

Many instances of excessive pollution or resource over-exploitation are due to market failures and policy distortions exacerbated by unemployment, landlessness, and poverty (Munasinghe et al. 1993). Therefore, broad policy reforms, which usually promote efficiency or reduce poverty, also should be generally beneficial for the environment. However, some of these reforms may have negative environmental effects, depending on pre-existing (and often localized) constraints or distortions—such as inadequately defined property or resource rights. The challenge is to trace the complicated paths by which such policy changes ultimately affect incentives for efficient resource use at the firm or household level. The objective is not necessarily to directly modify the original broader policies (which have other conventional, economic, or property related goals), but rather to design more specific or localized complementary measures. The latter would help mitigate negative effects or enhance the positive impacts of the original policies on the environment. Such complementary actions would include both market-based approaches (like Pigouvian taxes on environmental externalities or allocation of limited pollution rights coupled with marketable permits), as well as non-market methods (such as command-and-control techniques). This process of articulating a range of policies becomes more difficult when economywide reform programs address very broad macroeconomic distortions.

General Economywide Policies

At the outbreak of the economic crisis of the early 1980s, many developing countries that had been running substantial budget and trade deficits and financing these by increasing external debt were forced to adopt emergency stabilization programs.

These programs may have had unforeseen environmental consequences.

One important environmental impact of the crisis was related to poverty and unemployment. The stabilization efforts often 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 or desertification. Fuel price increases and lowered incomes also contributed to deforestation and reductions in soil fertility, as the poor were forced to use fuelwood and animal dung for heating, lighting, and cooking.

Aside from the contractionary aspects of short-term stabilization measures, many macroeconomic policies also have potentially important effects on resource use and the environment. Unfortunately, no easy generalizations as to the directions of these effects are possible; they can be either beneficial or negative, depending on specific conditions. For example, real currency devaluations have the effect of increasing international competitiveness, and raising production of internationally tradable goods (for example, forestry and agricultural products). If the agricultural response occurs through crop substitution, environmental impact would depend on whether the crop being promoted tended to be environmentally benign (such as tea, cocoa, rubber) or environmentally damaging (such as tobacco, sugarcane, and corn). Environmental impacts would also depend on whether increased production led to farming on new land (which could result in increased deforestation) or to more efficient use of existing farmland. Another possibility is that overvaluation of the exchange rate (and the resulting negative terms of trade, decreased competitiveness of products and lower farmgate prices), may well push small cultivators onto more environmentally fragile marginal lands, in an attempt to absorb the effects of the price changes.

In a recent review of the links between growth, trade policy and the environment, (Lopez 1991), the author argues that the output from a natural resource such as a forest or fishery (where production depends critically on the stock) also will be affected by other factors such as property rights. Thus, if trade policy increased the value of output (for example, 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). The possibility of the latter result is emphasized in another study (Capistrano and Kiker 1990). They propose that increasing the competitiveness of world exports would also increase the opportunity cost of keeping timber unharvested. This could lead to forest depletion that significantly exceeds natural regenerative capacity. Another recent study (Kahn and McDonald 1991) used empirical evidence to suggest that a correlative link exists between debt and deforestation. They propose that debt burdens cause myopic behavior that often results in overdepletion of forest resources—through deforestation rates that may not be optimal in the long run, but are necessary to meet short term needs.

The important influence of the macroeconomic context for agriculture has already been shown by the classic studies of Johnson (1973) and Schuh (1974). More recently Krueger, Schiff, and Valdes (1991) have compiled detailed country examples suggesting that economywide factors may in fact be more important than sectoral policies in agriculture. These studies point out that when a broad assessment perspective is adopted, direct output price interventions by government turn out to have less effect on agricultural incentives than indirect, economywide factors, such as foreign exchange rates and industrial protection policies.

The impact of economywide policies are important for the environment, although studies are only starting to quantify the importance of their role. For example, Hyde et al. (1991) cite studies in Brazil and in the Philippines that demonstrate how economic policy spillovers constitute an important source of deforestation. Agricultural subsidies in Brazil probably contribute to half of forest destruction in Amazonia (Mahar 1988, Binswanger 1989, Lewandroski and McClain 1990). A general equilibrium simulation for the Philippines suggests that foreign exchange rate changes, although motivated by general balance of payments concerns, have major implications for the demand for wood products, therefore influencing logging rates (Boyd et al. 1990). The case of fuelwood may be as interesting, since fuelwood shortages have been identified as the major forestry problem in many developing countries. It is possible that national price policies on fuel and investment policies on alternative energy sources may be as important as any sector specific program for addressing the fuelwood problem.

A recent study of World Bank country and sector work has sought to present an overview of how economywide policy reforms to promote development have numerous unanticipated environmental effects (Cruz and Munasinghe 1992). Ongoing work on this project includes a series of country case studies.

The linkages among economywide policies and the environment may be examined from two major perspectives — economic and environmental. First, consider the viewpoint of macroeconomic and sectoral planners or decision-makers, especially those involved in national economic planning in the Ministry of Finance or Planning, or in key sectoral line Ministries. Increasingly, they would wish to know the likely impact of a specific policy on a range of environmental issues. Typical policies might include local currency devaluation, price liberalization, the reduction of government subsidies, or energy pricing reforms. Each such policy would have different implications for various environmental areas of concern. For example, devaluation would significantly affect timber and crop prices and therefore influence deforestation trends (indicated by the arrows in the top half of Figure 2.4). This approach is explored more systematically in Table 2.1.

The first column of Table 2.1 contains a few among the many issues addressed by macroeconomic and sectoral decisionmakers. The economywide policies in the second column of the table are usually designed to address these issues, with the corresponding direct economic objectives or development impacts in the third column. Examples of second-order, and often unanticipated environmental impacts are listed in the fourth and last column. Industrial protection reform provides one example of how both positive and negative environmental effects (last row, last column of Table 2.1), might be associated with such an economywide policy. Therefore, to properly evaluate broad policy

Figure 2.4 Interaction Among Economic Policies and Environmental Issues

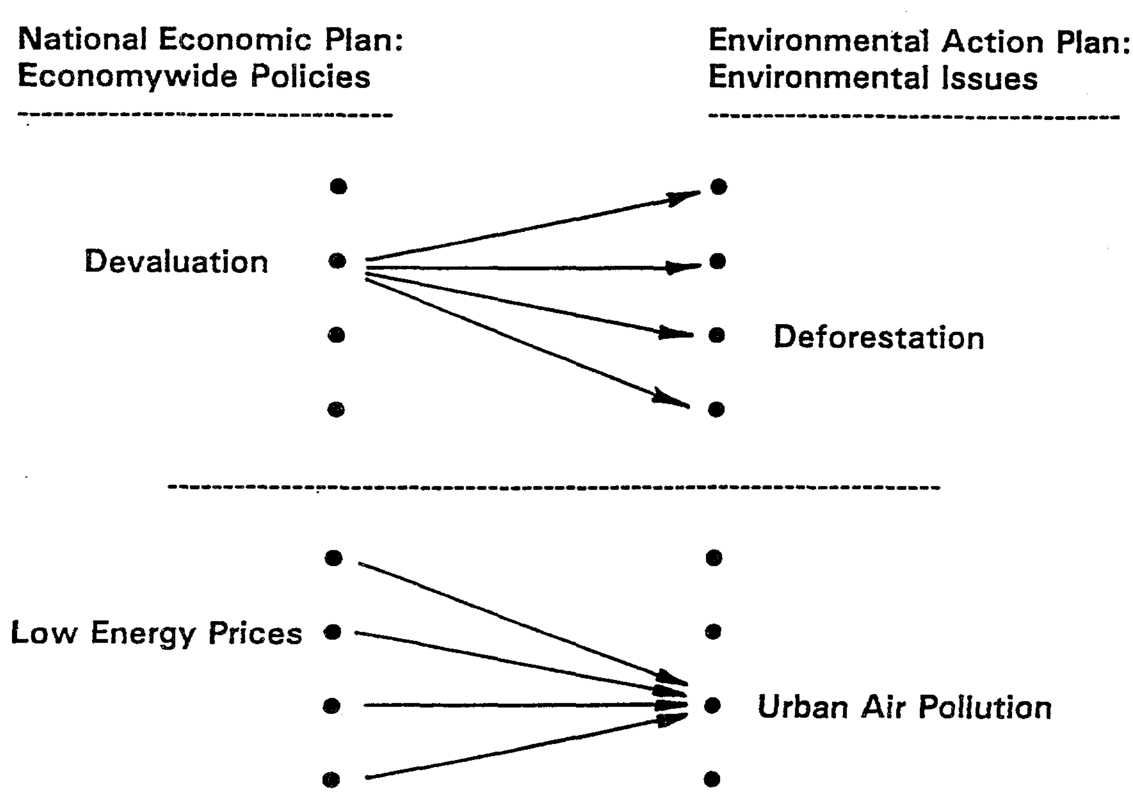


Table 2.1 Some Typical Examples of Direct and Indirect (Environmental) Impacts of Policies

Policy Issue	Policy Reform	Direct Objectives/Effects	Indirect (Environmental Effects)
1. Trade deficits.	Flexible exchange rates.	Promote industrial competitiveness, exports; reduce imports.	Export promotion may lead to more deforestation for export, but it could also lead to substitution of tree crops for annual crops. In addition, industrial job creation may reduce pressures on land resources.
2. Food security and unemployment.	Agricultural intensification in settled lands and resettlement programs for new areas.	Increase crop yields and acreage; absorb more rural labor.	May reduce spontaneous migration to ecologically fragil areas. However, there is potential for over-use of fertilizers and chemicals.
3. Industrialization protection, associated with inefficient production.	Reduce tariffs and special investment incentives.	Promote competition and industrial efficiency.	More openness may lead industry to adopt more energy-efficient or less pollution-prone technologies. However, it may also lead to in-migration of hazardous industries.

reforms, their direct and indirect effects need to be identified, and any trade-offs between their conventional development contribution and their environmental effects need to be assessed.

Returning to Figure 2.4, let us consider the second (or converse) viewpoint of environmental policymakers—e.g., those in the Environment Ministry who are charged with preparing the national environmental action plan (NEAP). They may be quite concerned to find out which of a bewilderingly wide range of economic policies (current or proposed) would have substantial impacts on a specific environmental issue that has high priority in the NEAP (e.g., urban air pollution or deforestation). If air pollution is the major concern, then the NEAP should include a detailed review of policies such as energy pricing (indicated by the arrows in the bottom part of Figure 2.4). On the other hand, addressing deforestation issues would require particular attention to be paid to a somewhat different set of economic policies, including foreign exchange and agricultural price policy reforms.

This second approach is illustrated in Table 2.2, where the first column lists some typical environmental issues that are incorporated in environmental action plans. These issues are catogorized according to varying economic characteristics in the second column. Column 3 contains a sampling of broad policy reforms that could affect the particular environmental problem. For example, water availability and quality will depend primarily on domestic price policies while energy generation will often be very sensitive to international fuel prices. Thus, rationalizing domestic water charges and subsidies will be crucial in promoting more sustainable water use, whereas trade and exchange rate policies (that influence fuel prices) will be relevant for improving energy efficiency.

Ideally, both the above approaches (economic and environmental) should be developed consis-

Table 2.2 Some Typical Environmental Issues, Their Characteristics, and Sensitivity to Policy Reforms

Resource/Environmental Management Issue	Sectoral Economic Characteristics	Relevant Policy Reforms
1. Agricultural expansion and deforestation	• many small, competitive decisionmakers are involved • outputs, inputs are mostly internationally traded • government implements substantial production subsidies and trade intervention	• reduction of taxes and subsidies • exchange rate and trade reforms • poverty and income distribution policies • property rights reforms
2. Water depletion and degradation	• supply side is dominated by government or monopolies; bulk of resource use goes to large commercial enterprises and irrigation systems • resource is not internationally traded but sectoral use and productivity for main user groups substantially differ • prices are highly regulated	• intersectoral pricing • reduction of subsidies and introduction of charges for resource degradation
3. Energy use and air pollution	• as with water, supply side dominated by government and monopolies • inputs (coal, oil) are generally traded; output broadly linked to all production activities • sectoral investment and pricing highly centralized	• exchange rate reforms • reduction of cross-subsidies • privatization programs for generating and distribution activities

tently within the same comprehensive framework of national decisionmaking. However, in practice they tend to be quite distinct and disjointed, often because of historical constraints. Overcoming such problems may require far-reaching reforms in decisionmaking processes and institutions, even before new policies are formulated and implemented.

Structural Adjustment

Structural adjustment programs address a well-defined set of reform areas. These will generally include establishing an appropriate macroeconomic framework for growth, introducing a set of supporting sectoral policies and investment efforts, and integrating the domestic economy into the world economy (Fischer and Thomas 1990).

Adjustment lending started in the early 1980s to address the problem of maintaining growth in countries severely affected by the worldwide economic crisis. The crisis was triggered by the second round of energy price hikes, the collapse of export markets, and increased international interest rates (World Bank 1988). These external conditions, combined with lack of competitiveness of local industries, lagging employment generation, and persistent budget deficits, led to unsustainable current account deficits.

Thus, trade-oriented reforms, including tariff reductions and devaluation, became key components of adjustment lending. Because the deficit is identically equal to the use of foreign savings, adjustment implications for managing external debt have also received much attention. In turn, this led to concern for stimulating domestic savings, increasing the role of taxation in resource mobilization, decreasing the extent of government expenditures, and making investments more productive.

The benefits and costs of such programs are highly country-specific. In a recent review of the Latin American experience, Birdsall and Wheeler (1991) conclude that there is no evidence to show that open developing country 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 benefitted from protective industrial and trade policies. Nevertheless, some concern persists 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.

Next, we examine to what extent those who design structural adjustment lending programs have progressed in recognizing their environmental implications and in incorporating policy measures that could reduce negative impacts or enhance environmentally beneficial effects. An initial assessment of the environmental relevance of structural adjustment reforms was undertaken by Sebastian and Alicbusan (1989). This study looked at how the adjustment lending reforms may have affected environmental factors. The reforms included (1) relative price changes in agricultural outputs, inputs, energy, export taxes; (2) trade and industry policy reform; (3) changes in public expenditure programs; and (4) institutional reforms by sector. At the time of completion of this paper, most of the links between adjustment-related policies and the environment focused on inter-sectoral effects, e.g., between increased agricultural export prices and incentives for agricultural land management. Also, little was known about the intervening or mediating role of factors such as property rights and population growth.

In the early to mid-1980s, environmental aspects were relatively neglected in adjustment lending operations. There were few, if any, explicit loan components or conditionalities that were "environmental." Thus, the 1989 study emphasized the potential complementarities between the adjustment reform components and environmental objectives. For example, trade liberalization was considered potentially environmentally beneficial. Increased agricultural export prices would imply higher land values and therefore more investment in land. Of course, assumptions on land tenure security were needed to complete the argument.

The above study has been updated recently (Warford et al. 1992). The current review concludes that environmental aspects have been increasing in importance in adjustment programs. Recent programs, from 1988–92, include more than just a nominal treatment of environment. For example, about 60% of the 58 countries involved in the review had adjustment programs whose loan components or conditionalities were environmentally motivated. During FY79-FY87, the comparable figure would only have been 37%. In addition, environmental policy reforms have been the subject of some sectoral adjustment programs.

In recent years, non-governmental organizations and academic institutions have contributed to the debate on the environmental effects of structural adjustment and stabilization programs—among the most recent efforts being the studies undertaken by the World Wildlife Fund (WWF) and the World Resources Institute (WRI).

The WWF-sponsored report (Reed, ed., 1992) included three case studies, in Côte d'Ivoire, Thailand, and Mexico. In Côte d'Ivoire, no direct linkage was established between macroeconomic policies and the environment. Underlying institutional factors and market and policy failure at the sectoral level had a greater impact on natural resource use than macroeconomic instruments. Again, in the case of Mexico, no clear linkages between macroeconomic policy and the environment could be established (although, at the micro level, inappropriate pricing for water and energy has resulted in adverse environmental consequences). In Thailand, evidence suggested that, while structural adjustment programs may have reduced resource depletion and environmental degradation per unit of output, overall environmental quality declined because of the increase of output in the aggregate. Because the underlying market failures with regard to the natural resource sector were not adequately addressed, and social and environmental costs were not fully internalized, the trade-off (between economic growth and loss of environmental quality) may not have been economically efficient or environmentally sustainable.

The WRI (Cruz and Repetto 1992) performed a study on the environmental effects of structural adjustment and stabilization programs in the Philippines. They found that structural adjustment policies had not adequately examined adverse environmental impacts of macroeconomic policies. This resulted in increased emissions, concentrated pollution and congestion, increased pressure on open-access resources, and encouraged overexploitation of non-renewable resources. They suggest several policies (for example, the taxation of resource rents, energy taxes, and the elimination of industrial incentives), that could limit environmental damage while at the same time promoting economic objectives such as fiscal balance, poverty alleviation, and economic efficiency.

Rationalization of public expenditure is an integral part of many Structural Adjustment Loans (SALs), and usually emerges from recommendations on spending priorities made in Public Investment/Expenditure Reviews (PI/ERs).

Such reviews provide a consistent framework within which the borrowing country and the Bank could discuss how spending decisions might be best tailored to meet the priority objectives of macroeconomic management. Environmental considerations would be incorporated better into decisions affecting intra sectoral resource allocation, as well as specific projects investment, by more effective use of the PI/ER process.

Sectoral Policies

While adjustment is inherently a macroeconomic effort, involving macroeconomic policy reform, it also requires specific sectoral reforms (Cruz and Munasinghe 1992). The key macroeconomic variables in adjustment programs are the investment-savings gap, the fiscal deficit, the trade deficit, the exchange rate, and the rate of inflation. The microeconomic or sectoral reforms relevant to adjustment include industrial promotion and investment incentives, tax incidence, import liberalization and trade, and energy pricing. These are undertaken to improve resource allocation, but they also have important implications for macroeconomic *stability and growth* (Fischer and Thomas 1990). The first is primarily a microeconomic goal while the second is an adjustment goal.

For example, taxation and government expenditures are the prime microeconomic mechanisms for resource allocation. However, they also comprise the basic elements of fiscal policy. In turn, fiscal policy has a critical macroeconomic impact because it directly determines the fiscal deficit and therefore affects the current account deficit and, after a lag, investment levels.[7] Tax reform issues are particularly relevant from an environmental management perspective because they can have a wide range of potential impacts on resource use. The choice of the tax or tariff base, for example, can lead to substantial changes in the level of pollution-related activities. Such environmental implications, however, are not considered in conventional assessments that focus on fiscal effectiveness. Other sectoral reforms, such as those dealing with energy pricing and industrial exports, also affect macroeconomic stability and have thus played a regular role in adjustment programs (Yagci et al. 1985, World Bank 1989).

Beyond their role in contributing to a stable macroeconomic environment, sectoral policies also have economy-wide relevance in terms of promoting growth from the supply side. These include sectoral investment and pricing policies as well as sectoral regulation and institutional development. As noted by Fischer and Thomas (1990), the traditional approach to development was through investment in agriculture, industry, infrastructure, and human resources. However, the contribution of these sectoral investments also depended largely on the macroeconomic policy context and on the presence of enabling institutions.

Practical examples of the effects sectoral policies have on the environment have been described in several studies. 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.

Two classic studies by Mahar (1989) and Binswanger (1989) highlighted how distorted public policies have exacerbated environmental problems in the Brazilian Amazon region over several decades. Mahar showed that poor and landless peasants have contributed to deforestation, basically responding to incentives such as highways that opened up jungle areas, government land grants, access to public infrastructure, and cash subsidies. Some of the blame is attributable directly to government settlement projects. Large scale livestock as well as iron ore smelting (in the Carajas area) have contributed to land degradation. Binswanger, focussing on the agricultural sector, argued that tax and land distribution policies, and the provision of credit to farmers, not only encouraged deforestation but also worsened income distribution (by favoring larger landowners).

More recently, Lutz and Young (1992) have stressed that rational agricultural policies that eliminated subsidies for farm inputs (like fertilizers and pesticides) could provide both economic and environmental gains. Schneider et al. (1993) argue that unsustainable destruction of the Amazon is the result of farmers, ranchers and loggers responding quite predictably and rationally to distorted incentives arising from poor government policies and political instability.

Some recent examples of World Bank sectoral work that attempted to address issues of environmental concern through policy reform are detailed in Annex 5 (Cruz and Munasinghe 1992).

Notes

1. For details, see World Bank, Operational Directive 4.01.

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

3. In the more technical 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, Sassone 1977).

4. A seminal reference on the free rider principle is P.A. Samuelson 1954. "The Pure Theory of Public Expenditures", *Review of Economics and Statistics*, 36, 370-89.

5. For a review of the basic theory of externalities, see R. Coase, "The Problem of Social Cost", *Journal of Law and Economics*, October 1960; and D.M.G. Newbery, "Externalities: The Theory of Environmental Policy" in G.A. Hughes and G.M. Heal (eds), 1980, *Public Policy and the Tax System*.

6. Dasgupta and Maler (1991) suggest that in order to avoid double-counting, expenditures that enhance the resource base, (such as planting forests), should not be included in national income computations, since they are already reflected in the value of changes in the resource stocks.

7. Stanley Fischer and Vinod Thomas, "Policies for Economic Development" in *American Journal of Agricultural Economics*, Vol. 72, No. 3, August 1990.

3. Framework For Environmental-Economic Decisionmaking

As discussed earlier, a comprehensive framework for cost-benefit analysis of projects in developing countries was in place by the 1970s, including sophisticated techniques of shadow pricing to compensate for economic distortions, as well as social weights to adjust for income distributional concerns. With the emphasis on market-oriented reforms and economic liberalization in the 1980s, some of the enthusiasm has waned for applying such a complex system rigorously (Little and Mirrlees, 1990).

Nevertheless, the rise of environmental concerns, and growing evidence of associated externalities and market failures have revived interest in economic evaluation of projects and policies. In view of the increasing risk of environmental degradation, even modest attempts to assess environmental impacts and risks would be well justified. Ideally, environmental cost and benefits should be quantified economically and integrated into traditional cost benefit analysis. In cases where valuation of environmental impacts is problematic, other techniques such as multicriteria analysis may be used to incorporate the environmental concerns into investment decisions and policies.

Valuation of Environmental Costs and Benefits

Incorporating environmental concerns into economic decisions involves two basic steps. First, the "with"and "without"project scenarios are compared to identify the physical impacts (broadly defined to include also ecological and social effects) of a given economic activity. Engineers, biologists, social scientists, and other experts are required to determine such impacts. An important issue, outside the scope of this paper, is that such physical impacts are complex and often poorly understood.

Economically valuing such physical impacts constitutes the second step in the environmental-economic analysis, as described below.

Basic Concepts of Economic Value

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.[1] One major category of *non-use value* is existence value (EV).[2] We may write:

$$TEV = UV + NUV$$

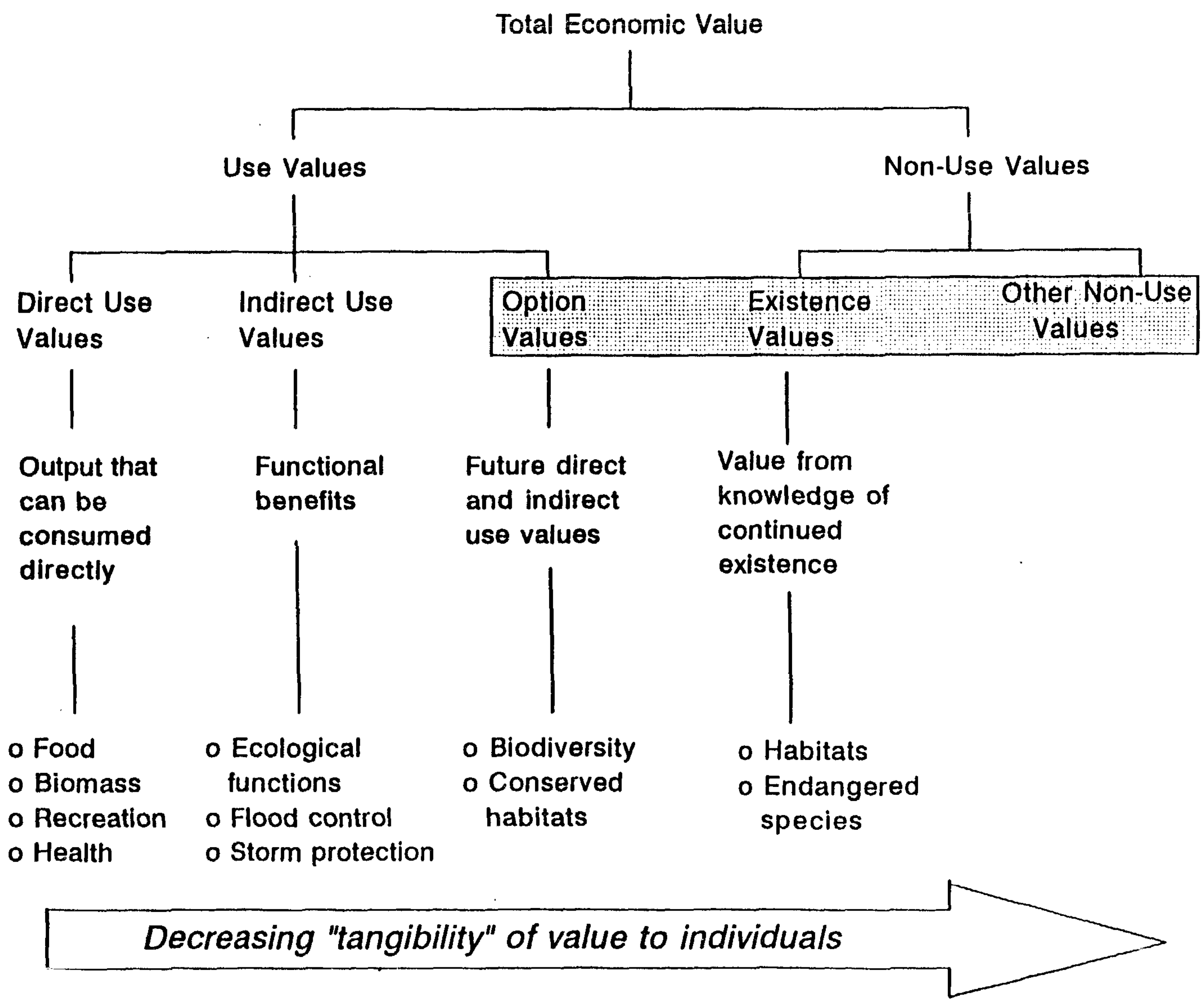
$$\text{or} \quad TEV = [DUV + IUV + OV] + [NUV]$$

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:

- *direct use value* is determined by the contribution an environmental asset makes to current production or consumption;
- *indirect use value* includes the benefits derived basically from functional services that the environment provides to support current production and consumption (e.g., ecological functions like natural filtration of polluted water or recycling of nutrients);
- *option value* is basically the premium that consumers are willing to pay for an unutilized asset, simply to avoid the risk of not having it available in the future (a more detailed version is provided later in this section); and
- *existence value* arises from the satisfaction of merely knowing that the asset exists, although the valuer has no intention of using it.

Option values and non-use values are shaded in the figure, to caution the analyst concerning some of the ambiguities associated with defining these concepts—as shown in the examples, they can spring

Figure 3.1 Categories of Economic Values Attributed to Environmental Assets (with Examples from a Tropical Forest)



Source: Adapted from Pearce (1992).

from similar or identical resources. Economic theory clearly defines TUV (see next section), but there tends to be considerable overlap and ambiguity in the breakdown categories, especially with regard to non-use values. Therefore, these categories are useful mainly as an indicative guide. Further, the distinctions often become irrelevant in practical estimation since the objective is to measure TUV rather than its components (see Randall 1991 for details).

Non-use values tend to be linked to more altruistic motives (Schechter and Freeman, 1992). The differing forms of altruism include intergenerational altruism, or the bequest motive; interpersonal altruism or the gift motive; stewardship (which has rather more ethical, as opposed to utilitarian origins); and q-Altruism, which states that the resource has an intrinsic right to exist. This final definition is clearly well outside the conventional economic theory, incorporating the notion that the welfare function should be derived from something more than purely human utility. Quiggin (1991) has put forward a more controversial point—that the more radical forms of altruism could not be reconciled within a conventional BCA framework.

There has been considerable debate recently concerning the applicability of non-use values. Smith (1992) states that further research is needed in order to better describe the public good services underlying non-use values. Consider the indirect utility function

$$U = V(Y,P,Q)$$

where Y is the individual's income, P is a vector of prices for private goods available on markets (or through well-defined conditions of access to assets such as recreation sites), and Q is a vector of services (both use and non-use) derived from a given environmental resource. The distinction between use and non-use value is made by introducing constraints that link Q to one or more of the goods rationed by prices. Smith points out that for Q to include services based on non-use values, it must be capable of changing without an individual undertaking any actions. The factors altering Q must satisfy the requirements of a public good—they must be non-exclusive and non-appropriable. If attention is paid to the source of services underlying nonuse values, it may emerge that the components of Q based on use values depend on the level of services attributed to nonuse values. The question of strictly partitioning use and non-use values therefore becomes more complex.

For the practitioner, what is important is not necessarily the precise conceptual basis of economic value, but rather the various empirical techniques that permit us to estimate a monetary value for many environmental assets and impacts. However, there is uncertainty in the results derived from some of these techniques even in developed market economies, and therefore their use in developing countries should be tempered by caution and sound judgement.

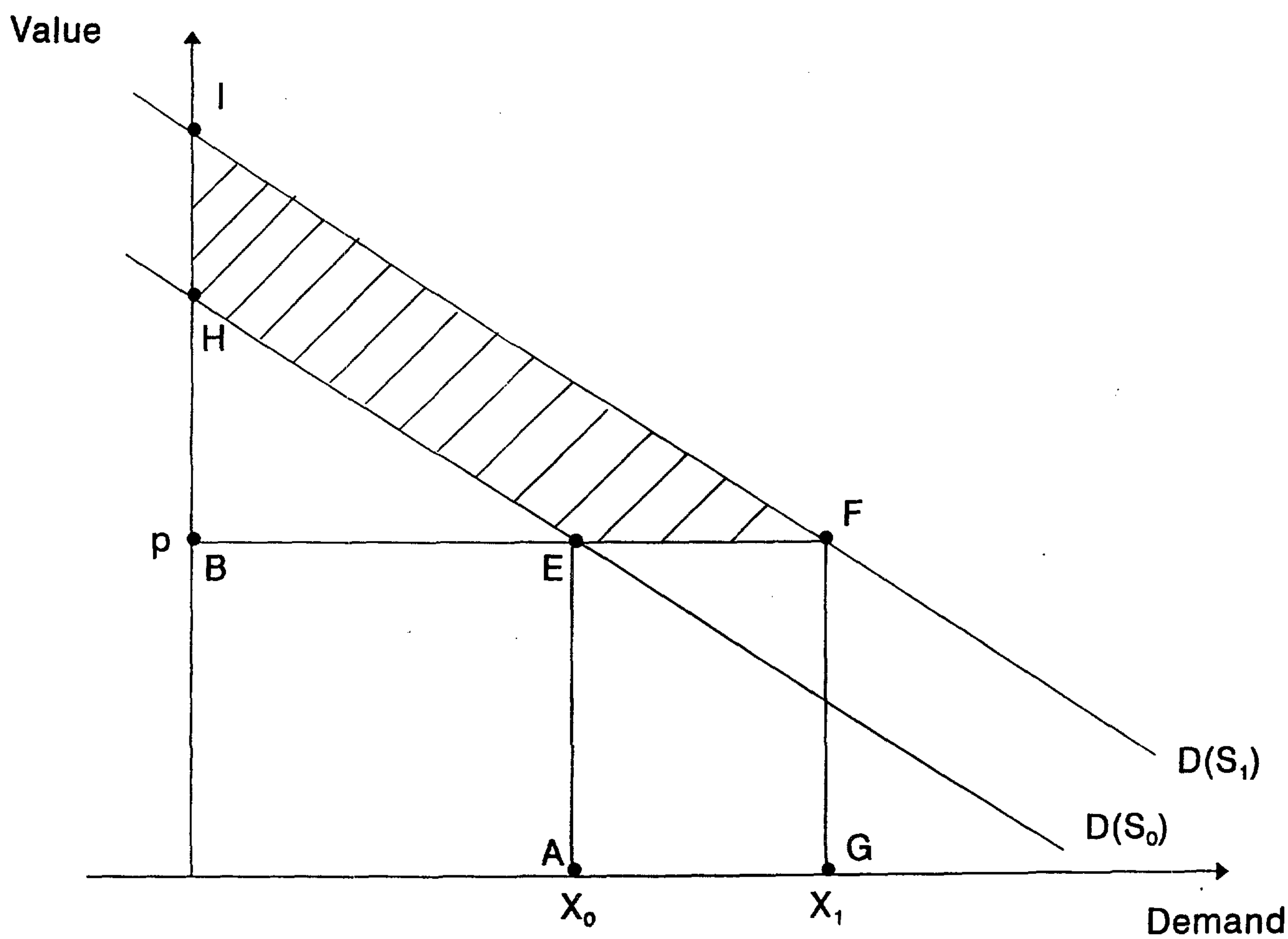
Overview of Practical Valuation Techniques

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.[3] Willingness to pay itself is based on the area under the demand curve, as illustrated below by a simplified case.

In Figure 3.2, the curve $D(S_0)$ indicates the demand for an environmental resource (e.g., the number of visits made per month, to a freshwater source like a river). X_0 is the original demand level at the price p (e.g., the cost of making a trip, including the value of time spent for travelling). The total WTP or value of the services provided by the environmental resource is measured by the area OHEA which consists of two main components: (1) the area OBEA or (pX_0), which represents the total cost; and (2) the area BEH, which is called the consumer surplus or net benefit (i.e., the net value over and above actual expenses). The point H represents the choke price, at which demand falls to zero.

Next, we extend this example to examine what could happen if the quality of the environmental service is improved (e.g., by clean-up of the freshwater source). The normal response would be an increase in demand, represented in Figure 3.2, by a shift in the demand curve from $D(S_0)$ to $D(S_1)$. The new level of demand is X_1 (assuming the same price p), yielding the corresponding total WTP equal to area OGFI, and the new net benefit measured by area BFI. Thus, the quality improvement will result in an incremental increase in the value

Figure 3.2 Benefit Increase Due to the Improvement in Quality of an Environmental Asset



of the environmental resource—given by the shaded area EFIH.[4]

The theoretically correct demand function to use in estimating value, is the compensated or Hicksian one which indicates how demand varies with price while keeping the user's utility level constant. Equivalently, the change in value of an environmental asset could be defined in terms of the difference between the values of two expenditure (or cost) functions. The latter are the minimum amounts required to achieve a given level of utility—for a household (or output—for a firm) *before* and *after* varying the quality of, price of, and/or access to, the environmental resource in question, while keeping all other aspects constant (see also Annex 3).

Problems of measurement may arise because the commonly estimated demand function is the Marshallian one—which indicates how demand varies with the price of the environmental good, while keeping the user's income level constant. In practice, it has been shown that the Marshallian and Hicksian estimates of WTP are in good agreement for a variety of conditions, and in a few cases the Hicksian function may be derived, once the Marshallian demand function has been estimated (Willig 1976, Kolstad and Braden 1991).

What people are willing to accept (WTA) in the way of compensation for environmental damage, is another measure of economic value that is related to WTP. WTA and WTP could diverge as discussed below (Cropper and Oates 1992). In practice either or both measures are used for valuation, and therefore references to WTP in the case studies may be broadly interpreted to include WTA also, unless otherwise stated.

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 of economic agents.[5]

Next, we provide some general comments about valuation, before separately discussing each of the techniques in Table 3.1 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 production.

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: a) 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 b) 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, and 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, and property valuation. The WTP can also be elicited through a controlled experiment or direct interviews, using the artificial market technique or contingent valuation.

While empirical evidence indicates that questions about willingness to accept compensation yield higher answers than questions about willingness to pay to retain the same amenity, there is no explanation for this discrepancy on the basis of economic theory. It has been suggested that WTA questions need more time to be properly understood and assimilated, and that the gap between WTA and WTP narrows with successive iterations. However, it has

Table 3.1 Taxonomy of Relevant Valuation Techniques

	Conventional market	Implicit market	Constructed market
Based on actual behavior	Effect on Production Effect on Health Defensive Cost Preventive Cost	Travel Cost Wage Differences Property Values Proxy Marketed Goods	Artificial Market
Based on potential behavior	Replacement Cost Shadow Project		Contingent Valuation Other

also been suggested that people are willing to spend actual income or wealth less readily than "opportunity" income or wealth—money they do not yet have but may obtain (Knetsch and Sinden, 1984). It may also be the case that individuals are more cautious when weighing the net benefits of changing assets than when no change is made. Generally, WTP is considered to be more consistent and credible a measure than WTA. However, when significant discrepancies exist between the two measures, then the higher values of WTA may be more appropriate when valuing losses in environmental benefits. This in turn would lead to higher values for conservation projects (Markandya 1991).

WTP is often used even when the situation being valued involves a loss of amenity—(the question is then presented in the form of what one is willing to pay to prevent a loss (Markandya, 1991). Hanemann (1991) showed that the measure to be employed depends on the problem under consideration. He demonstrated that the difference between WTA and WTP varies directly with the income elasticity of demand for S (the desired good or service) and inversely with the elasticity of substitution between S and private goods. Therefore, WTP and WTA are equal if the income elasticity of demand for S is zero, or if S is a perfect substitute for a private good. Conversely, as the elasticity of substitution between S and private goods approaches zero, then the difference between WTA and WTP could become large.

In developing countries, the ability to pay becomes a concern. Especially in low income areas, money values placed on environmental goods and services are traditionally low. One way of addressing this concern within cost benefit calculations is to use income weights. However, the use of income weights is somewhat constrained by the data problems in getting income or consumption levels of the concerned groups. In such cases, the decision criterion has to evaluate the income distribution impacts separately, i.e., based on the social concept of sustainable development discussed in Chapter 1 (see also the Madagascar case study in Chapter 5, and Markandya 1991). An alternative approach would be to measure benefits of environmental improvements in terms of willingness to accept income for loss of amenity, as opposed to willingness to pay for an environmental improvement. For example, in water supply projects, WTP can be zero, whereas WTA is more consistent with other measures of the demand for water (Markandya 1991).

Whittington et al. (1992) carried out a revealing study in Nigeria. The study was designed a) to measure the demand for different types of drinking water programs in Nigeria in a way that would allow predictions of household participation patterns with different designs and pricing schemes; b) to evaluate the feasibility of using CVM in rural villages where respondents have limited education and monetary resources; and c) to examine the consequences of giving respondents time to evaluate contingent valuation questions before taking their bids. The authors found that respondents who were allowed time to think about WTP questions made significantly lower bids the second time around. This was true for both public water systems and private connections. The authors concluded that the differences were not a result of strategic behavior because of the open-ended interview process used, and multivariate analyses of WTP bids. They noted that these findings are probably not easily transferable to developed country studies, given the increased consumer awareness in the industrialized world.

We conclude this section by noting that environmental impacts also may be classified as indicated in Table 3.2.

In the table, on-site and off-site are relative terms, since they depend on how widely the project site or "boundary" is defined. For example, inundation of land near a new dam is definitely on-site, whereas distant effects like extent of siltation far downstream of the dam are off-site. In-between impacts could be classified in either category, depending on the project boundary assumed in the analysis. There is a related time dimension. For example, off-site effects also tend to occur in the more distant future, than on-site impacts (although this is not always the case). Clearly, there is a systematic increase in the difficulty of valuation as the analyst progresses from on-site, short-run, market priced impacts to off-site, long-run, non-market priced effects. In the developing world, given data, time and resource constraints, it would be advisable to avoid attempting to value off-site, non-market priced environmental impacts.

Table 3.2 Ease of Valuation of Environmental Impacts

		Availability of Direct Market Prices to Value Impact	
Impact Location	Impact Time	Yes	No
On-Site	Short-Run	Quite Easy to Value	Sometimes Possible to Value
	Long-Run	Highly Possible to Value	Possible to Value in Special Cases
Off-Site	Short-Run	Often Possible to Value	Difficult to Value
	Long-Run	Sometimes Possible to Value	Rarely Possible to Value

Source: Adapted from Hamilton, Dixon and Miller (1989).

Actual Behavior in Conventional Markets

The techniques summarized below rely mainly on directly observable effects or actions valued at market prices (see north-west corner of Table 3.1).

Effect on production. An investment decision often has environmental impacts, which in turn affect the quantity, quality or production costs of a range of outputs—that may be valued readily in economic terms.There are examples of this in two case studies that follow in chapter 4. In the study on soil conservation in Lesotho, the increased production from conserved land is estimated. In the valuation of 1 hectare of Peruvian rainforest the values of different production schemes are compared. Further 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).

Effect on health. This approach is based on health effects caused by pollution and environmental degradation. One practical measure that is relevant is the value of human output lost due to ill health or (in some cases) premature death. The loss of potential net earnings (called the human capital technique) is one proxy for foregone output, to which the costs of health care or prevention may be added (as a form of replacement/defensive expenditure)—see the Zimbabwe water supply and health study in chapter 4. The above measure assumes that earnings reflect the value of marginal product and that medical treatment costs are well defined. The method also encounters difficulties when the cause-effect link between environmental quality and ill-health is unclear, or the sickness is chronic (i.e., of long duration).

This technique seeks to avoid ethical controversies associated with valuing a single specific life, attempting instead to place a value on changes in the statistical probability of ill-health or death (somewhat like the actuarial values used by life insurance firms). Moreover, governments and public health authorities routinely set priorities and allocate health expenditures which affect human well-being. This in turn provides a baseline for determining implicit values placed by society on various health risks, both for prevention and cure of illness.

Defensive or preventive costs. Often, costs may have been voluntarily incurred by communities or individuals to mitigate or undo the damage caused by an adverse environmental impact. For example, if the drinking water is polluted, extra filtration and/or purifying chemicals may need to be used. Then, such additional defensive or preventive expenditures (ex-post) could be taken as a minimum estimate of the benefits of mitigation. The assumption is that the benefits of avoided environmental degradation at least exceed the costs of avoidance. The advantage of the technique is that defensive or preventive outlays (already made) are easier to determine than the value of the original environmental damage. One weakness is that the defensive actions are sometimes decided upon quite arbitrarily with little reliance on market forces, so that the costs bear little relation to the potential environmental benefit.

Recently, Harrington et al. (1989) evaluated the economic damages of a waterborne disease outbreak, emphasizing that the valuation of averting behavior requires the establishment of a relationship between observable defensive expenditures, and non-observable willingness to pay.

Potential Behavior in Conventional Markets

This section summarizes techniques in which potential or future actions could be valued in conventional markets to provide a measure of environmental degradation, provided there is a high degree of certainty that such actions will be undertaken.

Replacement cost and shadow project. If an environmental resource that has been impaired is likely to be replaced in the future by another asset that provides equivalent services, then the costs of replacement may be used as a proxy for the environmental damage. This is an ex-ante measure similar in spirit to the (ex-post) defensive costs approach. It may be argued that the benefits from the environmental resource should be at least as valuable as the replacement expenses.This approach is especially relevant if there is a sustainability constraint that requires certain asset stocks to be maintained intact (see the discussion in Chapter 1).

The replacement cost approach has been applied to deterioration of groundwater resources in the Philippines, by determining the cost of developing alternative water sources (Munasinghe 1990c). The same technique of estimating potential ex-post mitigation expenditures represented by the increased costs of health care, is used in the Manicaland case study that follows.

The use of shadow projecst reflects an institutional judgement on the value of replaced environmental assets, and has been discussed in the context of project-level sustainability. Such a shadow project is usually designed specifically to offset the environmental damage caused by another project. The cost of the shadow project is a measure of the value of environmental assets that are thereby restored. The original project and shadow project together form a sustainable package which helps to maintain undiminished, some vital stock of environmental resources. For example, if the original project was a dam which inundated some forest land, then the shadow project might involve the replanting of an equivalent area of forest, elsewhere. Often the equivalency criterion is hard to satisfy exacly—in the above example, the two tracts of forest may have the same volume of biomass, but could differ widely in terms of biodiversity.

Implicit Markets

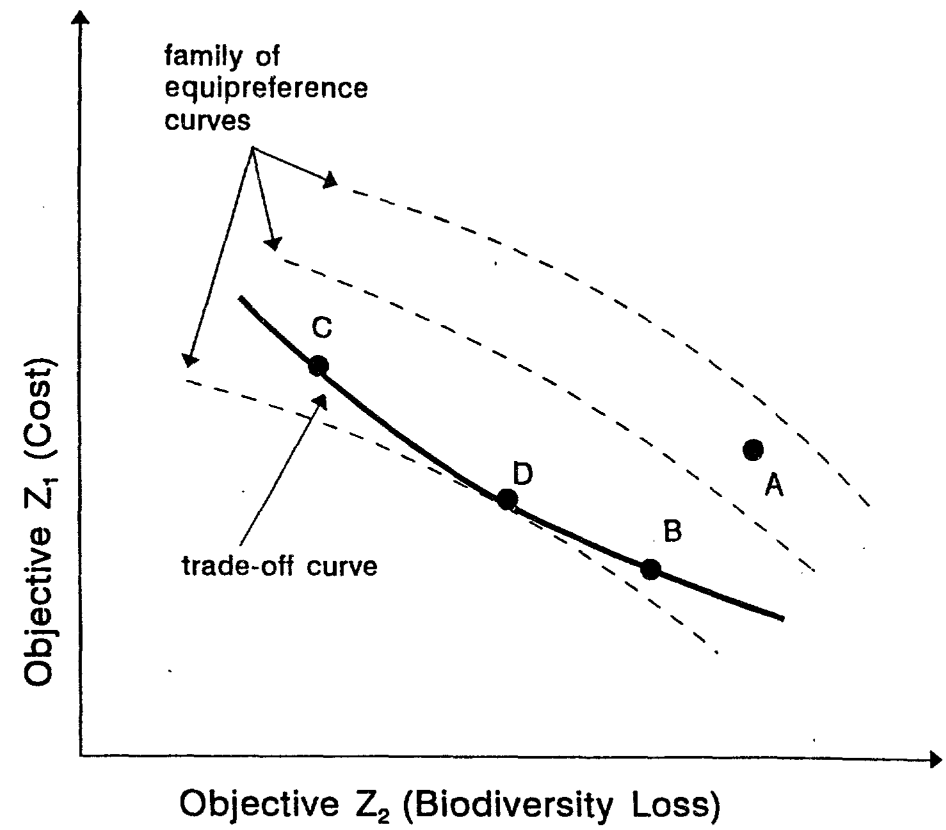
Often, relevant market data is not available in directly usable form, to value environmental resources. In many such cases, analysis of indirect market data (e.g., using statistical and econometric, multiple regression methods) permits the valuation to be carried out implicitly. A variety of such surrogate market-based methods—including travel cost, the "hedonic" methods (property value and wage differential), and proxy goods—as well as their applicability under different circumstances, are described below.

Travel cost. This method seeks to determine the demand for a recreational site (e.g., number of visits per year to a lake or game park), as a function of variables like consumer income, price, and various socio-economic characteristics. The price is usually the sum of observed cost elements like (a) entry price to the site; (b) costs of travelling to the site; and (c) foregone earnings or opportunity cost of time spent. The consumer surplus associated with the estimated demand curve provides a measure of the value of the recreational site in question. More sophisticated versions include comparisons (using regression analysis) across sites, where environmental quality is also included as a variable that affects demand (for a detailed survey, see Mendelsohn 1987 and Bockstael et al. 1991).

Until a few years ago, most applications of this technique were to be found in the market economies, but quite recently, several examples have emerged involving developing world applications. Three of the case studies summarized in chapter 4 use the travel cost method. In one case study, the travel cost for *domestic* trips to a forest reserve in Costa Rica is used. In another, a study on the value of elephants in Kenya, the travel cost of tourists from Europe and North America is used as one estimate of consumer surplus. Finally, Lumpinee Park in Thailand was used also as an example of travel cost analysis in a developing country setting. In chapter 5, the Madagascar case study uses a sophisticated international travel cost model.

Property value. In areas where relatively competitive markets exist for land, it is possible to decompose real estate prices into components attributable to different characteristics like house size, lot size, proximity to schools, shops, parks, etc. (Cropper and Oates 1992). To value an environ-

Figure 3.3 The Trade-Off Curve in Multi-Objective Decisionmaking

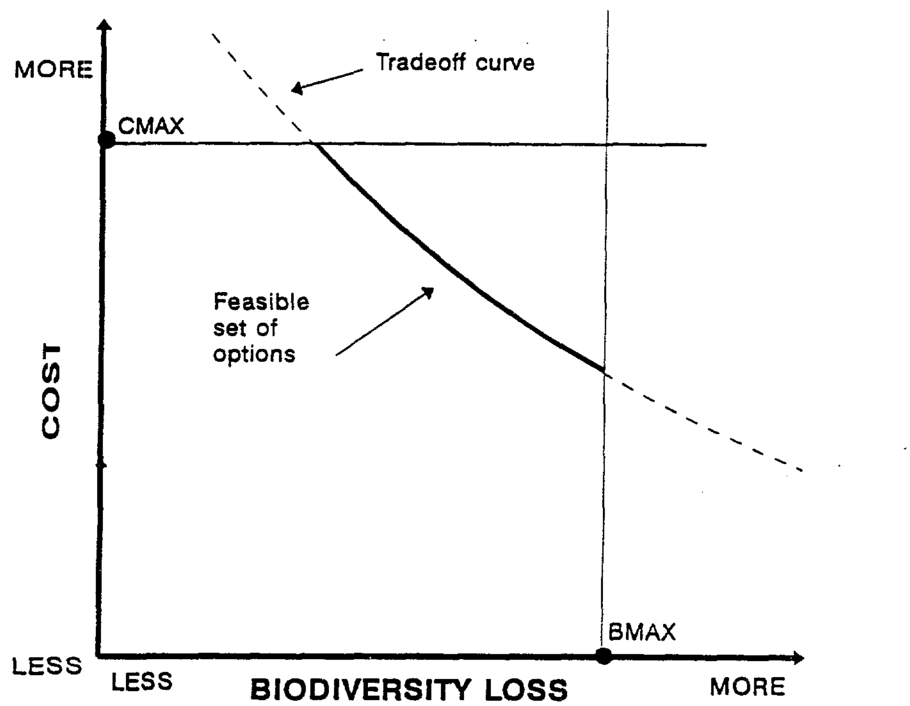


mental variable like air or water quality, the method seeks to determine that component of the property value attributable to the relevant environmental variable. Thus, the marginal WTP for improved local environmental quality (air, land or water) is reflected in the increased price of housing in cleaner neighborhoods.

This method has limited applicability in developing countries because it requires a well functioning housing market, as well as sophisticated information and tools of statistical analysis. Jimenez (1983) used this technique to explain changes in housing prices in a Manila slum area, upgraded partly due to water and sanitation service improvements. Markandya (1991) examines Inter-American Development Bank (IDB) projects that utilized the hedonic price method to estimate the benefits of installing a sewerage program in El Salvador, and a drainage program in Brazil. He points out that, since hedonic pricing can lead to an overestimation of benefits, it would be helpful if more than one method were used to value the benefits of the projects, to determine the bias of the hedonic method, if any. The IDB also used the hedonic price method to estimate the benefits of a water quality improvement project in Ecuador. However, the model used seems to undervalue the benefits of the sewerage connections, and the valuation of the waste treatment plant resulted in very uncertain benefits (the estimation model did not obtain a significant coefficient on the dummy variable used to measure water quality, although the sign is right). Additionally, the benefits of a cleaner river on a regional or national basis were not accounted for. The author concludes that the contingent valuation method (see below) may have been more appropriate to use in this case.

Wage differences. As in the case of property values, the wage differential method attempts to relate changes in an economic price variable (i.e., the wage rate), to environmental conditions. The underlying assumption is that there is some component of the wage that is determined by the environmental

Figure 3.4 Exclusionary Screening



pollution or hazard associated with the job or work site. The technique is relevant when competitive labor markets exist, where wages (that reflect the marginal product of labor) equilibrate the supply and demand for labor. (See earlier discussion on shadow pricing and wage rates). One consideration is that this method relies on private valuation of health risks, rather than social ones. In this context, the level of information concerning occupational hazards must be high in order for private individuals to make meaningful tradeoffs between health risks and remuneration. Finally, the effects of all factors other than environment (for example, skill level, job responsibility, etc.) that might influence wages must be eliminated, to isolate the impacts of environment.

Proxy marketed goods. This method is useful when an environmental good or service has no readily determined market value, but a close substitute exists which does have a competitively determined price. In such a case, the market price of the substitute may be used as a proxy for the value of the environmental resource. Barbier et al, (1991) provide an example involving marketed and non-marketed fish substitutes.

Constructed Markets

In cases, where market information cannot be used directly or indirectly, market-like behavior needs to be deduced through construction or simulation. The methods summarized below depend on direct questions, surveys or marketing experiments.

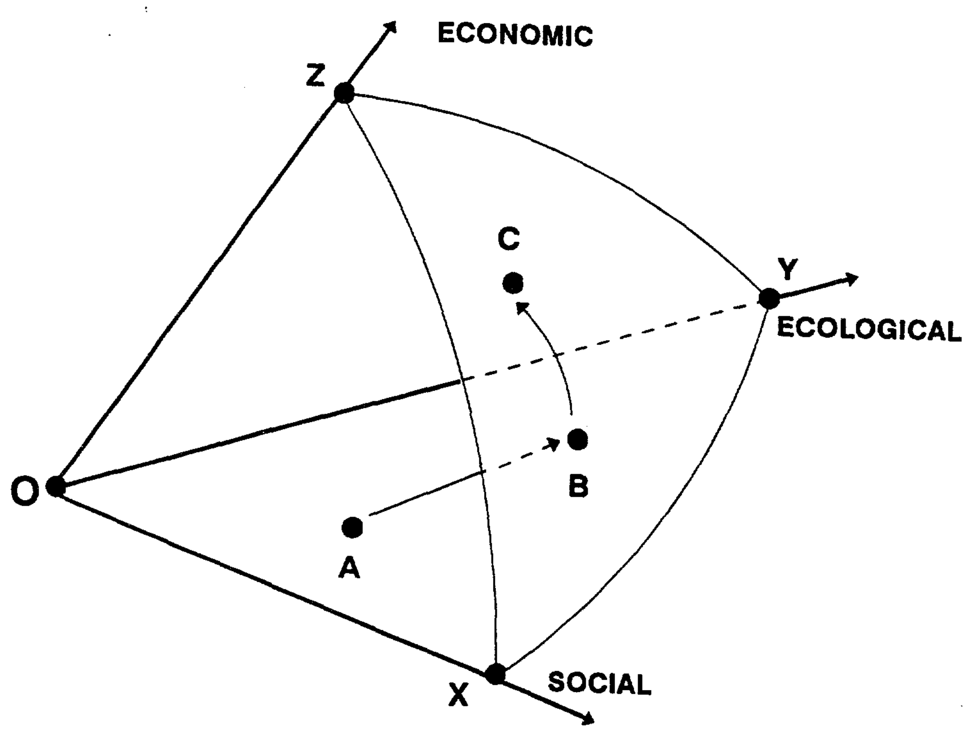
Contingent valuation. When relevant market behavior is not observable, the contingent valuation method (CVM) puts direct questions to individuals to determine how much they might be willing-to-pay (WTP) for an environmental resource, or how much compensation they would be willing-to-accept (WTA) if they were deprived of the same resource. The contingent valuation method is more effective when the respondents are familiar with the environmental good or service (e.g., water quality) and have adequate information on which to base their preferences. CVM is likely to be far less reliable when the object of the valuation exercise is a more abstract aspect like existence value.

Generally, declared WTA tends to be significantly greater than the corresponding WTP. This may be partly attributable to "strategic bias" where respondents feel that they would be better off inflating the amounts they would receive rather than the sums to be paid out, if the hypothetical questions posed were somehow to become a reality in the future. "Status quo bias" could also serve to increase WTA or WTP estimates—in this case, individuals who have become accustomed to a certain level of environmental quality simply may be signalling their instinctive resistance to change. Providing more information about options as well as opportunities to reconsider choices, could help to reduce this form of bias. In the case of poorer individuals, WTP may be limited by the ability-to-pay, whereas WTA is not. Generally, the CVM questionnaires have to be carefully designed, implemented and interpreted to overcome the above mentioned difficulties, as well as other types of bias. (For details, see The Energy Journal, 1988). Munasinghe (1990a) provides several early examples of the application of CVM to value the quality of electricity services in developing countries.

A review by Pearce and Markandya (1989) compared valuation estimates obtained from market-based techniques and CVM, using results from seven studies carried out in industrial nations. They found that the corresponding estimates overlapped within an accuracy range of plus or minus 60 percent. The conclusion is that CVM, cautiously and rigorously applied, could provide rough estimates of value that would be helpful in economic decisionmaking, especially when other valuation methods were unavailable.

Recently, Strand and Taraldset (1991) tested for multiple bias in a contingent valuation study in Norway. They followed a two-step procedure, comparing valuation of air pollution alone; and secondly deriving an implicit valuation of the air pollution issue from the ranking of a broader set of six envi-

Figure 3.5 Trade-Offs Among the Three Basic Objectives of Sustainable Development



ronmental issues (problems due to oil spills at sea; freshwater pollution; noise pollution; air pollution; garbage and waste accumulation; and pressure on recreational areas). They found that expressed valuations of air pollution reductions were three to four times as high as the true values, and believe that this is due to the upward bias of what they term "mental accounting"—whereby individuals tend to focus too much of their total valuation of a much larger set of environmental goods on the particular object to be valued. If biases had not existed, the authors estimate that from total WTP for all six issues the amount allocated for air pollution would be only 50-60% of the figure stated when they were asked about air pollution alone.

Despite the limitations of the method, in certain circumstances, contingent valuation may be the only available technique for estimating benefits. It can and has been applied to common property resources, amenity resources with scenic, ecological or other characteristics, and to other situations where market information is not available (Mitchell and Carson 1989).

Examples of contingent valuation surveys in developing countries are given in the case studies. The use of the contingent valuation method for estimating the value of viewing elephants in Kenya shows that it is possible to achieve an understanding of the order of magnitude of the benefits with only limited efforts. The study on willingness to pay for water services in southern Haiti tests the methodology for different biases and reliability of estimated values. The willingness to pay for improved sanitation in Kumasi, Ghana, is another example of CVM successfully employed in a developing country.

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 might be offered on the basis of different admission fees, thereby facilitating the estimation of the value placed by individuals on water purity or on the use of a recreational facility, respectively.

Other. A variety of essentially opinion- and survey-based techniques for determining values of environmental impacts have been used. They are related to the CVM approach but are more ad-hoc. One of these is the Delphi method, where the judgement of a group of relevant "experts"is sought to estimate the desired values.

Multi-Objective Decisionmaking (or Multi-Criteria Analysis)

Valuation techniques seek to estimate environmental impacts in economic terms. Often, projects or policies and their impacts are embedded in a system of broader (national) objectives, e.g., defined by social and ecological concerns of the type discussed in the introduction. To the extent that the impacts of projects and policies on these broader objectives may be valued economically, all such effects can be incorporated into the conventional decisionmaking framework of cost-benefit analysis. However, some social and biophysical impacts cannot be easily quantified in monetary terms, and multi-objective decisionmaking offers a complementary approach, which may facilitate the optimal choice among investment options or policies available.

Multi-objective decisionmaking, or multi-criteria analysis (MCA), differs from CBA in three major areas (van Pelt, 1991). While CBA focuses on efficiency (although incorporation of income distribution objectives may be attempted), MCA does not impose limits on the forms of criteria, allowing for consideration of social and other forms of equity. Secondly, while CBA requires that effects be measured in quantitative terms, to allow for the application of prices, multi-objective decisionmaking can be broken down into three groups: one that requires quantitative data, a second that uses only qualitative data, and a third that handles both simultaneously. Finally, multi-objective decisionmaking does not require the use of prices, although they might be used to arrive at a score. CBA uses prices which may sometimes be adjusted according to equity weighting. Multi-objective analysis uses weighting involving relative priorities of different groups as opposed to pricing. Van Pelt concludes that the choice between the two methodologies is a matter of the tradeoff between methodological and empirical considerations. If efficiency is the only criterion and prices are available to value efficiency attributes, CBA is preferable. However, in many cases, a paucity of data, and the need to incorporate social and biophysical impacts makes the use of multi-objective analysis a more practicable and realistic option.

Multi-objective decisionmaking calls for desirable objectives to be specified. These often exhibit a hierarchical structure. The highest level represents the broad overall objectives (for example, 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 in choosing 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 3.3. Assume that a scheme has two non-commensurable and conflicting objectives, Z_1 and Z_2. For example, Z_1 could be the additional project cost required to protect biodiversity, and Z_2, some index indicating the loss of biodiversity. 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 because B exhibits lower costs as well as biodiversity loss relative to A. 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_1 but worse with respect to Z_2. 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 an optimal trade-off curve or curve of best options.

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 or society trades off one objective against the other—typical equipreference curves are illustrated in Figure 3.3. 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 best equi-preference curve, with the trade-off curve.

Since the equi-preference curves are usually not known other practical techniques have been developed to narrow down the set of feasible choices on the trade-off curve. One approach uses limits on objectives or "exclusionary screening". For example, in Figure 3.4, the decisionmaker may face an upper bound on costs CMAX (i.e., a budgetary constraint). Similarly, ecological experts might set a maximum value of biodiversity loss BMAX (e.g., a level beyond which the ecosystem suffers catastrophic collapse). These two constraints help to define a more restricted portion of the trade-off curve (darker line), thereby narrowing and simplifying the choices available.

Of the several multi-criteria methods that have been developed, the practical method which is most suitable to determine the best alternative available depends upon the nature of the decision situation.[6] 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 or BOD not below 5 milograms per liter).

More generally, five main forms of multi-criteria evaluation methods have been identified (Pearce and Turner, OECD, 1990). These are the aggregation, lexicographic, graphical, consensus-maximizing, and concordance approaches.

Aggregation techniques add up scores over a range of criteria to identify the optimal solution. It includes methods such as the Environmental Valuation System, which estimates the net environmental impact of a project in terms of a single composite index score. Four key environmental factors are assessed: ecology, pollution, aesthetics and human interest. Criteria are weighted by a panel of experts using the Delphi method. Value transformation functions are applied to all project impacts, which could result in overly subjective indexing, and the application of scores to certain indicators of pollution (e.g., emission levels) can be questioned. Bearing these qualifications in mind, this method could be utilized for example, in determining whether to follow a more conventional (fossil-fuel based) energy policy in the medium term, or whether to pursue an alternative strategy which placed greater emphasis on energy conservation and renewable energy sources.

The lexicographic approach ranks criteria from the most to the least important, thereby not allowing for trade-offs among criteria. The method is best suited to cases where priorities are clear. An example is a toxic waste facility, where acceptable/non-acceptable risk levels can be relatively easily defined.

Graphical approaches employ a method that plots alternatives on graphs with reference to benchmark positions (which would be the 'best' scores of any particular alternative). Weighting is used to assign relative importance. The method does not consider possible collinearity between criteria, a problem that often emerges in multi-criteria analysis. It also requires that data be in ratio or interval form. A version of this method has been utilized in the U.S.A., to value the externalities that are to be reflected in bidding programs for permits to release sulfur dioxide.

Consensus maximization aggregates individual preferences to form group consensus. The Borda-Kendall method ranks criteria in terms of importance in order to reveal an overall index of importance. This method could be helpful, for example, in attempting to estimate the siting of a hydropower project, by taking into account preferences across different interest groups (farmers, government planners, conservation groups, etc.)

Concordance methods assume non-compensatory values between criteria, thereby negating the possibility of establishing trade-offs. Comparisons are carried out on a pairwise basis, and a mathematical concordance or discordance index is used to yield indexes of dominant and non-dominant solutions. A score for each alternative is established by examining the overall comparative performance of an alternative against the whole range of criteria. A possible application of this could be for a wetlands drainage project that would result in irreversible loss of biodiversity.

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 decision-maker (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 as 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.

In addition to facilitating specific tradeoff decisions at the project level, the multi-objective approach could also help in selecting strategic paths. The broadest representation of multi-criteria trade-offs arising from sustainable development efforts are shown in Figure 3.5, where the axes are labelled according to the three basic objectives (economic, social and ecological) discussed in the Introduction (see Figure 1.1). Conceptually, three broad indicators may be envisaged—one for each major objective, with movements along any given axis indicating an improvement in that indicator. In practice, each such indicator would itself consist of many disaggregate sub-indices. Some limited mapping from one axis to the other may be possible (e.g., to the extent that environmental assets could be valued, then ecological concerns may be incorporated within the economic indicator).

The non-inferior (or trade-off) surface XYZ shown in Figure 3.5 is the best that could be achieved given the current availability of resources and knowledge. In the real world, societies would operate at points such as A that are well within this surface—

due to constraints and inefficiencies. Therefore, the first step would be to identify actions that would move us closer towards the non-inferior surface (e.g., along the path AB). Such so-called "WIN-WIN" activities that simultaneously improve all three indicators would have the highest priority. One clear example might be to reduce the pollution and degradation of freshwater resources in developing countries. First, making higher quality water available would increase economic output (e.g., by improving health productivity). Second, it would certainly improve the ecological status. Finally, the social indicator would rise also, since water quality improvements tend to benefit mainly the poor. Once the shift from A to B is achieved, movements along the surface (such as BC) would be the next step—this process is more difficult to determine, since it would involve trade-offs among the different objectives.

The Discount Rate

Discounting is the process by which costs and benefits that occur in different time periods may be compared. Economists typically use a forward-looking approach in which past (or sunk) costs and benefits are ignored, while a discount rate is applied to future costs and benefits to yield their present values. The use of standard criteria for cost-benefit analysis (CBA), such as the net present value (NPV) and internal rate of return (IRR), have been explained in more detail earlier. (See the section on cost-benefit criteria).

The issue of choosing an appropriate discount rate has been discussed in the context of general CBA for many years.[7] The long term perspective required for sustainable development suggests that the discount rate might play a critical role in intertemporal decisions concerning the use of environmental resources.

Two concepts help shape the discount (or interest) rate in a market economy. First, there is the rate of time preference which determines how individuals compare present-day with future consumption. Second, there is the rate of return on investment (or opportunity cost of capital), which determines how an investment (made by foregoing today's consumption) would yield a stream of future consumption (net of replacement). In an ideally functioning market, the interest rate (determines the point of equilibrium between consumption and investment), equals both the marginal rates of time preference and return on capital. In practice, government policy distortions and market failures lead to divergences between the rates of time preference and return on capital. Furthermore, the social rate of time preference may be less than the individual time preference rate, because long-lasting societies are likely to have a bigger stake in the more distant future than relatively short-lived 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).

A study was conducted in rural India which compared estimated rates of time preference of heads of rural households. Results were derived from hypothetical questions, and games involving real and significant awards (Pender and Walker 1992), and indicated the existence of a marked positive time preference. Wealth was inversely and significantly related to the discount rate in many of the experimental games and hypothetical questions. A proportional 10% rise in net wealth was accompanied by a 3-7% fall in the discount rate.

In both the games and the questions, the discount rate declined with increases in the time frame and the magnitude of reward (Pender 1992). This suggests that the neoclassical discounted utility model, which implies that the rate of time preference is independent of time frames and the amounts of commodities, does not always hold true. The lack of properly developed capital markets in many developing economies often causes investment decisions to be linked to consumption decisions, and to depend on the nature of preferences. For policy purposes, the importance of understanding intertemporal preferences is evident.

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, some environmentalists have argued that discount rates should be lowered to facilitate environmentally sound projects meeting the CBA criteria. However, this would lead to more investment projects of all types, thereby possibly threatening the environmentally fragile resource bases. Krautkraemer (1988) argued that lowering discount rates can in fact worsen environmental degradation—by reducing 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 (for a more recent exposition of this point see Norgaard 1991).

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).

There is some basis, in traditional discount rate analysis, to argue in favour of using declining (and even negative) discount rates for evaluating costs and benefits over very long (or multi-generational) time periods, when welfare and returns on investment may be falling. Consider the consumer rate of time preference which has components: $CTP = \alpha + \beta g$ Here, α represents the preference of an individual for comsumption today rather than in the future—it may be based on the myopic notion of "pure" preference, as well as the risk perception that future consumption may never be realized. β is the elasticity of marginal welfare and g is the growth rate of consumption. The second term (βg) reflects the fact that the declining marginal welfare of consumption combined with increases in expected future consumption will combine to make future consumption less valuable than present-day consumption, i.e., since we are likely to be richer in the future, today's consumption is more highly valued.

The general consensus is that α is close to zero, usually 0–3%, and β may be in the range of 1 to 2. Thus if g is large (i.e., high expected economic growth rates), then CTP could be quite large too.[8] On the other hand, if we consider a long-range scenario in which growth and consumption are falling (e.g., catastrophic global warming in 100 years), then g could become negative and consequently CTP may be small or even negative. In this case, with CTP as the discount rate, future costs and benefits would loom much larger in present value terms than if the conventional opportunity cost of capital (say 8%) was used, thereby giving a larger weight to long-term, intergenerational concerns. The key point is that it may be misleading to choose discount rates without assuming some consistent future scenario.[9] Thus an optimistic future would be associated with higher discount rates than a gloomy one—which is consistent since the risk of future catastrophes should encourage greater concern for the future.

Pearce (1991) and van Pelt (1991) make the case that the discount rate traditionally used for project appraisal at international institutions may be too high. Pearce points out that if rates above 1–2% are used, then global warming is not taken into consideration as a serious concern, and future generations would be left to bear the cost. The only means of achieving such a low rate would be to disregard utility discounting as unethical, to abandon opportunity cost discounting, and to place specific restrictions on the nature of the income-utility function. He concludes that use of the opportunity cost rate alone does not appear justifiable on grounds of intergenerational equity, and therefore that an appropriate range of estimates would be 2–5%. Van Pelt argues that, in many parts of the world, high discount rates cannot be justified on the basis of CBA theory. Application of CBA principles would suggest that in many African countries as well as India, the rate of discount should be as low as 5%. He suggests that the rate of discount should be determined on a country-specific basis, and be regularly updated, as is the case with other shadow prices.

Norgaard makes the case that manipulating discount rates to reflect sustainability concerns results in an inefficient use of capital. Instead he 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, result 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.

Since the discount rate may be an inappropriate tool to facilitate such intergenerational transfers, a better 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. The aim would be to ensure that the overall stock of capital (broadly defined) is preserved or enhanced for future generations (see also the discussion of sustainability constraints in Chapter 1). In practice, this would entail monitoring and measurement of capital stocks (man-made, human and natural) and an overarching investment policy that sought to ensure that compensating investments offset depreciation of existing assets (Pearce 1991). Apart from the previously detailed attempts to include depreciation of natural resource stock in national income accounting, little has been accomplished in this area. Where such a sophisticated approach may be impractical, simple rules that limit specific environmental impacts (e.g., groundwater pollution standards) may be a useful first step to protect the rights of future generations.

In the case of projects leading to irreversible damage (such as destruction of natural habitats, and so on), 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 existence value possibly 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 normal range for opportunity costs of capital (e.g., 6–12 percent) may be used as the discount rate; (b) Efforts should be made to ensure that compensating investments offset capital stock degradation within a framework of policy and project decisions; (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; and (d) where valuation of environmental impacts is difficult, and large irreversible damage might occur, restrictions might be set to limit the environmental degradation within acceptable biological or physical norms.

Risk and Uncertainty

Risk and uncertainty are an inherent part of economic decisions. Risk represents the likelihood of occurrence of an undesirable event like an oil spill. In the case of uncertainty, the future outcome is basically unknown. Therefore, the risk of an event may be estimated by its probability of occurrence, whereas no such quantification is possible for uncertainty since the future is undefined. The risk probability and severity of damage could be used to determine an expected value of potential costs, which then would be used in the CBA.

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. 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. Global warming is an illustrative example. In the past, the greenhouse effect of CO_2 emissions was not known or recognized as a risk. At the present time, there is still considerable uncertainty about the future impacts of global warming, but given the large magnitude of potential consequences, caution is warranted. As more understanding of the phenomenon is gained, the uncertainty may be transformed into estimates of future risk probability.

The traditional and simple way of incorporating risk and uncertainty considerations in project level CBA has been through sensitivity analysis.Using optimistic and pessimistic values for different variables can indicate which variables will have the most pronounced effects on benefits and costs. Although 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). More sophisticated approaches to analyze risk and uncertainty are available. (See, for example, Braden and Kolstad 1991).In particular, deterministic a point estimate of value could be quite misleading, whereas a range of values helps identify more robust options. Various criteria such as mini-max and minimum-regret may be used (Friedman 1986).

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 valuation of elephants in Kenya.) While option value has been described in various ways, one useful technical definition is the difference between the ex-ante and ex-post welfare associated with the use of an environmental asset (Smith 1983). 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 (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.[10]

Recently, the applicability of option value has come into question (Markandya 1991). If calculations are performed in terms of the option price (valuing what a person would pay for future benefits today) then the option value may be redundant. The option value basically calls for an individual to add option value to expected future benefits to bring total value up to the option price. As most CVM methods carry out valuations in terms of the option price, the use of option value may be impractical in many cases. The issue is the practical redundancy of OV (which may be captured in other measures), rather than its conceptual validity. This view is reflected by Freeman (1993):"I think it is time to expunge option value from the list of possible benefits associated with environmental protection".

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 case of air pollution resulting from acid deposition. They are (i) identification of the sources of particular pollutants; (ii) ultimate destination of particular emissions; (iii) actual physical impacts at the point of destination; (iv) human valuation of the realized impacts at the point of destination of the emissions; (v) the extent to which a particular policy response will have an impact on the abovementioned factors; and (vi) 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. He terms them "missing markets," noting that "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: mandated pollution abatement; full compensation for future damages (e.g., by taxation); and 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 about land tenure, which leads to deforestation and unsustainable agricultural practices, and uncertainty about 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.

Notes

1. For a discussion and example of this, see Aylward, B. and E. Barbier, "Valuing Environmental Functions in Developing Countries", *Biodiversity and Conservation*, 1992, vol. 1, pp. 34-50.

2. The various terms in the equation for TEV may be grouped in somewhat different ways, for convenience. See for example Walsh, R. G., J. B. Loomis, and R. A. Gillman, 1984, "Valuing Option, Existence and Bequest Demands for Wilderness." *Land Economics*, 60, (1). 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].

3. For an up-to-date exposition, see C.D. Kolstad and J.B. Braden, "Environmental Demand Theory", Chapter 2 in Braden and Kolstad (eds.) 1991, *Measuring the Demand for Environmental Quality*, Elsevier, New York, 1991; and A. Randall, "Total and Non-Use Values", Chapter 10 in Braden and Kolstad (eds.) 1991.

4. From a theoretically strict viewpoint, the above measure of value is correct in this case, only if the good in question (i.e., visits to the water source) and the environmental quality attribute (i.e., cleanness of water) are weak complements (Maler 1974).

5. In a recent paper, Maler (1992) classifies valuation methods into two broad groups: (1) Surveys of Willingness to Pay (like contingent valuation), and (2) Production Function based. He divides category (2) into two sub-categories: (2a) output measurable in markets (corresponding to the second column in Table 3.1—conventional markets); and (2b) output not measurable (other methods in Columns 2 and 3 of Table 3.1).

6. For an introductory overview relevant to natural resource analysis, see Munasinghe, M. 1992. *Water Supply and Environmental Management*, Boulder, CO: Westview Press. An extensive survey including references to about 150 applications has been done by C. Romero and T. Rehman. 1987. pp. 61-89. A shorer, but more recent, survey is by F. Petry. 1990.

7. For more details, see P. Dasgupta, et al 1972; A.C. Harberger, 1976; and Little and Mirrlees, 1974.

8. Assuming a consumption based numeraire for welfare W, we may write W = W(c). Then $\beta = -\{c(d^2W/dc^2)/(dW/dc)\}$ and $g = (1/c)(dc/dt)$. Marginal welfare increases with consumption: $(dW/dc) > 0$; but at a declining rate: $(d^2W/dc^2) < 0$. Therefore $\beta > 0$, so that the sign of the term (βg) is the same as sign of g. (See Dasgupta & Heal 1979, chapter 10, for details).

9. For an example where the discount rate is endogenized and reflects future consumption, see Uzawa 1969.

10. See Pearce and Turner 1990, and Fisher and Hanemann 1987.

PART II: CASE STUDIES

4. Short Case Studies of Environmental Valuation

In this section shorter case studies from developing countries are briefly outlined. For ease of reference, they are grouped according to the valuation techniques described earlier. While the case studies are not necessarily ideal and exhibit various shortcomings, the main purpose of the exposition is to illustrate the implementation of some of the techniques of environmental impact valuation. 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. Because developing country examples describing attempts to estimate option, existence, and bequest values are rare, several studies applied to the industrialized countries are also presented.

Effect on Production Method

Cost-Benefit Analysis of Land Improvement in Lesotho[1]

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 of two cultivation options is carried out that compares a high commercial input alternative (implying the use of 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 real marginal internal financial rate of return of minus 21 and minus 30 percent, respectively for the two alternative options.

An economic cost-benefit analysis is performed, distinguishing between productivity gains due to increased use of commercial inputs, and impacts due to increased soil conservation. Unlike in the earlier financial analysis, soil conservation measures are included here, as the calculation covers a five-year period. Costs are primarily labor and material input costs. This analysis is carried out taking into account the perspective of the Lesotho government and the donor agency, the Swedish International Development Authority (SIDA). Primary benefit categories include increased production of sorghum and maize (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 details in Annex 2), the results of the base case are an NPV of minus M 7.0 million at a discount rate of 10 percent and minus M 5.6 million at 1 percent. Table A 2.2 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 is oriented towards production rather than preservation). 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 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 of its reliance on low-cost, labor-intensive field techniques.

Valuation of an Amazonian Rainforest[2]

Most financial appraisals of tropical forests have focused exclusively on timber resources and have ignored the market benefits of non-wood products, thus providing 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 US$6,820 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 US$3,184 for timber and pulpwood obtained from a 1 hectare plantation in Brazilian Amazonia, and an NPV of US$2,960 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. The broader validity of the results for remote areas is doubtful, since this study was carried out for an area that was quite close to a market town.

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.[3] 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.

Effect on Health Method

Economic Analysis of a Water Supply and Health Program in Zimbabwe[4]

Fredriksson and Persson (1989) evaluate the Manicaland Health, Water and Sanitation Program in Zimbabwe using social cost benefit analysis. The objectives of the program are to improve living conditions in the communal areas of Manicaland through: (i) improving existing and constructing new water supplies that ensure an acceptable quantity and quality of water for domestic use and that are reliable and accessible to the community; (ii) improving sanitation conditions by constructing latrines and consequently preventing fly breeding and the transmission of disease; and (iii) providing health education to improve hygienic practices and motivate behavioral changes.

The domestic price of labor is used as a numeraire. The shadow price of foreign exchange was estimated to be Z$1.75 per US$ in the analysis.

The shadow price of unskilled labor is set at zero in the dry season, due to unemployment in Zimbabwe. In the peak season, there is a shortage of labor. As uncertainty exists because of possible delays in the harvest, a sensitivity analysis is made in the evaluation, where the shadow wage of unskilled labor is set to 100%, 75% and 50% of the market wage of Z$0.46 per hour. The opportunity value of children's labor is set to zero during the whole year. (This is a little surprising, given that children represent a significant labor force in many developing countries). For skilled labor, the shadow wage is set at the market wage.

The social discount rate is assumed to be the rate of return in the private sector, which would mean a real social discount of 4.86% since the commercial bank lending rate to the industrial sector at the end of 1987 was 14.75% and the inflation rate was 9.89%. A time horizon of 40 years was established which was the duration time of benefits from the project.

Materials supplied by the project were valued at market prices. Community input is valued at the opportunity cost of unskilled labor. The constructor is assumed to be paid the shadow price of skilled labor.

The change in consumer surplus is determined by calculating the average price for water collected in the wet season and dry season, both before and after the project. The price of water in the wet season is calculated using 75 peak period days with no energy savings but with a shadow wage greater than zero. In the remaining 105 days energy is saved and the shadow wage equals zero. Using this information, the change in consumer surplus is then calculated at shadow wages of 50%, 75%, and 100%.

Cost of illness estimates consist of treatment costs, costs of lost production and costs for extra transportation. Since willingness to pay for healthier and longer lives was not estimated, the values used significantly underestimate the true values. For treatment costs, the costs for private treatment are used as the opportunity cost.

A life saved would be valued very highly by the individual concerned and his/her family. From society's viewpoint, a lower bound or minimum estimate of the gain from a life saved is derived by the authors using future production and consumption. The weighted average of the wage adjusted for both unemployment and the income in communal lands is used as an estimate of a child's future production, and future consumption is estimated as final household expenditure per capita. The net present value of the difference between production and consumption is the net output gained by saving the child. The same measure is utilized to determine net present output produced by an adult's life if he/she is saved today.

Sensitivity analyses were conducted for social discount rates of 2%, 4.86%, 7.24% and 9%; disease reductions of 40%, 70%and 100%; and wet season shadow wages for unskilled labor of 50%, 75%, and 100% of the market wage for casual workers on commercial farms in Manicaland. In the base case, with an estimated social discount rate of 4.86%, shadow wage 100% of the market wage, and a 100% health improvement, the internal rate of return was greater than the social discount rate and the net present value of the project was strongly positive. At a social discount rate of 7.24%, estimated in the alternative approach, the project is not found profitable even if a shadow wage of 100% and 100% disease reduction is achieved.

While most of the benefits come from disease reduction, it must be pointed out that benefits are probably underestimated through the use of a lower bound. This is because the value of a saved life has been underestimated, through the use of a lower bound. Secondly, the paper does not take into account other benefits such as local industry that would benefit from improved water supply. Third, as income distribution will probably improve as a result of the project, benefits could have been given a greater weight. The authors conclude that the project is a success from an overall societal point of view.

Travel Cost and Contingent Valuation Methods

The Consumer Surplus From Visits to a Costa Rican Rainforest[5]

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 $1,250 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.

It is unclear, however, whether the authors assess the cost (in foregone earnings) of time spent at site. It would have been useful to have a clearer definition of their term "cost of travel time."

In addition, they use a linear demand function 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.

As in the Costa Rican study, 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.

The Value of Viewing Elephants on Safaris in Kenya[6]

The travel cost method was used to estimate a demand function for safaris in Kenya. The analysis is based on the 80 percent 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 percent to reflect the fact that vacation time is valued at lower than the gross wage rate. A weighted average consumers' surplus of US$725 is estimated. This gives a total consumer surplus for those on safari in the range of US$182 million to US$218 million 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 percent of total enjoyment. Therefore, the estimated economic value of a safari yields a viewing value for elephants of US$23 million to U$27 million 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 US$22 million to US$27 million and US$25 to US$30 million, 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 US$25 million. Although these estimates are rough, they are a useful guide to the order of magnitude of value.

The Willingness to Pay for Water Services in Haiti[7]

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.

The mean of WTP bids for public standposts represented 1.7 percent of household income, while the mean WTP bid for private connections was 2.1 percent of household incomes. These bids are significantly lower than the 5 percent rule-of-thumb often used in rural water supply planning as an estimate of 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 in a case involving a familiar (basic need) commodity,it is possible to obtain reasonable, consistent answers in a contingent valuation survey conducted among a very poor, illiterate population. Contingent valuation is likely to see greater future use in developing countries; for collecting information on individuals' willingness to pay for various public infrastructure projects, and (with more difficulty), also for environmental protection services (such as the treatment of industrial wastewater flowing through residential areas).

Willingness to Pay for Improved Sanitation in Kumasi, Ghana[8]

Willingness to pay was estimated through a contingent valuation approach in Kumasi, Ghana (Whittington et al., 1992). Options provided to consumers were water closets with a piped sewerage system and ventilated pit latrines (KVIPs). KVIPs provided a cheaper option for sanitation, as they did not require sewer connections and installation of water closets.

Households that already had connections to water were asked their WTP for a water closet and a KVIP. Households with water closets were asked the amount they would pay for a sewer connection. Results showed that WTP for a WC or a KVIP was roughly the same for houses without WCs. Households with bucket latrines were willing to pay the lowest for KVIPs; those using public latrines bid significantly higher prices, up to 30-35% more, which demonstrated dissatisfaction with the inconvenience and lack of privacy in the public systems. Overall mean bids of around $1.5 per month compared to average existing expenditures of about $0.5 per month. WTP was found to be less than costs of supply.

The study concludes that the required subsidy for a WC system for Kumasi would amount to $60 million. The required overall subsidy would be $4 million for the KVIP system. Although benefits of improved health were not estimated, a subsidy would probably be justifiable in terms of benefits to public health.

Value of a Thai National Park[9]

In a 1980 study, TC and CVM methods are used to estimate the economic value to Bangkok residents, of the Lumpinee Park in Thailand. The study is unusual in that the urban setting is not usually considered suitable for a travel cost approach. However, even with short visits and minimal travel time and costs to use the park, the analysis still confirmed the expected inverse relationship between travel costs and number of visits.

The TC model used was of the standard form—visitation rates were assumed to be a function of total travel cost, availability of substitute sites, and income. The total travel cost variable included both out-of-pocket travel costs plus the monetary value of time spent traveling, using a representative wage rate. 187 people were interviewed and divided into 17 zones of origin within Bangkok. A regression equation of visitation rates on travel cost was estimated, and a demand curve derived for public use of the park. The area under the curve, (the consumers' surplus of park users), was estimated at 13.2 million baht a year.

The 187 persons interviewed for the TC study were also interviewed for the CVM study. Visitors for recreational purposes indicated a slightly lower WTP for yearly contributions to maintain the park than visitors for morning and evening exercise purposes. However, the latter group's willingness to pay per visit was less than that of recreational users.

An additional 225 people were interviewed throughout Bangkok, including people who had never used the park, in an attempt to estimate the broader "social" value of the park. When CVM results were adjusted by the appropriate age-corrected population figures, the WTP measure of park users was estimated at 13 million baht per year, and for the survey of Bangkok residents, 116.6 million baht per year, (thus demonstrating the more realistic WTP of constant users of the park). The consumers' surplus and welfare gain associated with the continued existence of the park is clearly demonstrated.

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

Hardly any developing country examples are available in this category, and a cautious approach is recommended. For illustrative purposes, four U.S. examples are provided below. These studies all used the contingent valuation approach to obtain actual measures for option, existence, and/or bequest values. The first case was quite possibly the earliest survey that developed a methodology to attempt to determine existence value. Both this first and the second studies, while revealing the significance of existence values, examine them as an adjunct to their main focus, which is recreational use value. The third case 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. The fourth study is basically an attempt to measure the effects of information disclosure (endangered status and physical appearance) on existence values for endangered species.

Existence Value of Preserving Visibility[10]

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 the focus. 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 higher electric power bills 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 nonuse value was an important component in the respondents' bids.

Option Price and Existence Value of Wildlife[11]

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 human activity in the area. A mail survey was sent out, with questions being directed towards hunters and nonhunters. Hunters were asked their WTP for a "stamp" allowing them to hunt in new hunting areas in either five or fifteen years for grizzly bear or bighorn sheep. Respondents were each confronted with only one time horizon. The probability of supply was variable. Nonhunters 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 US$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).

Option, Existence, and Bequest Values of Wilderness[12]

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: recreational 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 survey households and by 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. In-state wilderness users had a much higher option value than nonusers, indicating that recreational 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, a wide range of workers (skilled and unskilled) would pay US$1.50 more for existence demands than would persons in other occupations. Bequest value was not influenced by the number of children living at home with respondents. 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 US$6.15 more for bequest demand than were other respondents. All income groups valued bequest demands about equally.

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 value for wilderness.

Existence Value of Endangered Species[13]

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 United States. 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 percent from their original values, and the control group increased their bids by 20 percent. 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.

Finally, all control and experimental subjects were asked to fully allocate a lump-sum windfall gain of $30 among preservation funds for three animal species, given four scenarios, 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, the subjects' willingness to pay to preserve each species was nearly equal. Given information on physical appearance, they allocated more 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.

Notes

1. This case study is derived from J. Bojo 1991.
2. This case study is derived from Peters, et. al. 1989.
3. World Bank (1992).
4. This case study is derived from Fredriksson and Persson, 1989.
5. This case study is derived from Tobias and Mendelsohn, 1991.
6. This case study is derived from Brown and Henry, 1989.
7. This case study is derived from Whittington, et al. 1990.
8. This case study is derived from Whittington et al., 1992.
9. This case study is derived from Grandstaff and Dixon in Dixon and Hufschmidt (eds.), 1986.
10. This case study is derived from Schulze, et al. 1983.
11. This case study is derived from Brookshire, 1983.
12. This case study is derived from Walsh, et al. 1984.
13. This case study is derived from Samples, et al. 1986.

5. Two World Bank Valuation Case Studies

The two longer case studies in this section were carried out recently in the World Bank, and use combinations of valuation methods to facilitate decisionmaking.

Valuation of Biophysical Resources in Madagascar[1]

In the last two decades, environmental and resource economists in industrialized countries have developed non-market techniques for the valuation of environmental costs and benefits. These methods have been successfully applied in developed countries although they have rarely been used in developing countries where the need for national park creation is typically much higher. In this section, the estimation of the non-market costs and benefits of establishing a national park on nearby villages, and valuation of the park as an international tourism destination are discussed. The results summarized below are from the first stage in the analysis to arrive at a rational decision concerning the proposed creation of the Mantadia National Park in Madagascar. Further details are available in Kramer, Munasinghe, Sharma et al. (1992).

Madagascar is one of the economically poorest and ecologically richest countries in the world, and it has been designated by the international community as a prime area for biodiversity whose ecosystems are also at great risk. Madagascar is on IUCN's list of megadiversity countries because of its extraordinarily high rates of species endemism. As a result of the enormous biodiversity, the international donor community is providing large sums of money in order to save as much of Madagascar's biodiversity as possible. The government of Madagascar is also taking steps to control forest degradation and to protect biodiversity.

Three main methods for the valuation of environmental impacts are applied here—the contingent valuation, the travel cost, and the opportunity cost approaches.

The creation of a national park generates many both indirect and direct costs and benefits. Costs arise from land acquisition (if the land had been previously privately owned), the hiring of park personnel, and the development of roads, visitors' facilities, and other infrastructure. Another important set of costs that are often ignored are the opportunity costs associated with the foregone uses of park land.

Benefits include both use values and non-use values. Most parks do not allow exploitation of forest resources, and the primary uses are therefore for tourism and research. Tourism can generate considerable revenues for the country from both entrance fees and travel expenditures. National parks also generate a number of non-use benefits, among which existence value and option value are important. Existence value is defined as the willingness to pay (WTP) to preserve the park—by individuals who never plan to use it. Option value is defined as the willingness to pay to maintain the park for possible use in the future. Other benefits may include reduced deforestation, watershed protection and climate regulation. This study focuses on the measurement of some of the more important and more difficult to measure economic impacts, namely the impact of the park on local villagers and the benefits of the new park to foreign tourists.

Opportunity Cost Analysis

The opportunity cost approach uses standard economic analysis based on market values, to determine the net economic benefits associated with alternative uses of one or more resources. In this case, the relevant opportunity costs would be those associated with the alternative uses by people living near and in the park. The creation of the park imposes a considerable economic burden on the local population. The opportunity cost is estimated by determining recent land use and by projections of future land use changes in the absence of a national park.

There are no human settlements within the Mantadia National Park boundaries, but several villages lie in close proximity. The villagers depend on the forests in and around the park for forest products and agriculture. The form of shifting cultivation used for agriculture production in eastern Madagascar is critically important as a mechanism for deforestation. It is also the only means of livelihood known to many of the inhabitants of the region. Furthermore, fuelwood is collected from the forests, a wide range of fish and animals are consumed, and a number of different types of grass are harvested and used for assorted purposes.

The opportunity costs associated with these economic activities were estimated using a survey of 351 households in 17 villages within a 7.5 km radius around the park boundary. The survey was administered by a local NGO well versed in rural survey techniques, and it was undertaken following a reconnaissance visit to the village, several focus group interviews, conversations with people well acquainted with the area, and a pretest covering 25 households. It was administered in Malagasy, the national language.

The questionnaire focused upon (i) establishing the extent of the dependence of the local villagers on forests nearby for obtaining a wide variety of forest products; (ii) establishing the extent to which the villagers used the forest for shifting cultivation; and (iii) assessing local attitudes toward conservation of the forests. Questions related to socio-economic variables, land use, time allocation, and household production activities were also asked. The final section used the contingent valuation method discussed below.

A separate questionnaire was administered to the village leaders. It focused on issues pertaining to general agricultural patterns, markets and prices of goods sold, village history and migration patterns, forest related cultural issues, and details on shifting cultivation practices.

Contingent Valuation Method

The contingent valuation method (CVM) uses survey techniques to establish the value of goods and services which are not usually exchanged in markets.

In this study, the CVM was used in both the village survey and the tourist survey. In the tourist survey, the CVM was used as an alternative method to the travel cost method for estimating the total value of the park to the tourists. These questions were phrased in terms of how much more the foreign tourists would have been willing to pay for their trip, if the new park had been created for them to visit. These questions were also pretested and revised prior to the implementation of the tourist survey.

The village survey had to be modified, to overcome constraints. For example, in devising the questions for the village survey, initially it appeared from villager responses that they were willing to pay to protect the forest. However, it transpired that this response was not related to perceived non-use benefits from the park, but rather was the result of a sense of coercion arising from arrests of villagers by local authorities, for incursions into the park area. The questions were therefore reformulated in terms of willingness-to-accept compensation for being denied access to forestland within the park.

Travel Cost Method

Travel cost models use the amounts of time and money visitors spend traveling to a site as the price proxies, together with participation rates and visitor attributes, to estimate the recreational value of the site. Recreation in Madagascar's national parks contrasts sharply with the standard assumptions that the trip is a single-purpose, single destination day-trip to a site that affords some particular recreational experience or typical quality which can be substituted for those available at similar sites. Instead, recreators in Madagascar can be divided into two groups consuming distinct goods: (i) local visitors who make day trips to national parks to view the local natural environment; and (ii) international tourists who undertake lengthy trips to experience unusual natural settings and cultures. This part of the study focuses on the second aspect. The novel international travel cost method used here is summarized in Annex 3, and presented in full in Mercer and Kramer (1992).

The method is based on the assumption that individuals travel to a single country where they engage in a variety of activities. Estimating the model requires specific data on how each household distributes its time across activities during the time horizon of the model, and ideally it implies the collection of full trip itinerary data as well as travel cost information for foreign visitors. The itinerary data includes the distribution of time between activities for each individual, the costs of pursuing such activities, and the features of the various activities that lead to differences across individuals in their ability to undertake them.

Based on the theoretical model, several questionnaires were prepared and translated into French and administered to visitors in the small Perinet Forest Reserve adjacent to the Mantadia National Park. The questions consisted of questions on the cost of the current trip to Madagascar, details of previous nature related tourist trips, the process for deciding on trip destinations, contingent valuation questions for the willingness to pay for visits to the Mantadia National Park, and a series of socio-demographic and economic questions. In addition, a "Madagascar Trip Diary" was developed which elicited detailed itinerary, cost, time, and quality information for the current trip to Madagascar. The questionnaires were tested in the US with a focus group of previous visitors to Madagascar, and in Madagascar the questionnaires were revised following pretests with a small sample of visitors to the Perinet Reserve and discussions with local Malagasy collaborators. Due to political unrest in Madagascar during the time of the survey, only 94 surveys were completed, including a 14% return rate on the travel diaries. Although this data set is inadequate for full implementation of the international travel cost method, the estimates of mean willingness to pay to visit the new park derived from it provide useful insights.

Preliminary Empirical Results

The average household size in the surveyed villages was 4.6 persons. In 1988, average per capita income was $190 in Madagascar, and the villages in the survey may well have incomes lower than the average. Several villages are very isolated, and many do not have access to medical facilities, running tap water, electricity and primary schooling. Approximately 95% of the households own land, and the average amount of land owned is 1.9 hectares per household (see Table 5.1). In the survey, 36% of the households own a watch, 33% own a radio and 97% have a kerosene lamp to light their huts. The average household produces 487 kg of paddy rice per year, or about US $128 worth of rice. Most households also engage in shifting cultivation. Eighty percent of the households surveyed said that they would add to existing land for cultivation. Ninety-nine percent of these acknowledged that they planned to cut forests to add to their land. The average household planned to cut 1.6 hectares of forested land in the coming year to undertake shifting cultivation.

The survey indicates that fuelwood is the most important forest product collected (see Table 5.2). The average household collects about 6,164 kgs, or about US $38 worth of firewood per year. The total value of collected firewood is $13,289 per year. Total value of other collected forest products is US$ 818.

To estimate the opportunity cost to villagers of establishing the Mantadia National park, income from agricultural and forestry activities was estimated for three different groups of villages. The mean value of losses was $91 per household per year. Aggregating over all households living in the vicinity of the park and using a 10% discount rate and twenty year time horizon, the net present value of the opportunity costs was estimated to be $556,010.

The contingent valuation study of the villages indicates the villagers' perceptions of the forest. Forty percent seemed to think that forests do not help soil protection, although sixty-five percent agreed that floods occur less frequently with forests. Interestingly, 91% of the respondents agreed that primary forests are "more fun" than secondary forests, which suggests a recreational value of the forests, but 77% of the respondents did not think that preserving forests in order to preserve ancestral graves was very important. Finally, 68% of the respondents thought that it is advantageous to clear the forests as a form of pest management.

The responses to the contingent valuation questions indicate that on average, a compensation of rice equivalent in value to $108 per year per household would make households as well off with the park as without. Aggregating over the population in the park area, this implies a necessary one time compensation of approximately $673,078, assuming a 10% discount rate and twenty year time horizon.

In the tourist survey, income for the visitors ranged from $3,000 to $300,000 with a mean of $59,156 (see Table 5.3). The average tourist was 39 years old and had completed 15 years of education. Visitors came from 13 countries. Trips ranged from 3 to 100 days in length, with a mean of 27 days, and with 1-8 days spent at Perinet (mean of 2 days). Expenditures for the trip ranged from $335 to $6,363 with an average trip costing $2,874. The mean transport cost to reach Madagascar was about $1,390 while transport costs within the island averaged almost $590. A further breakdown of tourist charac-

Table 5.1 Land Use Information for Villages

Variable	Number of Observations	Range	Mean
Total quantity of farmland per household (hectares)	311	0 to 9	1.89
Planned increase in cultivated land per household (hectares)	256	0 to 10	1.70
Annual quantity of farmland planted with rice per household (hectares)	289	0.04 to 5	1.04
Total annual rice yield per household (kilograms)	296	2 to 3,600	487.00
Total annual quantity of rice marketed per household (kilograms)	249	0 to 990	41.80
Total annual value of rice yield per household ($)	296	$0.5 to 1,101	$128.00

Table 5.2 Value of Forest Products Collected by Villagers

Forest Products	Number of Observations	Total Annual Value for all Villages ($US)	Mean Annual Value per Household ($US)
Fuelwood	316	13,289	38.0
Crayfish	19	220	12.0
Crab	110	402	3.7
Tenreck	21	125	6.0
Frog	11	71	6.5

teristics by country of origin, showed considerable diversity (see Table 5.4).

Using data from the tourist survey supplemented by data from a separate survey of travel experts, an econometric analysis was performed to apply the travel cost method. The model, known as a random utility model, examines the allocation of trip choices to international nature tourism destinations as a function of travel costs, socioeconomic characterisitics, and quality variables. The model was used to project benefits to tourists that would result from a 10% improvement in facilities at the park. The average increase in willingness-to-pay was estimated to be $24 per tourist, resulting in an annual benefit to foreign tourists of $93,600, based on the current annual visitation rate at the Perinet Reserve.

Table 5.3 Summary Statistics for Complete Sample of Tourists

Variable	Number of Observations	Range	Mean
Income	71	$3,040 to 296,400	$59,156
Education	86	10 to 18 years	15 years
Age	87	16 to 71 years	38.5 years
Number of Days in Madagascar	83	3 to 100 days	26.6 days
Number of Days in Perinet	80	1 to 8 days	2 days
Total Cost of Trip to Madagascar	78	$335 to $6,363	$2,874
Total Cost to Madagascar	47	$352 to 5,000	$1,388
Total Cost in Madagascar	43	$8 to 2,000	$588

Table 5.4 Summary Statistics for Tourist by Country of Origin

Country	Percent of Sample	Mean Expenditure ($US)	Mean Number of Days in Madagascar	Mean Number of Days in Perinet	Mean Age (years)	Mean Education (years)	Mean Income ($US)
Britain	20.2	3,332	18	1.6	45	15.8	36,891
Italy	21.4	2,357	21.4	1.9	34	14.2	112,000
France	15.5	2,481	36	1.9	34	15	63,197
Germany	11.9	3,172	24.8	1.8	40	15	42,304
Switzerland	11.9	3,200	37.6	2.3	36	15.6	51,243
USA	4.8	3,097	18.5	2.75	49	16.5	53,515
Other (7 countries)	14.3	2,726	26.6	2.91	40.8	14	33,997

At a 10% discount rate, this would generate a net present value of $796,870 of benefits associated with the park over twenty years.

Utilizing the contingent valuation method, in a discrete choice format, the mean bid for tourists to view the new park (conditional on seeing the same number of lemurs) was $65. Assuming current visitation patterns continue, the total additional willingness-to-pay to visit the new park would be $253,500 annually. This amounts to $2.16 million as the present value for the stream of benefits over 20 years—again assuming a 10% discount rate.

Conclusions

Several tentative conclusions can be drawn from the early results of this study. Non-market valuation techniques can provide useful information for eco-

Table 5.5 Summary of Economic Analysis of Mantadia National Park

Estimates of Welfare Losses to Local Villagers from Establishment of Park

Method Used	Annual Mean Value per Household	Aggregate Net Present Value
Opportunity Cost	$91	$673,078
Contingent Valuation	$108	$566,070

Estimates of Welfare Gains to Foreign Tourists from Establishment of Park

Method Used	Annual Mean Value per Trip	Aggregate Net Present Value
Travel Cost	$24	$796,870
Opportunity Cost	$65	$2,160,000

nomic evaluation of national parks. A major strength of this study is the opportunity to compare valuation techniques (Table 5.5). For the village component, the estimated welfare estimates based on two entirely different methods, opportunity cost analysis and contingent valuation method, were remarkably similar ($91 and $108 per household per year). The estimates of tourist benefits based on the travel cost method and contingent valuation method were somewhat more disparate ($24 versus $65 per trip) but it is noteworthy that the benefit estimates are of the same order of magnitude. It is important to note that the higher contingent valuation estimate may reflect some non-use values, while the travel cost method is for use value only.

Further, research of this type would have implications for policy, investment decisions, resource mobilization, and project design and management. The information can help governments decide how to (a) allocate scarce capital resources among competing land use activities, and (b) choose and implement investments for natural resource conservation and development. Results can also be used in determining or influencing pricing, land use, and incentive policies. At the local level, the findings can be used to determine compensation for local villagers for foregone access to forest areas designated as national parks. In addition, the research findings can show the value of a park as a global environmental asset to foreigners, thus influencing the external assistance for conservation programs at the local level.

At the same time, the early findings indicate future issues. Reliance on WTP is fundamental to the economic approach, but tends to overemphasize the importance of value ascribed to richer foreign visitors. If conflicting claims to park access were to be determined purely on this basis, residents (especially, the poor local villagers) are likely to be excluded. Therefore, as indicated in the introduction, the sociocultural concepts of sustainable development (especially intragenerational equity and distributional concerns) would need to be invoked to protect the basic rights of local residents—perhaps in the form of a "safe minimum" degree of access to park facilities.

Improving Decisionmaking in the Sri Lanka Power Sector[2]

The incorporation of environmental externalities into decisionmaking is particularly important in the power sector, where environmental concerns (ranging from greenhouse gas emissions of fossil-fueled plants to the impacts of inundation at hydro plants) have posed increasingly difficult constraints to project implementation. It is also clear that in order for environmental concerns to play a real role in power sector decisionmaking, one must address these issues early—at the sectoral and regional planning stages, rather than only at the stage of project environmental assessment.

Unfortunately, as soon as one is dealing with power sector issues at this aggregate planning level, the application of many of the project-level valuation techniques discussed earlier becomes extremely difficult, for two main reasons. The first is the nature of the impacts themselves—the health effects of pollutants from coal fired generating stations, the potential loss of biodiversity associated with large scale hydro reservoirs, the impacts of greenhouse gas emissions—all are exceptionally difficult to value. Indeed, attempts to do so would very likely focus attention on the validity of the valuation techniques themselves, rather than the policy trade-offs that must be made. The second reason concerns the scale of analysis. Many of the techniques discussed in this paper are most appropriate at the micro-level: the use of the contingent valuation approach is much more valid where respondents can be asked specific questions about impacts of a particular project to which they can relate—as the previous example of Madagascar illustrates well. However, this may be very difficult to apply in situations where one is dealing with a potentially large number of technology, site and mitigation options.

It is in these kinds of situations that the techniques of multi-criteria analysis (MCA) may be applied. Such techniques first gained prominence as practical evaluation tools in the 1970s, when the intangible environmental externalities lying outside conventional CBA methodologies were increasingly recognized. It also met one objective of modern decisionmakers, who preferred to be presented with a range of feasible alternatives as opposed to one "best" solution. As explained earlier, MCA allows for the appraisal of alternatives with differing objectives and varied costs and benefits, which are often assessed in differing units of measurement.

Such an approach was used by Meier and Munasinghe (1992) in a study of Sri Lanka. The objective was to demonstrate how environmental externalities could be incorporated into power system planning in a systematic and efficient manner. Sri Lanka presently depends largely on hydro power for electricity generation, but over the next decade there seems little choice other than to begin building large coal- or oil-fired stations, or to build hydro plants whose economic returns and environmental impacts are increasingly unfavorable. In addition, there are a wide range of other options (such as wind power, increasing use of demand side management, and .system efficiency improvements), that make decisionmaking quite difficult—even in the absence of the environmental concerns. The study is relatively unique in its focus on these kinds of planning issues, as opposed to the more usual policy of assessing environmental concerns only at the project level after the strategic sectoral development decisions have already been made.

Environmental Issues

Sri Lanka (see map in Figure 5.1) is one of the more densely populated countries of the world, and land availability is an important issue. In general, hydro plants are in the wet zone areas where there is little vacant land nearby for resettled inhabitants to relocate, while land that is available at greater distances is often seen by potential evacuees as undesirable because of questions concerning the availability of adequate water supply. A rough but effective way of comparing the likely extent of potential land-related environmental impacts across projects is the area inundated per KWh of capacity. This varies between zero and as much as 150 hectares per KWh. The correlation between the installed capacity and the amount of land to be inundated is poor; large projects do not necessarily mean worse environmental impacts and vice versa.

The progressive loss of Sri Lanka's natural forests over the past 50 years is well documented, and is one of the country's most important environmental concerns. Power sector projects will be scrutinized very carefully for their potential impact on what natural forest areas remain, even if it is true that the power sector per se has been a relatively minor contributor to the loss of forest lands. The main reason for deforestation in the past has been planned agricultural development and settlement schemes, chena cultivation, encroachment by unplanned settlement and cropping, illicit logging and uncontrolled fuelwood and timber extraction.

Relatively little is known about ambient air quality in Sri Lanka. In most parts of the country the air quality is fairly good, a reflection of the limited extent of industrialization except in Colombo, and the natural ventilation provided by strong monsoonal winds. In Colombo, however, the sharp increase in automobile and bus traffic over the past decade has led to strong indications of increasing deterioration of air quality. Nevertheless, based upon what we do know about patterns of energy utilization certain inferences can be drawn. It is fairly certain that at present the power sector contributes only marginally to air pollution in Sri Lanka. However, this is expected to change significantly once the anticipated coal burning power plants are added to the system beginning in the late 1990's.

Acid rain is likely to become an increasingly important environmental issue in the Asia-Pacific region given the fact that the energy plans in many countries, in particular India and China, call for rapid development of fossil energy systems. Acid rain is largely a long-range phenomenon, and it is fairly obvious that the extent to which acid rain is or will be experienced in Sri Lanka is as much a function of emission trends of acid rain precursors in India as in Sri Lanka itself.

Global warming and transnational acid rain are conceptually different from local environmental impacts, since in the former case the impacts will occur predominantly in other countries. If the main economic objective is to maximize welfare in Sri Lanka, decision-makers in Sri Lanka would be unwilling to incur additional costs if the benefits of such actions accrue mainly to other nations. In this case study, it is assumed that Sri Lanka will be reimbursed by the international community for the incremental costs of global warming mitigation efforts, or that the Government would have signed an international agreement committing itself to undertake certain CO2 emission reduction measures.

Because Sri Lanka is a small island, which has been isolated for relatively long periods, there are a large number of endemic species. Among Asian countries, Sri Lanka has the highest level of biological diversity. The NSF Committee on Research Priorities in Tropical Biology identifies Sri Lanka as demanding special attention. Biological diversity is under threat in Sri Lanka primarily from the progressive reduction in its natural forests and other natural habitats, especially through the selective exploitation of tree species, particularly for timber. Therefore, the power sector is likely to come under intense scrutiny from this perspective.

As the generation mix shifts from one that is predominantly hydro to one in which large baseload fossil-fueled plants play an increasing role, it is inevitable that sites will need to be found on the coast to accommodate such thermal plants. The economic importance of preventing environmental degradation in the coastal zones is well established. Foreign tourism, an important source of foreign exchange, is largely focused on the country's sandy beaches and coastal estuaries and lagoons. The marine fishery industry provides employment to some 100,000 persons, and is the largest source of animal protein for Sri Lanka. The main environmental issue concerns the discharge of heated effluents into waters of the coastal zone, where there exist numerous ecosystems that are extremely sensitive to temperature increases, including 1) coral reefs, sea grass beds, benthic communities, mangrove stands, rocky and other shores, 2) zooplankton and phytoplankton communities which are free floating, and 3) nursery grounds for fish and prawns.

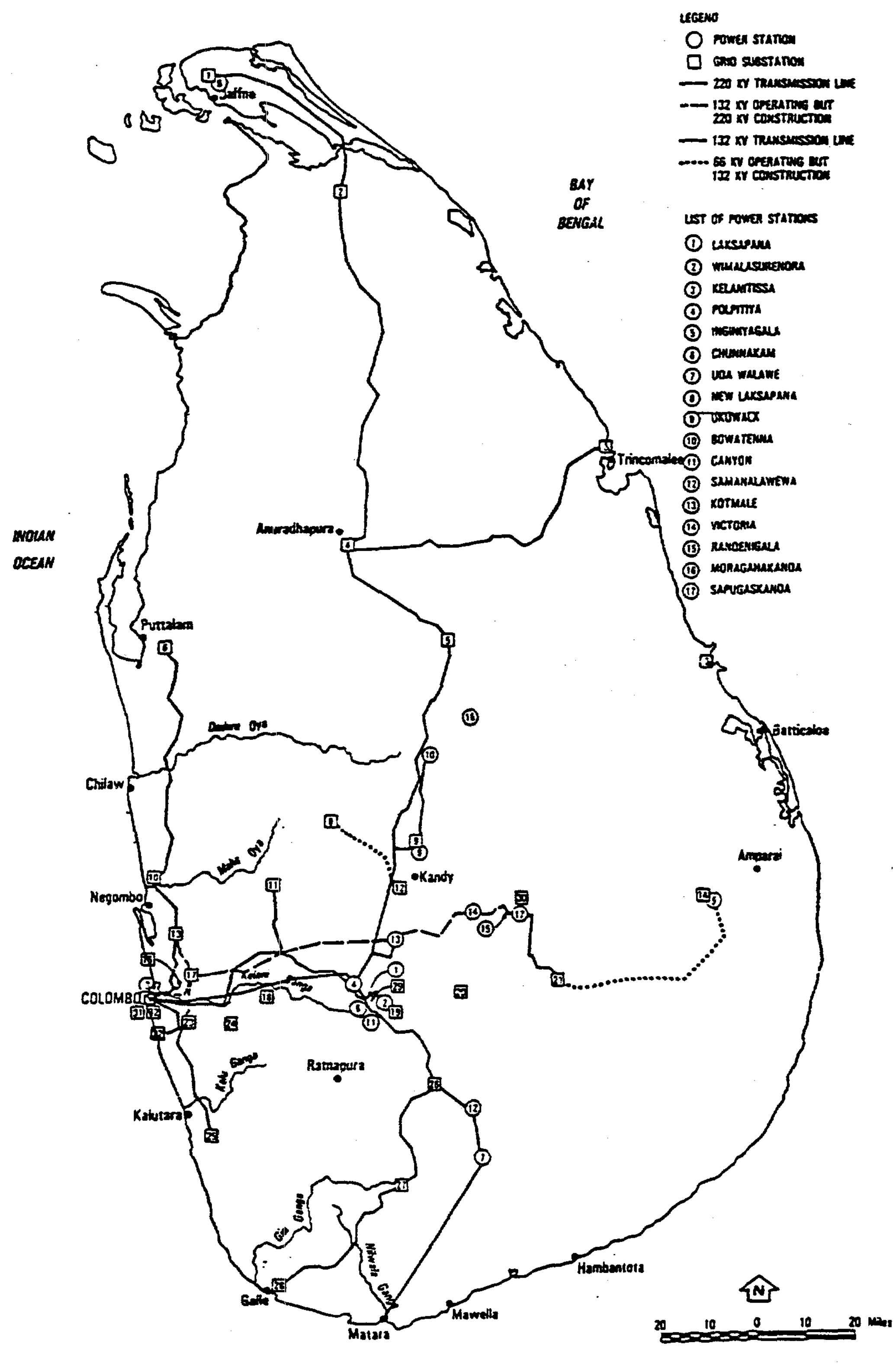
Methodology

Multi-criteria analysis has been developed expressly for situations where decisions must be made taking into consideration more than one objective which cannot be reduced to a single dimension. Its central focus is the quantification, display and resolution of trade-offs that must be made when objectives conflict. In the case of application to the power sector, there may well be strategies that have beneficial impacts on both environmental and economic objectives—most energy efficient investments that are economically justifiable also bring about a reduction in emissions and hence improve environmental quality as well as economic efficiency. But most options require that trade-offs must be made: wind plants, for example, potentially provide substantial environmental benefits but are more expensive than other options.

The overall methodology is illustrated in Figure 5.2, and involves the following steps:

- The definition of the options to be examined.
- The selection and definition of the attributes, selected to reflect planning objectives.
- The explicit economic valuation of those impacts for which valuation techniques can be applied with confidence. The resul-

Figure 5.1 Sri Lanka



tant values are then added to the system costs to define the overall cost attribute.

- The quantification of those attributes for which explicit economic valuation is inappropriate, but for which suitable quantitative impact scales can be defined.
- The translation of attribute value levels into value functions (known as "scaling").
- The display of the trade-off space, to facilitate understanding of the trade-offs to be made in decisionmaking.
- The definition of a candidate list of options for further study: this also involves the important step of eliminating from further consideration options that are clearly inferior.

In some applications it may be appropriate to add two further steps: the definition of weights for each attribute, and the application of an amalgamation rule to provide a single overall ranking of options. However, the Sri Lanka case study did not follow this approach.

Application to the Sri Lanka Power Sector

Policy option definition: A variety of options were selected for study,including a whole range of siting, pollution control mitigation and technology options. Indeed, it is very important that as few a priori judgements as possible are made about the "feasibility" or "practicality" of options, because for the analysis to be useful, meaningful trade-offs must be examined. For example, in the case of the Trincomalee coal fired power plant (on the north-east coast—see Figure 5.1), the environmental impact assessment prepared in the mid 1980s considered only a very narrow range of options: all alternatives studied involved sites on Trincomalee bay, with once-through cooling to a shallow bay inlet. Other south coast sites had been eliminated earlier on grounds of high cost (because these sites could not accommodate large coal transport vessels, resulting in higher transport costs). Yet the additional costs of an evaporative cooling system, or of an outfall system that would discharge heated effluents to the deeper parts of the Trincomalee Bay, proved to be less than the incremental coal transport costs to a site on the south coast.

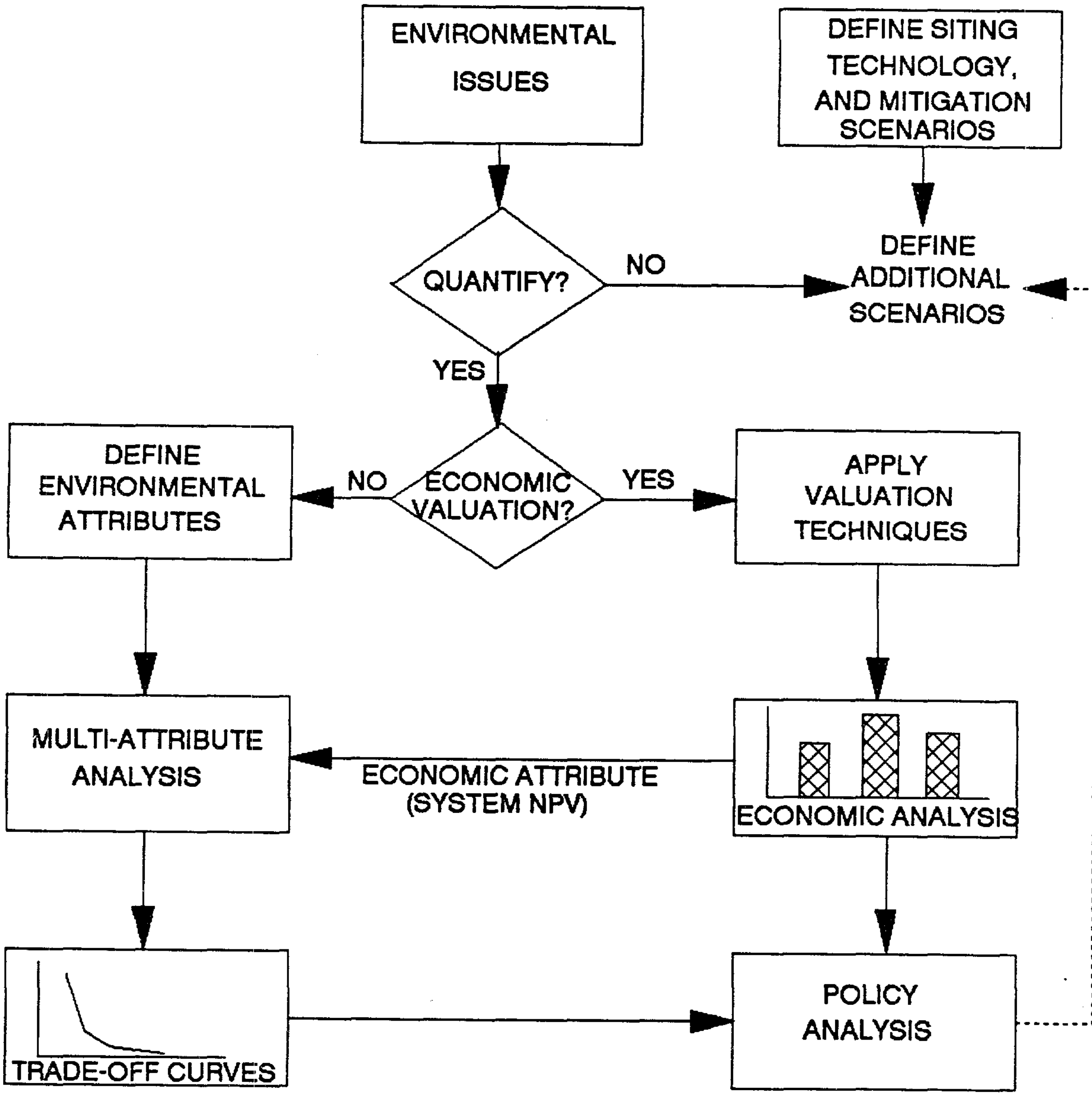
The main set of policy options examined, beyond variations in the mix of hydro and thermal plants, included (i) demand side management (using the illustrative example of compact fluorescent lighting); (ii) renewable energy options (using the illustrative technology of wind generation); (iii) improvements in system efficiency (using more ambitious targets for transmission and distribution losses than the base case assumption of 12% by 1997); (iv) clean coal technology (using pressurized fluidized bed combustion (PFBC) in a combined cycle mode as the illustrative technology); and (v) pollution control technology options (illustrated by a variety of fuel switching and pollution control options such as using imported low sulfur oil for diesels, and fitting coal burning power plants with flue gas desulfurization (FGD) systems).

Attribute selection: Great care needs to be exercised in criteria or attribute selection—they should reflect issues of national (as opposed to local project level) significance, and ought to be limited in number. There is little gain from a proliferation of attributes. Increasing the number of attributes is not a substitute for assigning proper weights to environmental attributes in the decision process. On the contrary, the more attributes considered the more complex the analysis, and the higher the probability that the results will be hard to interpret and decisionmakers will not find the exercise useful. It often occurs that, in a desire to be comprehensive, there is an inclusion of all possible impacts, making it more difficult to demonstrate trade-offs, and possibly introducing biases through a reluctance to assign low weighting to attributes.

The following environmental criteria or attributes were used in the study. To capture the potential impact on global warming, CO_2 emissions were defined as the appropriate proxy. To be sure, the relationship between global CO_2 concentrations and the actual physical impacts that may follow, such as sea level rise or changes in monsoonal rainfall patterns are still poorly understood, and in any event unlikely to be captured by simple linear correlations. However, since Sri Lanka's contribution to worldwide emissions will remain extremely small, the assumption of linearity of impacts (relative to global CO_2 emissions) is not unreasonable.

To capture health impacts, use was made of the population-weighted increment in fine particulates

Figure 5.2



and NO_x attributable to each source. To this end a simple Gaussian plume model was applied to all of the major sites, calculated incremental ambient concentrations for 1km square cells to within a 20km radius, and multiplied by the population in each cell.

To capture other potential air pollution impacts, such as acid rain, SO_2 and NO_x emissions were used. As an illustrative social impact, the study used the creation of labor opportunities. Employment creation is an important objective of national policy, and in Sri Lanka there has occurred frequent discussion of the need for employment creation in the south where youth unemployment rates are especially high. It should be noted that what is captured in this attribute is the separate and purely political objective of employment creation, rather than the strictly economic benefits that would be captured by the use of shadow wage rates appropriate to reflect high unemployment in the construction cost estimates. All of these impacts were appropriately discounted and expressed as a present value. Finally, to capture the potential biodiversity impacts, a probabilistic index was derived (as discussed below).

Attribute quantification: The problems of quantification are well illustrated in the case of the biodiversity attribute. At the planning level, detailed site specific information at the potential power plant sites is unlikely to be available. Consequently the only quantification that appears possible is to derive a probabilistic index that gives the decision-maker information about the likelihood that the detailed environmental impact statement will reveal the presence of an endemic species, significantly impact ecosystems of high biological diversity, or affect a habitat already in a marginal condition.

There are a number of practical problems in deriving an appropriate index. The first is that the value of the area lost is a function of what remains of the habitat. For example, the loss of the last hectare of an ecosystem would be unacceptable, whereas the loss of one hectare if 1,000 hectares remain would be much less. Second, ecosystems may require a minimum area for long term survival, which implies that the value function would need to tend to infinity as it approaches that minimum value. Perhaps even more importantly, the argument is sometimes made that the value to be ascribed to the loss of habitat associated with some regulatory or governmental decision depends on whether it remains secure. The details of the biodiversity index derived in the case study are discussed further in Annex 4.

Some impacts, however, resist direct quantification, even in terms of the sort of probabilistic scale derived for biodiversity. For example, the quantification of potential damages to aquatic ecosystems from thermal discharges is extremely problematic, in large part because of the difficulties in extrapolating from one ecosystem to the other. The general effects of thermal discharges into coastal waters are of course well known. Discharges into the well-mixed, surface layer would usually have the general tendency to repel fish. On the other hand, if the discharge is below the thermocline, thermal discharges would have a generally beneficial effect, as the upwelling effect caused by plume buoyancy brings nutrients to the layers near the surface. However, attaching specific numerical estimates to the values of this general function is essentially impossible. What can be done as a generic calculation that can be used to compare different sites is to begin with a definition of what is considered to constitute an acceptable environmental risk; for example, say a temperature increase of no more than 1°C at the surface. The surface area over which this criterion is exceeded is then calculated as a function of the cooling system design proposed.

Some Illustrative Results

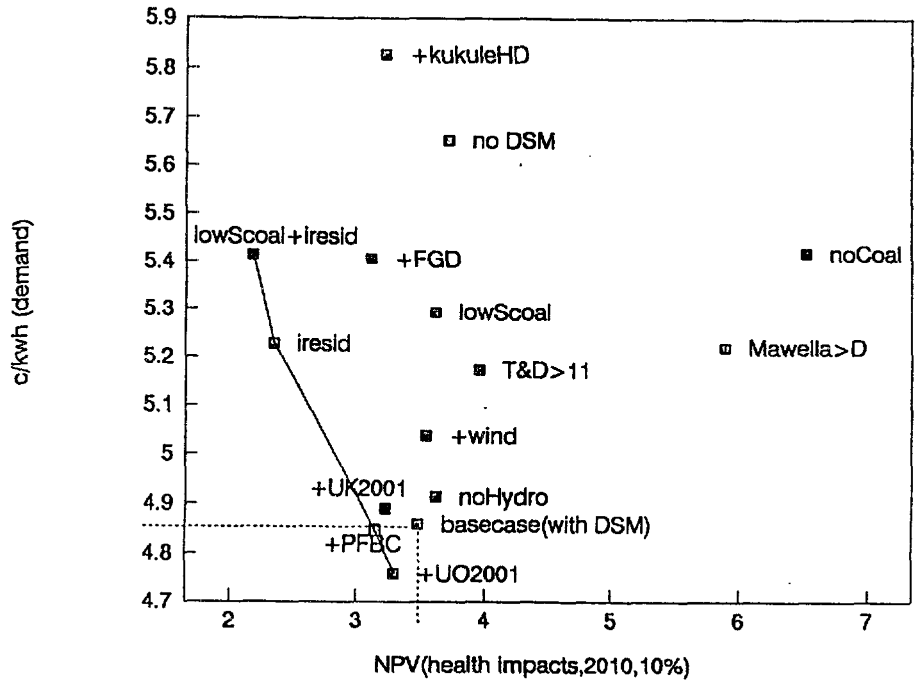
With options and attribute definitions in hand, the case study then generated the multi-dimensional trade-off space. Using the ENVIROPLAN model, the attribute values for each of the environmental attributes, and the cost attribute (for which average incremental cost over a 20-year planning horizon was used) were calculated for every option, with results displayed as a series of two-dimensional trade-off curves. In a final step, the list of candidate plans for further study was then derived by examining dominance relationships among all criteria simultaneously.

Figure 5.3 illustrates a typical trade-off curve, in this case for health impacts. The "best" solutions are those that lie closest to the origin, and the so-called trade-off curve, defined by the set of "non-inferior" solutions, represents the set of options that are superior, regardless of the weights assigned to the different objectives. For example, on this curve, the option defined as "iresid", which calls for the use of low sulfur imported fuel oil at diesel plants is better on both the cost and the environmental objective than the use of flue gas desulfurization systems (identified as the point "FGD").

A quite different trade-off curve was derived for biodiversity, and on Figure 5.4 is illustrated as the trade-off between biodiversity index value and average incremental cost. Most of the options have an index value that falls in the range of 50-100: the no hydro option has an essentially zero value, because the thermal projects that replace hydro plants in this option tend to lie at sites of poor biodiversity value (either close to load centers or on the coast). For example,while wind plants would require rather large land area, the vegetation of the area on the south coast has relatively low biodiversity value, and therefore the overall increase in biodiversity impact of this option is small. Thus, the best options (or non-inferior curve) include the no hydro option, and run-of-river hydro options that require essentially zero inundation. Note the extreme outlier at the top right hand corner, which is the Kukule hydro dam—it has a biodiversity loss index (B = 530) that is an order of magnitude larger than for other options (B = 50 to 70).

The case study drew several useful conclusions. The first four listed below are of a methodological nature, and deal with the extent to which multi-attribute methods are potentially effective in assisting

Figure 5.3 Trade-Off Curve of kWh Costs Versus Health Impacts Index



decision-makers. The remaining ones deal with the substantive policy recommendations whose focus is to ensure that environmental considerations are appropriately incorporated in the planning process.

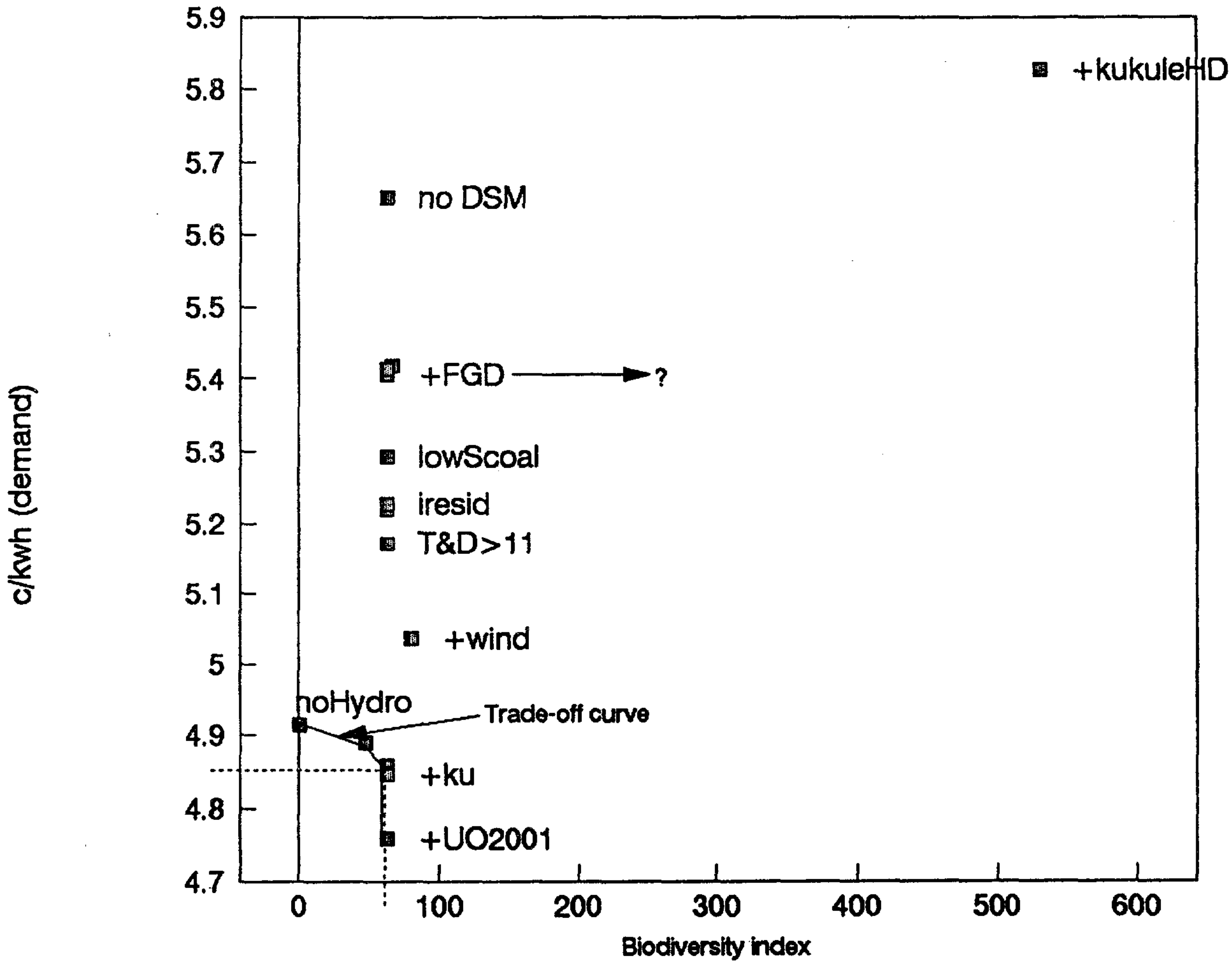
First, the results of the case study indicate that those impacts for which valuation techniques are relatively straightforward and well-established—such as valuing the opportunity costs of lost production from inundated land, or estimating the benefits of establishing fisheries in a reservoir—tend to be quite small in comparison to overall system costs, and their inclusion into the benefit-cost analysis does not materially change results.

Second, even in the case where explicit valuation may be difficult, such as in the case of mortality and morbidity effects of air pollution, implicit valuation based on analysis of the trade-off curve can provide important guidance to decisionmakers. For example, the study determined that the value of human life necessary to justify flue gas desulfurization at potential sites for coal fired-power plants was on the order of $1.5 million. This is at least one (if not two) orders of magnitude greater than what would be needed to justify the installation of modern diagnostic equipment at the regional hospitals.

Third, the case study indicated that certain options were in fact clearly inferior, or clearly superior, to all other options when one examines all impacts simultaneously. For example, the high dam version of the Kukule hydro project can be safely excluded from all further consideration as a result of poor performance on all attribute scales (including the economic one). On the other hand, implementation of certain demand side management measures dominates all other options; i.e., they yield positive gains in terms of economic and environmental criteria.

Fourth, the results indicate that it is possible to derive attribute scales that can be useful proxies for impacts that may be difficult to value. For example, use of the population-weighted incremental ambient air pollution scale as a proxy for health impacts permitted a number of important conclusions that are independent of the specific economic value assigned to health effects. Thus, the study clearly demonstrated that if the health effects of pollutants associated with fossil fuel combustion (particularly fine particulates and NO_x) are to be considered, then the most effective strategy for reducing the overall population dose is to install tighter pollution controls at oil-burning power plants located in or near urban

Figure 5.4 Trade-Off Curve of kWh Costs Versus Biodiversity Index



areas, rather than installing FGD systems at the more remote sites suitable for coal-burning power plants.

Finally, with respect to the practical implications for planning, the study came to a series of specific recommendations on priority options, including (i) the need to systematically examine demand side management options, especially fluorescent lighting; (ii) the need to examine whether the present transmission & distribution loss reduction target of 12% ought to be further reduced; (iii) the need to examine the possibilities of pressurized fluidized bed combustion (PFBC) technology for coal power; (iv) replacement of some coal-fired power plants (on the South coast) by diesel units; and (v) the need to re-examine cooling system options for coal plants.

Notes

1. This case study is derived from Kramer, Munasinghe, Sharma, et al., 1992.

2. This case study is derived from Meier and Munasinghe, 1992.

6. 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.

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. Even rough qualitative assessments early on in the project evaluation cycle may facilitate the process of internalizing these environmental externalities. The advantages include early exclusion of environmentally unsound alternatives; more effective in-depth consideration of environmentally preferable alternatives; and opportunities for redesigning projects and policies in order to achieve sustainable development goals.

Certain specific shortcomings and difficulties associated with the case studies were discussed earlier. More generally, greater application of the environmental valuation concepts and techniques presented in this paper to practical problems in a developing country is required rather than further theoretical development. Such case study work can be most effectively 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 nonuse values are virtually nonexistent in the developing world, and rather scarce even in the industrialized nations. The use of multiobjective decision methods also needs to be explored in greater depth, as an alternative to more purely economic valuation methods.

Nevertheless, developing countries are attempting increasingly to both improve and make use of economic techniques to value environmental assets. While the academic literature usually focuses mainly on the development of the techniques, there are also sector- or topic-related approaches.[14] 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, an extensive bibliography is included at the end of this chapter.

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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. Locally purchased items whose values are known only in terms of domestic market prices, however, must be converted to border prices by multiplying the former prices by appropriate conversion factors (CFs).

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 nonprice distortions lead to nonoptimal levels of consumption $Q \neq Q_{opt}$ characterized by differences between MSB and MSC. More generally, a weighted average of MSC and MSB should be used if both effects are present. 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) is broken down successively into components. This would include capital, labor, materials, and so on, which are valued at pesos $C_1, C_2, \ldots C_n$ 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 that 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.

Illustrative of important tradeable inputs used in many development projects are 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 the production or extraction of 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'th 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 $MU(c) = c\text{-}n$.

$$\text{Thus,} \quad d = MU(c)/MU(c_a) = (c_a/c)n \,.$$

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 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 is 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[1]

Effect on Production Method

Cost-Benefit Analysis of Land Improvement in Lesotho[2]

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 for study is further justified by its modern approach in dealing with land degradation: production orientation, labor-intensive techniques, and popular participation. Furthermore, information for research could be obtained at low cost. 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. It has rehabilitated old terrace structures, constructed new ones and added other structures for conservation; promoted hybrid maize, hybrid sorghum, and fodder grasses; and planted thousands of tree seedlings. It has also promoted rotational grazing on communal rangeland. The project area covers almost 26,000 hectares and reaches about 22,000 people.

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. In the economic analysis, soil conservation measures are considered as the calculation covers a five year period.

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 percent and 144 percent, respectively, in order to achieve a real rate of return of 10 percent. These target increases in yield are significantly higher than the average values achieved in the areas under high-input management. The two options actually yield negative real marginal IRRs of 21 and 30 percent, respectively.

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. Financial budgets for fruit and fuelwood trees show more promising returns, however, 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, among other things, 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.

Economic Analysis

The economic analysis considers the perspective of the Lesotho Government and the donor agency, the Swedish International Development Authority (SIDA). 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 to improved soil conservation. The distribution, sale, and use of commercial fertilizer and hybrid seed in the project areas has been monitored. In the short term, distribution of these inputs has increased somewhat as they are used as in-kind payments for conservation work on individually controlled land. Convincing signs are lacking, however, for 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. Financial costs have to be adjusted in several ways to arrive at real economic costs, however. Potential benefits of the project include increasing production of

- Maize, sorghum, and crop residues due to the use of fertilizer, hybrid seed and conservation of soil and nutrients
- Fruits (peaches and apples)
- Fuelwood from pine and other tree species
- Fodder grasses such as Eragrostis and Bana grass
- Vegetables from communal gardens sponsored by the project
- Livestock products by promoting improved grazing management.

Additional benefit items to consider are:

- Training of personnel, and the introduction of improved communal management, with potential **extra-project** impacts
- Off-site physical impacts, such as less siltation of dams, less maintenance costs for roads and bridges, improved water quality, etc
- 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, controversial. 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. First is the issue of whether soil loss actually affects crop production at all in this particular area. Second, if it does, to what extent soil loss occurs, and third, 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 be 25 centimeters, a level at which the water retention capacity is reduced. Research in the area indicates that the annual soil loss is roughly 15 tons per hectare (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 percent annual decline in yield on nonconserved land was assumed.

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

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

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 in kilograms per hectare;
ΣAC = accumulated area under conservation management (hectare);
PI = project impact: the share of AH affected by the project's actions (percent);
CS = the share of maize and sorghum respectively of the cultivated land (percent);
t = time index (year 1 ... T); and
i = crop index.

The assumption here is that PI (project impact) equals 1, as conservation activities are assumed to be nil in the absence of the project. [3]

Up to 1992, more than 18,000 seedlings of apple and peach trees were to be delivered to farmers in the project area. The survival rate was estimated to be 50 percent. The number of remaining 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.

Road and bridge maintenance in the area will not be significantly affected by the improved land management and soil retention, and no major dams for hydropower or irrigation in the project areas 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 Maloti. This indicates that the distorting impact of foreign exchange restrictions is not significant. The official exchange rates have therefore been used, based on International Monetary Fund data. In 1990 the exchange rate was set to roughly 3 Maloti 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.

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

(a) 5 percent will substitute dung (0.25 * M 100.61)
(b) 5 percent will substitute brushwood (0.75 * M 24.33)
Weighted average: M 43.40

As for the period after 1992, a number of assumptions have been made. The level of costs is assumed to remain at the average for 1985-1992, but with all costs associated with expatriate (nondomestic) 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

Table A2.1 Economic Value of Fuelwood Substitutes per Cubic Meter

	MJ/kg	Eq. kg	M/kg (1987)	M (1990)
Brushwood	16.0	550	.03	24.33
Dung	12.9	682	.10	100.61
Crop residues	14.0	629	.02	18.54

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 at 50 percent of the level achieved in 1986-1991.

Results and Sensitivity Analyses

Given these assumptions, the results of the base case are an NPV of minus M 7.0 million at a discount rate of 10 percent and minus M 5.6 million at 1 percent. The internal rate of return is minus 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 A2.2 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: discount rate, post-1992 project performance, fruit income, erosion impact on crop yields, future grain prices, and 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. If the lower rate of 1 percent is considered acceptable as a standard, however, 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. This weight, however, should then be consistently applied to alternative projects.

Table A2.2 Discounted Share of Total Benefit

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

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 approximates 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 decision makers 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. Establishing an economic capacity to buy grain on the world market through other development projects 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 nonagricultural 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 to raise production immediately but rather to protect to a significant degree the land base in the long term, more substantial subsidization of cover crops such as fodder grasses at the expense of traditional cropping could be justified. Even if fodder could not be commercially sold, the grower would provide an insurance service while protecting the land for future potential uses. The economic viability of this option needs 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.

Valuation of an Amazonian Rainforest[4]

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 hectare of Peruvian rainforest along the Rio Nanay near the small village of Mishana, 30 kilometers southwest of the city of Iquitos. Annual precipitation in the region averages 3,700 millimeters; soils are predominantly infertile white sands. The inhabitants of Mishana are indigenous people who make their living practicing shifting cultivation, fishing, and collecting a wide variety of forest products to sell in the Iquitos market.

Method and Data

The inventory showed 50 families, 275 species and 842 trees of at least 10.0 centimeters in diameter. Of the total number of trees on the site, 72 species (26.2 percent) and 350 individuals (41.6 percent) 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 person 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.[5] Based on earlier studies the transport cost for fruit and latex was estimated at 30 percent of total market value while extraction cost for timber was set at 40 percent of total value.

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 percent discount rate and assuming that 25 percent of the fruit crop is left in the forest for regeneration, is estimated at US$6,330.

The hectare of forest also contains 93.8 cubic meters 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 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 cubic meters per hectare every 20 years. With a weighted average price of US$17.21 per cubic meter and deducting harvest and transport costs, the net revenue is 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$6,820, with logging contributing about 7 percent 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.

Comparisons

The NPV of this piece of rainforest compares well with other uses of rainforests. Using the same discount rate, 5 percent, the NPV of the timber and pulpwood obtained from a 1 hectare plantation of *Gmelina arborea* in Brazilian Amazonia is estimated at US$3,184, 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 hectare per year. This gives a present value of US$2,960. 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.

Effect on Health Method

Economic Analysis of a Water Supply and Health Program in Zimbabwe[6]

The purpose of the paper is to evaluate the Manicaland Health, Water and Sanitation program in Zimbabwe utilizing social cost-benefit analysis. Data was gathered on cost-benefit analysis, water and sanitation projects, and health statistics in Zimbabwe. Because the health statistics do not fully reflect the mortality and morbidity rates, benefits of the proposed water and sanitation program will be underestimated.

Only communal lands in rural Manicaland are studied. No consideration is given to resettlement areas or commercial farm areas. The study considers only two major benefits—health improvements and change in consumer surplus for water.

Background

The Manicaland Province, organized in 7 districts, is situated in the east of Zimbabwe. It is characterized by a relatively high altitude and a diverse relief, implying varying patterns of rainfall, temperature, soils, and natural farming regions, and has the highest rainfall in the country. The province is agriculturally rich and produces forestry, fruit, maize, groundnuts, sunflowers, tea, coffee, cotton, dairy, and beef products. Approximately 90% of the provincial population of 1.2734 million (1987) lives in rural areas and 66% lives in communal lands. Over 50% of the population is under 15 years of age. Over 65% of the economically active population in Manicaland is working in agriculture, either as subsistence farmers or as permanent or seasonal laborers on commercial farms.

The objective of the program, within the framework of Swedish and Norwegian support to Zimbabwe's health sector, is to improve living conditions in the communal areas of Manicaland through:

- Improving existing and constructing new water supplies that ensure an acceptable quantity and quality of water for domestic use and that are reliable and accessible for the community;

- Improving sanitation conditions by constructing latrines;
- Giving health education to improve hygienic practices and instigate behavioral changes.

Shadow Prices Used

Domestic prices were used as a numeraire. That is, local currency is expressed in Zimbabwean dollars (Z$) and foreign currency is expressed in $US.

Foreign exchange rate. Harberger's formula is utilized to calculate the shadow price of foreign exchange. Since Zimbabwe is a pricetaker, the supply and demand elasticities of foreign exchange can be replaced by the import demand and export supply elasticities. Assuming that the export supply elasticity is set to zero, and that no quantitative restrictions exist, the Harberger's formula reduces to

$$R' = \frac{n\,M\,(1+T)R}{n\,M} = (1+T)\,R$$

where R' = the shadow price of foreign exchange and R the official exchange rate; M = c.i.f. value of imports in terms of foreign currency; T = import duties; and n = elasticity of demand for foreign exchange.

Given the assumption that the export supply elasticity equals zero, the Harberger's formula now approaches the standard UNIDO guidelines approach. Using 1987 data, the authors determine that one extra unit of foreign exchange can buy goods worth 1.1799 units on the domestic market. Because of the existence of capital restrictions in the form of quotas in Zimbabwe, import duties are increased substantially so that the demand for foreign exchange equals the supply. Therefore a shadow price of foreign exchange of 1.75 is used.

Shadow price of labor. In the dry season, there is underemployment in the agricultural sector, so the shadow wage for labor is set at zero. Given that uncertainty exists in the peak harvest season, when there is a shortage of labor, the authors conduct a sensitivity analysis, where the shadow wage is set at 100%, 75%, and 50% of the market wage of Z$0.46 per hour. For skilled laborers, it is assumed that the shadow wage meets the market wage. The opportunity cost of children's time is set at zero.

Social rate of discount. Using Helmer's approach (taking the rate of return in the private sector), one would derive a real social discount rate of 4.86%. If the World Bank discount rate of 10% were used, adjusted for foreign exchange rate changes, the real discount rate would be 7.24%. There is no official discount rate for government projects in Zimbabwe, so the authors conducted a sensitivity analysis with the social discount rate ranging from 2% to 4%.

Time horizon. A time horizon of 40 years is used in the analysis, given that benefits are expected to remain as a result of reinvestment.

Calculation of Costs

The materials supplied by the project are valued at market prices. Community input, except for the constructor's payment in case of latrines, is valued at the opportunity cost of labor. Since the shadow wage of unskilled labor has been set at zero during the dry season (when construction takes place), the costs of community input except for the constructor's payments are zero. The constructor is paid the shadow price of skilled labor: $Z50 for a double latrine, and $Z250 for a multi-compartment latrine.

Calculation of Benefits

Change in consumer surplus. The price of water is calculated by mean kCals of energy used in walking to and carrying water, the energy cost per $Z1, and the time cost with shadow wages set at 50%, 75%, and 100%. The change in consumer surplus per year is equal to

$$180\left[q_1\,(p_{w1}-p_{w2}) + \frac{(q_2-q_1)}{2}\,(p_{w1}-p_{w2})\right]$$
$$+\,185\left[q_1\,(p_{d1}-p_{d2}) + \frac{(q_2-q_1)}{2}\,(p_{d1}-p_{d2})\right]$$

where:

q_1 = quantity carried home in 1 day, before the project;
q_2 = quantity carried home in 1 day, after the project;
p_{w1} = price/1 in the wet season, before the project;
p_{w2} = price/1 in the wet season, after the project;

p_{d1} = price/l in the dry season, before the project; p_{d2} = price/l in the dry season, after the project.

The change in consumer surplus per person, when full coverage is reached, is shown below.

	Shadow wage	
50 percent	75 percent	100 percent
0.99	1.18	1.37

Health improvements. Cost of illness estimates consist of treatment costs, costs of lost production, and costs for extra transportation. The authors point out that as willingness to pay is not taken into account, the values arrived at may severely underestimate true values.

For treatment costs, the costs of private treatment are used as the opportunity cost. A consultation with a physician costs $Z10.80 and the cost of nursing is $Z3.00 per hour. The transportation cost used is $Z 0.50 per single journey for all inpatients. The lower bound of the total value per year of reduced morbidity when full reduction is reached, is shown in Table A2.3.

The value of a life saved would be very high to the individual concerned or his/her family. The authors attempt to establish a minimum value by adopting society's viewpoint to determine the net output gained by saving a life. They use the human capital approach—based on the stream of average income minus average consumption, discounted back to the time of avoided death.

The average household income in communal lands is $Z550. If the household consists of 2 adults and 4.5 children on average, the income received by each adult is $Z275. The authors estimate that each child consumes $Z64.71 per year, and that each adult living on communal lands consumes $Z129.41.

Assuming an urban migration rate of 20%, and an unemployment rate of 20%, the authors use the weighted average of the wage adjusted for unemployment and the income in communal lands as an estimate of the child's future production: $Z1307.21. Future consumption is estimated as final household expenditure per capita, $Z795.13.

The net present value of output gained by preventing a child's death, taking into consideration only production and consumption aspects, is:

$$V_C = -64.71/(1 + i)^t + (1307.21 - 795.13)/(1 + i)^t$$

The corresponding net present value of output gained by society, for each adult saved, is:

$$V_A = (275.00 - 129.41)/(1 + i)^t;$$

with i = social rate of discount.

In Table A2.4 the values for different discount rates are shown as lower bound estimates.

In the base case, with an estimated social discount rate of 4.86%, shadow wage at 100% of the market wage, and a 100% health improvement, the internal rate of return was greater than the social discount rate and the net present value of the project was strongly positive. At a social discount rate of 7.24%, estimated in the alternative approach, the project is not found profitable even if a shadow wage of 100% and 100% disease reduction is achieved.

While most of the benefits come from disease reduction, it must be pointed out that benefits are probably underestimated because the value of a saved life has been understated—through the use of a lower bound. Secondly, the paper does not take into account other benefits such as local industry that would benefit from improved water supply. Third, as income distribution will probably improve as a result of the project, benefits could have been given a greater weight on social equity grounds. Therefore

Table A2.3 Total value in $Z of health improvements per year after the year 2005 at a social discount rate of 4.86% for different values of disease reductions and shadow wage

Shadow wage (percent)	Disease reduction'		
	40%	70%	100%
50	2,501,936	4,378,388	6,254,839
75	2,505,760	4,385,081	6,264,401
100	2,509,585	4,391,774	6,273,962

the authors conclude that the project is likely to be a success from a societal point of view.

Travel Cost and Contingent Valuation Methods

The Consumer Surplus From Visits to a Costa Rican Rainforest [7]

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 hectares 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.

Data, Method and Results

In 1988, 755 out of approximately 3,000 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 cantón is treated as an observation (this is used instead of the concentric zones mentioned in Chapter 3). Visitation rates (number of visits per 100,000 residents) were calculated for each cantón by dividing observed numbers of trips by census populations.

Table A2.4 Lower bound gain to society from a saved life in $Z at different discount rates

	Social discount rate (percent)			
	2	4.8	7.24	9
Child (< 5 yrs)	8,441	2,813	1,094	934
Adult (> 5 yrs)	1,307	1,131	1,011	489

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 kilometer. 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).

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

where 'e' is an error term assumed to be independent and normally distributed. The model was estimated using multiple regressions. The semi-log functional form could not be used on this data because the visitation rate from many cantóns was zero. Two specifications were estimated; with and without illiteracy rates. The results are presented in Table A2.5.

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 A2.5 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 A2.5 suggest that visitation would drop to zero only at distances of 328 kilometers and 347 kilometers, respectively, for the two regressions. At the presumed US$0.15 per kilometer, 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 3,000 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 percent, the present value of domestic recreation at this site is between US$2.4 million and US$2.9 million.

Discussion

This consumer surplus estimate of about US$100,000 per year 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 with higher incomes and lack of nearby substitutes probably value the site more than domestic visitors. The present value estimate is probably too low considering the fact that visitation has been growing at 15 percent a year for the last five years. Still, if the same figure, US$35, is used for all visitors and also for the future, that would mean a net present value of US$1,250 per hectare. The price that the reserve currently pays to acquire new land is between US$30 and US$100 per hectare. 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.

Value of Viewing Elephants on Safaris in Kenya[8]

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 actually pay 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.

The analysis is based on a survey taken from samples of the approximately 80 percent of the tourists to Kenya who came either from North America or Europe. The other 20 percent of the tourists were assumed to have the same average consumer surplus as the sample.

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 travel costs, air fare, and travel time costs. These are summarized in Table A2.6. Land costs were estimated by creating a quality weighted price index from the tour operators' surveys.[9] The air fare and travel time were estimated from visitors' surveys. Average annual income was US$45,000 giving an estimated hourly wage of US$22.50, which is weighted at 30 percent to reflect that vacation time is less valued than gross wage rate.

Table A2.5 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 $R^2 = 0.156$

Note: The t-statistics are in parentheses. The number of observations (cantóns) are 81. The low R^2 values are probably due to the lack of additional data. For example, information is unavailable on socioeconomic variables that might better explain differences in visitor travel behavior.

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.

Given a linear demand curve, per person consumer surplus is the choke price (the price at which demand is driven to zero) minus the actual price paid, divided by two. For North America, the consumer surplus is given by:

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

For Europe it is

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

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 percent more than it costs. It seems plausible that a similar experience at less cost would be worth 35 percent more than the cost for a European.

Results From Travel Cost Approach

The weighted average consumer surplus is about US$725. 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 US$182–US$218 million 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 percent of the pleasure according to the answers. In a follow-up question concerning only the enjoyment of the wildlife, the interviewees attributed 25 percent of their wildlife pleasure to seeing African elephants. Applying the share of 12.6 percent, 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.

Contingent Valuation Approach

The tourists' survey contains a series of contingent valuation questions. One of the questions (see box A2.1) 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.

Some respondents dislike translating important qualitative experiences into a dollar metric and re-

Table A2.6 Land, Airfare, and Travel Time Costs (all monetary units US$)

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

spond 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.

Respondents could have a strategic bias to give large values if they thought the result would lead to policy decisions they like but would 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 percent of the respondent's income and about 3 percent of the cost of his/her 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 percent 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.

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 million and 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 more likely 25 million dollars annually than 2.5 million 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.

***The Willingness to Pay for Water Services in Southern Haiti*[10]**

In rural areas, many of those who are in the service area of 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, the "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, or "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.

Box A2.1 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 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.

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 the United States Agency for International Development 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 percent of the population is illiterate and malnourishment among children is widespread.

There are seven sources of fresh water within approximately 2 kilometers 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 kilometers 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.

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 respondents believe they may influence an investment or policy decision by not answering the interviewer's questions truthfully. Such strategic behavior may influence answers in either of two ways. Suppose an individual is asked how much he would be willing to pay to have a public standpost near his house. If he/she thinks the water agency or donor will provide the service if the responses from the village are positive, but that someone else will ultimately pay for the service, there will be an incentive to overstate his/her WTP. On the other hand, if the individual believes the water agency has already made the decision to install public standposts in the village and that the purpose of the survey is to determine the amount people will pay for the service (in order to assess charges), the individual will have an incentive to understate the 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 intended to minimize strategic bias. The group was told that the international agency, CARE, had already decided to build the new system and that people would neither have to pay CARE for the system nor 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 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 wanted to please the interviewer and interpreted 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 for 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. For example, it may be difficult for people to perceive what a change 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 during 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?

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 on 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 percent).

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 percent 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 percent of household income and is significantly lower than the 5 percent 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 percent of household income), but these bids were based on the assumption that the public standposts were 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 A2.7. 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.

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.

Willingness to Pay for Improved Sanitation in Kumasi, Ghana[11]

A case study was conducted in Kumasi, Ghana, to determine household demand for two sanitation technologies: water closets (WCs) with a piped sewerage system, and Kumasi ventilated improved pit latrines (KVIPs). The objective of the study is to demonstrate how information on household demand for improved sanitation services can be gathered utilizing a contingent valuation survey, and how this information can be used to plan sanitation investments.

Study Design

Observers were placed at a random sample of 30 public latrines in neighborhoods in Kumasi, and at all 10 public latrines near the public marketplace, to determine usage levels of public latrines (such usage requires payment of a fee in some localities). A series of interviews was then carried out with personnel involved in the management and operation of all 40 public latrines in the sample. Information was gathered on the cash flow position regarding the latrines, and on the facilities themselves. Data was gathered also on the amount of waste collected by Kumasi's six desludging trucks.

The major part of the field work was related to the design and implementation of a large household survey, to collect information on existing sanitation practices and WTP for improved sanitation services. An initial household survey of 50 households was conducted in July 1989. This was

Table A2.7 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	Coefficient	*t*-ratio	Coefficient	*t*-ratio
Intercept	0.841	1.350	-0.896	-1.344
Household wealth index	0.126	2.939	0.217	4.166
Household with foreign income (1 if yes)	0.064	0.232	0.046	0.194
Occupation index (1 if farmer)	-0.209	-0.848	-0.597	-2.541
Household education level	0.157	2.113	0.090	1.818
Distance from existing water source	0.001	5.716	0.000	1.949
Quality index of existing source	-0.072	-2.163	-0.099	-2.526
Sex of respondent	-0.104	-5.41	-0.045	-0.207
Log-likelihood	-206.01		-173.56	
Restricted log-likelihood	-231.95		-202.48	
Chi-square (freedom=7)	51.88		57.83	
Adjusted likelihood ratio	0.142		0.177	
Degrees of freedom	137		120	

followed by a pretesting questionnaire for a hundred households.

The final survey questionnaire had four parts. The first part related to demographic characteristics. The second was concerned with the household's existing sanitation conditions, and the level of satisfaction with these services. The third contained questions about WTP for improved sanitation facilities. Fourth and finally, there were questions relating to socioeconomic characteristics, such as education, income, etc. A two-stage, stratified sampling procedure was utilized to select a random sample of 1,633 households. The household survey was carried out over a five-week period in October and November 1989. The overall response rate to the survey was very high—only 45 households refused to be interviewed. Usable interviews were completed by 1,224 respondents.

Household preferences for improved technologies

Surveyors asked the question: "If a WC (connected to a sewer system) and a KVIP each cost the same amount per month, which one would you prefer?" Contrary to expectations that respondents would strongly prefer a WC, 45% indicated a preference for KVIPs, and only 54% preferred WCs. In an attempt to identify any underlying patterns for expressed preferences, a logit model was estimated to examine the relationship between household preferences and socioeconomic and other characteristics of the household. The dependent variable was the household's preference for either WCs or KVIPs assuming equal costs; higher values of the dependent variable indicated a preference for the KVIP over a WC. Dependent variables included sex, age, education, income, and existing household sanitation facilities.

The unrestricted model used a list of 21 independent variables to explain household preferences. The overall fit of this model was not good; it could not be confirmed that parameter estimates were not equal to zero. Surprisingly, no linkage could be established between higher incomes and/or better education and a greater preference for WCs.

The restricted model used four independent variables, all of which were significant at the 10% level in the unrestricted model. In this restricted model, the variable related to the "time-to-think" effect was significant at the 5% level, which indicates that respondents who had time to consider their answers were more likely to prefer KVIPs. The authors suggest that this later hesitancy may be linked to a diminished enthusiasm for an unfamiliar system (WCs connected to a sewer system) once respondents were able to reconsider their responses.

Household willingness to pay for improved sanitation

Respondents were asked about their WTP for five different types of services: KVIPs, WCs with sewer connections, sewer connections for households that already had WCs, private water connections, and both a private water connection and a WC with a sewer connection for households currently without water. Each household was only asked about its WTP for services relevant to its specific circumstances.

On average households without a WC were willing to pay about the same for a WC or KVIP ($1.43 vs. $1.47). Households with a WC were willing to pay $1.32 for a sewer connection. Households without water connections were willing to pay $1.56 for a KVIP and $2.53 per month for both a water connection and WC. Results suggest that expenditures for water and sanitation are not substitutable—the demand is additive.

Three multivariate modeling approaches were utilized to analyze the relationship of various determinants in the WTP bids. These were Ordinary Least Squares (OLS), Stewart Maximum Likelihood, and Ordered Probit. Results obtained from the multivariate analysis are robust, and show that WTP information is systematically related to socioeconomic characteristics of the household in all areas, and that responses obtained conformed with prior expectations and consumer demand theory.

Household with higher incomes bid significantly more for improved services than those with lower incomes. Owners bid more for improved facilities than renters. Respondents with access to a private water connection bid more for KVIPs than respondents without a private connection, suggesting a desire to continue improving basic services. Households in multistory buildings were willing to pay less for a KVIP than households living in single-story buildings, possibly because of the limited convenience of KVIPs in multistory dwellings.

Policy options

The authors point out that information on WTP for improved sanitation can help in sanitation planning. Costs of both KVIPs and WCs are higher than what households are willing to pay for them, and therefore public subsidization would be necessary if improvements were to be implemented. It is evident that conventional sewerage systems, and therefore WCs, are not affordable for the majority of the population. The authors suggest that if policy reforms were introduced in the financial and housing markets, household demand for KVIPs might be significantly increased without the need for subsidization.

Applicability of CVM in Estimating Household Demand for Sewerage Services

The study identifies two areas in which additional research is needed. Contingent valuation questions for alternative technologies were asked sequentially in this survey. Research is required to develop cost-effective ways of determining how households would choose between multiple options presented simultaneously at varying prices.

Secondly, the study used the single household as the unit of analysis. Additional research should be undertaken on how best to estimate collective willingness to pay for improved facilities in situations where group housing is common—for example, in an apartment building.

The study helps to broaden the horizons of planners, engineers, and policy analysts, by placing more of a focus on "demand-side" issues (for housing, capital, and infrastructure), as opposed to purely technological alternatives or government financing.

***Value of a Thai National Park*[12]**

In an attempt to measure the value of Lumpinee Park in Thailand, two surveys were conducted, a demand function for the service of the park was estimated, and the value of the consumer's surplus associated with the demand curve was computed to represent the value of the park in the year of the study (1980).

The Travel Cost model used was of the standard form—visitation rates were assumed to be a function of total travel cost, availability of substitute sites, and income. The total travel cost variable included both out-of-pocket travel costs plus the monetary value of time spent traveling, using a representative wage rate. 187 people were interviewed and divided into 17 zones of origin within Bangkok. The initial survey was divided into weekday and weekend users. It was found that the park's use rate was heaviest on the weekend. An attempt was made to determine if weekday and weekend users were statistically different in terms of values, income, etc. It was found that this was not the case.

Visitation rates or number of visits per 1,000 people, (not the number of visitors, since many make repeat visits) were calculated for all 17 zones, and are demonstrated in Table A2.8. Information on the round-trip monetary travel cost and the average time for each trip was collected. Time spent traveling was then changed into a monetary value using a representative wage rate and was then added to the travel cost. A regression equation was estimated, regressing visitation rates against average total travel cost. Using data on changes in admission fees, changes in demand for visits with higher fees can be estimated (Table A2.9). These results were then plotted on a linear demand curve, and the consumer surplus was estimated at Baht 13.2×10^6. Capitalized at 10%, this yielded a value of Baht 132 million, or $US 6 million, at the 1980 exchange rate.

Under the contingent valuation approach, users were directly asked a hypothetical question: "If the government could no longer allocate the budget to maintain the park but in fact was considering turning it into other uses, what would be the maximum amount you are willing to contribute per year to keep the park?" Two sets of values were obtained from the survey—a user value, from interviews conducted at the park, and values from respondents who were interviewed at their residences.

The 187 persons interviewed for the TC study were also interviewed for the CVM study. The amount per year that respondents were willing to pay appeared to be linked with the frequency of visits. Visitors for recreational purposes indicated a slightly lower WTP for yearly contributions to maintain the park than visitors for morning and evening exercise purposes. However, the latter group's willingness to pay per visit was less than that of recreational users. The authors decided to estimate the number of visitors per year (2.1 million) as the number of visits, as the value of the park will depend to a large extent on the proportion of the visitors using the park for recreational and exercise purposes and their average visitation rates.

User's willingness to pay, or what the authors call the user's hypothetical valuation, was estimated at 13 million baht, and is therefore virtually identical to the travel cost results.

An additional 225 people were interviewed throughout Bangkok, including people who had never used the park, in an attempt to estimate the broader "social" (or what is now more commonly termed "non-use") value of the park. When CVM results were adjusted by the appropriate age-corrected population figures, the WTP measure of park users was estimated at 13 million baht per year, and for the survey of Bangkok residents, 116.6 million baht per year, (thus demonstrating the more realistic WTP of constant users of the park). The consumer surplus and welfare gain associated with the continued existence of the park is clearly significant.

Notes

1. Portions of this Annex are based on an original draft prepared by Gunnar Kohlin.
2. This case study is derived from J. Bojo, 1991.
3. This is supported by observations during field work in the area before project initiation.
4. This case study is derived from Peters, et al. 1989.
5. All prices in 1987 U.S. dollars using an exchange rate of twenty intis to the dollar.
6. This case study is derived from Fredriksson and Persson, 1989.
7. This case study is derived from Tobias and Mendelsohn, 1991.
8. This case study is derived from Brown and Henry, 1989.
9. 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.
10. This case study is derived from Whittington, et al., 1990.
11. This case study is derived from Whittington et al., 1992.
12. This case study is derived from Grandstaff and Dixon, in Dixon and Hufschmidt (eds.), 1986.

Table A2.8 Visitation Rate per 1,000 Population per Year for All Zones

		Sample		
Zone	Population	Person	Percent	Visitation rate/1,000
1	190,450	10	5.3	590
2	235,647	27	14.4	1,288
3	77,112	4	2.1	583
4	131,542	23	12.3	1,965
5	380,416	30	16.0	886
6	519,869	18	9.6	389
7	523,831	37	19.8	794
8	123,109	3	1.6	274
9	479,659	4	2.1	94
10	201,334	4	2.1	223
11	388,333	6	3.2	174
12	255,555	7	3.7	308
13	262,097	1	0.5	43
14	140,249	4	2.1	320
15	382,621	5	2.7	147
16	204,434	1	0.5	55
17	113,769	3	1.6	296
Total	4,610,027	187	99.6[a]	

a. Percentages do not total 100 due to rounding.

Table A2.9 Visits in One Year at Various Admission Fees in Baht (B)

			Number of visits at various admission fees (B)										
Zone	Population	Total cost (B/visit)	0	2	4	6	8	10	12	14	16	18	20
1	190,450	8.08	161,978	139,714	117,438	95,169	72,900	50,631	28,362	6,093	--	--	--
2	235,647	3.72	260,483	232,929	205,375	177,821	150,268	122,714	95,160	67,606	40,052	12,499	--
3	77,112	10.25	55,800	46,783	37,768	28,750	19,734	10,717	1,700	--	--	--	--
4	131,542	5.04	135,254	119,873	104,492	89,111	73,730	58,349	42,968	27,587	12,206	--	--
5	380,416	8.64	311,085	266,604	222,123	177,641	133,160	88,678	44,197	--	--	--	--
6	519,869	10.00	383,788	323,000	262,213	201,426	140,639	79,851	19,064	--	--	--	--
7	523,831	13.66	274,624	213,373	152.123	90,872	29,621	--	--	--	--	--	--
8	123,109	16.65	43,021	28,626	14,231	--	--	--	--	--	--	--	--
9	479,659	14.18	236,884	180,798	124,713	68,627	12,541	--	--	--	--	--	--
10	201,334	15.50	83,893	60,352	36,810	13,268	--	--	--	--	--	--	--
11	388,333	20.35	51,701	6,294	--	--	--	--	--	--	--	--	--
12	255,555	19.52	46,424	16,543	--	--	--	--	--	--	--	--	--
13	262,097	17.16	83,776	53,129	22,482	--	--	--	--	--	--	--	--
14	140,249	17.01	46,058	29,659	13,260	--	--	--	--	--	--	--	--
15	382,621	18.43	93,890	49,151	4,412	--	--	--	--	--	--	--	--
16	204,434	27.59	--	--	--	--	--	--	--	--	--	--	--
17	113,769	21.70	6,167	--	--	--	--	--	--	--	--	--	--
Total visits per year			2,274,826	1,766,828	1,317,440	942,685	632,593	410,940	231,451	101,286	52,258	12,499	0

ANNEX 3. ESTIMATING INTERNATIONAL TRAVEL COSTS[1]

Most travel cost studies specify the problem in terms of valuing single-purpose, single destination day-trips to a site that provides a particular recreation experience of typical quality that is interchangeable with those available at many similar sites. Recreation in Madagascar's national parks is not consistent with these assumptions. Recreators in Madagascar can be divided into two groups consuming two distinct goods: a) local recreators who consume day-trips to national parks to escape the city and view the local natural environment; and b) international nature tourists who consume multi-week trips to an exotic land, to experience unusual landscapes, fauna, flora, and cultures.

Basic travel cost models can be applied directly to estimate the demand of local recreators. By contrast, the decision by foreigners to pursue nature tourism in Madagascar and at a particular site such as the proposed national park is much more complex than the models presented in standard travel cost studies. Such foreign visitors fly great distances and utilize various modes of travel to visit numerous sites and enjoy many different activities in Madagascar. Few foreign tourists plan trips solely to visit a particular national park in Madagascar. More commonly, they first decide to take a trip to Madagascar to view nature. Then, they decide on a specific itinerary that may include several parks, cultural sites, etc. Therefore, modeling the demand for foreign travel to a national park in Madagascar for nature related recreation on the basis of the travel cost method requires a significant reformulation of traditional models.

The international travel cost method is most easily understood by dividing the decision process into several stages. First, the household examines the costs associated with enjoying the various activities available in each country. Using the knowledge given in the first stage, the household minimizes the total cost of nature tourism trip experiences defined by a certain bundle of activities. Finally, the household uses the information from stages one and two to compare the benefits and (minimized) costs of a trip to Madagascar, relative to trips to other countries. This is described in more detail below (for a rigorous mathematical analysis, see Mercer and Kramer 1992).

There are two types of goods in the model: recreation service flows and nonrecreation service flows. Recreational service flows are produces by combining market travel services and time to travel to a country with nature tourism trip experiences in the country. Nonrecreation service flows include market commodities combined with time.

Nature tourism trip experiences in a country are produced by choosing a bundle of activities and utilizing in-country market services and travel time to visit the location of the activities. The activities can be thought of either as single destinations within the country, or groups of destinations. Activities in Madagascar, for example, might include travelling to the proposed Mantadia National Park to view the indiri lemurs and to a specific beach to swim and sunbathe, or to a group of parks for birdwatching and a group of beaches for snorkeling. The production function of these nonhomogeneous nature tourism trip experiences is therefore a function of the activities chosen, the travel time to reach the location of the activities, and the market goods used to travel to the location of the activities.

Once the site of the activity is reached, the activity is produced by combining market goods (e.g. guide services, camping equipment), environmental services of the site of the activity, and on-site time. Households considering international nature tourism are assumed to attempt to maximize utility. The utility function of the individual is then solved subject to the production function above and the usual full income constraint.

This model can be used to specify the total use value of international nature trips in terms of the maximal amount an individual would be willing to pay for the trip and still enjoy a given level of satisfaction or utility. This implies that the value of a trip is the difference between the minimum income required to reach the given initial level of utility at choke price levels, minus the minimum income required to reach the initial utility level at the initial prices. This is explained below.

A specific application of the model is that it seeks to identify the tourists' willingness-to-pay for the creation of a new national park (Mantadia). Mercer and Kramer define a total use value (TUV) based on two major components:

a) decision to visit Madagascar (versus other countries);
b) decision to undertake specific recreational activities in Madagascar.

With respect to item (b), a further disaggregation is made. Thus the model focuses on two activities within Madagascar:

(b) (i) Recreation outside Mantadia park;
(b) (ii) Recreation in Mantadia park.

We may write

$$TUV = Y^* - Y^0 \qquad (1)$$

The Y's are income levels which may be expressed in terms of corresponding expenditure functions **e**, as follows:

$$Y^0 = e(P^0_V, C^0_{NM}, C^0_M, Z^0, U^0) \qquad (2)$$

where P^0_V = base price of a visit to Madagascar

C^0_{NM} = base cost of recreation outside Mantadia park

C^0_M = base cost of recreation in Mantadia park

Z^0 = vector expressing base levels of other goods and services

U^0 = base utility level

In other words, Y^0 is the minimum expenditure required to achieve the utility level U^0, given the base levels for all prices and costs.

Similarly $Y^* = e(P^*_V, C^*_{NM}, C^*_M, Z^0, U^0) \quad (3)$

Thus, Y^* is the minimum expenditure required to achieve the *same* utility level U^0, if choke prices P^*_V, C^*_{NM} and C^*_M prevailed for visits to Madagascar and for activities within Madagascar (i.e., if these prices were raised from the base level up to values just high enough to choke off demand for international travel and in-country activities—in Figure 3.2 in Chapter 3, the point H is an example of a choke price).

TUV may be broken down into components in several different ways, but for their purposes, the authors rewrite (1) as follows:

$$TUV = e(P^*_V, C^*_{NM}, C^*_M, Z^0, U^0) - e(P^0_V, C^0_{NM}, C^0_M, Z^0, U^0)$$

$$= [e(P^*_V, C^*_{NM}, C^*_M, Z^0, U^0) - e(P^0_V, C^*_{NM}, C^*_M, Z^0, U^0)] \qquad (4)$$

$$+ [e(P^0_V, C^*_{NM}, C^*_M, Z^0, U^0) - e(P^0_V, C^0_{NM}, C^*_M, Z^0, U^0)] \qquad (5)$$

$$+ [e(P^0_V, C^0_{NM}, C^*_M, Z^0, U^0) - e(P^0_V, C^0_{NM}, C^0_M, Z^0, U^0) \qquad (6)$$

Note that line (4) indicates the willingness-to-pay for (or value of) a simple visit to Madagascar—but with *no* recreational activities undertaken (i.e., choke prices C^*_{NM} and C^*_M prevail). Line (5) relaxes the cost of recreation outside Mantadia (C^0_{NM}) and indicates the WTP both to visit Madagascar and to undertake activity outside Mantadia park. Finally, by reducing the cost of recreation in Mantadia (C^0_M), line (6) indicates the value of a visit to Madagascar plus recreational activities both outside and within Mantadia.

The above sequencing of components facilitates the estimation of value attached by tourists to the creation of a new national park. Survey techniques may then be used to determine actual cash costs and time expended by international tourists visiting Madagascar, and thereby estimate their WTP for the various components.

Note

1. This annex is drawn from a detailed paper by Mercer and Kramer (1992).

ANNEX 4: USING A SIMPLE BIODIVERSITY INDEX

This annex summarizes the development of a basic biodiversity index that was developed to facilitate the analysis of environmental impacts at hydroelectric dam sites in Sri Lanka. It may be considered a first step, constrained by scarcity of data, resources and time.

Detailed site specific information at potential power plant sites is unlikely to be available at the long-range system planning stage. Thus, the only quantification of biodiversity impacts that appears possible at this level of aggregation is a probabilistic estimate that gives the decision-maker information about the likelihood that the detailed environmental impact study will reveal adverse effects on an endemic species, significant impacts on ecosystems of high biological diversity, or degradation of a habitat already in a marginal condition. It should be noted that endemicity and bio-diversity are not necessarily correlated: an endemic species may be encountered in an area of low biodiversity, and areas of high biodiversity may contain no endemic species. It is certainly true, however, that extinction of an endemic species would very likely constitute a "show-stopper" at the project stage; and it is also true that at least as far as Sri Lanka is concerned, its endemic species are most likely to be encountered in areas of high biodiversity.

A biodiversity index will have several constituent elements. First is the nature of the impacted system itself. In Table A4.1, the main ecosystems encountered in Sri Lanka are ranked and assigned a value, w_j, that captures the relative biodiversity value of different habitats. The scale is to be interpreted as a strict ratio scale (i.e. zero indicates zero amount of the characteristic involved, and a habitat value of 0.1 implies ten times the value of a habitat assigned the value of 0.01).

The second element concerns the *relative* valuation, because the *value* of the area lost is a function of the proportion of the habitat that is lost. For example, the loss of the *last* hectare (ha) of an ecosystem would be unacceptable, and hence assigned an infinite value (even if the habitat involved were of low biodiversity, such as a sand dune) whereas the loss of one hectare if 1,000 ha remain would be much less.

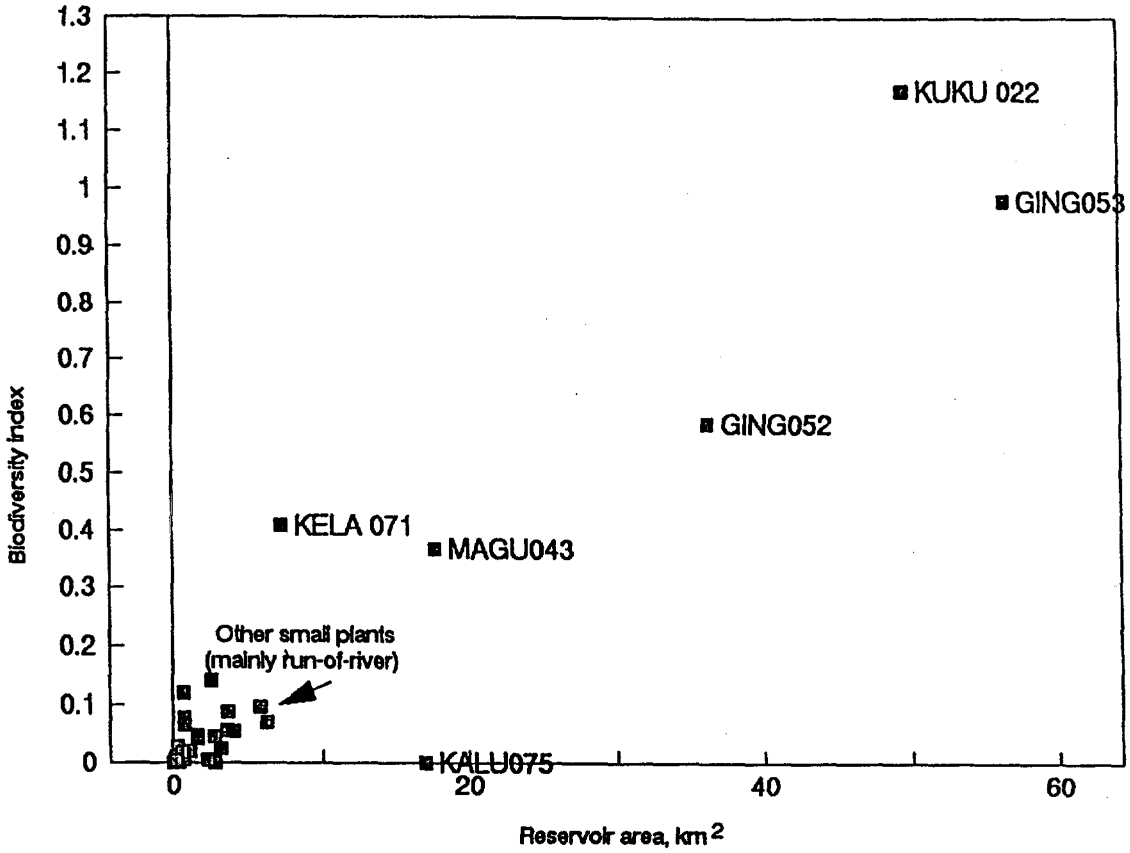
This approach to valuation of biodiversity is subject to several caveats. First, ecosystems may require some minimum area for long term survival, which implies that the value function would need to tend to infinity as it approaches that minimum value.

Second, and perhaps more importantly, the argument is sometimes made that the value to be ascribed to the habitat associated with some regulatory or governmental decision depends upon whether what remains is secure. For example, the cost of the loss of 1 ha of habitat if 1,000 remains might be valued as negligible, if that remaining habitat is

Table A4.1 Relative Biodiversity Value

rank	ecosystem	w
1	lowland wet evergreen forest	0.98
2	lowland moist evergreen forest	0.98
3	lower montane forest	0.90
4	upper montane forest	0.90
5	riverine forest	0.75
6	dry mixed evergreen forest	0.50
7	villus	0.40
8	mangroves	0.40
9	thorn forest	0.30
10	grasslands	0.30
11	rubber lands	0.20
12	home gardens	0.20
13	salt marshes	0.10
14	sand dunes	0.10

Figure A4.1 Biodiversity Index Value and Reservoir Size in Sri Lanka



protected from encroachment. On the other hand, if the remaining 1,000 ha is vulnerable to encroachment, then the loss of that 1 ha under consideration might be assigned a much higher value.

Such reasoning is not logical, because there is a confusion between costs and benefits. On the cost side, it really does not matter whether the loss is attributable to a power plant, or to agricultural development, or even to illicit felling: the loss is the same in both cases. On the other hand, the benefits to society of these activities may be quite different. Yet it is only land use planning at the local or regional level that can address the costs and benefits of alternative uses in a systematic way.

Thus the biodiversity index associated with site i, B_i, is simply defined as

$$B_i = \sum_i A_{ij} w_j$$

where A_{ij} is the ha of ecosystem of type j at site i; and w_j is relative biodiversity value of type j (as defined in Table A4.1).

In the case of Sri Lanka, the biodiversity index is strongly correlated with reservoir size (see Figure A4.1). This is simply a consequence of the fact that all of the larger projects inundate relatively large amounts of natural forest of high biodiversity value: this would not necessarily be the case elsewhere. However, when one excludes the five very large projects with reservoir sizes in excess of 15 km^2, the correlation is quite poor, reflecting the diversity of ecosystem types encountered at the smaller sites.

ANNEX 5: RECENT WORK ON ECONOMIC POLICIES AND ENVIRONMENTAL IMPLICATIONS

Country (Study)	Environmental Area/Problem					Policy Issue or Reform	
	Land degradation and deforestation	Water degradation and depletion	Air and atmospheric pollution	Energy and transportation efficiency	Other environmental problems	Within Sector	Economy-wide
AFRICA							
Burkina Faso Environmental management project, PR5434,1991	Declining forest				Loss of wildlife and biodiversity	Promote community land management, technical support and environmental monitoring	
Burundi Energy sector rehabilitation project, PR5411,1991				Inefficient use of energy			Reform price structure of power, oil, and woodfuels
Central African Republic Natural resource management project, PR5225, 1990	Deforestation				Wildlife degradation	Support to government for forest and wildlife protection	
Ghana Environmental implication of accelerated growth, white cover, Jasdip Singh, 1992	Agricultural intensification and land degradation	Pollution from domestic and industrial waste	Industrial pollution		Mining externalities		Effect of agricultural development on sustainable agriculture. Sectoral implications of accelerated growth strategy

Note: This list focuses on work outside the Environment Department. Note on report codes: ER–Economic Report; PR–President's Report; AR–Appraisal Report; SR–Sector

Ivory Coast Trade liberalization and deforestation, conference paper, 1991, Ramon Lopez	Deforestation and decline of fallow						Trade policy effects on land use change (using GIS)
Forestry sector project, PR4879,1990	Deforestation				Inefficient wood processing	Forest protection; training and investment in wood industry	
Kenya Forestry development project, PR5380,1990	Deforestation; agroforestry promotion	Agricultural water depletion				Introduce environmental regulation; tree planting; fiscal subsidies; tenure reform	Impact of irrigation investments
Protected areas and wildlife services project, PR5644, 1992					Need for wildlife management	Promote community wildlife management	
Lesotho Land management and conservation project, PR4053, 1988	Land degradation and soil erosion					Soil conservation programs, such as pasture improvement, tree planting	
Madagascar Environment program, AR8348, 1990 (first phase of EAP)	Soil erosion, deforestation				Coastal fishery over-use		Improve land security through titling; promote environmental education
Malawi (Economic Report, Env. Mgt. Strategy)	Soil erosion, deforestation	Agricultural water depletion; urban water pollution				Pricing reforms; institution building	
Mauritius Environmental monitoring and development project, PR5381,1990	Lack of land use planning					Investment program and institution support for land management	
Economic development with environmental management, SR7264, 1988	Land allocation	Industrial water pollution			Loss of biodiversity	Establish environmental institutions and use economic incentives for pollution abatement	Devise a National environmental policy

Mozambique (Olivares)	Soil salinization from irrigation; mangrove degradation	Water-borne diseases from irrigation				Address resource undervaluation	Unanticipated effects of irrigation development
Nigeria Towards the development of an environmental action plan for Nigeria, gray cover SR9002,1990	Deforestation and soil degradation	Water contamination, especially among rural and landless poor				Institutional and policy reforms for specific resource areas	Establish land security to promote conservation; recommended review of trade policy impacts on resource-based products; energy pricing reforms
Rwanda Issues and options in the energy sector, SR8017, 1991				Excess demand for fuelwood		Woodfuel pricing and taxation	Policies governing fuelwood and petroleum substitution
Senegal Second agricultural research project, PR5064, 1990	Soil erosion					Promote research on agro-forestry and soil conservation	
Uganda Second water supply project, PR5214, 1990		Urban water availability and waste water treatment				Institutional and physical improvements in delivery and treatment capacity; more pollution control proposed	
Zambia Economic recovery program, PR5483, 1991					Dependence on mining		Export promotion to reduce dependence on mining
Zimbabwe Forest resources management and development project, PR5086, 1990	Land degradation, forest loss				Overgrazing and decline of wildlife	Introduce forestry regulation	Need for tenure reforms and re-distribution
Economics of Wildlife (IM)					Decline of wildlife and biodiversity loss		Devaluation and tourism implications on wildlife
Agriculture sector memorandum, SR9429, 1991	Inefficient land use						Promote land equity and conservation

Country (Study)	Environmental Area/Problem					Policy Issue or Reform	
	Land degradation and deforestation	Water degradation and depletion	Air and atmospheric pollution	Energy and transportation efficiency	Other environmental problems	Within Sector	Economy-wide
ASIA							
Bangladesh Fishery sector review, gray cover SR8830, 1991					Freshwater fishery development	Increase private sector role in fishery development; improve credit access	
India India's environment-a strategy for World Bank assistance, SR7676, 1989	Deforestation and watershed stabilization	Water resource degradation	Industry pollution			Industry regulation; soil conservation program	Role of population pressure on limited land; protection of material and energy intensive industry
Maharashtra rural water supply and environmental sanitation, AR9202, 1991		High incidence of water-borne disease				Investment in rural water supply and sanitation systems	
Industrial pollution control project, PR5485, 1991		Urban water pollution, water supply and sanitation	Industrial air pollution			Investment, technical assistance, and monitoring at the state level	
Integrated watershed development (plains) project, PR5241, 1990; (hills) project, PR5187, 1990	Deforestation and land degradation; soil erosion, watershed degradation		Industrial pollution	Environmental impact of energy projects		Institutional and investment support for watershed management; community management	

China Environmental Strategy paper, green cover SR 9669, 1991 Nick Anderson	Excessive use of fertilizer and degradation of marginal lands		Urban air pollution	Inefficient coal use		*Institutional reforms*	Reform of industrial incentives; implications of economic re-structuring
Liaoning urban infrastructure project, AR8250, 1991	Urban water use and pollution					Technical assistance for pollution abatement and water pricing	
Efficiency and environmental impact of coal use, gray cover SR8915, 1991			Urban air pollution	Widespread coal use		Investments and policy options for reducing coal-related pollution	Investment and policy options for reducing household energy use
National afforestation project, AR8487, 1990	Gap between forest resources and use; poor quality of plantation efforts					Technical and institutional support for plantation management and forest sector planning	
Coal pricing in China, WBDP138, Yves Albouy				Inefficient use of coal		Reforms in subsidized coal pricing system	

Indonesia Second Jabotabek urban development project, AR8339, 1990		Contaminated urban water			Unsafe solid waste disposal	Investment, technical assistance and policy reforms to reduce water-related pollution	
Third Jabotabek urban development project, AR8397, 1990					Household waste disposal	Community participation in waste disposal systems	
Trade and deforestation, conference paper, Carlos Braga, 1991	Excessive logging						Trade policy, gains from trade, and implications for net welfare
Taxation and environment, Eskeland et al.			Urban air pollution			Role of taxes and subsidies in energy, transport, and petrochemical industries	
Second forestry institutions and conservation project, PR5320, 1990	Deforestation					Technical assistance and concession monitoring	
Fertilizer restructuring project, PR5231, 1990					Environmental impact of fertilizer use	Investment in industry together with environmental management program	
Yogyakarta upland area development project, PR5383, 1991	Soil erosion					Technical support for soil conservation and watershed stabilization	
Korea Gas utilization study, SR8142,1990			Urban air pollution	LNG utilization		LNG promotion to reduce air pollution	
Malaysia Forestry sector study, green cover, 1991, Wiens	Reforestation and sustainable forestry					Support for reforestation based on social and global benefits	

Nepal SAL	Soil erosion and forest loss						Agricultural development policy effects; SAL incorporates resource management
Papua New Guinea The forestry sector: a TFAP review, SR8031, 1990	Forest loss					Institution building and forestry investments	
Philippines Environment and natural resource sector adjustment program, red cover, 1989, PR5452	Deforestation and soil erosion			Mangrove degradation and coastal fishery depletion		Resource rent taxation and institutional reforms in Env. SECAL	
Sri Lanka Environmental Management Strategy, green cover SR9649, 1991	Mining, coastal land degradation		Urban water pollution	Excess fuelwood demand		New regulation and energy conservation	
Thailand Country economic memorandum, gray cover ER9627, 1991	Forest loss and soil erosion		Urban air and water pollution		Degradation of resources associated with accelerated growth	Under-pricing of dirty fuels; regulate land use	Growth-oriented policies not sufficiently sensitive to distribution and environmental implications

Country (Study)	Environmental Area/Problem					Policy Issue or Reform	
	Land degradation and deforestation	Water degradation and depletion	Air and atmospheric pollution	Energy and transportation efficiency	Other environmental problems	Within Sector	Economy-wide
Europe and Central Asia.							
Bulgaria Structural adjustment loan project, SAL P5588, 1991				Inefficient energy use		State enterprise and price reforms	
Environment strategy study, yellow cover, 1991			Industrial pollution	Material and energy intensive industry			Economic restructuring implications for pollution and energy
Czechoslovakia Structural adjustment loan project, PR5583, 1991				Inefficient energy use		Pricing and regulatory reform in energy sector; establish institutional and policy framework for environmental protection	
Turkey Turkish electricity authority restructuring loan project, PR5422, 1991				Inefficient electricity use		Reform power pricing and provide technical assistance for environmental assessment	
Poland Environment management project, PR5256, 1990		Water pollution from industry	Air pollution			Promote decentralized mgt. approach; institutional support	
Energy market development, SR8224, 1991				Energy use efficiency		Energy price reform	

Country (Study)	Environmental Area/Problem					Policy Issue or Reform	
	Land degradation and deforestation	Water degradation and depletion	Air and atmospheric pollution	Energy and transportation efficiency	Other environmental problems	Within Sector	Economy-wide
Middle East and North Africa							
Algeria Agriculture: a new opportunity for growth, SR7419, 1990		Water resource over-exploitation					Assess water use in agriculture
Environmental problems and issues, yellow cover in French, 1991, Nadia Saad	Land degradation	Agricultural water depletion	Industrial pollution from promoted heavy industries		Population growth and pressure on limited arable land; tourism and site degradation	Hazardous waste management, and water treatment	Industrial expansion programs need to be coordinated with pollution abatement
Egypt Land reclamation subsector review, SR8047, 1990	Need for land reclamation	Agricultural water supply				Improve efficiency of future investments in land reclamation	
Environmental issues paper, white cover, Nadia Saad, 1990		Water resource scarcity identified as most serious environmental constraint		Potential use of natural gas reserves	Tourism development has not ensured protection of sites	Need for legislation and institutional capacity for management; investments needed for water development	
Jordan Energy sector study, SR7984, 1990				Inefficient energy use		Oil and energy price reforms	

Tunisia Agricultural expenditure review, SR9511, 1991	Overgrazing	Vulnerability to drought and agricultural water depletion				Low efficiency of water use	Address increase in herd size from fodder subsidy during drought
Small farmers' potential and prospects: a technical study, SR9323, 1991	Inadequate land conservation	Inefficient use of irrigation at farm level				Water pricing reform	Land tenure, reform land markets to promote soil conservation
Yemen		Massive tubewell expansion and groundwater depletion				Remove irrigation subsidies	

Country (Study)	Environmental Area/Problem					Policy Issue or Reform	
	Land degradation and deforestation	Water degradation and depletion	Air and atmospheric pollution	Energy and transportation efficiency	Other environmental problems	Within Sector	Economy-wide
Latin America and Caribbean							
Argentina Energy sector study, SR7993, 1990				Energy price and tax distortions		Assess tax and subsidy schemes	
Agricultural sciences and institutional development project, 1991 ER					Pest control and increased chemical residues; overfishing	Increased government capacity for environmental management	
Environmental issues paper, SR8141, 1989	Soil erosion, salinization, and deforestation	Urban water pollution			Biodiversity losses	Institutional reorganization	Undertake natural resource accounting
Bolivia Agricultural technology development project, 1991 ER	Deforestation; land degradation and soil erosion in the Altiplano					Technology improvement to reduce wind erosion and chemical use	

Brazil Trade and Environment conference paper,1991, Carlos Braga	Increased logging						Trade lib., gains from trade, and net welfare
National Environmental Project, AR 8146	Deforestation and soil erosion	Water pollution	Air pollution		Migration and deforestation in northern frontier	Strengthen government env. agencies, and regulation	
Hydrocarbon transport and processing, ER 1991				Promote LNG substitution and increased efficiency of petroleum use		Promote more efficient energy pricing	
Chile Structural adjustment and environment study, 1991, Scarsborough	Deforestation		Industrial pollution		Overfishing	Resource undervaluation and rent-seeking	Economic openness and contribution to cleaner industrial technologies
Colombia Industrial restructuring and development project, ER 1991			Industrial pollution			Technical assistance to government and industrial enterprises	
Costa Rica Country Economic Memorandum, 1989 (El-Serafy)	Deforestation; pasture land degradation					Resource undervaluation; focus on regulatory approach	Cattle industry subsidies promote forest clearing; inequitable land distribution
Dominican Republic Issues and options in the energy sector, SR8234, 1991				Limited energy resources and distortions		Remove energy subsidies	

Ecuador Rural development project, AR9437,1991	Deforestation, erosion						Improve land tenure to encourage conservation. Reduce poverty and absorb rural labor to reduce pressure on resources
Lower Guayas flood control project, ER 1991		Improve drainage works in farms and rivers				Environmental monitoring, mangrove management, institutional strengthening	Land titling to encourage farm improvements
Municipal development and urban infrastructure project, ER 1991					Waste disposal and sewage infrastructure	Investment in infrastructure and technical assistance for environmental monitoring	
Haiti Forestry and environmental protection project, AR9307, 1991	Deforestation and soil erosion			Excessive consumption of fuelwood resources		Technical and financial support to TFAP	
Honduras Structural adjustment credit project, PR5453	Deforestation and soil erosion				Poverty and environmental degradation	Support for government resource mgt. efforts	ASAL addresses land tenure and forest mgt. issues, poverty reduction
Peru Structural adjustment study, 1991, Scarsborough	Deforestation		Industrial pollution		Overfishing	Resource undervaluation and rent-seeking	Economic openness and contribution to cleaner industrial technologies
Venezuela Environmental issues in Venezuela, gray cover SR8272, 1991	Deforestation from cattle and illegal logging	Wasteful use of agricultural, industrial, and household water			Decline of wildlife	Institutional progress including first environment ministry in LAC; stumpage valuation; water charges	Increase fertilizer and pesticide prices to reduce water contamination

Mexico Fiscal policy and environment project			Industrial and transportation pollution				Trade and trucking restrictions and impact on air pollution
Transport and telecom. SECAL, PR5254, 1990			Pollution from trucking			Monitoring and enforcement of standards	
Water and sanitation project, PR8973, 1990		Urban water supply and sanitation				Price reforms, project investment and government monitoring capacity	
Mining sector restructuring project, AR9428, 1991					Allocation of mining rights and off-site costs	Deregulate mining and establish environmental standards; improve institutional capacity at local levels	
Decentralization and regional development project for disadvantaged states, AR8786, 1991							Promote employment and access to social servies to poor and indigenous populations to reduce pressure on forests
Transport Air Quality Management in the Mexico Metropolitan Area, SR10045, 1992	Conserve remaining humid forest		Pollution from transport sources				Comprehensive transportation policy to promote efficiency and pollution abatement

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The World Bank

Headquarters
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

Telephone: (202) 477-1234
Facsimile: (202) 477-6391
Telex: WUI 64145 WORLDBANK
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Cable Address: INTBAFRAD
WASHINGTONDC

European Office
66, avenue d'Iéna
75116 Paris, France

Telephone: (1) 40.69.30.00
Facsimile: (1) 40.69.30.66
Telex: 640651

Tokyo Office
Kokusai Building
1-1 Marunouchi 3-chome
Chiyoda-ku, Tokyo 100, Japan

Telephone: (3) 3214-5001
Facsimile: (3) 3214-3657
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