ECONOMY AND ENVIRONMENT PROGRAM FOR SOUTHEAST ASIA

The Economic Valuation of Tropical Forest Land Use Options: *A Manual for Researchers*

Camille Bann

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Mailing address: Tanglin PO Box 101, Singapore 912404.
Visiting address: 7th Storey RELC Building, 30 Orange Grove Road.
Tel: 65 235 1344   Fax: 65 235 1849
Internet: dglover@idrc.org.sg or hermi@laguna.net
Website: http://www.idrc.org.sg/eepsea

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A MANUAL FOR RESEARCHERS

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Comments should be sent to the author, Camille Bann, at Flat 5, 28 Charleville Road, London W14 9JH United Kingdom, Tel/Fax: 44 171 381 3193. E-mail: CABann@aol.com

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PREFACE

This manual has been prepared as an aid to researchers in Southeast Asia involved in the economic evaluation of tropical forest land use options. It was developed initially to serve as an aid to Cambodian researchers in the execution of an EEPSEA-financed study of non-timber forest values in Ratanakiri Province, Cambodia. (The report resulting from that study is available as an EEPSEA Research Report.) The aim of the manual is to provide non-specialists with a basic theoretical background to economic valuation of the environment and with a practical methodology for an *economic* evaluation of alternative tropical forest land uses.

The manual is organised as follows:

Section A provides a basic theoretical background to environmental valuation.

Section B develops a methodology for comparing alternative uses of forest land using cost benefit analysis (CBA). Theoretical issues such as discounting, risk and uncertainty and distributional equity are discussed.

Section C presents a range of valuation techniques available for estimating environmental goods and services. The theory and methodology of a number of first best valuation techniques is discussed. However, in light of the practical difficulties of carrying out economic valuation of environmental goods and services in remote underdeveloped areas where data and resources are likely to be limited, alternative rapid and less rigorous approaches are also highlighted.

It should be noted that the valuation techniques presented here do not represent an exhaustive list. Furthermore, new methods and innovative insights to valuation are constantly evolving thereby increasing the scope of the valuation process.

Section D discusses the valuation methodologies that might be applied to value each individual component of a tropical forest, and presents results from previous studies.

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INTRODUCTION

For many developing countries, tropical forests represent an important resource base for economic development. If managed wisely, the forest has the capacity to provide a perpetual stream of income and subsistence products, while supporting other economic activities (such as fisheries and agriculture) through its ecological services and functions.

Tropical forestland may be utilised in many different ways. It can be used for commercial timber extraction, it may be converted for commercial agriculture purposes such as oil palm or rubber plantations, it may be used for traditional subsistence activities (for example, traditional agricultural practices such as agroforestry and shifting cultivation, and/or for the extraction of non-timber forest products or it may be afforded various levels of protection through the establishment of a Protected Area, a National Park or Wildlife Sanctuary (IIED 1994).

How best to manage tropical forests has become a growing concern for policy makers, interest groups and the public due to: the increasing scarcity of virgin forest land; greater awareness and understanding of the social and economic implications of destructive forest practices; and, a growing realisation that the significant opportunities for economic development based on forestry activities should not be wasted.

Greater attempts are now being made to rationalise the decision making process with respect to the use of tropical forestland. If the returns from forest land are to be maximised over the long term, then the forest needs to be managed sustainably (i.e., the production of goods and services needs to be balanced with the conservation of the resource base).

In order to make sustainable forest management decisions, more reliable information on the environmental, social, and economic value of forests in their own right and relative to other land uses is *urgently* needed.

A problem has been that traditional project evaluation procedures do not incorporate the full range of environmental and social costs associated with different forestland use options. Due to this omission, decisions on forestland use have been biased in favour of development options, some of which have been shown to be *economically unjustifiable* once the relevant environmental costs are accounted for.

One reason for this shortcoming has been a lack of understanding of, and expertise in, monetary evaluation of environmental impacts such that they can be included in the appraisal process. In response to the need to value environmental goods and services, economists have developed a range of new valuation techniques (see Section C). Meaningful assignment of monetary values to environmental goods and services is therefore possible. This facilitates their use in the economic appraisal framework and thereby refines (improves) traditional measurement. A key objective of economic valuation of the environment is therefore the integration of environmental concerns into the conventional economic decision making process in order to furnish policy analysts and decision makers with better information upon which to base decisions.

A wide range of tools are available to evaluate tropical forestland use options. Methods of appraisal include physical approaches such as environmental impact assessment, as well as financial and economic methods such as cost benefit analysis and cost effective analysis (see Section B16). This manual focuses on the **economic** appraisal of the different uses of forestland. This is based on the premise that economic analysis of competing forest management options is an important tool for achieving sustainable forest management.

The methodology presented is consistent with the framework of cost benefit analysis (CBA) widely used in the economic appraisal of development projects. A comprehensive social cost-benefit-analysis implies economic assessment of the wide range of environmental goods, services and attributes provided by the forest. However, other land use appraisal frameworks may be usefully employed in conjunction with CBA to account for environmental values for which monetary quantification is not possible within the time period set for appraisal (see Section B11).

SECTION A

Economic Valuation of the Environment

1.0 THE RATIONALE FOR ECONOMIC VALUATION OF THE ENVIRONMENT

A central theme of environmental economics, and crucial for sustainable development, is the need to place proper values on environmental goods and services. The problem with valuing environmental assets is that many of them have a zero price because no market place exists in which their true values can be revealed through the acts of buying and selling. Therefore, they are provided free. Examples may be the storm protection function of a mangrove forest, or the biological diversity within a tropical forest. Since environmental goods and services are often available to consumers at a zero price, they do not appear to affect markets, and cannot be measured as easily as marketed goods can be. This is a serious issue because, typically, environmental goods and services have a positive value (not a zero price) and many people are willing to pay to insure their continued availability (Pearce *et al* 1989).

Economists are committed to the principle that economic efficiency should be a fundamental criterion of public investment and policy making. This implies that scarce resources should be used to maximise the benefits from them, net of the costs of using them in each case. This principle is enshrined in cost benefit analysis (CBA), which is widely used as a decision tool. CBA is a method of judging projects and policies proposals according to the size of their net economic benefits.

However, traditional CBA fails to adequately capture the many environmental benefits that do not enter the market or cannot for other reasons be adequately valued in economic terms. As a consequence, projects and policies may be selected that are not truly efficient.

Since impacts on the environment often go unrecorded in CBA, too many projects are undertaken which cause environmental damage, and too few activities are undertaken which produce environmental benefits. In effect, project selection is biased in favour of development options whose output have a market price and therefore are easily measured; and against conservation options whose benefits are not bought and sold in the market and are therefore harder to measure.

Information on the economic value of environmental goods and services is therefore important for people who make decisions that affect the environment if optimal choices are to be made[1] . Unless the full range of costs and benefits of projects, including their impact on the environment, are fully accounted for, comparisons between options cannot be made fairly. Bad projects may be chosen, and good projects will not get fair consideration.

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1 There are other good reasons why it is important to correctly value environmental goods and assets:

(i) The elementary theory of supply and demand explains that if something is provided at a zero or low price, more of it will be demanded than if it is provided at a higher price. The danger will be that this greater level of demand will be unrelated to the capacity of the relevant natural environment to meet the demand.

(ii) Valuation provides the raw data for national resource accounting, which adjusts national account (Gross National Product (GNP), Gross Domestic Product [GDP] to allow for environmental 'depreciation' (e.g., soil erosion, depletion of petroleum reserves, deforestation). These adjustments provide a more accurate indicator of a country's performance. If environmental damage and depletion is not entered into national accounts, then government, citizens, and international agencies receive the wrong signals about an economy's true performance.

(iii) By indicating the size of environmental costs and benefits, valuation provides guidance on the size of taxes, subsidies, user charges and other financial devices necessary to correct market and policy failures.

2.0 BASIC PRINCIPLES THAT DETERMINE ECONOMIC VALUES[2]

To the economist, *scarcity* is what imparts value to a good or service. Where a market for the good or service exists, its scarcity is measured by its *price.* A market is where the supply of product or service confronts the demand for it. Market prices are established through the exchange of goods and/or services in the marketplace, an interaction of producer values (supply) and consumer values (demand).

Theoretically, an 'efficient' market is one that is highly competitive, with many buyers and sellers, all of whom have perfect information about the market. In such a market, goods and services will be priced at their marginal value product and reflect the full opportunity cost of resource use[3]. An efficient price is achieved when the price clears the market so that demand is equal to supply, where efficiency implies that the net benefit to society from resource use is maximised (IIED 1994).

In this way, prices act as a signal of the opportunity cost of scare resources used to produce goods and services, and the relative utility that consumers obtain from the good or service[4].

Where markets operate reasonably well, **prices** will give a reliable indication of a good's relative scarcity. However, it is important to recognise that markets fail for a number of reasons and the market price therefore does not signal the true value (scarcity) of a good or service (Box A2.2).

Furthermore, prices determined in this way are likely to give only a *minimum* estimate of values.

The consumer demand curve reflects how much consumers are willing to consume of a product at different prices while the producer supply curve reflects how much producers are willing to supply of a product at different prices. The total satisfaction of the consumer is represented by the entire area under the demand curve. Therefore, the area of the demand curve which lies above the price actually paid is the consumer surplus, indicating the excess of what the consumer would have been willing to pay over what he or she actually had to pay. Producer surplus is the area above the supply curve below the market price. The net social benefit is the sum of consumer and producer surplus (Figure 1).

D - D1 represents the demand curve indicating what the demand for a good would be at different price levels (i.e., consumers' willingness to pay for the good or service in question). Generally, demand is inversely related to supply, i.e. as price increases, demand falls. S-S1 represents the supply curve, indicating how much of a good will be supplied at a given price. Generally, supply is positively related to price, i.e., as price increases, so does supply.

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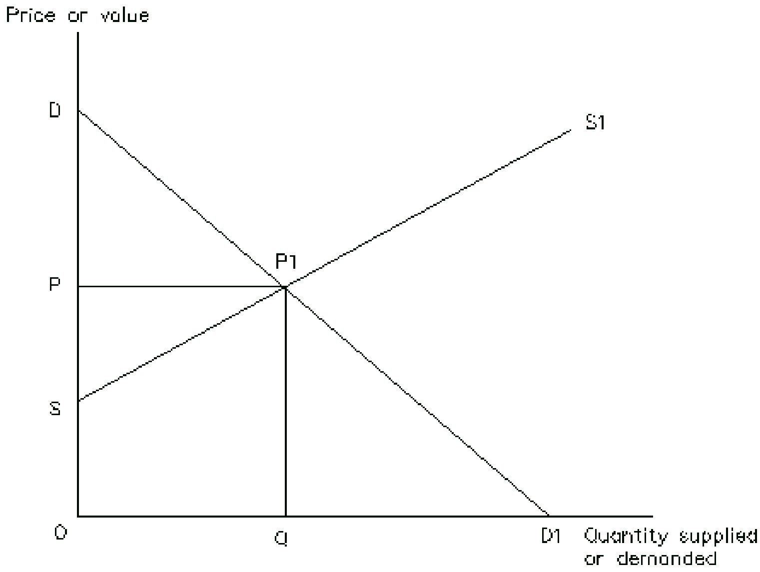
2 Section complied from OECD 1995

3 Marginal value product may be defined as the value that the last unit utilized contributes to production.

4 Opportunity cost is a fundamental economic concept. The opportunity cost of an action is the value of the foregone alternative action. Opportunity costs can only arise in a world where the resources available to meet wants are limited so that all wants cannot be satisfied.Consumer surplus should be added to benefits whenever the demand curve is downward sloping. This concept is important for many kinds of environmental assets, the price of which is zero or very small (e.g., national parks). It also applies to services where the fee charged is much below what users would be willing to pay (e.g., concession fees and royalties paid by timber companies to cut forests).

Figure 1 Supply,Demand,Price and Consumer Surplus



The value of an environmental good or service is therefore equal to the market value (P*Q) plus the consumer surplus (D- P1-P). In practice, the area D-P1-P is often irregular due to the non-linear shape of the demand curve. To be truly accurate, estimation of consumer surplus would generally need to be done algebraically.

Strictly, the demand curve traces out the WTP for extra (or 'marginal') amounts of a good or service. The demand curve is therefore a 'marginal willingness to pay' schedule. The marginal cost, or marginal benefit, is the change in total cost or benefit from an increase or decrease in the amount supplied or used. The steeper the supply and demand curves, the higher the marginal cost and benefits. Changes in consumers' (and producers') surplus are used to measure gross welfare effects. If the change is positive, it counts as a benefit. If the change is negative, it counts as a cost.

The entire area under the demand curve represents the *Consumer Surplus*. If the price is fixed at P, consumer surplus will equal the area above the price, P, and below the demand curve, i.e., the area D-P1-P.In such cases, taking prices as the measure would seriously underestimate the values of the assets in question.

The correct measure of value is the individual's maximum willingness to pay (WTP) to prevent environmental damage or realise an environmental benefit (represented by the area under the demand curve).

Economic Values Comprise Both the Prices Paid in Markets and the Consumer Surplus that Users Obtain.

2.1 Market and Policy Failure[5]

Much of the mismanagement and inefficient use of natural resources and environmental degradation can be explained in terms of market and policy failure.

A successful economy depends on a well functioning market. This signals the relative scarcity of different resources through their prices, and allocates them to their most highly valued users. However, markets fail to function efficiently for a number of reasons. For example, the existence of externalities, unpriced assets and missing markets, transaction costs, the lack of property rights, and incomplete information (Box A2.2). Some of these reasons apply to other sectors of the economy, but they arise with particular severity in the case of natural resources. Prices generated by such markets do not reflect the true social costs and benefits of resource use[6] ; convey misleading information about resource scarcity; and provide inadequate incentives for management, efficient use, and conservation of natural resources (Panayotou 1993).

For example, if too much of the environment is being consumed (e.g., too many trees cut down, too many fish caught, too much effluent poured into rivers) this is a sign that the market is failing to signal the growing scarcity of environmental resources (forest, fisheries, the capacity of rivers to assimilate waste). Looked at from the supply side, the same failure is evident. People are not investing in the environment (planting trees, conserving wildlife, cleaning up rivers) because it is not advantageous for them to do so. For various reasons, the market is failing to reward environmental conservers and investors.

It follows that a government's environmental policy should address the above market failures. This calls for an active agenda: not a prescription for *laissez-faire* approach, or letting prices find a natural level. For example, if externalities are to be internalised in some way, financial transfers have to be arranged between the perpetrator and 'victim'. However, in reality Governments often intervene in markets and make the situation worse. The term *policy failure* covers both omissions and commissions. That is, not only a failure to correct market distortions and biases, but also the introduction of new distortions or worsening of existing ones as a result of inappropriate government policies.

[5] Section compiled from OECD, 1995

[6] The social cost of a given output is defined as the sum of money which is just adequate when paid as compensation to restore the original utility levels of all who lose as a result of the production of the output. The social cost is the opportunity cost to society (i.e. to all individuals in society) rather than just to one firm or individual. One of the main reasons why social costs differ from the observed private costs is due to the existence of externalities or external costs.

Policy failure occurs when:

(i) the government policy interventions necessary to correct market failures are not taken, or over correct or under correct the problem (e.g., lack of management of open access forests).

(ii) government decisions — exchange rate controls, price ceilings or supports, subsidies or taxes that create incentives for unsustainable forest use, inappropriate land reforms which create tenure insecurity, nationalisation of forest land without the means to control and manage it — are responsible for distorting market prices.

Box A1.1
Low Income and Willingness to Pay Estimates

Willingness to pay (WTP) indicates the strength of one's preference for environmental quality, and it is influenced typically by several factors, including an individual's income, gender, cultural preferences, education, or age.

Although monetary estimates of WTP may be of low value in developing counties as compared to developed countries, it does not necessarily mean that people in developing countries have low absolute values for environmental resources.

Many individuals in low-income countries have been shown to spend significant portions of their income on goods related to environmental quality. Others invest considerable time and effort to obtain environmental benefits such as clean water. Such expenditures of effort should be reflected in WTP estimates, wherever feasible.

Another way to look at WTP is as the proportion of total household income it reflects, rather than the absolute value. This provides a measure of the value of the good relative to other purchased goods and services (but does not provide an absolute value that can be used directly in cost benefit comparison).

Source: ADB, 1995

Box A2.2
Types of Market Failure

Externalities are the effects of an action (on other parties) which are not taken into account by the perpetrator. For example, a private industry releasing effluent into a river used for bathing and drinking is causing externalities by reducing the welfare or increasing the costs for others, since these repercussions do not enter into the **private** calculations of the firm. In other words, the market does not signal the costs of the externalities back to the perpetrator, who has no incentive to curb this anti-social behaviour (unless there are regulations and fines governing such actions). Externalities can also be beneficial, for example, the value of trees planted for their timber value may also be of value as a windbreak for adjacent farmers. The task of policy makers is to **internalise** externalities by imposing on offenders themselves the **full costs** of their actions on others.

Many environmental assets valued by society, such as clean air, attractive landscapes and biological diversity, are not bought and sold in markets. As a result **many environmental assets are unpriced**. Unless restrained by other measures, individuals have no incentive to reduce their use of these assets, still less to invest in their preservation and growth.

In some cases, resources are unpriced because they are **public goods**, and charging for them would be difficult or impossible. A public good is one that is available to everyone and which cannot be denied to anyone. They are, therefore, **open access resources**. Under such circumstances it is unprofitable for a private party to invest in the protection or enhancement of the resource, because of the impossibility of recovering costs from other users (free riders). There is also no incentive for a user to abstain from consumption — since someone else would step in instead. This quality of public goods is sometimes called *non-exclusivity*.

For public goods that are depletable, one person's use is at the expense of someone else's (e.g., use of public forest for firewood and timber, hunting wild game, sea fishing, use of irrigation water, grazing animals on common pasture). Some of the worst environmental degradation occurs in resources which are depletable but, in practice (if not in theory), non-excludable. This situation has been called **The Tragedy of the Commons** (it applies to situations of open access resources, and may exaggerate the problem in cases where there are effective systems — often traditional — of common property management).

Implicit in the Tragedy of the Commons is the assumption that the users of the common resource (e.g., the pasture) are unable or unwilling to get together to agree on a viable system of management. While each of them has a strong-short term interest in maximising their use of the common resource, in the long-term each of them has a stronger incentive to preserve it, even if that means accepting limitations on access.

There are many reasons, however, why the parties fail to reach agreement, the cost and difficulty of enforcing contracts and policing a deal, the time and trouble of getting many parties together, the cost of supplying information, among others. Collectively these costs are known as **transaction costs**. Where they are high relative to the benefits which are expected, effective agreement is unlikely and the environment continues to be degraded.

Markets to perform well, need to be supported by institutions and, specifically, a system of **property rights**. An obvious case is the farmer. A farmer who owns his/her land, or has secure and long term tenure, has an obvious incentive to look after it and reinvest in it, especially if it is also possible to sell it and realise those investments. Tenant farmers, squatters, and those enjoying only the right to use land (*usufruct*) have much less incentive to manage their land or invest in it, and indeed have every reason to squeeze as much as possible from the soil while they still occupy it. So long as property rights, in the general sense, are clear, exclusive, secure, enforceable and transferable, the owners have every incentive to safeguard their resource. If some or all of these conditions are absent, this incentive is diminished. In developing countries, much environmental degradation follows from the attempts by governments to override customary laws, or to nationalise resources (forest, common land) which were formally subject to customary management. In practice, these actions often cause confusion and uncertainty. The traditional system of control is undermined without being replaced by an effective alternative.

Incomplete information (ignorance and uncertainty) also hinder the functioning of markets. In such cases markets are imperfect. The function of markets is to signal emerging scarcities, such as environmental resources. Because environmental processes are badly understood, changes (and their implications) may not be perceived in time for prices to operate. Short-sightedness (myopia) compounds the problem. Most individuals have quite short planning horizons, in the sense that they pay greatest attention to financial welfare considerations occurring in the near future. The fact that planting trees may yield great benefits after 30 years does not weigh very heavily in most people's decisions. The result is that both long-term costs and benefits tend to be heavily discounted when decisions are made. Environmental projects are particularly liable to this bias.

Markets fail when environmental processes are irreversible. Where the future is uncertain, there is value in keeping future development options open. Where an attractive valley is flooded to create a hydroelectric scheme, society loses the option of preserving that landscape for future generations. Generating the same power from a thermal power station would retain that option, yet the market would point to the hydro project if it were cheaper. In other words the market would ignore the option values which are destroyed by building the dam. The issue is an important one in practice because society is becoming increasingly interested in environmental quality, which means that option values are rising all the time.

Source: Adapted from OECD, 1995

SECTION B

Economic Analysis of Tropical Forest Land Use Options

1.0 ECONOMIC VALUATION OF ALTERNATIVE TROPICAL FOREST LAND USE OPTIONS[1]

The decision of how to use forest land is an economic issue. Every choice or land use option for the forest — to preserve it from all human uses, or to exploit it for timber, or to clear it entirely and convert the land to another use such as agriculture — has implications in terms of economic values gained and lost (i.e., costs and benefits).

Deforestation is an economic issue because important values are lost, some perhaps irreversibly, when natural or virgin forests are logged, degraded or converted to other uses. For example, if the forest is cleared for agriculture, not only should the direct costs of conversion (e.g., clearing and burning the forest and establishing crops) be included as part of the costs of this land use option but also the foregone values of the forest that has been converted. That is both the value of the important environmental functions lost (e.g., watershed protection, micro-climate maintenance and biodiversty) and the value of lost resources (e.g., commercial hardwoods, non-timber products and wildlife).

On the other hand, forest preservation involves the direct costs of preservation in terms of setting up a protected area, paying forest guards and rangers to protect and maintain the area, and perhaps the cost of establishing a buffer zone for local communities to use. Furthermore, development options, such as the use of the forest for commercial timber exploitation or conversion of forest land for agriculture, mining or hydroelectric power generation, are sacrificed if preservation is chosen. These foregone development benefits are therefore additional costs associated with the preservation option.

The decision of what land use option to pursue for a given forest area can only be made if all the gains and losses associated with each land use option are properly evaluated.

While the benefits of development options are easily identifiable as they often comprise marketable outputs (e.g., timber revenue and agricultural income), many values of the natural or managed forest have **no market**, and thus are generally ignored in land use decisions. For example, the market value of land converted to agriculture often fails to reflect lost environmental benefits such as watershed protection, which may be highly significant. Choice of land use is therefore often biased in favour of development options. However, if owners had to pay for the full social cost of developing forested land (i.e., the environmental and social costs that typically remain outside of the decision framework), less land would be converted or over exploited.

The task of the analyst is then to explicitly and fully account for the non-marketed environmental goods and services of the tropical forest. Failure to do this is likely to result in inappropriate forest projects and policies. To be clear, this is not an argument for forest preservation, but for a more rational decision making process. It is not necessarily the case that preservation will be the best economic option, even when non-marketed values are explicitly considered. If alternative uses of forest land yield higher returns than intact forest, then conversion is warranted. It is imperative, however, that such decisions first take into consideration the totality of goods and services provided by forests, affected communities, and the impact on the sustainability of environmental systems supported by forest.

[1] Section based on IIED, 1994

This manual sets out a methodology for comparing alternative forest land use options using Cost Benefit Analysis (CBA). Where the analyst's task is not to compare alternative land use options, but rather to assess the impact of a particular forestry activity or to evaluate the total economic value of a single land use, impact assessment or total economic valuation should be employed rather than CBA (Section B15). However, the methodology and theoretical concerns presented in the discussion on CBA, in conjunction with the discussion on valuation techniques (Section C), covers the issues and the necessary information requirements for all three different assessment approaches.

2.0 COST BENEFIT ANALYSIS

Cost Benefit Analysis (CBA) is the most common method of economic project and policy appraisal. CBA is a decision tool which judges projects according to a comparison between their costs (disadvantages) and benefits (advantages). If a project shows a net benefit, it can be approved, and different projects can be ranked according to the size of their net benefit.

Therefore, a project or policy is accepted if:

$$[Ba - Ca] > 0 \quad (1)$$

where:
Ba = benefits of project a (including environmental benefits)
Ca = costs of project a (including environmental costs)

Costs and benefits are defined according to satisfaction of wants, or preferences. If something meets a want, then it is a benefit. If it detracts from a want, it is a cost. Put more formally, anything is a benefit that increases human well-being, and anything is a cost that reduces human well-being. For the economist, whether well-being has increased or not is discovered by looking at people's preferences. If an individual states a preference for situation A to the present condition, then the benefits of moving to A must be positive for the individual. Preferences are expressed through an individual's willingness to pay (WTP). WTP is therefore used to measure benefits. (See Section A2.)

For CBA to be analytically sound, it should compare a given project to the most likely outcome in the absence of the project. This is because resources that go into a project have alternative uses. If they were not used up in a particular project they could be used for other purposes, some of which would have a positive rate of return. Where resources (inputs) have alternative uses they cannot, obviously, be regarded as 'free' or as uniquely earmarked or destined for the project in hand. Each input has an opportunity cost, and should contribute in output to the project at least as much as it could produce in the next best alternative (opportunity cost is the *foregone benefit* (opportunity lost) from undertaking a particular project). Therefore, it is not sufficient for the net benefits of A to be positive. The opportunity cost of undertaking project A must also be accounted for. Opportunity cost is equal to the benefits of the next best alternative.

The opportunity cost of choosing Option A is therefore the net benefits of Option B (the next best alternative). The net benefits of A (*NBa*) must then exceed the net benefits of B (*NBb*) if A is to be the preferred land use option.

$$NBa - NBb > 0 \qquad (2)$$

For example, consider two alternative tropical forest land use options: Option A (agricultural conversion) and Option B (sustainable traditional) use of the forest. If the forest is to be cleared for agriculture (Option A), not only should the direct costs of conversion (e.g., clearing and burning the forest and establishing crops) be included as part of the costs of this land use option but so must the foregone benefits (opportunity cost) of the forest that has been converted. Without conversion, the forest could have been conserved closer to its natural state through limited and sustainable use (Option B). Foregone benefits associated with Option A may include the loss of important environmental functions (e.g., watershed protection and micro-climate maintenance) and resources (e.g., commercial hardwoods, non-timber products, wildlife).

An important point for the analyst to remember is that it may not be necessary to estimate all the values associated with the alternative (Option B). Such a task would be time consuming and expensive. This is because an evaluation of only a few of the more significant foregone forest values may be sufficient to reveal that Option A, for example, is uneconomic. It is therefore important that the different forest values are carefully ranked before proceeding with valuation (see Section B6.5) so that the analysis may focus on significant values.

Equation (2) is timeless. It does not indicate the time period over which costs and benefits are being added up. But, changes in a situation could involve costs and benefits occurring over long periods of time, occurring immediately after which they disappear, or occurring later on. Streams of costs and benefits therefore need to be discounted so that they can be compared on an equal footing allowing for the years in which they occur. This can reduce both streams to a single figure, namely present value. Discounting is discussed in more detail in Section B9. The modified CBA rule incorporating time is presented below:

$$\Sigma_{\mathbf{t}} (B_t - C_t) (1+r)^{-t} > 0 \qquad (3)$$

where
subscript *t* refers to time.
B - benefits (including environmental benefits)
C - costs (including environmental costs)
r - discount rate

2.1 Financial Analysis Versus Economic Analysis

CBA draws a distinction between financial values and economic values.

Financial analysis is usually the first step in assessing the monetary costs and benefits of projects or land use options. A financial analysis is taken from the perspective of the private investor who is typically interested in the actual money costs and returns on his project. It therefore measures private profits accruing to households or firms based on market prices. While financial analysis can be invaluable in illustrating the motivations of the private sector it does not ask the question as to whether the market price is the *proper* price and reflects the true economic value. No account is made of any market or policy failures that may distort market prices. (See Section A2.1.)

An economic analysis goes beyond a financial analysis in order to perceive the economic costs and benefits of a project on the welfare of society as a whole. It therefore examines all of a project's impacts, including its environmental consequences.

An economic analysis typically requires various adjustments to financial prices in order to correct for market imperfections, policy distortions and distributional inequities. The aim is to estimate shadow prices or marginal social costs. (See Section C1.2.)

2.2 Methodology for Performing a Cost Benefit Analysis of Alternative Tropical Forest Land Use Options

An economic assessment of alternative tropical forest land use options using CBA involves a number of analytical steps. These are summarised below and discussed in more detail in other sections of this manual.

While the analytical steps are presented sequentially, actual implementation should involve an iterative or feedback process. That is, *at any stage* in the analysis it may be necessary to return to previous steps in order to revise the assessment process, to improve the analysis or to redefine information needs.

STEP 1 Define the problem or objective of the analysis (see Section B3)

STEP 2 Define the analysis by setting the scope and stating all significant assumptions explicitly, in other words, the baseline for the analysis, and the geographical and analytical boundaries of the system, including the time horizon for the analysis (see Section B4)

STEP 3 Identify the ecological functions of the forest ecosystem (see Section B5)

STEP 4 Identify physical impacts of alternative land uses (including with and without project framework) (see Section B5)

STEP 5 Identify Total Economic Value (TEV) of the forest ecosystem and the economic values associated with physical impacts (see Section B6)

STEP 6 Rank economic costs and benefits for monetary valuation and identify information requirements (see Section B6)

STEP 7 Quantify costs and benefits in monetary terms (see Sections B6, B7, C and D)

STEP 8 Pool monetized environmental costs and benefits with conventional project costs (e.g., capital equipment, operations and maintenance, depreciation)

STEP 9 Review all project costs and benefits (environmental and non-environmental) to ensure that they are based on similar assumptions

STEP 10 Aggregate on an annual basis, over the life time of the project (or beyond, if the impacts occur over a longer term) the valued costs and benefits (environmental and non-environmental) to determine the annual costs and benefits stream

STEP 11 Discount to estimate the present value of future costs and benefits (see Section B9)

STEP 12 Establish decision criteria by which to judge alternative options; three types of decision criteria are commonly used: the net present value (NPV); the internal rate of return (IRR); and the benefit/cost ratio (BCR) (see Section B10.)

STEP 13 Compare alternative scenarios using chosen decision (investment) criteria (see Section B10.4) [2]

STEP 14 Identify variables with high uncertainty and risk (see Section B11)

STEP 15 Carry out sensitivity analysis to show how different assumptions influence outcomes (see Section B11)

Experience shows that projects usually turn out very differently from what was expected. Sensitivity analysis tries to pinpoint the events which could have the greatest effect on the outcome of a project. It should be conducted for key project variables, environmental as well as financial. A probability analysis should be conducted for those variables identified through sensitivity analysis as having significant impacts on the investment criteria.

STEP 16 Incorporate distributional considerations (see Section B12)

STEP 17 State omissions, biases and uncertainties (see Section B13)

A risk and sensitivity analysis should ideally be extended to cover those environmental costs and benefits that could not be valued.

STEP 18 Incorporate the results of the economic valuation of environmental impacts into the project economic analysis.

The results should be incorporated into project preparation documents, including the project brief that is presented at management review meetings and during project economic analysis.

STEP 19 Draw investments or policy conclusions. The objective of the economic analysis is to indicate to policy makers which options are viable.

[2] It is important that the evaluation criteria used are consistent across projects (e.g., discount rates, shadow pricing rules and taxation burdens). That is, *all* projects in an economy should be subjected to the same evaluation criteria and assumptions to avoid investment biases.

Box B3.1 Summary of Steps to Carrying out CBA

Step 1:	Define the problem/objective
Step 2:	Define analysis
Step 3:	Identify ecological functions of forest ecosystem
Step 4:	Identify and prioritise physical impacts (with and without project)
Step 5:	Identify TEV of forest ecosystem and economic values associated with physical impacts
Step 6:	Rank costs and benefits for evaluation and identify information requirements
Step 7:	Estimate environmental costs and benefits in monetary terms
Step 8:	Pool environmental and conventional costs and benefits
Step 9:	Review all project costs and benefits to check assumptions are consistent
Step 10:	Aggregate all costs and benefits on annual basis
Step 11:	Discount future costs and benefits
Step 12:	Establish decision criteria
Step 13:	Compare alternative scenarios using chosen decision criteria
Step 14:	Identify variables with high uncertainty
Step 15:	Carry out sensitivity analysis
Step 16:	Incorporate distributional considerations
Step 17:	State omissions, biases and uncertainties
Step 18:	Incorporate results into project analysis
Step 19:	Draw investments or policy conclusions

3.0 DEFINING THE PROBLEM OR OBJECTIVE OF ANALYSIS (STEP 1)

The first step is to clearly state the problem or objective of the analysis. Obviously, this will be site specific and require an understanding of the forest area under evaluation, i.e., type of forest and the development issues associated with the area (e.g., whether forest is considered to have timber of commercial value, whether it acts as an important watershed, and the degree to which communities depend on the forest).

A comparative economic analysis will involve a comparison of two or more tropical forest land use options for a given forest area (see Box B3.2). Some hypothetical scenarios of the types of problems that might be analysed are highlighted below[3].

(i) We may want to know whether a particular forest area should be exploited for its timber or preserved for traditional uses such as the collection of NTFP.

(ii) The analysis might focus on alternative management regimes for a *particular* land use. For example, if the forest is to be exploited for timber, the following management options may be compared: clear-cutting versus selective harvesting under a range of cutting cycles.

[3] This manual focuses on the analysis of projects. However, a similar approach could be used to evaluate different policy options (e.g., the economic value of different export tariffs, stumpage rates or royalties for timber, or the effectiveness of log export bans).

(iii) Alternative land uses are not necessarily exclusive and a combination of uses and activities may be optimal for a given forest area. For example, sustainable harvesting of non-timber forest products may be compared to clear-cutting of timber, and to the periodic selective timber harvesting *combined with* the sustainable harvest of non-forest products. Likewise, forest conservation or managing the forest for subsistence purposes may have a higher social return if an ecotourism element is included.

As mentioned in Section B2, for CBA to be analytically sound, a given project should be compared to the next best alternative. Specifying a 'project' is usually quite straightforward; specifying alternatives to the project may require some attention. A common short cut approach, is to assume that 'nothing' (or some other extreme such as clear-cutting) will happen in the absence of the project, but this assumption is often incorrect. A more careful approach in situations where a large amount of information regarding development options is available, would involve specifying the alternative judgementally. If, on the other hand, very little is known regarding development alternatives, a wider range of alternatives should be accepted as potentially viable (Ruitenbeek 1995).

The analyst is responsible for ensuring that all feasible alternatives have been explored, and that the alternatives chosen to include in the analysis are the most robust and cost effective.

Box B3.2 A Taxonomy of Tropical Forest Land Use Options

TIMBER PRODUCTION
- Natural Forest (clear-cutting, or sustained yield)
- Plantation or silviculture

COMMERCIAL AGRICULTURE
- Plantation agriculture
- Agro-forestry
- Cattle ranching

SUBSISTENCE AGRICULTURE
- Shifting cultivation

COLLECTION OF NON TIMBER FOREST PRODUCTS
- (for subsistence and / or commercial purposes)

CONSERVATION
- National park
- Wildlife reserve
- Protected area

ECOTOURISM

OTHER
- Human habitat

4.0 SETTING THE SCOPE OF THE ANALYSIS (STEP 2)

Once the objective of the analysis has been defined, the following analytical parameters need to be identified:

(i) the baseline

(ii) the geographical and analytical boundaries of the system

4.1 Setting the Baseline, the 'With or Without Project' Case

A critical aspect of any economic evaluation is the definition of the baseline. Typically, the baseline reflects the conditions as they would occur without the project (i.e., without any change in land use). Assessment of the 'without' project scenario allows one to judge the real difference the project would make.

Even if alternative projects are being considered, the 'without-project' option should be retained (sometimes an alternative project is used *instead* of the 'without project' scenario as the baseline). The reason for this is that we have to be able to specify the changes which will be brought about by the project as compared to what would happen if no project was undertaken. For example, a proposed agricultural development project in an upland area may cause soil erosion and increase damages to irrigated rice fields downstream. The environmental 'cost' of the project is not the total damage to the rice fields, but only that caused by the additional load of sediment produced by the project. An analysis which postulates both 'with' and 'without' scenarios will help to clarify the degree of damage (or the damage avoided) as a result of the project. Unless this is done, there is a risk of attributing too much (or too little) damage to a particular cause. This is particularly important when the event in question occurs in an ongoing process (e.g., where there is already serious air and water pollution or soil erosion).

4.2 Defining the Geographical and Analytical Boundaries

The appropriate geographical and analytical boundary of the analysis and the appropriate time horizon will depend on the type of the problem to be analysed.

For example, if logging will impact a downstream fishery through resulting soil erosion and sedimentation, the analyst would have to include both activities in its 'analytical' boundary. He would also have to consider a time horizon sufficient to cover the duration of the soil erosion and sedimentation impact of logging on fishing downstream.

An attempt to measure the economic contribution of a particular forest land use on the welfare of society as a whole would have an extremely wide analytical boundary. The boundary should be sufficient to cover all possible social values of the forest, as well as a very long time horizon, perhaps sufficiently large to include intergenerational issues.

Typically, the benefits and costs of many land uses occur over relatively long time periods. Setting an appropriate time horizon for land use appraisal is therefore an important issue and will depend on the nature of the problem being evaluated.

In the case of agricultural uses this may be a relatively short period of a few years, corresponding to one full crop rotation (including fallow where relevant). In forestry, the normal practice is to consider the entire cycle of tree growth and maturation. For certain environmental or aesthetic benefits, however, even a 30-year timber rotation may not be enough time to reflect all of the consequences of a change in land use. Changes in soil hydrology or climate, for example, may not be revealed for decades. The aesthetic value of certain old-growth forest ecosystems may reflect centuries — or even millennia — of growth, decay and adaptation.

There is no hard and fast rule for setting a time horizon for forest land use appraisal. What is important is to ensure that all relevant costs and benefits are included in the analysis, whenever they occur, and that alternative land uses are compared over the same time frame.

5.0 ECOLOGICAL ANALYSIS AND IDENTIFICATION OF PHYSICAL IMPACT (STEPS 3-4)

To provide the foundation for an economic evaluation of environmental values, the analyst must first identify and quantify all the actual and potential physical impacts of a specific land use practice (see Box B5.1). For example, the effects of logging on non-timber forest products or on important environmental services such as watershed protection, and nutrient cycling. This requires an understanding of a system's ecological resources, functions and attributes[4] .

If an Environmental Impact Assessment (EIA) has been undertaken for the project, this will be the most important source of information on the physical impacts of the project.

Typically an EIA will include:

(i) an ecological analysis of forest ecosystem to identify its resources, functions and attributes.

(ii) identification of a project's actual and potential impacts (this step should describe the nature of the impact and how changes on one component might affect changes in other components). Ideally, impacts should be quantified. This ensures that the impacts are consistently portrayed so that they can be compared to each other and used to determine economic values.

(iii) screening of impacts to determine which are the most economically or ecologically important for that area. Impacts may be classified as being of high, medium or low importance.

5.1 Important Ecological Functions of a Tropical Forest

5.1.1 Watershed Functions

Forests serve important watershed functions. When forested mountain slopes are denuded, forest soils lose their water retention capacity and most rainfall disappears rapidly as surface runoff which can result in excessive flooding along riverbeds. Damage from

[4] A function is an aspect of an ecosystem that potentially or actually supports or protects human activities or human property without being used directly, or supports or protects natural systems or natural process. Functions are classified as 'indirect use values' by economists.
An attribute is an aspect of an ecosystem which does not necessarily provide a function or support a use, but is valued by a group within society.

widespread flooding can include: crop damage; loss of livestock and otheranimals;damage to human dwellings, infrastructure and equipment; displacement of people; and, the spread of disease.Forests also protect against soil erosion due to surface water runoff and wind. If an area is deforested this soil retention capacity is reduced, allowing the erosion of fertile topsoil. This reduces the productivity of the land and can result in the siltation of riverbeds and reservoirs downstream, thereby affecting hydroelectric projects, fisheries and agriculture.

Forests also play a role in providing fresh water supply. The destruction of watersheds can therefore be devastating, especially to rural poor communities that rely on natural resources for their basic requirements (Randall *et al* 1995).

Box B5.1 Environmental Impacts to be Considered for Economic Valuation

A project's environmental impacts can be defined as any changes in the quality and/or supply of an environmental good or service that results from that project. These impacts can be of the following types:

Positive and negative impacts

A project activity will generally produce positive and/or negative impacts (i.e., benefits and damages). Damages have the net effect of increasing the cost figures used to estimate the economic values of the project, while benefits have the opposite effect.

On-site and off-site impacts

On-site impacts are those impacts that occur within the boundaries of the forest area. Off-site impacts occur outside of the forest boundary, for example siltation of downstream waterways as a result of deforestation.

Physical, socio-economic and psychological

Physical impacts on people and the environment include, for example, loss of species diversity and diseases that result from polluted waters. Socio-economic impacts include such effects as lost income and changes to buildings of cultural importance. Psychological impacts include increased stress as a result of a project activity.

Near-term and long-term impacts

Environmental impacts can occur at any time; some will arise at the onset of the project, while others may start later or extend for decades into the future. Some impacts, regardless of when they begin, may be irreversible (e.g., a project that permanently alters a culturally important site or endangers a species).

Impacts that occur at different times need to be addressed carefully through the discounting procedure. All potentially irreversible impacts require special consideration, and should be clearly identified and described in a project economic analysis regardless of whether they are amenable to valuation and/or monetization.

Internal and external impacts

If the impacts of actions taken to produce or consume a good are reflected in its cost or prices, or if the impacts affect only those involved in its production or consumption, then impacts are internal to the project. Impacts not reflected in prices, or which affect those not compensated or directly involved in a good's production or consumption, are considered external (i.e., externalities). Internal impacts are generally easy to quantify and value, and are thus typically incorporated in financial and economic analysis. External costs may be difficult to monetize because market prices and costs do not exist, or because no mechanism exists to compensate for losses.

Source: Adapted from ADB, 1996

5.1.2 Micro Climate Functions

Forests have a significant role in stabilising regional climate and hydrological systems, particularly by affecting rainfall patterns. Loss of forest cover may cause changes in rainfall patterns resulting in changing patterns of vegetation. Rich biomass may be replaced by less dense shrubs and bushes that require more moisture.

5.1.3 Carbon Storage

Tropical forests and forest soils serve as vast storehouses for carbon due to their high density of biomass. It is estimated that tropical forests contain up to three times the amount of carbon found in the atmosphere (Sharma *et al* 1992).

Deforestation increases atmospheric carbon by releasing carbon in the atmosphere when forests burn and the subsequent absence of biomass to sequester atmospheric carbon. Increasing levels of atmospheric carbon cause the build-up of greenhouse gases, believed to result in a rise in the earth's surface temperature, or the greenhouse effect. The Intergovernmental Panel on Climatic Change (IPCC) estimates that tropical deforestation contributes about one-sixth of the total global emissions of carbon into the atmosphere.

5.1.4 Biodiversity

Tropical forests cover 9% of the earth's surface but support about one half of the 1.4 million named species found among the entire world biota (Schucking and Anderson 1991). It is estimated that less than 5% of the biodiversity within tropical rain forests is known to science.

Biodiversity conservation is important for a number of reasons.

There is an intrinsic value to biodiversity itself. Tropical forests are complex ecosystems with intricate dependencies among the various species of animals and plants. Species and genetic diversity, as well as the diversity of tropical forest ecosystems, are vital for maintaining the balance of natural ecosystems. The extinction of a single species can drive several others to endangered status or extinction (Randall *et al* 1995). Loss of genetic diversity can cause maladaption of species to changing environmental conditions and increase susceptibility to diseases. Conservation of biodiversity therefore contributes to increased resilience of ecosystems, ecosystem stability, and improved habitat.

Biodiversity conservation prevents the loss of genetic material that could be of commercial value in the future. For example, one gene from a single Ethiopian barley plant now protects California's barley crop (worth US$160 million annually) from yellow dwarf virus. The diversity of species also has high potential medicinal value. Globally, medicines from wild products are estimated to be worth approximately US$40 billion a year (Randall *et al* 1995). (See Section D.2.2.)

Tropical forests are important for fulfilling the sociocultural dimensions of development. Preservation of the unique social and cultural diversity of the many indigenous and tribal groups dependent on the forest requires that forest resource be kept intact.

Forests also have a role in improving air quality and in enriching soils through nitrogen fixing.

6.0 IDENTIFYING TOTAL ECONOMIC VALUE OF THE FOREST ECOSYSTEM AND ECONOMIC VALUES ASSOCIATED WITH PHYSICAL IMPACTS (STEP 6)

Once the ecological functions of the forest ecosystem and the actual and potential physical impacts of a particular land use option have been identified, they need to be related to economic values.

The framework for economic valuation of environmental resources such as tropical forests is **Total Economic Value** (TEV). TEV comprises three main types of values — direct use values, indirect use values, and non-use values (see Table B6.1).

Table B6.1 Total Economic Value of a Tropical Forest

Use Values			Non Use Values
(1) Direct Value	(2) Indirect Value	(3) Option Value	
Sustainable timber	Watershed protection	Future use as per (1) and (2)	Existence value
Non timber forest products	Nutrient cycling		Cultural heritage
Recreation and tourism	Air pollution reduction		Biodiversity
Medicine	Micro climatic functions		
Plant genetics	Carbon store		
Education	Biodiversity		
Human habitat			

6.1 Direct Use Value

Direct use values are values derived from direct use or interaction with a tropical forest's resources and services. They involve both commercial, subsistence, leisure, or other activities associated with a resource. Subsistence activities are often crucially important to rural populations.

Timber is the most recognised economic product from tropical forests. However, forests are the source of many non-timber forest products (NTFP) including: fuelwood; extractives such as bark, dyes, fibres, gums, incense, latexes, oils, resins, shellac, tanning compounds and waxes; parts of plants and animals for medicinal, ceremonial or decorative purposes; and, food such as bush meat, flowers, fruits, honey, nuts, leaves, seeds and spices.

Most NTFP are consumed locally (i.e., nationally). Nevertheless, they constitute a valuable resource, and their commercial value per hectare of land can exceed that of wood products. Certain NTFP have considerable international markets as well. Rattan, latex, palm oil, cocoa, vanilla, nuts, spices, gum and ornamental plants are commodities for which markets do exist and are expanding in developed countries[5] .

Ecotourism within tropical forests is an emerging economic activity with tremendous potential to generate foreign exchange. Local residents also derive recreational benefits from visiting tropical forest reserves, but their WTP for this activity is generally lower than that of international travellers.

6.2 Indirect Use Value

Indirect use value relates to the indirect support and protection provided to economic activity and property by the tropical forest's natural functions, or regulatory environmental services. For example, the watershed protection function of a tropical forest may have indirect use value through controlling sedimentation and flood drainage that affect downstream agriculture, fishing, water supplies and other economic activities. The micro-climate function of some tropical forests may also have indirect use value through the support of neighbouring agricultural areas.

If the environmental functions and services provided by the forest are disturbed, then there will be a corresponding change in the value of production or consumption of the activity and property that is protected or supported by the forest. As indirect values cannot, typically, be directly or indirectly inferred from observed human or market behaviour, they are often difficult to value.

6.3 Option Value

Option value is a type of use value in that it relates to future use of the tropical forest. Option value arises because individuals may value the option to be able to use a tropical forest some time in the future. Thus there is an additional premium placed on preserving a forest system and its resources and functions for future use, particularly if one is uncertain about the future value but believe it may be high, and if current exploitation or conversion may be irreversible.

For example, forest resources may be underutilised today but may have a high future value in terms of scientific, educational, commercial and other economic uses. Similarly, the environmental regulatory functions of the forest ecosystem may become increasingly important over time as economic activities develop and spread in the region.

A special category of option values are **bequest values**, which result from individuals placing a high value on the conservation of tropical forests for future generations to use. The motive is the desire to pass something on to one's descendants. Bequest values may be particularly high among the local populations currently using or inhabiting a tropical forest in that they would like to pass on to their heirs and future generations their life and culture that has co-evolved in conjunction with the forest.

Option and bequest value is difficult to assess as it involves some assumptions concerning future incomes and preferences, as well as technological change.

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5 Indonesia is one of the world's largest exporters of tropical non-wood products. Rattan, resin, essential oils, kapok and cinchona bark (quinine) exports in 1986 generated US $134 million in foreign exchange.

6.4 Non-use Value

Non-use values are derived neither from current direct nor indirect use of the tropical forest. There are individuals who do not use the tropical forest but nevertheless wish to see it preserved in their own right. These intrinsic values are often referred to as existence values. Existence value is derived from the pure pleasure in something's existence, unrelated to whether the person concerned will ever be able to benefit directly or indirectly from it. Existence values are difficult to measure as they involve subjective valuations by individuals unrelated to either their own or others use, whether current or future. However, several economic studies have shown the existence value of tropical forests to constitute a significant percentage of total economic value.

6.5 Ranking Economic Values for Valuation

Once the main economic values (direct and indirect use values, option and existence values) have been identified, they need to be ranked according to their expected importance to the outcome of the assessment. Values may be classified as high, medium or low.

Ideally, all the benefits and costs associated with each land use option under evaluation should be estimated. Realistically however, the analyst's ability to estimate environmental values will be constrained (perhaps seriously) by data limitations, finances and skills. The objective of the assessment is likely to be providing the best information possible to aid decision making. Thus, it is important to judge the relative importance of the different value components and to determine the cost effectiveness of acquiring the necessary data. The analyst needs to determine which of the forest resources, functions and attributes are most important to value and how easy it is to quantify and value them.

Priority should obviously be given to estimating value components with the highest ranking. However, it is possible that a component with a high ranking will face constraints which will prevent its valuation. Resource and data constraints will also influence the choice of *valuation technique* selected (Section B7).

Where it is *not* possible to quantify a given environmental value, a detailed qualitative assessment should be undertaken and presented.

7.0 MONETARY ESTIMATION OF ENVIRONMENTAL COSTS AND BENEFITS (STEP 7)

A range of techniques may be employed in the valuation of environmental goods and services. These are categorised in Box B7.1[6] . Table B7.1 presents the techniques which are commonly used to value the different value components of a tropical forest. A key point is that in any given analysis a number of different techniques may be used.

6 All the valuation techniques used in CBA generally assume that a project is 'small' compared to the rest of the economy. Analytically, 'small' may be defined as a project that does *not* affect prices. Practically defining the scale of a project is more difficult. One possible rule of thumb is that a project's scale should be compared to local GDP and, if the scale represents more than one or two years' worth of economic growth, then it has a potential price effect that should be accounted for in the valuation. Ideally, this requires the use of a general equilibrium model to calculate prices with and without the project. The sophisticated approaches required to analyse large scale projects are not covered in this manual.

Box B7.1 Categories of Valuation Techniques

PRICE BASED

Price based approaches use the market price of forest goods and services (corrected for market imperfections and policy failures that may distort prices).

RELATED GOODS APPROACH

The related goods approach uses information on the relationship between a marketed and non-marketed good or service in order to estimate the value of the non-marketed good (e.g., barter exchange approach, direct substitute approach, indirect substitute approach).

INDIRECT APPROACHES

Indirect approaches are those techniques that seek to elicit preferences from actual, observed market based information. These techniques are indirect because they do not rely on people's direct answers to questions about how much they would be WTP. The indirect group of techniques can be divided into two categories:

Surrogate Markets Approach (Revealed Preference Approach) which use information about a marketed commodity to infer the value of a related, non-marketed commodity (e.g., travel cost method (TCM), hedonic pricing)

Conventional Markets Approach (Market Valuation of Physical Effects) which use market prices to value environmental services in situations where environmental damage or improvement shows up in changes in the quantity or price of marketed inputs or outputs (e.g., the value of changes in productivity approach; the production function approach; dose-response functions)

DIRECT APPROACHES

Constructed Market Approaches — such as contingent valuation method (CVM) — are used to elicit directly, through survey methods, consumer's willingness to pay for non-marketed environmental values.

COST-BASED METHODS

Cost based methods use some estimate of the costs of providing or replacing a good or service as an approximate estimate of its benefit (e.g., opportunity cost, indirect opportunity cost, restoration cost, replacement cost, relocation cost, preventive expenditure).

Cost-based methods are second best techniques and must be used with caution.

Direct use values of forest resources and services are relatively straightforward to measure, and usually involve the market value of production gains. *However, it should be remembered that the use of prices alone will normally underestimate benefits, as they do not account for consumer surplus.* Other techniques, such as indirect opportunity cost, indirect substitute cost and replacement cost, are also available for direct use values but are generally second best.

Since environmental functions are rarely exchanged in markets, measurement of **indirect use values** typically entails the use of non-market valuation techniques. These include such techniques as the change in productivity approach, contingent valuation, the travel cost method and hedonic pricing.

Option, bequest and existence values can effectively be defined only from surveys of people's preference about their WTP (e.g., Contingent Valuation). Such approaches may be difficult to apply in developing countries due to their high data requirements.

The valuation techniques are discussed in more detail in Section C. Section D summarises the approaches commonly employed in valuing each individual value component of a tropical forest.

Table B7.1 Valuation Techniques Commonly Used to Value the Different Value Components of a Tropical Forest

TEV	Valuation Technique
Direct Use Value	
Timber	Market analysis
NTFP	Market analysis, price of substitutes, indirect substitution approach, indirect opportunity cost approach, value of changes in productivity, barter exchange approach
Educational, recreational and cultural uses	Travel cost method, hedonic prices
Human habitat	Hedonic prices, [replacement cost]
Indirect Use Value	
Watershed protection Nutrient cycling Air pollution reduction Microclimate regulation Carbon store Biodiversity	Damage costs avoided Preventive expenditure Value of changes in production [Relocation costs] [Replacement costs]
Option Value	Contingent valuation method
Existence Value	Contingent valuation method

8.0 CHOICE OF VALUATION TECHNIQUE AND INFORMATION REQUIREMENTS[7]

It is obviously important to base economic analysis on correct conceptual foundation, sound data, and robust empirical techniques. Concern about the reliability and objectivity of the results is a strong motivation for attempting to apply state of the art valuation techniques. This objective is perhaps particularly intense for the analysis of environmental costs and benefits since this new area is still seeking to establish a legitimate technical foundation and general acceptance.

The problem is that the first best valuation techniques typically require a lot of data which is costly and time consuming to collect. Often it is simply not feasible to get all the data or the best data for every single piece of appraisal. In practice, therefore, project analysis involves trade-offs of time, money, and effort. The analyst needs to judge what information is best to invest in, and how much time and money to spend in its pursuit. This will depend on the nature of the project and the importance of the environmental impacts on the outcome of the analysis. In reality, it may not be possible to measure some important impacts and/or to use first best valuation techniques in the analysis.

8.1 Choice of Valuation Technique

Broadly speaking, the choice of which environmental values to analyse and which valuation techniques to apply should be based on:

(I) which types of values are most prominent;
(II) what information is available and feasible to collect; and,
(III) the resources available to the analysts.

Collecting data for the various valuation techniques has different costs and collection difficulties. In choosing an appropriate valuation technique, consideration should be given to the type and amount of information that is available, and the feasibility and cost of obtaining it.

The resources available for conducting the exercise are an important factor. If the valuation is part of a long-term research or consultancy study with adequate time and funding, different considerations will apply when compared to a feasibility study for a specific project with a tight budget and deadline.

The techniques adopted should also be institutionally acceptable because they fit into current decision making processes. This is often important because there are differing views on the acceptability of the environment's monetary estimates and the analyst should be sensitive to this. By extension, it is important to consider the needs of the users of the valuation study. For example, estimates obtained from the travel cost method or hedonic pricing method might be too theoretical or complex for the target audience, or contingent valuation estimates might be seen as too subjective and unreliable to support policy debate and discussion.

For marketable goods and services valuation is relatively easy. For goods and services where markets are underdeveloped (e.g., subsistence foods, and non-timber forest products) some survey work will be necessary on the range of products in question, their uses, and their substitutes.

[7] Section based on ADB, 1996

Where market prices do not exist or are inappropriate measures of value, non-market valuation techniques will have to be used. However, these valuation techniques typically entail more effort and can be costly and time consuming.

Both CVM and TCM are survey-based methods requiring careful sampling, training of enumerators, and methods of preparation and analysis. Hedonic pricing is the most data intensive of all. Where the schedule for the project cycle is adequate, surveys (e.g., CVM, TCM) can be set in motion in time to yield results for the appraisal. Where this is not possible, the analyst should try to ensure that a baseline survey is undertaken, and that a system of monitoring and reporting is included as part of the project. Then, relevant information can be generated as the project evolves, with provision for feedback.

When time and resources, and/or available data are limited or non-existent, the analyst may be able to rely on a benefits transfer approach. Benefits transfer involves adapting the results from other studies to the study site (see Section C6).

8.2 Data Requirements

For forest products, in addition to biophysical data on harvesting, yield or use rates, types of products, rates of biological productivity and so forth, information has to be gathered on the economic costs of the inputs involved and the 'prices' of the outputs.

On the cost side, a distinction needs to be made between *purchased* or *cash* inputs (e.g., purchased or rented materials, tools and other supplies, hired labour, license fees) and *own* or *non-cash* inputs (e.g., use of own, family or exchange labour; use of any self supplied or borrowed equipment, materials and supplies).

Information on the use rates of all of these inputs (e.g., labour-time per activity, amount of materials and supplies used, rate of use and depreciation of capital equipment) is required. Relevant prices paid for the cash inputs or for equivalent purchased inputs that could substitute non-cash inputs are required as well.

Similarly, on the output side a distinction should be made between marketed and non-marketed products. Information on the producer prices, the final market prices, and the transportation and other intermediary costs of marketed goods is required.

To help value the non-marketed outputs, it is necessary to know their rates of consumption as well as the market prices of any potential substitutes or alternative products. Similar information on inputs and outputs is required for all the economic activities that are directly supported or protected by a tropical forest's ecological functions. Often, lack of ecological data on forest functions and services limits the ability to value indirect use values.

Recreation and tourism is a special environmental function in that it is directly used. For recreation, information should be collected on use rates, types of uses made and for what purposes (e.g., recreational fishing or sight seeing), actual prices paid (if any), and the costs of alternatives or substitutes.

The information required to assess non-use or preservation values is extremely difficult to collect for developing countries and may warrant a qualitative rather than a quantitative evaluation.

More general social and economic data should be collected. This would include demographic and economic data on population and communities living within the forest and adjacent regions. Such information (depending on the evaluation exercise) may include data on population growth and distribution, income levels and wealth, rural credit conditions and rates, and levels and types of employment. General economic data, such as standard project discount rates, inflation and exchange rates, should also prove useful (Ruitenbeek 1995).

8.3 Methods of Obtaining Information for Economic Valuation of the Environment

8.3.1 Collection of existing data

The analyst may either collect original data specific to the project, or draw on data used elsewhere that can be adapted to fit the analysis. Before a decision is made, it is prudent to assess the feasibility of using existing data. Data may be collected from a number of sources: other projects (benefits transfer); international data for comparable situations; local expert opinion; historical records; or, surveys of interested parties (see Box B8.1).

A literature survey should cover both specific economic and social studies of the forest and adjacent regions as well as available statistics that cover these regions. In many instances, this will provide much of the general economic and social data needed for the evaluation. Biophysical data may be obtained from government agencies that monitor these activities. It may be based on compliance monitoring and industry reported statistics, or on actual sales volumes as reported through the customs and excise department of government.

8.3.2 Surveys

The next step is to undertake a survey of the forest area under study. Surveys of the actual system can be done in the field. In some cases, it is done remotely using air photos or satellite images. Ecological surveys may also include analyses of the structure and functions of forest ecosystems such as biomass measurement, productivity, and sedimentation. Details will depend on the specifics of the problem and the area.

Site surveys of specific activities, communities and population groups are required for economic data on inputs and outputs. For non-marketed and traditional uses where no existing information is available to provide any comparable figures of either material or monetary flows, a detailed survey of local villages would be necessary to gather such information.

A household survey would need to be designed that would provide an adequate indication of these flows. The survey should be designed in such a way that it provides (Ruitenbeek 1995):

i. flexibility in response;

ii. the opportunity for replication at a latter date (e.g., the location of households interviewed should be carefully noted); and,

iii. a number of explicit quality control variables that subsequently permit analysts to assess the reliability of the data.

8.3.3. Controlled Experiments

More sophisticated approaches may be needed to obtain the required physical data for valuation purposes. Two possibilities are ecosystem modelling using computer simulation models, and controlled experiments. Experiments are typically more expensive than surveys. They should be undertaken only if necessary for project goals, and only if a suitably exhaustive literature review has revealed no useable prior experiments.

8.4 Rapid Research Approaches

Rapid analytic methods include a range of techniques and practices that provide objective and relevant information on environmental values when time, data and budgetary constraints make more detailed and robust primary research infeasible. Rapid analytic methods involve ascertaining what impact, quantification and valuation data are readily available, and then using these data in a logical and well-documented manner to provide key insights into the project's overall economic analysis. Although rapid analytical methods are not generally as precise or technically robust and defensible as more stringent approaches, when carefully applied they can be very useful.

Under a rapid analysis, data for economic valuation may be obtained during a short field visit. The analysis is based on a 'practical and quick' evaluation of the magnitude or range of potential impact values based on readily observable measures (e.g., anticipated changes in productivity). The monetary value assigned in a rapid analysis may be based on observable market prices (ADB 1996).

In a rapid, or first phase assessment, it may be useful to employ various Rapid Rural Appraisal (RRA) techniques based on quick farmer or producer interviews, wealth and preference ranking, and group participation. More detailed baseline surveys or observation studies may be required for in depth, long-term evaluations.

RRA typically concentrates on conventional hypothesis-testing through surveys conducted by outsiders who use well-structured questionnaires conducted by outsiders, with a view to generating specific products that assist in identifying interventions or projects. By contrast, Participatory Rural Appraisal (PRA) involves local people in research question design, information gathering, and final analysis; a key objective of PRA is local empowerment and awareness building. RRA techniques are generally faster than the PRA processes, can generate more detailed and consistent data sets, and can generate well-defined products for policy-maker. PRA techniques however are likely to be more innovative. RRA runs the risk of overlooking or understating important local issues, or generate the feeling that affected parties are outside of the decision process.

Box B8.1 Sources of Information

The main sources of information for environmental project and policies appraisal are as follows:

(i) National and international reports on environmental indicators

These provide much useful background information, but are unlikely to contain information on specific impacts: UNEP, Environmental Data Report; World Resources Institute (with UNDP and UNEP); World Bank, World Development Report; UNDP, Human Development Report.

Individual countries sometimes produce their own regular environmental surveys (state of the environment reports). For developing countries, the following are good sources: National Environmental Action Plans; National Conservation Strategies.

A list of major environmental reports, country by country, appears in: IIED/WRI/IUCN, Directory of country environmental studies.

(ii) Other national databases of more specific relevance

Projects concerned with specific habitats or problems need more detailed, and geographically restricted, information on the state of the environment and its determinants. GIS data can throw light on trends in the extent of major vegetational zones. Models of river basins, aquifers and coastal waters can be invaluable in predicting future water supplies, water pollution, and the impact of proposed hydraulic works. Predicting the impact of proposed projects or control measures, on air quality can be helped by models of 'airsheds'.

(iii) Environmental Impact Assessments (EIAs)

EIAs are usually commissioned specifically to report on the impact of a particular project or measure. Many governments and international lending/donor agencies have requirements for the provision of EIAs for investments and policies considered to be environmentally sensitive. EIAs are normally concerned with physical impacts (on natural environment and animal receptors) rather than with their social and economic implications. They should be regarded as sources of raw environmental data on which economists and others subsequently work. However, it is highly desirable that terms of reference for EIAs should be cleared by economists and other social scientists so that they will include data necessary for appraisal purposes.

(iv) Environmental Audits

Firms operating in countries with stringent environmental legislation have become highly sensitive to their legal liabilities. The same awareness is extending, though more slowly, to public sector concerns which can no longer regard themselves as above the law. There is an active market in the provision of audits which indicate the impact of current and prospective activities on the environment, and the firm's potential liability. Audits are normally kept confidential by the client, but some firms publish them. Those germane to a public investment decision should be accessible, but used with discretion.

(v) Appraisal and Feasibility Reports

If time permits, the analyst may be able to commission consultants to assemble the necessary information and carry out surveys.

Source: Adapted from OECD, 1995

9.0 ACCOUNTING FOR TIME

9.1 The Rationale for Discounting

Time is a crucial dimension when assessing projects and making comparisons between them. Changes in a situation could involve costs and benefits occurring over long periods of time, occurring immediately (after which they disappear) or occurring later on. Thus, the benefits in each time period should be added up.

Consider a project where the benefits accrue at a constant rate over 30 years, and the costs occur in the first five years, but then disappear. The simplest way to add up these costs and benefits would be to add the benefit in Year 1 to the benefit in Year 2, and so on to Year 30, then compare this to the sum of the costs in Year 1 to Year 5. This would be correct if the people concerned did not care when the benefits and costs occurred. But typically people do care. People have what is called *time preference* — they prefer to have benefits as soon as possible and to postpone costs. Individuals therefore attach less weight to a benefit or cost in the future than they do to a benefit or cost now. This may be due to myopia, an urgent need for gratification (e.g., because of poverty or greed), or the belief that they will be richer in the future. Thus, the marginal utility for them of a given unit of consumption will be in the future. Governments, acting in a rational way on behalf of their citizens, may also have social time preferences. For example, where they expect future incomes to be greater, and where $1 now is worth more to society than the same in the future (Pearce 1983).

Since the underlying value judgement of CBA is that consumer preferences count, it is essential to consider preferences for time. This is achieved through discounting that adjusts future sums to arrive at their present value. Discounting is an integral part of conventional CBA.

The second justification for discounting is the *opportunity cost of capital*. A sum of money is worth more now than the same amount in the future because it can be employed productively (e.g., invested profitably; lent for interest). Funds used on a project to generate a given return on some future date could have been used instead to generate returns immediately.

As a rule, costs and benefits arising in the future have a lower value than those arising now. The more distant in time they occur, the less they are valued.

Accurate comparisons between projects can only be made if allowance is made for the time factor. Projects with the same net benefits over a 20-year period will not be of equal attractiveness if one has its net benefits bunched in the first 10 years, and the other in the later 10-year period. An equally common problem is to make a comparison between a project with a high initial cost but a low running cost, and an alternative with a lower initial cost but a higher running cost.

9.2 Discounting

Discounting is the inverse of compound interest.

Thus, $1 in Year 1 would accumulate to $ $(1+r)$ in year 2 if the interest rate is r per cent (r is typically expressed as the corresponding decimal — e.g., 5% would be 0.05).

Looked at from the standpoint of Year 1, one can ask the question: "How much is $1 in year 2 worth to us in year 1?" The answer is that it is worth $\$1/(1+r)$, for the simple reason that if one had this sum in Year 1, then he or she could invest it at *r* per cent and obtain in Year 2

$$\$1 / (1 + r) * (1 + r) = \$1$$

In the same way, $1 in Year 3 can be expressed as a value in Year 1 as:

$$\$1 / (1 + r)^2$$

Since in Year 3

$$\$1 / (1 + r)^2 * (1 + r) * (1 + r) = \$1$$

This is the general formula for discounting. A benefit in time *t* can be written as Bt, and from the above procedure we know that this benefit will have a value in Year 1 of

$$Bt / (1 + r)^t$$

The procedure is the same for costs. The procedure looks at future costs and benefits from the standpoint of the present. The values derived in such a process are known as *present values.* The procedure for finding a present value is known as *discounting* and the rate at which the benefits or costs are discounted is known as the *discount rate*. CBA is concerned with the costs and benefits to a whole society. Hence the discount rate used is a *social discount rate*.

Many computer programmes and the more powerful calculators can calculate present values. Published tables of discount rates may also be consulted for manual calculations.

Box: B9.1 Modified CBA Rule

With time incorporated into the approach, we have as our decision rule that any project is potentially worthwhile if:

$$\Sigma_t (B_t - C_t)(1+r)^{-t} > 0$$

where

subscript *t* refers to time
B = benefits (including environmental benefits)
C = costs (including environmental costs)
r = discount rate

9.3 Discounting and the Environment

A common environmental critique is that discount rates are set too high. Because discounting attaches a lower weight to benefits and costs occurring in the future, it can mitigate against the interests of future generations and has some unfortunate effects as far as the environment is concerned (Turner *et al* 1994).

Where damage, or risk of damage, to the environment occurs far into the future, discounting will make the present value of this damage considerably smaller — or insignificant — than the actual damage. For instance, the cost of the future loss of habitat or groundwater contamination might not register in the scales of CBA compared to more immediate costs.

Discounting future costs will reduce the negative impacts on society of long lived effects, such as global warming or species extinction.

Conversely, where the benefits of a project accrue to people 50-100 years hence, discounting will lower the values of such benefits and may make it difficult to justify the project or policy. For example, a reforestation project on slow growing indigenous species.

Higher discount rates are also likely to encourage the extraction of natural resources (renewable and non-renewable). This leads to an exploitative rather than a conservationist bias to concession exploitation. In the extreme cases, where the discount rate exceeds the rate of natural regeneration, it is rational to harvest a resource to extinction.

A number of solutions have been suggested to deal with these issues. However, each solution is not without its own problems. These are discussed below.

Solution 1: Adopt a low or zero social rate of discount where environmental concerns are paramount.

Problems:

(a) This raises the problem of how to choose which projects or land use options will benefit from the lower rate, given that all forest land use options have environmental effects. A clear distinction is required between environmental and other projects, or between environmental and other effects within the same projects.

(b) Introducing differential discount rates could disrupt capital markets where government and private investors are active in the same sectors.

(c) Applying low discount rates in poor countries that are short of capital would encourage the use of capital intensive schemes. This would discourage employment and increase poverty, often increasing pressure on the environment. Low discount rates would also allow more unproductive schemes to proceed, namely those unable to meet the normal required rate of return. This would encourage the use of natural resources and encroachment on hitherto undeveloped areas. More generally, it would result in wasteful use of capital (OECD 1995).

Solution 2: Apply distributional weights to costs and benefits accruing to future generations

Problem: Using distributional weights to benefit future generations is fraught with philosophical, moral, economic and practical problems. It is a highly subjective and arbitrary process which is rarely used in CBA (OECD 1995).

Solution 3: Impose a *sustainability criterion* on projects with environmental impacts. This would require that the total environmental benefits provided by forest lands do not diminish in the long run. Such a condition would require for compensatory projects to insure that total environmental benefits were maintained, although such projects may not have to show a specific rate of return (Barbier *et al* 1990). A basic assumption of this approach is that the compensatory project actually replaces the benefits destroyed by the original activity. One application of this idea has been oil and electric power companies compensating for their contribution to global warming by initiating carbon storage projects — principally forest plantations in developing countries (IIED 1994).

More fundamentally, there is no unique relationship between high discounts rates and environmental deterioration. High rates may well shift the cost burden to future generations, but as the discount rate rises, so the overall level of investment falls, thus slowing the pace of economic development in general. Since natural resources are required for investment, the demand for such resources is lower the higher the discount rate. High discount rates may also discourage development projects that compete with existing environmentally benign uses (e.g., watershed development as opposed to existing wilderness use). Exactly how the choice of the discount rate impacts on the overall profile of natural resources and environmental use is thus ambiguous (Turner *et al* 1994).

Concerns about future environmental risks may be quite legitimate (see Section B10). A serious future risk which has a low probability will be heavily discounted. However, future environmental damage is often undervalued because too little is known about the processes involved. In such cases, the appropriate action is to invest in information and undertake risk management rather than acting through the discount rate.

Justice to future generations is controversial, and difficult to translate into operational principles. This is especially true where future generations are expected to be materially better off, and have substantially different lifestyles. If the principle means keeping options open, then it implies preserving biodiversity, avoiding the extinction of species, slowing down the exploitation of scarce finite resources, and investing in information about the environment and its processes. Discounting is peripheral to many of these initiatives.

Finally, many environmental concerns can be addressed by more complete economic evaluation. From the environmental point of view for any given discount rate, too many damaging projects and too few beneficial ones, are approved because environmental assets are undervalued. Economic valuation of environmental assets can therefore promote a shift in portfolio choice in a direction which addresses some discounting concerns.

9.3.1 Tropical Forest Land Use Option and Discounting

How the discount rates will affect the overall pattern of forest land use is, as for other environmental issues, ambiguous. First, certain environmentally benign projects, such as sustainable harvesting of highly valued timber species, may satisfy the requirement of a high rate of return. The use of a normal rate of discount may not discriminate against them. However, where environmentally desirable land use options do not satisfy the high discount rate criterion, the process of forest development supported by such an allocation rule may not be optimal.

Second, because high discount rates can discourage general economic activity and investment, they may reduce the pace of development of forestry and agricultural sectors and can therefore indirectly contribute to the preservation of natural forest lands. On the other hand, a high discount rate can encourage excessive depletion and accelerated use of valuable forest lands, by making it financially unattractive to hold natural resource assets for long periods.

A related problem arises from the commonplace presumption that private firms and households have a high degree of time preference, and thus employ higher discount rates on average, than society as a whole. The argument is that society can more effectively minimise risk by diversifying its investments; and of course society lives forever while private firms and households do not. High rates of private time preference may be associated with extreme poverty when immediate subsistence is uncertain.

Tenure problems and inappropriate concession terms can also engender high rates of private time preference wherever insecure or short-term use rights or shared access to scarce resources discourage investment and prudent exploitation. The divergence between public and private rates of time preference leads the private sector to discount future costs and benefits excessively and thus to consume assets that society as a whole would conserve. Hence a socially optimal rate of logging and forest clearance will fall below the level chosen by private concession holders and farmers.

Box B9.3 Recommendations on Discounting

i. use of conventional discount rates for environmental appraisal

ii. the actual discount rate used should be critically examined

iii. environmental costs and benefits should be properly valued

iv. any long-term change in the expected relative values of environmental assets should be reflected in their appraisal prices

v. the sustainability criterion should be used, implying the avoidance of critical natural capital and entering the cost of resources used in excess of sustainable yield

Note: In many situations, analysts are given a specific discount rate to work with. Most governments and agencies adopt a particular discount rate to apply to all public investments projects.

Source: Derived from OECD, 1995.

9.4 Conclusion

In general, the theoretical arguments about discounting are unresolved. Notwithstanding this, discounting is an irreplaceable device for allocating capital between projects and over time. The discount rate performs two key functions — it signals time preference and it allocates capital according to its opportunity cost (OECD 1995).

Discounting does not satisfactorily deal with significant environmental costs and benefits occurring in the future. However, dropping discounting or altering the rate, is widely seen as impractical and undesirable (OECD 1995). It is therefore recommended that the normal project discount rate be used, and the particular environmental concerns be dealt with directly, rather than by adjusting the discount rate which would create additional distortions.

10.0 DECISION RULES

All the information on benefits and costs must be collected and aggregated on an annual basis over the life time of the project to determine the annual streams of costs and benefits. Then, a project's social economic benefit can be assessed and a comparison made between alternative projects.

Three types of decision rules are commonly used: the net present value (NPV), the internal rate of return (IRR) and the benefit/cost ratio (BCR). All three depend on similar information — the generation of benefits and costs associated with the project or land use alternative over the appropriate time horizon.

10.1 Net Present Value

Net present value is the general formula used to determine the viability of a project. It computes present value by discounting a set of benefits and costs that occur through time back to the beginning of the base year (t=0). Two equivalent formulas may be used:

$$NPV = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t} \quad \text{or} \quad NPV = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$$

The CBA rule is that for any project or policy, the NPV should be positive. An illustration of the NPV decision rule is provided below.

	Year 1	Year 2	Year 3	Year 4	Year 5
Cost	30	10	0	0	0
Benefit	0	5	15	15	15
Net Benefit	-30	-5	15	15	15

The table shows the flows of costs and benefits over a five-year period for a hypothetical project. Supposing the discount rate, r, is 10% (i.e., 0.1), then the computation is:

$$[-30 \div 1.1] + [-5 \div (1.1)^2] + [15 \div (1.1)^3] + [15 \div (1.1)^4] + [15 \div (1.1)^5]$$

$$= -27.3 - 4.1 + 11.3 + 10.3 + 9.3 = -0.5$$

The calculation shows that the NPV is negative and therefore the project is not worthwhile. Interestingly, without discounting, benefits of 45 exceed costs of 35. Discounting can therefore make a big difference to the ultimate decision to accept or reject a project.

As stated in Section B2.2 it is not enough for the net benefits of an individual project to be greater than its costs. This is a necessary but not sufficient condition for approval. The net benefits of a project minus the net benefits of the next best alternative, must be greater than zero before the project is approved.

10.2 The Internal Rate of Return

The internal rate of return (IRR) is the discount rate at which the streams of costs and benefits are equal (i.e., the net present value is zero).

The IRR method is convenient in that it enables a comparison to be made between the rate of return of projects and the minimum or cut off rate that the government or sponsoring agency may stipulate, and the rates of return on other feasible investments. Thus, an agricultural investor may set minimum interest rates of, say, 10%. The IRR criterion enables it to accept and reject projects that come out, respectively, above and below 10%. This concept is also intuitively attractive to people who think in terms of private rates of profit, even though the two ideas may be different in other important respects.

$$\text{IRR} = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t} = 0 \qquad \text{or} \qquad \text{IRR} = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

10.3 The Benefit Cost Ratio

The benefit cost ratio is the ratio between discounted total benefits and costs. Thus, if discounted total benefits are 120 and discounted total costs are 100, then the benefit cost ratio is 1.2:1 (and the NPV is 20). This ratio enables a distinction to be made between projects with high (i.e., large) NPV, and projects that have a genuinely high rate of return. The BCR, like the NPV, should never be quoted without stating the discount rates that have been used.

$$\text{BCR} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$$

10.4 Choosing a Decision Criteria

In most cases, the IRR, NPV and BCR will give the same results and will produce the same project ranking. There are a few cases where the IRR will produce results different from the NPV and BCR. In general, where the government is using some sort of target (minimum, or cut off) rate of return on capital, maximising NPV should be the criterion, with the BCR as a supplementary check. However, some people find the IRR more meaningful. In such cases, the decision maker should choose the most easily comprehensible formula.

These different decision criteria may be expressed for a project or land use as a whole or in terms of different inputs (e.g., NPV per unit of land area, per unit of labour input, or per unit of capital employed). There is no one preferred denominator for expressing economic returns. Although returns per unit of land may seem appropriate for comparing land use options, it is often desirable to express returns relative to various factors. This is necessary to compare alternative land use options which vary in the extent to which they use other inputs besides land.

10.5 Comparing Projects

Cost Benefit Analysis by defining a projects net worth (NPV) is a tool that can be used to determine if a project is viable or not; make comparisons between projects; and, rank projects.

Ranking alternatives or choosing between mutually exclusive alternatives which all have a positive NPV, should be made on the basis of the highest NPV.

Another decision context arises where a number of projects can be chosen but the budget available is limited. The rule is then to rank the projects according to the ratio of the PV of benefits to the PV of costs (the benefit-cost ratio) and work down the ranked list until the budget is exhausted.

It is tempting to simply rank projects by the NPV of their benefits. But this is wrong. For example consider three projects X, Y and Z:

Project	PV (C)	PV (B)	NPV (B)	PV (B) / PV (C)
X	100	200	100	2.0
Y	50	110	60	2.2
Z	50	120	70	2.4

Source: Pearce,1983

Suppose the budget constraint is $100. A ranking by NPV(B) would derive X, Z Y and X could only be undertaken at a cost of 100. But in fact, Y and Z can be afforded, and the NPV would be 130 (NPV (Y) + NPV(Z)). Ranking by NPV does not give the right answer, and the benefit cost ratio should be used.

11.0 RISK AND UNCERTAINTY[8]

The outcome of most human activities cannot be accurately predicted. This is due to ignorance of the possible outcomes, which is an extreme case of uncertainty about future events. As knowledge improves, uncertainty about future outcomes may be expressed in terms of the probability of them happening. In this case, uncertainty would have been converted into risk. Uncertainty describes ignorance about the future, while risk is the likelihood of specific outcomes occurring (risk has been described as measurable uncertainty).

Because economic evaluation is a predictive tool, it is difficult to determine accurately what a project's benefits and costs will be in the future. Sometimes, due to time and money constraints, it will not be possible to gather good data and evaluations will be based on data not directly applicable to the project or on information rooted in judgements. Alternatively, there simply may not be enough knowledge to make an accurate predictive assessment.

There is a lot of uncertainty associated with projects with environmental effects. Many environmental process are not well understood, and it is not possible to be confident about the environmental impact of a project. The possible types of impacts might be clear, but not their scale or timing. It is especially difficult to anticipate the eventual impact of something that sets off a chain reaction, or triggers complex feed-back processes, or that has a cumulative effect. Irreversible effects, such as extinction of species, damage to the ozone layer or permanent modification of a landscape, are of particular concern.

All tropical forest land use projects entail an element of risk and uncertainty (see Box B11.1). In a production orientated project (e.g., timber production, extraction of NTFP, agriculture production) future prices and expected yields will be subject to uncertainty. For a watershed conservation project, the rates of soil erosion and/or their off-site effects both with and without the project may be unknown (IIED 1994). These uncertainties could seriously affect the outcome of the project and must be accounted for in the appraisal process.

Faced with uncertainty, the economist can contribute in various ways:

(i) invest in more information;

(ii) undertake sensitivity analysis;

(iii) present the various possible outcomes, with their probabilities (risk assessment);

(iv) take into account the perceptions and preferences of the decision maker and/or the general public (acceptable risk assessment); and

(v) devise appropriate decision rules and investment strategies (risk management).

No empirical studies to date of tropical forestland use have attempted to integrate risk and uncertainty formally into the analysis — although sensitivity analysis is common. At a minimum, therefore, a sensitivity analysis should be conducted for critical parameters and assumptions.

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8 Section 11 compiled mainly from OECD, 1995

11.1 Investing in Information

Where environmental effects are uncertain, but believed to be potentially large, it is important to gain more information about them. This could be done through: environmental impact assessment (see Section 16.2); setting up pilot schemes, in which environmental effects can be tested in controlled circumstances; or through scientific research. Where information already exists, the role of the analyst is to marshall data in a way pertinent to the decision at hand.

In certain cases, it may be prudent to delay the project pending further survey work (i.e., in situations where it is clear that additional survey work will provide the information required). Alternatively, it may make more sense to carefully structure the project so that it proceeds in a stepwise fashion which will permit realistic monitoring of the uncertain impacts. Information can then be used to redefine the project mid-way.

Any delay in starting a project has an option value, in that it keeps open a choice which would be foreclosed if the project went ahead immediately. This option value could be very large for projects with irreversible environmental effects.

Modifying the project to account for new information or delaying the project may have additional costs. The opportunity costs incurred where project is revised or delayed should therefore be assessed. However, identifying an environmental problem earlier, rather than after the project is implemented, may avoid more expensive modifications later. Moreover, more accurate knowledge about an effect could reduce the size of the safety margin built into a project following the precautionary principle (see Box B11.1)

11.2 Sensitivity Analysis

One useful and simple way of gaining insight into the impact of uncertain outcomes is sensitivity analysis.

Sensitivity analysis involves using different assumptions (values) for key input variables and relationships, and variables of high uncertainty in order to see the effect such variations will have on economic worth. Optimist and pessimist values for key variables can be used to produce upper and lower bound value estimates (positive or negative). While sensitivity analysis may not reflect the probability of the upper or lower values occurring, it is important for determining which variables are most important to the success or failure of the project. For example, suppose a particular environmental change may happen which would affect the costs and benefits of the project, but cannot be assigned a probability. Although the probability of the effect cannot be specified, the sensitivity of the project to this change can be illustrated by how the NPV would respond to a given change in each environmentally-sensitive variable. If the outcome is not sensitive to changes in value assumptions, then one can be less worried about the uncertainty surrounding the values. If the outcome is highly sensitive, more attention should be paid to reducing the level of uncertainty.

Some conservationists have argued that the use of sensitivity analysis is an inadequate substitute for a proper treatment of risk, especially where environmental dangers are concerned.

Box B11.1 Uncertainty and the Valuation of Tropical Forests

Value estimates derived for tropical forests will be uncertain for two main reasons: the poor state of knowledge about the physical input-output information associated with forest change; and the uncertainty about future values.

Physical data: Valuation is hampered by uncertainty over basic physical data for tropical forests. Information (essential for the valuation process) on the productivity, dynamics, and other basic characteristics of tropical forest systems is weak for most forest areas. Very little is known about spatial patterns of forest production, and even less about how such production affects the ecology of the species and ecosystems involved. Also, because of the heterogeneity of composition of most forests, studies of the composition and values of a particular location are very site-specific, and the results cannot be extrapolated usefully over larger areas to arrive at total values for a forest.

A specific example of uncertainty is the impact of forest change on climate. The burning of forests for conversion purposes releases large amounts of carbon dioxide into the atmosphere. But is not clear to what extent additional CO_2 is absorbed, for example, by new vegetation on previously burned land. Nor are the likely global impacts of increases on CO_2 well understood.

Uncertainty over future values: Uncertainty surrounding the dynamics of use, and thus the value of products of tropical forest, is great. Trading in forest products may be one of several income generating options available. Profit margins and returns to labour are typically very narrow, so economies based on these activities can be very fragile. The emergence or decline of alternatives, changes in labour availability, and fluctuations in forest (or crop) prices, are among the factors that can trigger rapid shifts into or out of forest-based activities. Therefore, present values and magnitudes of involvement in the forest-based sector provide only limited guidance as to future values of these products.

Source: Gregerson *et al*, 1995

Box B11.2 The Precautionary Principle and Other Rules

The Precautionary Principle, in its extreme form, holds that no action should be taken if there is the remotest risk of substantial environmental damage. On a more practical level, the principle states that the risk of substantial environmental damage should be avoided, provided that the cost of doing so, including the opportunity cost of inaction, is reasonable. What is *reasonable* is a matter of judgement.

A related concept is the **Safe Minimum Standard** (SMS). The SMS applies a modified version of the minimax criteria, preferring the option that minimises the maximum possible loss that could result from making the wrong decision. Depending on the context, the analyst decides what is “unacceptably large”.

The **critical load** of a substance is the maximum annual amount that an area, habitat or receptor body can safely absorb and tolerate. It may apply to the capacity of the atmosphere to assimilate pollutants, or a river or lake to absorb untreated sewage or industrial effluent. Once the critical load is extended, the function of natural assimilation is impaired or destroyed— in some cases, irreversibly.

Source: OECD, 1995

11.3 Switching Values

Switching values is another practical way of dealing with risk and uncertainty. These show the critical values for each variable in the analysis, in other words, the amount by which the NPV of each benefit (cost) would have to fall (rise) in order to reduce the NPV of the whole project to zero, assuming all other costs stay constant. High switching values can be ignored, because they imply that very large changes would be necessary to substantially affect the NPV of the whole project. On the other hand, switching values that are relatively low is of interest because they signify that relatively small movements in that variable could damage the project. This information enables the decision maker to focus on factors which are vital to the performance of the project.

Table B11.1 shows switching values for a forestry and land reclamation project in Djibouti. In this example, the lowest switching value is for forage production. If this benefit fell to approximately half its expected value, the project would have a zero NPV. All other benefits have negative switching values, indicating that these benefits would not only have to disappear, but would have to become implausibly huge negative amounts for the project to fail. It can therefore be concluded that this project is fairly robust.

Table B11.1 Switching Values in Djibouti Forestry Project (Ahmed 1993)

Benefit Stream	Appraisal Present Value	Switching Present Value	**Per cent Change**
Forage production	607, 832	312, 375	-48
Wood production	25, 704	-269, 783	-1 149
Charcoal production	80, 907	-214, 580	-365
Avoidance of loss	75, 932	-219, 555	-389
Apiculture	17, 054	-278, 433	-1732
Avicultue	2, 396	-293, 091	-12 330
Woodcraft	24, 008	-271, 497	-1230
Total benefits	833, 866	538, 378	-35
Total costs	538, 378	833, 866	54

11.4 Risk Assessment

Risk assessment is the process of converting uncertainty into risk. It entails three main steps:

(i) analysing the initiating events and the routes (pathways) through which the effect occurs;

(ii) specifying the size and severity of the risk; and,

(iii) estimating the probabilities and expected values.

11.4.1 Identifying the Pathways

The first step is to understand the predisposing factors or the events likely to trigger an occurrence of the risk, and the pathways through which subsequent damage occurs. This entails analysing the process through which impacts occur and breaking it down into manageable parts for assigning probabilities.

In the case of an industrial process, fault tree analyses can be used to pinpoint likely failures and the many possible pathways through which they can be transmitted to other parts of the system. This is important for systems where there is a possibility, however remote, of serious explosions, leaks, emissions or collapses (e.g., chemical factories, large buildings, dams).

Other environmental processes may entail less dramatic accidents, but it is equally important to identify the pathways through which they operate. For example, the potential contamination of groundwater by animal waste and agro-chemical residuals will depend heavily on soil conditions, the geological sub-stratum, rainfall, and the type and frequency of discharges. In this case the pathways to contamination are complex, and may need to be modelled by computer.

For risks like soil erosion and sedimentation, the likelihood of erosion can be predicted using models such as the Universal Soil Loss Equation. It may be possible to predict the movements of soil particles over short distances, but the deposition of soil downstream in rivers, irrigation channels, reservoirs and estuaries is much more difficult to predict and model.

11.4.2 Specifying the Size and Severity of the Risk

A risk has two properties — probability and magnitude. Before probability can be considered, the size of the possible outcomes needs to be established.

For a particular plot, cultivation practices and crop, the possible amount of soil erosion, could, for instance, be expressed in terms of the loss of varying amounts of soil depth (in cm) per year, depending on rainfall.

For flood risk estimation, the amount of damage to property associated with different flood severities (e.g., 1 in 100 years, 1 in 20 years) can be specified.

Certain environmental dangers have a low probability but an extremely high severity (e.g., collapse of a large dam, a catastrophic flood, a water-related epidemic). These are referred to as zero-infinity problems, and pose particular problems to risk management.

Evidence of the severity of possible environmental damage can be obtained from various sources — historical observation (e.g., flood damage), field trials and observations (e.g., soil erosion, acid rain), the transfer of dose response relationships or functions established elsewhere (e.g., water pollution and the health of swimmers), modelling (e.g., groundwater contamination), laboratory or control group trials (e.g., corrosion from air pollution).

A crucial dimension of risk is the size of the exposed population, or the number of people living near an environmental hazard.

For the economic analysis, the above information needs to be turned into economic values.

11.4.3 Estimating Probabilities and Expected Values

A probability measures the chance of a specified event happening. If it is based on scientific observation and estimation, it is described as an *objective probability*, whereas if it is derived from judgements of professionals and decision makers it is a *subjective probability*.

If different outcomes are mutually exclusive, the sum of their probabilities is 1.0. When outcomes are not mutually exclusive, probabilities need not add up to 1.0. One way of expressing such probabilities is as a chance of *x* in a million of a particular event happening, based on historical records or epidemiological data, among others. If it can be shown that *x* people normally die from poor sanitary conditions, then this can be used as the probability of such events, assuming comparable circumstances.

Risk assessment involves transforming uncertainty (where the probabilities of different outcomes are not known) into risk (where probabilities can be assigned to the likelihood of occurrences of various outcomes). Each possible outcome (or combination of events) is thus weighted by the probability of it occurring. Possible outcomes can be summed to arrive at the mean, or most probable rate of return.

A simple hypothetical example of how to estimate expected value is presented in Table B11.2. Here the probability of a given weather condition (i), and the crop yield associated with that weather condition (ii), are estimated in order to derive the expected value (iii). In this case the expected value is 22, in other words, on average output will tend towards this production level, other things being equal over a number of years, but it may vary substantially from one year to the other. If an investment program is being proposed that will yield output over 25 years, the expected value might be a reasonable average to use.

Table B11.2. Estimating Expected Yield

Weather conditions	Probability (i)	Yield (ii) tons	Expected value (iii) = (i) * (ii) **(tons)**
Drought	0.1	5	0.5
Very dry	0.4	15	6
Moderate rain	0.3	35	10.5
Heavy rain	0.2	25	5
Expected Value			22.0

Source: Convery, 1995

Expected values are useful where decision-makers and the constituents are risk neutral. Where this is not the case, the analyst needs consider risk perceptions and subjective preferences.

11.5 Risk Perceptions and Subjective Preferences: Acceptable Risk Analysis

Most people are not risk-neutral (i.e., interested only in objective expected values). Some people are gamblers and prefer risky situations; others are risk adverse. Some risks, although objectively very small, would be so catastrophic for the individuals or societies exposed to them that people are prepared to take extreme measures to reduce these risks.

Farmers are rational to be risk adverse in approaching a new crop, if the risk of failure would expose them to loss of land or crippling indebtedness. Many societies have taken their fear of a major nuclear plant accident, objectively very small, to the point where they oppose nuclear plant projects. As a general point, expert and public opinion frequently differ on the relative importance of different hazards.

Expected value is the outcome objectively determined on the basis of weighted probability. Probabilities are determined by expert opinion or by the statistical analysis of past events. However, Acceptable Risk Analysis demonstrates that many "objective" risks have a large judgmental component, especially for new and intricate hazards (Fishoff *et al* 1981).

Since environmental economics uses individual preferences as the basis for valuation, if people prefer a less risky outcome, even one with a lower expected value, this should be reflected in the analysis. The various outcomes should therefore be weighted not only by their (objective) probability, but also by their respective utilities. If the decision-maker were particularly averse to a loss an unusually high weight would be attached to this outcome.

In practice, the production of expected utilities is an arbitrary process. Decision-makers, their constituents, and the general public perceive risks in very subjective ways and react accordingly.

11.6 Conclusion

Uncertainty and risk are important issues to be accounted for in environmental appraisal. In order to make the problem more tractable, the issue of uncertainty should if possible be turned into one of managing risk. The most common way of doing this is to use expected values for all those variables whose precise values cannot be known in advance (i.e., Risk Assessment).

A project's expected value signifies its *weighted probable outcome*, but ignores the preferences for different outcomes held by people affected, for example people might be risk averse. Where affected party's subjective values are thought to be significant, their views should be canvassed. This would determine the degree of risk adverseness among stakeholders.

In the common situation where parties are risk-adverse, the broad options are to redesign projects in order to eliminate or minimise risk elements that are of the most concern, and/ or applying the Precautionary Principle, or choosing different projects.

Sensitivity and switching analysis should be used to identify variables of particular importance to the project. This information should be used in conjunction with data on the risk perceptions and preferences of parties concerned. Projects can then be modified or supplemented accordingly.

Managing risk is not free, but yields some utility to those affected. The size of the trade off between the sacrifice or (expected) returns and the avoidance of unwanted outcomes is something that can only be decided by the parties involved.

12.0 DISTRIBUTIONAL EQUITY [9]

An important part of equity or fairness is deciding who receives the benefits and who pays the costs. Such equity issues should be addressed quantitatively. However, they are rarely (if ever) considered as part of a standard economic evaluation.

Just as financial analysis is misleading because it ignores the real cost of resources or the economy, so an analysis which fails to account explicitly for distributional concerns may seriously misrepresent a project's true worth. Few tropical forest studies to date have dealt adequately with distributional equity, despite the fact that concerns over equity might be very high.

12.1 Theoretical Rationale for Adjusting Prices for Distributional Impacts

The primary objective of economic appraisal is to evaluate the costs and benefits of alternative activities in terms of economic efficiency. CBA converts costs and benefits to a common currency, and the size of the NPV is one measure of the project's desirability. A shortcoming of conventional economic appraisal is that *only* the net impact of an activity counts, no account is taken of to whom costs and benefits accrue. Hence it makes no difference if one group is made significantly worse off so long as another group is made better off by a larger amount (see Box B12.1).

Box B12.1 The Compensation Mechanism

The Pareto Principle asserts that an activity is 'optimal' and socially desirable if the 'winners' could, in theory, fully compensate the 'losers' and still come out ahead, irrespective of whether the compensation actually occurs. For example, if a project has a NPV of $1,000, this means that up to $1,000 is available to compensate those parties likely to lose from the project. The $1,000 measures the potential ability of gainers to compensate losers — either directly, or through the state's intermediation through its fiscal transfer mechanism. In practice, such compensation rarely takes place and is by no means costless when it does.

[9] Section compiled from IIED, 1994

In addition, prevailing market prices reflect the existing pattern of demand within the economy, which in turn is a function of the underlying distribution of income and welfare in society. A fundamental normative judgement underlying convention CBA is that the existing distribution of income is in some sense optimal. However, in a market economy, consumer preferences that are not backed by money are ineffective and will have no effect on price levels. If certain groups cannot afford to bid for particular goods and services by offering to pay money for them, then the level of total demand for those goods and services (and their prices) will be lower than.

"Efficient" prices (market prices adjusted to account for market imperfections and policy failures) which theoretically maximise overall social welfare, also take the existing distribution of income and wealth as given, even though prices and values may be significantly different with a more equitable distribution.

Thus, projects which benefit wealthy individuals at the expense of poorer ones may be undesirable from **a social point of view**, even if they show a high rate of return or total welfare gain. Distributional concerns are especially important for environmental appraisal, where uncompensated externalities are likely to be common.

Equity concerns argue for:

i. the careful identification of impacts and their incidence on different groups and people (gainers and losers);

ii. consideration of mitigation measures to ease the impact on injured parties; and,

iii. working out financial and institutional mechanisms to facilitate actual transfers to the people most likely to lose.

12.2 Methods to Assess Distributional Impacts

Alternative tropical forest land use options may have widely different distributional implications. These distributional impacts should be identified and included in the appraisal process. Approaches for incorporating distributional concerns include:

i. The distributional consequences of land use options can be made explicit by assigning costs and benefits, defined in terms of financial or efficiency prices, to specific groups. This does not require any adjustment to market prices; it simply traces the distribution of costs and benefits (assuming that these can all be quantified and valued).

ii. Equity objectives can be built into economic analysis by defining numerical distribution weights which are used to emphasise costs and benefits accruing to specific groups (e.g., the poor). This approach is justified on the grounds that prevailing market prices are 'sub-optimal' purely as a result of distributional inequities.

iii. More generally, the entitlements (use and access rights) of particular groups with respect to certain forest resources or benefits may be protected by defining minimum standard or guarantees. This approach is more prescriptive than analytical and is essentially non-economic, to the extent that trade offs are not explicitly made.

To some extent the first approach is a prerequisite of the second and third. Unless the costs and benefits of a project or land use option can be linked to a specific group there is no way to know where the distributional weights should be attached or what rights need to be protected.

The main problem is measurement. It is not easy to quantify the impacts of any given land use on particular groups. By comparison, the main problem with using distributional weights is conceptual — to many analysts they can seem subjective and arbitrary. A right-based or entitlement approach may appear even less rational, if the basis for assigning rights is not made very clear.

12.2.1 Tracing and Quantifying Distributional Impacts

The first step in any distributional analysis is to identify the different stakeholders in the forest. This will depend on the region and particular land uses in question.

Box B12.2 Steps to Quantifying Distributional Impacts

1. Identify different stakeholders
2. Determine which groups are affected by the various impacts of alternative land use options
3. Quantify the costs and benefits to different groups

The next step is to determine which groups are affected by the various impacts of alternative land use options. This involves linking specific costs and benefits with particular groups. Obviously, some costs and benefits may be spread widely among a number of groups, while in other cases the impact on certain stakeholders will be more concentrated.

For example, the benefits of timber harvesting will be spread among the owners of logging companies and their employees, and the firms involved in providing equipment, wood processing, transport, distribution and sales. It may not be possible to single out every industry (let alone every firm) which benefits from a particular land use option, but in practice it should be possible to distinguish impacts on the broad sectors of the economy and the labour force.

Box B12.3 Possible Stakeholders in Forest Land

Indigenous hunter/gather populations
Subsistence farmers
Commercial farmers
Small-scale traders
Industrial firms (owners and employees)
Local, state and national government agencies
Domestic and foreign consumers

Finally, the link between costs and benefits and different groups needs to be quantified to indicate the magnitude of the distributional impact. Ideally this will be in monetary terms using efficient prices. If certain costs and benefits have not been monetized, their impact on different stakeholders should be described in physical and qualitative terms.

Various approaches may be used to measure the costs and benefits accruing to different groups. For example, once the direct use benefits of natural forest management have been valued, household budget surveys may be used to determine the relative importance of these benefits in the livelihood of local populations.

One might ask:

What proportion of total cash income derives from wages paid in the logging or wood processing industry?

What percentage of monthly food consumption is composed of wild plants and animals collected in the forest?

How much income do households derive, in cash or in kind, by selling or bartering minor forest products?

Similar questions may be posed to logging companies, timber mills, and transport companies involved in bringing products to market.

Government tax receipts and expenditure on forestry research and extension activities can be treated in the same way.

It may be instructive to ask the same questions of different groups, to elicit any differences in the relative importance of perceived costs and benefits. For example, the value of non-use benefits to northern consumers (elicited via CVM) may well exceed the magnitude of these values to local populations.

It is important not to 'double count' costs and benefits.

If wages are a benefit to the local labour force, then this amount must be deducted from the gross receipts received by the firms which employ them.

If local households sell or consume wild food products obtained from the forest, then the net benefits they receive are equal to the value of sales or consumption less the cost of collection and processing.

The usual practice is to estimate the value added that a particular group or enterprise obtains from an activity. By aggregating across stakeholders at a sectoral or macroeconomic level, it may be possible to estimate the total economic welfare obtained from different land use benefits.

The distribution of non-marketed costs and benefits may be harder to trace, although the techniques used to value these items can often be extended to distinguish different groups. For example, the valuation of watershed protection benefits provided by an upland forest may rely on a production function approach, by looking at the impact of land use changes (e.g., clearing for agriculture) or rain water run-off, soil erosion, stream flow and sedimentation. The latter impacts may be valued in terms of flooding damages or reduced reservoir storage capacity. In each case it may be possible to identify the ultimate beneficiaries of the threatened watershed protection function (e.g., land owners and residents of the floodplain, the regional water or irrigation management authority).

12.3 Integrating Equity Objectives in Land Use Appraisal

Linking costs and benefits to particular social and economic groups may be sufficient to account for concerns about the adverse distributional effects of alternative land use options. However, in some cases it may be desirable to integrate equity objectives more formally in the analytical framework.

The underlying justification for doing that is that prevailing market prices will reflect the existing distribution of income and wealth and are therefore 'distorted' with respect to social equity objectives (in addition to their market and policy distortions).

The use of distributional weights on prices is a systematic and very explicit way of giving greater (or lesser) importance to costs and benefits which accrue to certain groups. Distribution weights may be used to derive *socially oriented shadow prices* for certain goods or services which accrue largely or entirely to target groups. Alternatively, distribution weights may be used to derive a shadow wage to account for employment objectives.

12.3.1 Distribution Weights: Socially-orientated Shadow Pricing

Distribution weights explicitly incorporate equity objectives in economic analysis. Basically market prices are adjusted to emphasise certain costs and benefits affecting particular social and economic groups.

Typically, a multiplier is defined (i.e., a subjective numerical factor which is applied to some or all costs and benefits accruing to the target groups). For example, if the intention is to emphasize certain costs and benefits which accrue principally to the poor (e.g., fuelwood or wild food resources), a multiplier with a value greater than 1 may be used to adjust financial prices upwards. The resulting adjusted price is known as the **socially-orientated shadow price**.

When the level of employment of local unskilled labour is an important concern, it may be appropriate to define a multiplier of less than 1 and apply it to the relevant market wage rate. In this case, the rationale would be that the market wage rate overstates the true social cost of employment of unskilled labour, since this wage rate fails to reflect equity concerns. Hence the shadow price would be less than the market wage.

One of the advantages of using distribution weights is that they force the analyst — and the decision-maker — to be explicit about their subjective preferences for income, investment or consumption by certain groups.

To what degree is investment preferred to consumption, or public sector income preferred to private income?

How much is consumption by the rich preferred to consumption by the poor?

Despite the strong theoretical rationale for distributional weighting and relative ease in application, many economists and policy-makers are reluctant to censure their judgements with respect to equity concerns. A practical problem with their use is the difficulty of tracing costs and benefits distribution among different groups. In practice, therefore, distribution weights are rarely used in economic analysis.

12.3.2 Rights-based Approaches

Another way to ensure that land use decisions do not adversely affect certain groups is to define certain rights or *minimum standards* as absolute targets or limits. This approach is similar to Cost Effective Analysis (CEA), which is used to identify land use options which achieve the highest economic return consistent with some exogenously defined target (e.g., biodiversity, conservation or aesthetic quality). (See Section B16.)

A right-based or entitlements approach to land use allocation proceeds from given entitlements; for instance, the requirement that indigenous populations retain their traditional access rights to particular forest areas. Entitlements thus define the boundaries or parameters of the analysis. Like distribution weights, such rights or limits cannot be determined objectively, but are a product of political or ethical judgement.

Conversely, economic analysis can be used to reveal the economic cost of preserving human rights or other absolute limits on certain highly profitable types of land. The 'implicit price rule' is a way of showing the public and policymakers just how much income they must forego to preserve or protect non-economic objectives.

13.0 ACCOUNTING FOR OMISSIONS, BIASES AND UNCERTAINTIES

All types of economic valuation involve a certain degree of estimation. Monetary estimates of most environmental assets are approximations of true values embodying omissions, biases, and uncertainties, and are influenced by the discount rate employed as well as other factors. Thus, economic valuation of environmental impacts can be imprecise and controversial, and it is important for project analysts to understand and state the limitations of the analysis.

Omissions: In most cases, information gaps will exist regarding the environmental effects of proposed projects. It is thus important to identify omissions and explicitly describe them in the project economic analysis report. The likely effects should be characterised with either a plus or minus sign to indicate how they would change the estimated present value of benefits (i.e., how they might affect the projects economic viability) (ADB 1996).

Biases: The term *bias* refers to any factor causing the quantified estimates of benefits and costs to be larger or smaller than their actual values. For example, if all project costs are included in an evaluation but some project benefits are omitted (e.g., due to lack of data), then the quantified net benefits (benefits minus costs) will be biased downwards. Biases should be explicitly recognised. If the effect of the bias cannot be accurately quantified, then at least the way in which the bias may affect the analysis (i.e., whether it would result in over or under statement of net benefits) should be documented (ADB 1996).

Uncertainty: As discussed in Section B11, uncertainty is a significant concern for environmental projects. The types and sources of uncertainty should be examined and highlighted in the economic analysis.

13.1 Qualitative Assessment Procedures

It is important to accept that it may not be possible to estimate all values in monetary terms due to lack of data. This is especially likely for projects in remote areas where little prior research has been performed. In such cases, all important values that cannot be quantified must be described qualitatively.

Qualitatively assessed impacts should be listed in the evaluation summary along with the monetised benefits and costs. The direction of change an impact is expected to have on the net present value of the project or policy should also be identified.

When certain benefits or costs cannot be measured directly in money terms, CBA can be modified to an implicit price rule. For example, suppose that the benefits accruing from forest protection in terms of biodiversity conservation are known but are not explicitly valued in monetary terms. The decision to protect the forest then reduces to a qualitative judgement, in this case that the non-monetary benefits of biodiversity conservation are worth more than the monetised costs of forest protection.

14.0 ADDITIONAL METHODOLOGICAL ISSUES

14.1 Sustainability and CBA

The concept of sustainable development is central to the management of the environment. Sustainable development entails leaving patrimony, including natural environmental assets, intact over time. It means bequeathing to future generations the same capital embodying opportunities for potential welfare, that are currently enjoyed.

The environment may be viewed as a form of natural capital, analogous to physical or financial capital assets. Damaging the environment is therefore similar to running down capital, which sooner or later reduces the value of its recurrent services (or income stream). Some level of environmental use is in a sense “sustainable” and consistent with preserving environmental capital.

The literal view of the environment as a capital stock that should not be diminished is difficult to interpret and apply. But its value is in reminding us that human activities consume various kinds of environmental resources, which need to be restored in the long term unless all are to become poorer.

Environmental economics distinguishes three broad types of capital:

i. *man made capital* (e.g., factories, roads, houses etc) can be increased or decreased at our discretion (although of course there are associated sacrifices and demands on the natural environment) ;

ii. *critical natural capital* (e.g., ozone layer, global climate, biodiversity) comprises natural assets essential to life that cannot be replaced or substituted by man- made capital; and

iii. *other natural capital* includes renewable natural resources (e.g., forests and fisheries) and non-renewable (finite) resources (e.g., minerals) that can be wholly or partly replenished or substituted by man-made capital.

The sustainability criteria has different implications depending on whether the resources in question are critical, renewable, or finite.

The preservation of irreplaceable critical natural capital should ideally be an absolute constraint on all activities. It implies setting safe minimum standards (e.g., for water and air quality, preservation of biodiversity) and ruling out certain kinds of development.

Non-critical natural capital should be valued in economic terms. If activities lead to a reduction in natural capital (by using up resources in production, or destroying them through pollution or other externalities) these costs should be debited to the activities responsible for them.

For renewable capital (forests, fisheries), the value of the resource is equal to its economic 'rent' from its extraction if the resource is used within its maximum sustainable yield (Section B14.2). *Economic rent is the residual value left when all other production costs have been subtracted from its price.* If the use of the resource exceeds its sustainable yield, a cost should be debited to the project equal to that of regenerating the resource (replanting, restocking) or the potential damage incurred (e.g., an aquifer damaged through over use).

In the case of non-renewable resources, sustainability means setting aside part of sales proceeds to investment in maintaining consumption after the resource is exhausted. It also means investing in research and alternatives, and into more efficient ways of using it so that future generations are not cheated of discoveries relying on the continuing supply of the resource.

A project which makes substantial use of natural resources, may be profitable in conventional economic criteria yet non-sustainable in environmental terms. That is, a project may be profitable in the sense that $B>C$ as a whole, but the benefits to some sub group *i* may be less than the cost of the project (i.e., $Bi<Ci$). Such a project may be unsustainable if there are many external costs resulting from the harvesting and consumption decisions of this sub-group *i* following the implementation of the project. From a practical point of view, it is very important that the distributional benefits of the project are understood and evaluated (see Section 14.1).

In view of this, many economists now accept the need for a more developed approach to CBA. This includes discounting, full environmental valuation, and the application of the sustainability criteria.

While monetary valuation of environmental resources is important for planning and appraisal proposes, they can also be used as a basis for compensating losers from a project's gains, and for setting specific environmental protection measures. Where damage or over-exploitation is caused by a number of separate projects, one possible compensation mechanism is to set up a *compensatory project* which restores the environment. The cost of this project would be covered by each of the projects responsible for the damage.

Box B14.1 The Sustainabilty Criterion

Sustainable projects should observe the following criteria:

(i) place economic values on environmental costs and benefits

(ii) avoid damage to critical natural capital as far as possible

(iii) avoid irreversible processes

(iv) limit the use of renewable natural assets to their sustainable yield

(v) assess how the benefits of the project are distributed, and how this distribution might affect the sustainability of the project

(vi) where damage occurs, the full cost of damage should be attributed to the responsible party and compensatory projects should be considered

14.2 Estimating Maximum Sustainable Yield

Many tropical forest resources either are exploited under an open access regime or are state property and priced below their real opportunity cost (e.g., wildlife, fuelwood, timber). As a result, the prevailing harvest rates are often inefficient in economic terms, or unsustainable in ecological terms.

In such cases, simply multiplying current harvest by price (even when an efficient price is used) will *overstate* the net benefit of the resource or land use. It may therefore be necessary to define an optimal rate of exploitation in biological terms and to estimate the maximum sustainable yield (MYS).

For example, when comparing two or more sustainable management regimes (e.g., the maximum sustainable harvest of NTFP and the maximum sustainable timber yield), physical output in each case should be based on models that relate productivity to fundamental ecological constraints. The value of the sustainable harvest is then calculated by multiplying the amount harvested by the appropriate efficiency price.

When the sustainable or economically efficient harvest is not known and cannot be estimated directly the analyst may rely on sensitivity analysis to illustrate differences in net benefits under different assumptions about physical output (Ruitenbeek 1991). The compensatory project approach may also be helpful in this situation as a way of accounting for the loss of benefits due to excessive levels of resource exploitation.

14.3 Accounting for Non-Human Values

Another difficult issue is that since CBA, as an economic approach, is conducted from the viewpoint of human welfare (i.e., it is anthropomorphic), non-human interests are not taken into account. Yet, environmental issues concern non-human living species as well. Many would argue that other species have rights (standing) in debates about the environment. What CBA can do is:

(i) identify, so far as is feasible and as knowledge permits, the wider impacts of human interventions;

(ii) invoke the precautionary principle or a similar safeguard where impacts on the natural order are likely to be sufficiently grave or irreversible;

(iii) indicate what costs are involved in protecting non-human species, and appropriate alternatives which are less threatening to them.

The interests of non-humans can, of course, only be articulated through humans. But if enough people feel strongly about non-human species' rights, their views can be expressed through democratic channels, and can become a counterweight to the use of purely economic approaches.

14.4 Institutional Concerns

Project analysis will often rely on assumptions about the extent to which institutions will ensure that environmental pollution controls and other mitigation methods are fully implemented and enforced. One approach to account for the uncertainty associated with such institutional capabilities is to conduct sensitivity analyses to select different enforcement and other institutional scenarios.

14.5 Conclusion [10]

CBA is predicated on measuring as far as possible, the costs and benefits of a project or land use option in monetary terms. The use of money as a unit of account is often criticised on the grounds that there are many costs and benefits that cannot be expressed in money terms. However, a wide range of environmental goods and services theoretically can be measured. Furthermore, where monetary valuation is not possible, non-monetary costs and benefits can be listed and fully described so that the analyst is aware of any impacts not included in the CBA. CBA is a method for quantifying values, but it does not imply that quantification is always possible.

Another criticism is that the data requirements for a comprehensive CBA is substantial. This is true but this criticism is not unique to CBA and it is difficult to identify methods which handle the problem better.

Some argue that it is not only impossible but ultimately illegitimate to attempt to reduce such fundamentally different values to a common numeric metric, others that it is immoral to try to put a monetary value on some environmental assets.

How to compare different values among themselves is a difficult issue. Natural forest is characterised by greater biological diversity than plantation forest or agricultural land, but how are the benefits of biodiversity weighed against the benefit of increased output of timber or food? How can aesthetic or cultural values be compared to commodity benefits?

Without monetary estimates, it is difficult to rationally debate relative advantages and disadvantages. Trade-offs among widely divergent concerns are inevitable, and some way must be found to reconcile these differences. Economics is not the final arbiter of worth,

[10] Compiled from IIED, 1994

but it can contribute to the decision making process by attempting to express many different concerns in a single consistent framework. Economic valuation makes trade-offs comparable and intelligible, by expressing different costs and benefits in terms of a single numeraire (i.e., monetary value). In this way, one can directly compare, for example, the value of timber crop production that must be foregone to preserve certain environmental benefits.

15.0 ALTERNATIVE ASSESSMENT APPROACHES[11]

This manual focuses on the use of CBA as a tool for undertaking a *comparative economic analysis* of two or more alternative tropical forest land use options. There are, however, other types of issues or problems relating to tropical forest land use which do not concern alternative uses of forest land, but for which economic information will also be important in the decision making process. Two alternative assessment approaches are *total valuation* and *impact assessment*.

Total valuation assesses the total economic contribution, or net benefit, of one particular forest land use. Total valuation may be necessary for national income accounting.

Impact assessment involves the assessment of external damages from a specific land use. For example, the external effects of logging on wildlife or soil erosion.

In both these circumstances there is no need to value alternative land uses, hence the resource requirements for such assessments are typically less than those required for a comparative economic analysis.

15.1 Total Valuation

Total valuation is most appropriate where a full account of the economic contribution associated with a particular forest land use option is required (e.g., as part of a natural resource accounting exercise). The aim of a total valuation is to value as many, of the net production and environmental benefits associated with the forest land use option.

As with all valuation, a problem is that the net production benefits of certain land use options, such as timber operations, land clearing for agriculture, mining, will be much more visible than the net environmental impacts of these land uses. Extra effort is therefore required in order to estimate the non-marketed values of the forest.

Moreover, to the extent that many land use options involve the eventual depletion of the productive capacity of the resources (e.g., timber, wildlife habitat, soil fertility), there is also a *user cost* element[12] which must be accounted for. That is, the forest resource can be viewed as a form of natural capital, and any degradation and depletion of that resource due to current activities means that future income opportunities are foregone.

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11 Section compiled from IIED, 1994

12 User cost (of capital) is the implicit rental value of capital services, or the price a firm should pay itself for the use of the capital stock it owns or is considering acquiring. It may also be considered as the price the firm would pay if it rented capital goods to obtain capital services, just as in the case of labour.

Thus, a full accounting of the total economic value (TEV) of any single forest land use option involves the valuation of net production or direct benefits, NBd, plus (or minus) any external environmental impacts, NBi, less any user costs, Cu, resulting from degradation or deforestation associated with that option.

$$TEV = NBd + NBi - Cu$$

Total valuation is clearly data and research intensive and has rarely been attempted for tropical forests. This is largely due to the difficulty of obtaining reasonable monetary estimates of non-marketed benefits and external environmental impacts.

Since most attempts at a total valuation of tropical forest have difficulty in obtaining realistic estimates of net external environmental impacts, they tend to concentrate instead on deducting a measure of user cost from the direct production or income benefits earned.

Studies in Indonesia and Costa Rica have employed a depreciation accounting approach to measuring user costs for agricultural conversion and unsustainable timber harvesting (Repetto *et al* 1989; TSC/WRI 1991). In these studies, net forest depreciation is assumed equivalent to the entire net receipts (in terms of stumpage value) that could be derived annually from the marketing of wood removed through deforestation and unsustainable timber extraction. The full potential rent foregone is then multiplied by the net changes in the forest stock to derive the user cost of deforestation and forest degradation. In Indonesia, this amounted to an estimated cost of US$3.1 billion in 1984, or approximately 4% of GDP (Repetto *et al*, 1989). In Costa Rica, annual depreciation due to deforestation has ranged from US$ 42 million to US$ 422 million from 1970-89; in 1989 this amounted to around 8% of GDP (TSC/WRI 1991).

Following an alternative user cost approach advocated by El Serafy (1989), da Motta and May (1992) estimated the user cost of forest conversion for agriculture in Brazil. Only part of the net receipt (stumpage value) is subtracted from agricultural value added on the grounds that the true user cost is equal to the present value of sustainable production (i.e., of wood products) that could be obtained from the forest resource if land were not converted. At the margin, this should be equivalent to setting aside annually some portion of the receipts from agricultural conversion in an alternative economic asset, such that the asset earns an income stream in perpetuity that would be equivalent to the income earned from sustainable forest utilisation (e.g., timber extraction that would leave the forest resource intact). Based on this calculation, the authors estimate the annual user cost (at 5% discount rate) to range from US$13.7 to US$121.2 million over the period 1971-1980 (approximately 0.1 to 0.5% of Brazilian agricultural product annually). In contrast over the same period, the depreciation approach yielded a cost of US$7.5 to US$ 20.7 billion, or approximately 46-86% of national agricultural product. The authors agree that the former approach provides a more accurate measure of the user cost of forest conversion.

15.2 Impact Analysis

Impact analysis is most relevant in situations where a particular tropical forest land use option results in specific environmental impacts.

For example, suppose that logging of a timber stand in an upper watershed results in increased runoff and sedimentation, affecting fish production, agriculture and water quality downstream. The external, or off-site, costs of this activity are the losses in economic values arising from the downstream impacts of watershed degradation. These off site costs must be weighed against the net production benefit gained through the timber operation. Only by assessing and valuing the external losses from watershed degradation can a true measure of the net benefits of the timber operation be derived.

Given direct benefits (e.g., timber earnings), *Bd*, and direct costs (e.g., harvesting, transport and financial costs), *Cd*, then the *direct net benefits* of the project, *NBd* are determined as follows:

$$NBd = Bd - Cd$$

However, given the downstream impacts of logging, this clearly overstates the net economic benefits of the timber operation. In addition, the cost of these impacts, *Ci* (*i*) for indirect in the sense of being downstream) must be taken into account. From society's perspective, logging the upper watershed is a worthwhile land use option only if:

$$NBd > Ci$$

Even in cases where this rule holds, there are still difficult practical issues concerning the distributional implications of timber operators gaining at the expense of these engaged in downstream economic activities. The rule is therefore efficient only in the narrow sense because those who gain (e.g., timber operators) are able, at least potentially, to **compensate** the losers (e.g. downstream fishermen, water users, farmers).

However, if timber operators as a group are wealthier than downstream users, which may be imagined the case in many situations, then policy makers may be interested in the equity implications of who gains and who loses from an outcome governed by the above rule. Hence the need to assess the distributional impacts of tropical forest land use options, and the importance of this assessment in assisting policy decisions. Finally, if the downstream costs of watershed degradation are irreversible, then what is efficient in a narrow sense may not be sustainable.

Box: 15.1 The Impacts of Selective Logging in the Philippines

Paris and Ruzicka (1991) developed a hypothetical illustration to examine what the net economic gain from logging would be if selective timber harvesting was carried out in a sustainable manner — both in terms of direct net benefits alone and if downstream environmental impacts were taken into account.

After accounting for the costs of protection, timber stand improvements and enrichment planting to ensure the sustainability of production, the present value of the direct net benefits of the project NBd are given as US$95 per hectare. However, the costs of (undefined) marginal off-site damages to downstream activities, Ci, are assumed to be US$250/ha. It is therefore suggested that the appropriate policy decision would be to stop logging old growth forests where downstream impacts from watershed degradation are considered significant.

16.0 ALTERNATIVE ANALYTICAL FRAMEWORKS[13]

There are a range of analytical frameworks, other than CBA, which may be used to assess alternative forest land use options in terms of ecological, economic or social criteria. When performing an economic analysis of tropical forest, other non-economic assessment approaches may be valuably employed in conjunction with CBA for insight into tropical forest values, especially where quantification is not feasible.

The main types of appraisal frameworks widely used to assess projects, policies and land use options are:

Cost-Benefit Analysis (CBA)

Cost-Effectiveness Analysis (CEA)

Environmental Appraisal and Environmental Impact Assessment

Land Suitability

Subjective Scoring Methods

Multi-Criteria Analysis

Risk-Benefit Assessment

Acceptable Risk Analysis

Macroeconomic and Behavioural Models

Only CBA and CEA are essentially economic approaches to evaluation. The value judgements underlying CBA and CEA are that individual preferences count, and that preferences should be weighed by the common factor of money. Although no decision method is completely objective and value free, CBA and CEA are less arbitrary than most alternatives.

Qualitative assessments of alternative land use options are more common than quantitative. However, they can suffer from lack of consistency, transparency and objectivity and it is also difficult to compare alternative land use options based on a purely qualitative assessment. Notwithstanding this, such assessments are extremely useful where a quantitative assessment is too difficult or inappropriate (for example where public sentiment about the loss of indigenous cultures is an over riding concern).

Non-economic decision criteria also have an important role to play in providing the physical information for economic analysis (e.g., in defining the ecological suitability or physical carrying capacity of forest lands for particular uses). At a project or local scale, relevant physical criteria may include indicators such as soil fertility, climate and accessibility, as well as measures of ecological integrity such as species richness and extinction. This type of analysis is fundamental and, to a large extent, a prerequisite for economic appraisal. However, purely physical indicators say little about the relative trade offs among different concerns.

[13] This Section is compiled from IIED,1994

16.1 Cost-Effectiveness Analysis

Cost effectiveness is a criterion for determining the most efficient (economical or cost-effective) way of achieving a specified objective. Cost Effectiveness Analysis (CEA) is used when the major benefits of a project or land use prove exceptionally difficult to quantify, or where an environmental goal has been set by national authorities or an international agreement.

The first step in the CEA is to fix a target, expressed in non-monetary units. For example, the analyst may be asked to determine the most economical way to ensure a certain level of species diversity. Different forest land use options (e.g. selective timber harvesting, extractivism, shifting cultivation, plantation forestry) will have different implications for the diversity of indigenous plant and animal species.

Even without expressing the benefits of species preservation in monetary terms, it may be possible to measure the relative trade-offs between net financial or economic returns and species diversity for each land use.

Provided that policy makers have determined the minimum acceptable level of species diversity (on an ecological basis or simply on political grounds), it is relatively simple to select the form(s) of land use which preserve that level of species diversity while generating the highest economic return. Such an analysis could form the basis for land use zoning or for specific prohibitions on particular types of land use.

CEA consists of calculating all the *costs*, both capital and recurrent, of a project, applying the appropriate shadow prices, and discounting the resulting stream to obtain a present value for costs. This procedure is repeated for the main alternative ways of carrying out the project, and the one with the lowest present value is chosen. This criteria assumes that all the alternatives being compared can carry out the project equally well. If there are quality differences in the service being supplied, then the basis for the comparison is invalid.

16.2 Environmental Appraisal and Environmental Impact Assessment

Environmental appraisal (EA) and environmental impact assessment (EIA) involve the prediction of the environment impacts (positive and negative) of any proposed investment plan or project.

Normally, EA is a simpler and less costly procedure, and is used to assess projects and programmes which are not expected to have significant environmental impacts. EIA is more demanding. Both techniques generally entail the specification of an impact mitigation plan. If the assessment is carried out at an early stage, it can be used to modify project design to mitigate any negative impacts.

EIA is important in land use planning because it ensures a full documentation of the potential environmental effects of projects and options. EIA is particularly well-suited to tropical forest planning because the environmental implications of many tropical forest land use options are numerous, long-term (or even irreversible) and far reaching but also because many of the benefits (or values) provided by tropical forests fall outside of the market.

EIA can be seen as a complement or a prerequisite for proper CBA. It identifies the impacts that CBA should attempt to evaluate. However, EIA is not designed to make comparisons among projects and is therefore of little use in appraising alternative forestland use options.

16.3 Land Suitability Classification

Land suitability classification typically entails little or no monetary valuation. It involves the identification and measurement of physical or qualitative criteria that determine the suitability of certain lands for particular uses or crops.

It is usually employed for mapping large areas as part of a regional or national land use planning exercise. Such assessments may not explicitly consider the balance of costs and benefits that accrue to alternative land uses. However, economic trade-offs are implicit in such an approach, to the extent that the suitability of a given area for a particular use is defined by characteristics which ultimately determine relative profitability.

16.4 Subjective Scoring Methods

Subjective scoring methods invite experts to score and rank projects on the basis of stated criteria. Sometimes known as the Delphi Technique, it allows wider, non-quantifiable and more subjective criteria to enter into the decision process.

The risk is that the method can become arbitrary unless the exercise is well controlled. If there are a number of criteria, some quantifiable and others not, it is reasonable to canvass various opinions on how the project has performed on the non-quantifiable criteria. However, the relative weights of the different criteria must be agreed from the outset if the exercise is not to become indeterminate.

16.5 Multicriteria Analysis

Multicriteria analysis involves the application of more than one criterion to the task of judging performance. The quantifiable economic rate of return would normally be included if it were available. Also, depending on the type of projects and their relevance, other criteria such as cost per beneficiary, number and beneficiaries, distribution of benefits, ease and speed of implementation, or other systematic judgements made by experts or decision-makers may be used. In practice, MCA is widely used. Although such methods as CBA purport to give a categorical and definitive rule on the acceptability of a project or policy, most decision makers are more comfortable using CBA alongside other criteria and methods, including subjective judgements.

16.6 Risk-benefit Analysis

Risk-benefit analysis aims to prevent serious risks. It can be viewed as the inversion of normal CBA, because it starts by presuming no action. The cost of inaction is the likelihood of the risk occurring (i.e., an explosion at a chemical plant). On the other hand, the benefit of inaction is the saving in the cost of the preventive measures. If the costs are less than the benefits, no action is justified, and vice versa. For projects where risk is the paramount consideration, RBA is a useful way of bringing out the issues. It assumes that costs (risks) can be fully captured in money values, which is not always the case. Moreover, the use of expected values is unlikely to give due weight to a catastrophical event with only a small probability.

16.7 Acceptable Risk Analysis

The conventional way to treat risk in CBA is by using expected values and sensitivity analysis. This assumes that the various possible outcomes can be defined and specified and that the costs and benefits of each possible outcome can be attributed and measured. These conditions do not always hold for environmental risks, many of which are poorly understood and for which individuals may have preferences that do not equate with the objective analysis of risk.

Acceptable Risk Analysis (ARA) tackles the question, "How safe is safe enough?" (Fischoff *et al* 1981). ARA drops the assumption implicit in CBA that decision-makers are risk neutral, and analyses the effect of risk-averseness. It is an eclectic approach that avoids exclusive reliance on a single formula to select the most acceptable option.

ARA proceeds rather like CBA up to the point where outcomes and probabilities have been established. At that point it draws up and assesses decision-maker's preferences, judgements and trade-offs, to obtain the *weight* that the decision-maker would attach to outcomes carrying different levels of risk. Expected values are weighted by attitudes to risk to become expected utilities. In deciding what is acceptable risk, ARA therefore complements formal methods such as CBA with professional opinion, and takes account of the lessons of past experience. ARA denies that there are value-free methods for choosing the most acceptable option, and requires all parties to understand the value assumptions contained in their views. It is argued that in the case of most new and intricate hazards, even so called objective risks have a large judgmental component. Moreover, ARA asserts that the expertise necessary for these decisions is scattered throughout society. Expert opinion should be combined with that of people in all walks of life, including the lay public.

For instance, the risk adverse decision-maker would prefer an option that avoided the risk of a particular bad outcome, to one which offered the chance of greater gain as well as greater loss. The preferences of the decision-makers may be expressed in "utility weights" for the various outcomes. These could be used to devise decision rules such as Mini-Max (minimising the maximum possible loss). Finally, the expected utility of each possible outcome is obtained by multiplying the probability of its occurrence by its utility. The preferred alternative is that with the highest expected utility.

SECTION C

Valuation Techniques

1.0 MARKET PRICES

Many goods and services from tropical forestland uses are traded, either in local markets or internationally. For products that are commercially traded, market prices can be used in the assessment (IIED 1994). However, for economic valuation purposes *efficiency prices* may need to be derived from market prices. It should also be noted that market prices tend to underestimate economic value as they do not account for consumer surplus.

1.1 Net Value versus Gross Value

Since net value is of interest, all costs associated with harvesting and transportation must be deducted from market (gross) prices.

1.2 Efficiency Prices (Shadow Price)

As discussed in Section B2.1, financial analysis is usually taken from the perspective of the individual or private firm concerned with narrowly defined profits or losses of alternative forest land uses and do not reflect the value to society as a whole.

For economic valuation the market prices of goods and services may need to be revised to correct for any market and policy failures so that they more closely reflect the opportunity costs of resource use to society and any distributional objectives.

The adjusted market price is often referred to as the *efficiency* or *shadow price* and is an indication of the economic value of the good or service, that is, the true WTP.

Box C1.1 Caution on Employing Shadow Prices

There are a number of reasons why shadow prices should be used with caution:

1. Market prices are often more readily accepted by decision makers than are artificial values derived by the analyst;

2. Market prices are generally easy to observe, both at a single point and over time;

3. Market prices reflect the decisions of many buyers, whereas calculated shadow prices may often rely just on the judgement of the analyst;

4. The procedures for calculating shadow prices are imperfect and therefore estimates can, in certain cases, introduce larger discrepancies than the 'imperfect' market price would.

Source: Gregerson *et al*, 1987

In some cases the market price may be used as rough approximation of the economic value of the good and service, in particular when changes to the market are small, and where calculation of economic value would involve highly complex statistical adjustments or is constrained by available data. However, in other cases it may be possible and appropriate to adjust the market price to correct for major market and policy failures that distort prices (IIED 1994).

There are basically four steps involved in determining efficiency prices from market prices (IIED 1994):

1. Adjust for direct transfer payments

   Direct transfer payments must be removed from the accounting procedure. A transfer payment is a payment made to an individual which does not form part of any exchange of goods and services. Transfer payments include direct taxes, direct subsidies and credit transfers including loans, receipt, principal repayment, and interest payments.

2. Adjust for price distortions in traded items

   This involves removing any indirect transfer payments that operate through changing market prices of traded goods and services. The basic approach is to adjust the border price of the good and service for domestic transport and marketing costs incurred between the project boundary (or farmgate) and the border. However, if border prices are distorted then these have to be adjusted first. For imports, the border price used is c.i.f. price (i.e., cost, insurance, freight or charged in full). For exports, the border price used is the free on board or f.o.b price (see Box C1.2).

3. Adjust for price distortions in non-traded items

   Often, the value of a non-traded good can be derived from market prices. However, if the market price of the non-traded good or service is distorted due to market and policy failures, then the shadow price needs to be determined. For example, using rural wages to value agricultural labour may be misleading when there is surplus labour in the low season and the marginal value product of the additional worker is much lower than the going wage rate.

4. Adjust for foreign exchange premiums

   National trade policies that restrict the free flow of internationally traded commodities (e.g., bans on roundwood exports, quotas on timber imports, tariffs on imported goods, subsidies on exported goods) and over (or under) valued exchange rates may lead to individuals paying a premium on traded goods over (or below) what they pay for non-traded goods. This is generally referred to as a *foreign exchange premium*. There are two approaches to incorporating the foreign exchange premium into economic analysis:

   i. Multiply the official exchange rate by the foreign exchange premium to derive a *shadow foreign exchange rate*. The shadow foreign exchange rate is then used to convert the foreign exchange price of traded items into domestic currency by the amount of the foreign exchange premium (assuming a positive foreign exchange premium).

ii. Alternatively, a standard conversion factor can be derived by taking the ratio of the value of all exports and imports at border prices to their value at domestic prices. Market prices of non-traded goods are then multiplied by this standard conversion factor, and this reduces them to their appropriate economic values (again, assuming a positive exchange premium).

The relationship between the official exchange rate (OER), the foreign exchange premium (FEP), the shadow exchange rate (SER), and the standard conversion factor (SCF) is explained by four equations (Gittinger 1982, Squire and Van der Tak 1975):

$$OER * (1 + FEP) = SER \qquad 1 / (1 + FEP) = SCF$$

$$SER = OER/SCF \qquad SCF = OER/SER$$

Where money costs and benefits in the economy are seriously distorted in various ways, a project's inputs and outputs should be valued according to their international or border prices. This entails working out what they would cost if imported or what they would realise if exported.

Box C1.2 Different Categories of Prices

The farmgate price or stumpage price is what farmers or foresters receive when they sell products or buy inputs from the boundary of their farm/timber stand — that is, the price without any transport or marketing costs included.

Domestic market prices will reflect any transport and marketing costs involved in getting the product to the local market and may reflect costs of processing the product before it reaches the market.

The border price reflects the value of output if the nation sells it abroad (i.e., exports it) or uses the output to substitute for produce that would otherwise have to be imported. It therefore reflects the true opportunity cost of domestic output, and must be contrasted with the value of the output when measured at domestic market prices which are often below world prices. Border prices are typically given f.o.b (free on board) for exports, and c.i.f (cost, insurance, fright) for imports.

The choice of which price to use in the analysis depends on whether the good is traded, the level and type of analysis, and the project boundary.

Source: IIED, 1994

Box C1.3 A Note on Transfer Payments

Economic analysis needs to account for transfer payments when using market prices as a measure of value of forest goods and services.

From the private investor's point of view, subsidies reduce costs (increase benefits). They therefore affect the *value* attached to benefits and costs by those who are subsidised. From the public point of view, a subsidy is merely a transfer of resources from one to another. But to the individual receiving the subsidy, the result is an increase in net benefits.

Forest clearing for agriculture, hydropower development, and other activities often involve government subsidies. If prices are not adjusted for these subsidies, values will be distorted.

Conversely, taxes represent a cost to private parties interested in the forest. Taxes may be in the form of concession fees or income taxes. Taxes reduce the net economic value of the forest or forest land to the potential user. From the public point of view, a tax is merely a transfer of control over given resources from one person or group to another. It is not treated as a cost or return in social economics, but merely as a 'transfer payment'.

2.0 RELATED GOODS APPROACH[1]

A non-marketed good or service may be related to a marketed good or service. By using information about this relationship and the price of the marketed product, the analyst may be able to infer the value of the non-marketed product. The related goods approach consists of three similar valuation techniques: barter exchange approach, direct substitute approach, and, indirect substitute approach.

2.1 Barter Exchange Approach

The barter exchange approach attempts to infer the value of non-marketed forest products from the market value of barter goods.

Many tropical forest products are not widely traded in formal markets (e.g., wild fruits, medicines, structural fibres). However, some of these forest products may be exchanged in a non-commercial market through a process of barter.

[1] Section based on IIED, 1994

Box C2.1 Steps For Using Barter Exchange Approach

1. Carry out household survey to determine which goods are commonly bartered
2. Determine if good exchanged for non-marketed forest product is sold in the market
3. If yes, determine quantitative relationship (units of exchange) between bartered good and non- marketed forest good
4. Determine market price of bartered good .
5. Estimate value of non-marketed forest good based on market price of bartered good and quantity of non-marketed forest good harvested (price of marketed good * quantity harvested of non-marketed forest good)
6. State any imperfections in market structure that might affect exchange relationship

Note: *Value estimates using the barter exchange approach will tend to underestimate value as consumer surplus is not included in the value estimate.*

If the bartered good that is exchanged for the forest product is also sold in a commercial market, then it may be possible to derive the value of the non-marketed good using information about the relationship (i.e., units of exchange) between the two goods and the market value of the commercial good.

For example, consider a situation where leafy vegetables are collected from the forest for local consumption, but are not sold in the local market and therefore cannot be valued directly through market prices. However, if a basket of leafy vegetables of known weight is routinely bartered for six eggs and six eggs fetch US$1 in the local market, then it can be inferred that a basket of leafy vegetables is worth US$1.

The market price of the marketed good is then used to estimate indirectly the value of the non-marketed good.

The barter exchange approach must be used with care. Bartering may occur in an 'imperfect' non-commercial market and the rate of exchange may reflect a wider range of socio-economic factors than just the value of the good exchanged.

While this approach has not been widely used, it is potentially useful in developing countries where bartering is common. Use of barter exchange techniques would require socio-economic surveys of household behaviour. In particular, these would provide quantitative data on the units of exchange between the bartered product and the market price of the other good. In addition, quantitative information on market structure, price trends, and market conditions in both the commercial and informal market would be required.

2.2 Direct Substitute Approach

The direct substitute approach estimates the value of a non-marketed good or service from the value or price of substitute or comparable goods and services under similar conditions.

For example, the value of a non-marketed forest product such as fuelwood could be estimated at the cost of an equivalent quantity of a similar marketed good (e.g., fuelwood purchased from other areas), or by the value of the next best alternative/substitute good (e.g., kerosene or charcoal) which would provide the same cooking requirements or heating. The extent to which the value of the marketed good reflects the value of the non-marketed good depends, to a large extent, on the degree of similarity between the two goods. If the goods are perfect substitutes, then their economic values should be very close. As the level of substitution decreases so does the extent to which the value of the marketed good can be taken as an indication of the non-marketed forest good.

Box C2.2 Summary of Substitution Approaches

1. Identify substitute good for non-marketed good to be valued.

2. *If* substitute good has a market price, then the value of non-marketed good is equal to the market price of the substitute good multiplied by the quantity of the non-marketed good harvested.

3. *If* substitute good is not marketed, then the indirect substitution approach may be used where the value of the non-marketed forest good is again equal to the price (value) of substitute good multiplied by the quantity of non-marketed good harvested.

But where the value of the substitute good is based on its value in an alternative productive use. That is, the change in output as a result of less of the 'substitute' good being used as an input into the production process * price of output.

Again, account should be taken of market imperfection which may distort the economic value of the good or service reflected in the market place.

2.3 Indirect Substitution Approach

The indirect substitution valuation approach is similar to the direct substitution approach but requires an additional step. This additional step essentially consists of combining the production function approach (see Section C3.6) with the direct substitution approach.

If the value of the substitute good cannot be determined directly from the market, then it may be possible to derive its value indirectly by looking at its value in an alternative use. For example, non-marketed fuelwood may be valued using information on the alternative use of one of its substitutes — cattle dung. When wood is unavailable, cattle dung is sometimes dried and burned instead of wood. If it is not used as fuelwood, cattle dung is typically used as a fertiliser. The opportunity cost of using cattle dung as a fuel rather than a fertiliser could therefore be used to value fuelwood by estimating the loss in agricultural productivity as a result of using less fertiliser.

The indirect substitute approach is based on fairly stringent assumptions about the level of substitution between the two goods, the role of the substitute good as an input to economic output, and the value of that economic output. The technique is also fairly data intensive. The physical relationship between input (e.g., cow dung) and economic output (e.g., agricultural productivity) needs to be understood and modelled. Given that this valuation approach rests on a number of tenuous links and its heavy data requirements ,it can be expected to provide only a rough indication of value, and should only be employed when more direct routes to valuation are not possible.

3.0 INDIRECT VALUATION TECHNIQUES

Indirect valuation techniques seek to determine preferences for the environment from actual, observed market based information. Peoples' preferences for the environment can be revealed *indirectly* by examining their behaviour in markets that are *linked* to the environment. Some goods and services are complements to environmental quality, others are proxies, surrogates or substitutes for it. By examining the prices paid in environment-related markets, peoples' environmental preferences can be uncovered.

These techniques are termed *indirect* because they do not rely on people's direct answers to questions about how much they would be willing to pay (or accept) for an environmental quality change (see Section C4) (Pearce and Moran 1994) .

Indirect valuation techniques are commonly employed to value *non-marketed* environmental goods and services and can be divided into two categories: surrogate market approaches and market valuation of physical effects (MVPE).

Surrogate market techniques involve looking at markets for goods and services which are related to the environmental good or service. The goods or services bought and sold in these surrogate markets will often complement, or substitute for the environmental commodities in question. Individuals reveal their preferences for both the marketed good and the environmental good when purchasing the marketed good. They leave what may be called a behavioural trail. An advantage of these techniques is that they rely on actual choices rather than on hypothetical choices as direct market approaches do. Surrogate market approaches include the household production function approaches such as the travel cost method (see Section C3.1) and hedonic pricing and wage techniques (see Sections C3.2 and C3.3) (Pearce and Moran 1994).

Market valuation of physical effects is sometimes thought of as a short cut valuation method because it proceeds straight to estimating the impact of environmental change on the receptor concerned (OECD 1995). Where environmental damage or improvement shows up in changes in the *quantity* or *price* of marketed inputs or outputs, the value of the change can be measured using market prices. Theoretically, changes in the total consumers' plus producers' surplus should be measured. However, if changes are small, the monetary measure can be approximated by market values. A valuation technique in this category is the production function approach (see Section C3.4).

Unlike other techniques, these techniques are not concerned with what people say they prefer, or with inferring environmental values indirectly by observing what people do. It is particularly useful, therefore, where individuals are *unaware* of the impact on utility of a change in environmental quality. In such cases, a direct WTP estimate would clearly be an inappropriate measure.

3.1 Travel Cost Method

Household production function approaches (HPF) such as the travel cost method (TCM) place values on environmental resources by specifying some familiar structural relation between the environmental services of interest and other private goods. Expenditure on commodities that are substitutes or complements for the environmental characteristics are used to value changes in that environmental characteristic. For example, travel is a *complement* to the recreational experience at a recreational site (it is necessary to travel to experience the recreational benefit). The value of the environmental resource (i.e., the recreational site) can therefore be found by looking at expenditures on travel.

TCM is based on the proposition that observed behaviour (expenditures on travel) can be used to derive a demand curve and to estimate value (including consumer surplus) for an unpriced environmental good by treating travel costs as the *surrogate* price for the non-market asset.

The travel cost approach has been extensively used in developed countries (especially North America) and has been implemented in some developing countries. Its main application has been in the valuation of environmental benefits at recreational sites (e.g., national parks, wildlife reserves, trekking areas and beaches). It can also be used to value the benefits of forest conservation for fuelwood (using travel time as a measure of the value of fuelwood), and similarly for water supply (using travel time as a proxy for the value of improved water supply facilities).

Many recreational, cultural, historic or scenic goods are unpriced because there is no entrance charge or other fees for users. The challenge is to find quantitative evidence of the value of these unpriced resources to visitors. TCM takes the visitors' travel cost as a proxy for the price they are willing to pay. (Another approach is to ask them directly — Contingent Valuation Method is discussed in Section C4.) The principle behind TCM is that rather than pay an entrance fee, users incur travel costs (in transport costs and time) to make the visits. It is assumed that the value to the consumer is at least equal to the travel costs the consumer is willing pay to obtain the desired good or service.

However, the value of the benefits or utility derived from a park (for example) is often much larger than the entrance fee, with the difference being equal to consumer surplus. To estimate consumer surplus, a demand curve must be derived for park users.

The basic theory of supply and demand indicates that less of a good is usually demanded as its price goes up. By analogy, the number of visits would normally be inversely related to the size of travel cost. Information on peoples' responses to travel costs can therefore be used to derive a demand curve for the resource in question. The area under the demand curve represents the total benefit of the resource (i.e., the consumer surplus). Furthermore, how people respond to differences in travel costs can also be used to infer how they might respond to changes in the entry price, since one acts as a surrogate for the other and a variation in these prices results in variation in consumption.

Box C3.1
Potential Situations or Sectors where TCM Might Be Applied

(i) Recreational sites
(ii) Nature reserves, national parks, forest and wetlands used for recreation
(iii) Dams, reservoirs, forest with recreational by-products
(iv) Fuelwood supply
(v) Collection of drinking water

When TCM is Most Appropriate

(i) The site is accessible, at least part of the time
(ii) There is no direct charge or entry fee for the good or service in question, or where such charges are very low
(iii) People spend significant time or incur other costs to travel to the site

3.1.1 Methodology [2]

The main steps involved in TCM are summarised in Box C3.2 and discussed below.

Box C3.2
Main Steps to TCM

1. Select site
2. Divide the area into zones
3. Sample visitors to the site
4. Obtain visitation rates for each zone
5. Estimate travel costs
6. Derive a statistical regression
7. Construct a demand curve
8. Estimate consumer surplus
9. Estimate benefits of environmental improvements at site

[2] Section compiled from OECD (1995) and Pearce and Moran (1994)

3.1.1.1 Zoning

The area around the site is first divided into zones, such that the travel cost to the site from each point in the same zone is roughly equal. Zones may be set by simply drawing concentric circles around the site. Or, the zones could be irregular contours or non-concentric, depending on how travel costs vary within the catchment area. In a TCM study in Bangkok, the zones correspond to different districts of the city (Grandstaff and Dixon 1986). One simplification would be to define zones according to their travel costs instead of distance.

Zoning becomes problematic if foreign visitors are included in the exercise. However, this may be justified in the case of an international attraction.

3.1.1.2 Sampling visitors

A survey is undertaken of a representative sample of individuals visiting the site. The survey should elicit information on the costs incurred in visiting the site (i.e., foregone earnings), the monetary costs of getting to and from the site and any entrance or parking fee required to visit the site. In addition, information is required on: the place of origin for the journey; frequency of visits; duration of journey and time spent at the site; number of years that visits have been made; basic socio-economic factors such as income, age, education of the individual; motives for the trip and other sites visited during the journey; environmental quality attributes of the site and its substitutes; and, the total population in each zone.

The survey can be carried out at the site, on travel routes to it, in the homes of catchment area visitors, or in a combination of these locations.

3.1.1.3 Visitation rates

For each zone, the number of annual visits (or visitor-days in the case of overnight stays) per head of the total population is estimated from the survey information.

3.1.1.4 Travel Cost Estimation

The cost of visiting a site consists of transportation costs plus the cost of the time taken to get to the site and the time spent at the site. The role of time is critical in estimating travel costs because time has an opportunity cost (e.g., one could be earning money working instead).

If time cost is ignored, then benefits and demand may be biased. For example, two visitors may have had to travel different distances to the site, thus requiring substantially different times to get there. Unless time costs are included, visitation costs and therefore WTP for the site may wrongly appear equal for the two individuals.

Time costs are given a money value using some shadow prices of time. Typically, the marginal wage rate is used as the appropriate shadow price of time since this reflects the opportunity cost of time between working and not working. However, this trade off may be distorted by institutional constraints such as maximum working hours, and taxation. The marginal wage rate may also be inappropriate for certain groups such as the unemployed.

Previous empirical work has suggested that the shadow price of time may be substantially less than the wage rate and lies somewhere between 25% and 50% of the wage rate with a value of 33% of the wage rate being most appropriate (Cesario 1976).

Time spent at the site should be included in travel costs because it may not be independent of the distance travelled. The shadow price of the time at the site and time getting to the site may be different. For example, individuals deriving pleasure from the journey to the site by taking a scenic route. If no pleasure or displeasure is evident from the travel experience, then the shadow prices are the same.

Box C3.3
Summary of Travel Costs to be Included in the Analysis

Direct expenses incurred by visitor in getting to and from the site, including fares, fuel and other incidentals.

Value of time spent on the journey, including time spent at the site. Valuing leisure time is inherently problematic. If there are no specific estimates of the value of leisure, a yardstick of one-third of the average wage may be taken.

Entry fees, guide fees and other incidental expenses at the site.

Source: OECD, 1995

3.1.1.5 Statistical regression

The first step in specifying the demand relationship for the site is to test the relationship between visitation rates and the relevant explanatory factors. This is done through *multiple regression analysis*, which seeks to explain visitation rates (consumer demand for visits) in terms of travel costs, other socio-economic variables and the prices and distances of competing sites[3] .

A basic travel cost model is presented below.

$$Vi = a + b\text{TC}i + c\ \text{INC}i + d\text{ED}i....f\text{STC}$$

where:

Vi	=	the number of visits to the site
TC	=	total travel cost
INC	=	individuals income
ED	=	respondents educational level
STC	=	travel cost to substitute sites
i	=	the respondent

a, *b*, *c*, *d* and *f* are the coefficients to be estimated

3 Regression analysis involves the fitting of a regression equation (or mathematical relationship) to a set of data points for the purpose of establishing quantitative economic relationships (estimating the value of parameters), or testing economic hypothesis. Multiple regression involves the fitting of a linear function containing two or more independent variables.

Coefficient *b* is of particular interest, denoting the change in visitation rate (demand for the site) as a function of travel cost. The travel cost model hypothesises that demand for the site may also be influenced by income, education, and the availability of other sites.

Specification of the functional form is crucial to the benefit estimates obtained[4] . Standard statistical techniques will, in general, not be able to discriminate in favour of one specification or another. In practice the choice of the functional form needs to be determined empirically on an individual study basis. However, there is some consensus that a semi-log form gives the best results, namely regressing the logarithm of visitation rates against travel costs.

3.1.1.6 Constructing the Demand Curve

Travel costs *per se* are not equal to the value of the park. Data from the demand function (travel cost regression equation) relating visitation rates to travel costs is only used to estimate the demand curve for the environmental resource in question. If visitation rates can be shown to vary according to price (for which travel cost is a proxy) this relationship can be viewed as the demand curve for the environment.

Box C3.4 Deriving a Demand Curve: Key Assumptions

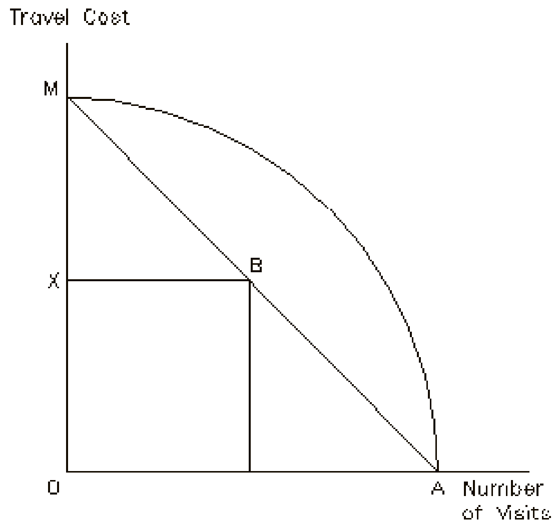
1. Residents can be grouped into residential zones where the inhabitants have similar preferences.

2. People will react to differences in travel costs in much the same way as they would react to the imposition of an admission charge (and successive increases in it) at the park (i.e., as the cost of travel increases the projected visitation rate will drop). This means that if a certain number of visits occurred at an entrance fee of zero, positive rising entrance fees would normally be associated with progressively diminishing visitation rates. Furthermore, at some level of admission fee (or cost of travel) no one would use the park because, given other recreational options, it would be too expensive.

The objective is to determine consumer's willingness to pay, up to the point at which no one from a given zone would visit the park. For each individual zone, the demand curve is built up by iteration starting at the observed number of visits when the entry price (travel cost) is zero, up to the entry price at which no one will visit the park (i.e., demand is zero). This procedure generates a succession of points, used to produce the demand curve, or the precise slope which would be given by the functional relationship employed. The area below the demand curve and above the cost curve is used as an estimate of the consumer's surplus of the present park users from that zone (see Figure 2).

4 The functional form is a mathematical formalization of the relationship whereby the values of a set of independent variables determine the value of the dependent variable. In the basic travel cost model presented, V is the dependent variable, and TC, INC, ED and STC are the independent variables. To say that V is a function of TC, INC, ED and STC (the independent variable) implies that these independent variables in some sense 'cause' V (the dependent variable) to take on certain values.

Figure 2. Demand Curve for Frequency of Visits



Given the demand function relating visitation to travel cost, a demand curve MA is derived starting at point A, the number of visits when the entry charge is zero, up to the point M which represents the entry price at which no one would visit the park.

If no entry fee exits, the entire area under the curve represents consumer surplus. At an entrance fee (travel cost) X, consumer surplus is equal to the area XBM

The consumer's surplus from all zones is added together to estimate the total consumer's surplus for users of the park.

In the absence of an entry fee, the entire area under the demand curve would represent consumer surplus. If no other benefits were obtained from the resource and if no costs arose in maintaining it, this area would also be equivalent to the total benefit from keeping the resource.

Sites with unique features would tend to have relatively steep demand curves, implying that visitors are prepared to incur high travel costs to visit them. Less interesting sites would have flatter demand curves, reflecting the unwillingness of visitors to travel far to reach them.

3.1.1.7 Estimating the Benefit of Environmental Improvement

TCM may be used to estimate the effect on visitation (demand) of changes, or proposed changes, in amenity, or the demand for one site over that of another with a different level of environmental quality.

If the model presented above is to be used to evaluate the benefits of *environmental improvements,* then some further work is required. It is necessary to determine how much the WTP of a particular stratification of households for a site, will change for a given change in the supply (i.e., environmental quality). For example, how much the willingness to pay of a category of each household will increase if the facility at a particular site is improved to allow for the possibility of fishing in a lake where none was possible before. This requires knowledge of how much WTP for alternative sites alters with changes in each of its specific facilities. By comparing the willingness to pay across sites with different facilities, it is possible to trace out changes in willingness to pay as facilities change.

The data required for such an exercise would include the facilities of each alternative site and the location of each household relative to all sites. This is clearly a very large amount of information and some simplifying assumptions will be necessary in many cases.

3.1.2 Some Practical Complications

3.1.2.1 Data Problems

(i) Large data requirements:
This technique requires very large quantities of data which can be expensive to collect and collate.

(ii) Data on travel costs and travel time
The cost of visiting an area includes the transportation costs and the opportunity cost of travel time. Time spent at the site also involves an opportunity cost. Significant biases may result from using incorrect values for these very difficult to measure costs.

(iii) Household characteristics
Hourly wage rates are rarely available. A hedonic wage equation must therefore be used to estimate the wage rate necessary for the calculation of travel costs. This is information intensive (e.g., information on education must be obtained) and there are a number of statistical problems inherent in providing a good hedonic wage equation.

(iv) Site Variables
Data on recreational facilities requires careful measurement and description of site characteristics and quality.

3.1.2.2 Economic Assumptions and Interpretation

(i) Multi-purpose visits
Most studies assume that travel is undertaken for the single purpose of visiting a particular site. However, visiting a site may be part of a round trip involving visits to other locations, or it may be a detour from a journey with a different motive (e.g., for work or visiting relatives). In such cases it would be incorrect to attribute the whole travel cost to the site in question. Where visits are multi-purpose, some crude allocation of costs would be necessary — bound to have an arbitrary element which may seriously affect the accuracy of the results.

(ii) Utility or extra disutility from travelling
In many cases, travel itself is part of the pleasure of the excursion. Up to a point, a longer journey through pleasant scenery may give more pleasure than a shorter, quicker one. Walking or cycling to a park or a beach may be regarded as part of the pleasure derived from visiting a site. Therefore, the expenditure of leisure time on travel to a recreational or cultural amenity is not necessarily a cost to the traveller. On the other hand, travel cost estimates may underestimate the true cost of travel for people who dislike travel, or where the transport mode is unpleasant. These considerations are particularly relevant in developing countries. In principle, surveys of visitors should elicit their attitudes to travel.

(iii) Sampling biases
The high cost of collecting data through questionnaire surveys tends to limit the size of the sample and the period over which interviews are conducted. This could introduce a bias in favour of frequent visitors, and discourage the use of household interviews. The failure to interview *non-users* gives rise to **truncation bias** in the survey, and deprives the study of important information. Non-users should be included to indicate what determines participation. If the cost per visit were lowered or the quality of the site were improved, it is possible that some of these non-visitors would frequent the site. However, it is very difficult to trace these individuals and to ascertain the extent of possible truncation bias[5] .

(iv) Non-user and off-site benefits
TCM is a method of capturing the benefits to the direct user (i.e., visitors) of the site. It does not deal with off-site use values (e.g., watershed protection, biodiversity) or services and goods provided to local inhabitants (fuelwood, fruits, medicinal products, etc). Nor does it capture option or existence values. Hence, TCM tends to *underestimate* total benefits. Ideally, TCM should be employed in conjunction with other techniques that can account for these other benefits (Grandstaff and Dixon 1986).

[5] Truncation bias has been found to have a significant impact on estimates such that the estimated demand curve is flatter than the true one. One suggestion has been to use maximum likelihood estimation instead of OLS (Ordinary Least Squares) in order to counter this problem.

3.1.2.3 Mathematical and Statistical Difficulties

Choice of the functional form in the regression The estimation procedure will have a great influence on the results, and hence on the demand schedule. Mis-specification of the functional form can lead to biased parameter estimates.

3.1.3 Overall Evaluation

TCM is a well established method for estimating the demand for recreational facilities, and hence their preservation and enhancement value (OECD 1995). Since the earliest applications of TCM in the USA in the late 1950s, the technique has been steadily improved and a number of theoretical and empirical issues have been resolved. However, the usefulness of TCM in the valuation of tropical forest recreational uses is still constrained by a number of factors including: large amount of data required from questionnaire surveys which can be expensive to collect and collate; restrictive assumptions about individuals' behaviour; and, sensitivity of the results to the statistical methods used to specify the demand relationship (IIED 1994).

TCM works best for accessible, isolated single sites where characteristics of the site and rival attractions remain constant. It is most relevant where people regard travelling time as a cost. TCM gives less clear results where visits are made for several purposes. It is difficult to apply to urban sites where travel cost is small, and to visits where the travel is considered part of the benefit. The omission of local benefits, off-site and non-use values, is likely to be significant for tropical forests and wildlife reserves.

TCM is a useful aid for policy decision on setting the level of entry fees to national parks and reserve areas, allocating national recreation and conservation budgets between different sites and judging whether it is worth preserving a site for recreational use rather than a rival land use (OECD 1995).

3.2 Hedonic Pricing Method

The Hedonic Pricing Method (HPM) attempts to estimate an implicit price for non-marketed environmental attributes by looking at real markets in which those characteristics are effectively traded. Thus, clean air and peace and quiet are effectively traded in the property market since purchasers of houses and land do consider these environmental dimensions as characteristics of property (Pearce and Moran 1994).

The most common applications of this technique are the property value approach and the wage differential approach.

The property value approach is based on the assumption that the value of land is related to the stream of benefits derived from it. Agricultural output and shelter are the most obvious benefits. However, the value of a house, for example, is affected by many other variables including size, construction, location and the quality of the environment (air quality and noise pollution). Ostensibly, land values in developing countries will be partly dependent on environmental quality reflecting, for example, the presence of soil conservation measures and access to fuelwood.

The property value approach observes systematic differences in the value of properties between locations and isolates the effect of environmental quality on these values. While the variables of size, construction and location are controlled for, some of the price differential between similar units reflects environmental quality. The value of the environmental amenity is therefore imputed from the observed land market.

3.2.1 Methodology

To derive the demand function relating the quality of the environmental attribute to individuals' WTP, it is first necessary to define the market commodity (e.g., land) and the attributes of the market commodity including its environmental attributes (e.g., soil quality). A functional relationship is then specified between the market price and all the relevant attributes of the market commodity. This is called the *hedonic price function*.

A common hedonic price function is presented below (IIED 1994):

Pi = f (Qi, Ri....) i = 1,.....n

Where:

Pi = price of the land
Qi = environmental quality of the land
Ri = size of the property
i = index of properties

The hedonic price function is then estimated using multiple regression techniques from data on land values and the associated attributes of the land. The hedonic price function coefficient on the attribute of interest can thus be found, and this coefficient is known as the marginal implicit price of the attribute (the demand function). It gives the additional amount of money that must be paid by an individual to buy an identical market good but with a higher level of environmental attribute (i.e., how land prices change with changes in environmental quality). From this it is possible to infer how much people are willing to pay for a change in environmental quality and, therefore, what the social value of the change could be.

Box C3.5
Steps to Performing Hedonic Pricing Method

1 Define market commodity (e.g., land) and its attributes (including environmental attributes)

2. Specify hedonic price function (i.e., relationship between market price and all relevant attributes of the commodity)

3. Estimate hedonic price function using multiple regression techniques

3.2.2 Application to the Valuation of Tropical Forests[6]

The property value approach has been applied successfully in developed countries to estimate the costs of air and noise pollution and of changes in amenities. However, the hedonic pricing technique is based on fairly stringent assumptions (e.g., well functioning markets and available information on environmental conditions) that are unlikely to be fulfilled in many developing countries.

Application of the hedonic pricing technique in the valuation of tropical forests is therefore likely to be limited due to poorly established property markets (especially at the frontier of tropical forests where formal property rights have not been granted and the forest land is essentially an open access resource), and inadequate information and knowledge of the benefits of tropical forests and their impacts on the value of the good and service.

Furthermore, the hedonic pricing technique is data intensive and the forest resource, function or attribute being valued needs to be well known and easily measurable. Although individuals may be familiar with the goods and services provided by the forest, it may be difficult to quantify their access to and the availability of forest goods and services. Collecting such detailed information severely inhibits the use of this approach in developing countries.

The property value approach may have potential use in assessing the value of ecological forest functions in relation to their impact on agricultural land values. For example, agricultural land near well established and maintained tropical forests may benefit from more stable groundwater recharge functions and evenly dispersed water run-off. In addition, the micro-climatic impact of tropical forests may lead to preferable rain and temperature regimes near the forest. Such beneficial ecological functions of tropical forests may lead to more productive agricultural land in the water/climate catchment zone surrounding the tropical forest. If the link between improved land productivity and the ecological functions of tropical forests is known by those in the agricultural land markets, then one would expect the value of the tropical forest functions to be reflected in agricultural prices.

3.3 Labour Market Approach

The labour market (or wage differential) approach involves analysing differences in wage levels for similar jobs as a function of different levels of attributes of the job relating to working and living conditions. For example, a higher wage is needed to induce workers to work in polluted or noisy environments. The wage risk premium has been used for valuing changes in morbidity and mortality arising from environmental (and safety) hazards. High risk jobs may well have a risk premium in wages to compensate for risk. The attributes of risk and environmental quality are therefore traded in the labour market. If the relationship between the wage level and environmental attributes can be estimated, then the benefits from an improvement in these attributes can also be estimated.

Since labour markets in developing countries are unlikely to function so as to capture risk aversion, this approach has limited application in the developing country context. However it may be appropriate to adjust calculations (from developed economies) derived from wage risk studies to provide approximations of statistical life values for developing countries (Pearce 1986).

[6] Compiled from IIED, 1994

3.4 Market Valuation of Physical Effects [7]

The market valuation of physical effects (MVPE)[8], is often thought of as the most straightforward way to valuing the environment. MVPE observes physical changes in environmental quality and estimates what differences these changes will make to the value of goods and services which are marketed (e.g., agricultural and forest products, and fish)[9]. For example, consider a change in environmental quality such as a reduction in water quality. This may reduce the quantity of marketed fish caught. This lost productivity could be estimated using market prices (Pearce and Moran 1994).

The main valuation methods under this category are:

Dose-response

Dose-response measures estimate the physical impacts of an environmental change on a receptor. For example, they may measure the physical impact of deforestation on soil erosion or water pollution on health.

The aim is to establish a *relationship* between environmental damage (the response such as soil erosion) and some cause of the damage (the dose such as deforestation) such that a given level of damage can be associated with a given change in environmental quality. The technique is obviously feasible only where there is a known relationship between the dose and response. The next step is to relate the environmental damage to a change in value (quantity or quality) of a good or service which is marketed.

Damage functions

Damage functions use dose-response data to estimate the economic cost of environmental change. The physical impact (soil erosion) caused by environmental change (deforestation) is converted to economic values by associating that impact with a given change in a marketed output (e.g., crop yields) which can be measured using the market or shadow prices for the units of output.

The production function approach

The production function approach is essentially the dose-response approach *in its most basic form*. It looks at environmental resources which lead to marginal changes in the output of a marketed good and values the impact *directly* in terms of output changes at market prices (Pearce and Moran 1994). In theory, this valuation approach could be applied to many tropical forest components.

The production function approach is a common economic technique which relates output to different levels of inputs of the so-called factors of production (land, labour, capital, raw materials). The concept is that a change in the use of one of these inputs, such as labour, will result in a certain change in output. Production is therefore a function of these inputs

7 Based on OECD, 1994

8 Sometimes referred to as Conventional Market Approaches

9 The MVPE approach could also be applied to output which is not marketed but where an actual market exists for similar /substitute goods.

and can be related to them algebraically. Environmental resources may similarly be thought of as 'inputs' (factors of production) to be included in the production process where they can be measured and where they have a clear effect on output (e.g., soil fertility and air and water quality). Following these principles, the production function approach relates environmental inputs to output, and measures variations in output as a result of the changes in the various kinds of input.

More formally, the production function for a single output may be given by:

$$y = F(X, Z)$$

where X is a set of inputs (e.g., land, capital) and Z is the input of the unpriced environmental resource. Assume that output *y* which has a market price can be measured. If prices of inputs X are not expected to change when supply of the environmental resource (Z) changes, then the economic value of the change in the supply of Z is the value of the production change associated with the change in Z at constant inputs of the other factors (X) (Pearce and Moran 1994).

For example, assume that an ecological function of a tropical forest is support for downstream fisheries. It ensures a regular flow of clean water to streams important as spawning grounds for fish and nurseries for fry. The forest area in the watershed (S) may therefore have a direct influence on the catch of some fish species dependant on the area, Q, which is independent from the standard inputs of commercial fishery, Xi...Xk. Including forest watershed area as a determinant of fish catch may therefore capture some element of the economic contribution of this ecological support function (Barbier 1992).

$$Q = F(X_i \ldots X_k, S)$$

Human capital approach

The *human capital* approach estimates the cost of bad health as a result of environmental change. Evidence on the relationship between a change in the environment and health effects may be found in epidemiological data, controlled group experiments, or other observations. The economic cost of bad health is estimated through its effect on the productivity of workers. The term human capital is used because the approach is based on the value of a person as a working unit (the person's subjective valuation of health, his/her WTP for better health, the cost of pain and suffering, etc., are not considered) (OECD 1995).

Box C3.6 When is the MVPE Approach Appropriate

MVPE is appropriate where:

The environmental change directly causes an increase or decrease in the output of a good (or service) which is marketed, or is potentially marketed, or which has a close substitute which is marketed.

The effect is clear and can be observed or tested empirically

Markets function well, so that price is a good indicator of economic value

Source: OECD, 1995

3.4.1 Methodology

The three main steps to valuation using MVPE approach are summarised in Box C3.7.

Determining the physical effect

The physical effect of the environmental quality change on the economic activities concerned can be determined by:

i. laboratory or field research.

ii. observation or controlled experiments, in which the effect is deliberately induced, (e.g., agronomic trails on the land with different degrees of erosion or making observations on receptors with and without the effect of using control groups as the norm).

iii. modelling relationships based on plausible information drawn from real life. In soil erosion studies, for example, it is common to use some variant of the Soil Loss Equation, which predicts erosion according to slope, rainfall, soil type and a dummy variable for management practices and type of crop.

iv. statistical regression techniques that try to isolate the influence of a particular effect from that of a number of others.

Box C3.7 Main Steps for Using the MVPE

The MPVE entails three basic steps:

1. Identify the physical effect of environmental quality change on the economic activity concerned (agriculture, fisheries, health, property)

   As an example, consider using the MVPE approach to estimate the cost of soil erosion. Assume that upland deforestation (the environmental change) causes soil losses of 3% per annum (the physical effect) .

2. Estimate what difference this physical effect will have in terms of output or costs

   For the example, assume a 3% per annum loss of soil may reduce the output of maize by 2% on a typical 100/kg plot of land.

3. Estimate the market value of this change in output. Account for affects of changes in output on prices, adopt shadow pricing, and calculate net effects (e.g., deduct savings in harvesting costs as a result of reduced output) where necessary.

   *For the example, assume that the market price of maize is $3, the loss of 100 kg of maize per year would then cause a net loss of income to the farmer of, say, $250 (100 kg * $3 / kg = $300, minus a $50 saving on harvesting and other variable costs)*

Attaching market values

The easiest approach for estimating the value of the change in productivity is to use ruling market prices (i.e., the change in output is multiplied by the market price of the output). This is acceptable if the change in output is not large, and if the prices are efficient.

When the change in output is large, prices are likely to be affected (for example, if a large part of national supply comes from the area). In such cases, some attempt should be made to predict price changes.

If the change in resource supply is large, but prices do not change, then the value of resource supply change must be measured as the difference between the profit after the change and before the change, taking all changes in factor use into consideration.

If prices do change (working through quantity), then there will be changes in profit plus an additional effect on consumer surplus. The full effect of the change in environmental quality will become difficult to determine, for example, if producers take steps to mitigate the environmental damage.

The use of actual prices is also misleading where markets are distorted due to market and policy failures (e.g., price controls or protection against imports). For instance, if the crop that is subject to soil erosion is kept at an artificially high support price, using prevailing market prices would overestimate the real environmental damage. Wherever possible, prices should be adjusted to their market clearing or competitive levels (i.e., efficiency prices should be calculated) (OECD 1995).

Furthermore, accuracy requires that the *net* effect of output and price changes be estimated. G*ross* sums should be adjusted for any resulting changes in production costs such as harvesting and transport costs. For example, if soil erosion reduces the output of crops, there may be partially offsetting savings in harvesting costs. Alternatively, environmental damage increases cost of an item, as well as reduce its output (e.g., if it takes longer to catch fewer fish in polluted waters) (OECD 1995).

Box C3.8 Applications of the Production Function Approach in the Analysis of Tropical Forest Land Use

Tropical forests support downstream fisheries by ensuring a regular flow of clean water to streams used both as spawning grounds for fish and as nursery for fry. The value of this forest function could be estimated as the change in the value of fish productivity as a result of damage or loss to this ecological service through deforestation.

Watershed disturbance can result in soil erosion. The watershed value of a tropical forest could be based on the change in the value of crop yields as a result of soil erosion.

The effect of downstream siltation, as a result of soil erosion, could be estimated by looking at the resulting loss in productivity to lowland farmers, irrigators, water utilities, power companies, river and estuary navigators.

3.4.2 The Production Function Approach and Valuation of Tropical Forests

The production function approach may be used to estimate the non-marketed indirect use values of tropical forests through their contribution to economic activities. It has been used frequently in developing regions to estimate the impact of deforestation on soil erosion, wetlands and reef destruction.

The production function approach is easier to apply to single use systems, such as tropical forest systems, in which the predominant economic value is a single regulatory function. In the case of multiple use systems (i.e., tropical forest systems) in which a regulatory function may support or protect many different economic activities, or which may have more than one regulatory ecological function of economic value — application will be more problematic. Assumptions concerning the ecological relationships among these various use functions would need to be carefully constructed. Two major difficulties in specifying ecological-economic relationships are the problems of double counting and trade-offs between various direct and indirect uses. This problem arises when analysts attempt to aggregate the total economic value of the tropical forests from different use value sub-components (IIED 1994).

3.4.3 Problems and Limitations of MVPE Approaches

While the MVPE approach may seem straightforward, there are a number of practical limitations to its use:

i. Specifying the physical effect of a change in environmental quality, and the resulting impact of this physical effect on the economic activities can be difficult and data intensive in practice. For example, it is extremely important that the relationship between the environmental regulatory function of the tropical forests and the economic activity it supports is well understood.

ii. Markets for some products are absent or underdeveloped, especially in subsistence economies. Thus, the recourse of using roundabout valuation methods, or the use of proxies and substitutes.

iii. Where environmental change has a sizeable effect on markets, a more complex view needs to be taken of the market structure, elasticities, and supply and demand responses. Consumer and producer behaviour needs to be introduced into the analysis as behaviour may change in response to changes in the environment. If this is not possible, the direction of any resulting bias should be stated (if known). Furthermore, the impacts of market conditions and regulatory policies affecting production decisions must be accounted for.

iv. Prices, even when they are taken from an efficient and undistorted market, will underestimate economic values where there is significant consumer surplus. Market prices also include externalities, both positive and negative.

v. The production function approach is mainly applicable to environmental changes that have impacts on marketable goods and so is not suitable for valuing non-use benefits.

3.4.4 Overall Evaluation

The MVPE approach has widespread application and is by far the most common valuation method used by countries regardless of stage of development. It appeals to intuition and common sense, and is easy to explain and justify. It relies on observed market behaviour, is readily intelligible to decision makers, and concentrates on output which potentially enters GNP and the budgets of firms and households.

Uncertainty associated with MVPE approaches relates mainly to the specification of the physical effects of a change in environmental quality. The approach can be costly if large databases are needed to model the relationships. Its limitations are further exposed where markets are badly developed or distorted, and where the changes in output are likely to have a significant effect on prices.

4.0 CONSTRUCTED MARKET APPROACH

Price-based valuation and surrogate market techniques rely on preferences in real markets. However, certain kinds of environmental changes do not affect goods and services that are marketed. In cases where there are no market prices that satisfactorily can be used as direct measures or proxies of value, it is possible to 'construct' markets in order to try and estimate consumer's WTP for goods and services. Constructed market techniques can be divided into two categories: simulated market techniques and contingent valuation method. The most notable of these approaches is the **Contingent Valuation Method** (CVM)[10] .

The CVM uses survey techniques to ask people directly what their environmental preferences are. It is therefore a form of market research, where the product in question is a change in environment quality. A hypothetical market is constructed and consumers are asked what they would be WTP for a hypothetical environmental improvement or to prevent a deterioration. Also, what they would be willing to accept (WTA) in compensation for tolerating a loss. Typical questions would include: *Would you be willing to pay $x to (improve air/water quality, preserve views of attractive landscape)?* A hypothetical market is taken to include not just the good itself (an improved view, better water quality, etc.), but also the institutional context in which it would be provided, and the way in which it would be financed.

Since responses to a hypothetical situation are derived from potential consumers, CVM *assumes* that the consumer's expressed WTP in a hypothetical situation is a measure of the consumer's value in an actual situation. It is particularly difficult to apply meaningfully when, like with many functions of the tropical forest, the respondent is being asked to express a value for something that has no established monetary market value (e.g., cleaner water), and that might become available in a hypothetical set of circumstances (e.g., through a reduction in upstream harvesting activities).

[10] Simulated market techniques rely on the construction of a market where money actually exchanges hands - though mainly within the confines of an experimental setting such as a laboratory. Simulated market techniques are used in order to elicit the preferences of test subjects and explore the determination of these preferences. As such, these techniques rely heavily on expertise in other social science disciplines - such as psychology, sociology, and political science - in design and implementation. One potential application of simulated markets to the valuation of tropical forests would be as a means of investigating option and existence value held by people in developed countries. Beyond this one possibility, however, these techniques are impractical for evaluating rural resource issues in developing countries.

However, if people understand clearly the change in environmental quality being offered, and answer truthfully, CVM is ideal. It measures precisely what the analyst wants to know — the individuals' strength of preference for the proposed change. Its principle drawback is that it depends on what people say rather than what they would do. The issue is whether the intentions people indicate *ex ante* (before the change) will accurately describe their behaviour *ex-post* (after the change) when they face no penalty or cost associated with a discrepancy between the two. Such biases in responses, can however, be minimised by careful survey design.

An important advantage of CVM is that it is applicable, technically, to all circumstances. It is the *only* practical method for uncovering existence values (e.g., preservation of rare species, biodiversity for its own sake) which generally do not pass through markets and do not have substitutes or complements that pass through markets.[11] Constructed markets can also account for the existence of uncertainty (option values) and are therefore the only source of evidence on the value of future changes in environmental quality. Further, it suggests that, if sequenced properly, constructed markets provide the opportunity to estimate an internally consistent set of value components (use and non-use values) that can be aggregated into a true measure of total economic value (Randall 1992).

Box C4.1 Characteristics of CVM

i. CVM differs from conventional market research in that it is concerned with a *hypothetical* event, namely an improvement or deterioration in the environment.

ii. CVM often deals with changes in public goods - such as air quality, landscape, or the existence values of wildlife. However, it may also apply to environmental goods that are sold to individuals, such as improved water supply and sewage.

iii. CVM may apply to both use values (water quality, viewing wild animals, direct enjoyment of a view), or non-use values (existence values)

iv. The values that people express in CVM interviews depend (are contingent) upon such factors as the description of the good, the way it is provided, and the way it would be paid for.

Conditions under which CVM is most Appropriate

i. Environmental changes have no direct impact on marketed output.

ii. It is not feasible to observe people's preferences directly.

iii. The population in the sample is representative, interested in and well informed of

iv. the subject in question.

v. There are adequate funds, human resources and time to do the study properly (obtaining reliable information requires a substantial investment of time, care and resources, which makes a good CVM exercise expensive).

Source: Based on OECD, 1995

[11] Other valuation techniques are not aimed at capturing non-use values. While it may be possible to infer estimates of existence values from market behaviour - such as donations to philanthropic pursuits - it is almost impossible to separate out use and existence values revealed in such markets.

CVM therefore has great potential as a source of data in areas where other techniques are not feasible. It is also useful as a check on data obtained by other methods and it is increasingly common to find CVM being used in combination with other techniques.

Interest in CVM has increased over the last decade or so because: it is the only means available for valuing non-use values; estimates obtained from well designed, properly executed surveys appear to be as good as estimates obtained from other methods; and, the design, analysis and interpretation of surveys have improved greatly as scientific sampling theory, the economic theory of benefit estimation, computerised data management and public opinion have improved.

4.1 Methodology [12]

The aim of the CVM is to elicit valuations — or bids — which are close to those that would be revealed if an actual market existed. The hypothetical market — the questioner, questionnaire and respondent — must therefore be as close as possible to a real market.

Box C4.2 Steps to CVM

1 Select interview technique (mail, telephone, personal interviews)

2 Design questionnaire

3. Design sample

4 Select elicitation procedure (i.e., how questions are posed)

5 Analyse data

6 Check accuracy of results

7. Draw inferences from results

4.1.1 Questionnaire Design

The design of the questionnaire is of critical importance.

The questionnaire should begin with an account of the problem (e.g., the environmental change that is envisaged, illustrated if possible with diagrams or photographs). This is to ensure that the respondent is aware of the issues and is well-informed about them.

When environmental improvements (e.g., water supply, sewerage) are the subject of the survey, a hypothetical description (scenario) of the terms under which the good or service is to be offered should be presented to the respondent. Information should be conveyed on when the service would be available, how the respondent would be expected to pay for it (known as the payment vehicle — such as a local tax or direct entry charge), how much others would be expected to pay, what institutions will be responsible for the delivery of the service, and the quality and reliability of the service.

[12] Compiled from OECD, 1995

The second part of the questionnaire should elicit the value that the respondents would place on the environmental change. For environmental improvements, questions should be designed to uncover WTP. For losses to the environment, the respondents should in theory be asked about their WTA.

Also, the questionnaire should include a set of questions about the social, economic and demographic background of the respondents and their families. This information is necessary to analyse and cross-check their WTP replies, especially where the answers are of a yes/no nature.

4.1.2 Interview Techniques

Interviews can be carried out by mail, telephone or personal visits. The best results can be expected from personal interviews, provided the enumerators are capable and well trained. In rural areas and developing countries with limited telephone ownership, poor postal services and wide spread illiteracy, personal interviews or focus groups will be the realistic choice (despite being relatively expensive).

Box C4.3
Overview of Contingent Market Techniques

Elicitation Methods

1. Direct questions
2. Bidding game
3. Payment card
4. Take-it-or-leave-it (discrete or binary choice)
5. Contingent ranking

Research Procedures

1. Personal interviews
2. Telephone
3. Mail questionnaires
4. Focus groups
5. Laboratory

Applications of CVM

1. Water quality
2. Air quality
3. Risk studies
4. Land/recreation facilities studies
5. Wildlife, hunting and fishing

Source: Extracted from Carson (1991)

4.1.3 Elicitation Procedures

There are a number of elicitation procedures that can be used. Most methods elicit the WTP of survey participants for a specific amenity and quantity change.

People could simply be asked the maximum they would be WTP, or the minimum they would accept in compensation for the change in question given the scenario constructed by the researcher. These are called **direct** or **open-ended questions.**

An alternative is to ask whether they would be willing to buy the service or accept the change if it costs a specified amount. These are known as **discrete** or **yes/no dichotomous questions**. This procedure has the advantage of avoiding certain biases in answers as such 'take it or leave it' questions mimic market transactions where goods are bought at a fixed price and are familiar to most respondents. However, the dichotomous type of question demands more complex statistical treatment and some strict assumptions for maximum WTP.

These two types can be combined in a CV questionnaire to create different ways of eliciting valuation information (e.g., bidding games).

Bidding games and payment card methods are slightly more sophisticated methods, requiring the respondent either to go through a series of bids until a negative response is generated and a threshold thereby established, or to select from a range of values.

The questioner suggests the first bid (the starting point bid or price) and the respondent agrees or denies that he or she would be willing to pay it. An iterative procedure follows: the starting-point price is increased to see if the respondent would be willing to pay it, and so on until the respondent declares he/she is not willing to pay the extra increment in the bid. The last accepted bid, then, is the maximum willingness to pay.

In addition, respondents may be shown a list of possible answers in the form of a payment card, and asked to indicate their choice, although this requires a careful determination of the range of possible answers.

The take-it-or-leave-it method requires the respondent to indicate approval or disapproval of a single monetary sum which is varied across the interview sample.

The contingent ranking method differs from the other methods in that it does not ask respondents to place a monetary value on environmental amenity itself. Instead a range of amenities are ranked and then scored relative to each other with one of the amenities serving as an anchor. The respondents' WTP for the anchor is then elicited and used in inferring their WTP for their amenities.

The appropriate choice for a specific problem is a matter of judgement on the part of the analyst. Many recent studies have opted for the dichotomous choice format for its bias-reducing properties. However, there is no one correct procedure, and several of the assumptions routinely employed are subject to current debate among practitioners.

4.1.4 Selecting a Random Sample

The careful definition of target population is important and can obviously affect the size of society's WTP. This is a key problem for environmental issues of national and international importance where there are many potential stakeholders.

Grossing up estimates from a random sample is a common statistical problem which can be eased by the careful choice of the random sample. The involvement of a statistician with sampling experience is highly desirable, particularly in deciding sampling methods and sample size.

4.1.5 Analysing the Data

CVM studies may contain three levels of analysis of respondent's data:

i. Definition of a frequency distribution, relating the size of different WTP statements to the number of people making them

ii. Cross-tabulation of WTP responses with the respondents' socio-economic characteristics and other relevant factors

iii. Employment of multivariate statistical techniques to correlate answers to the respondents' socio-economic attributes

The analytical approach will depend on the elicitation procedure employed. The simplest kind of CVM elicitation procedure is the open-ended question about WTP. For each price, the total amount of WTP is added, and a demand curve is built up from these data. This shows how the demand, or WTP, for the environmental change varies with its price. Carrying out the second of the above procedures should be done as a useful check on the plausibility of the answers.

For CVM studies using yes/no questions (the referendum model) the second and third steps will be necessary to produce a demand function. The result is either a probability-weighted distribution of the willing to pay various amounts among the sample population, or an estimate of the proportion of the population willingness to pay a particular amount. Discrete choice statistical methods are used to process the data.

In any event, preliminary screening or trimming of the data should be conducted to remove suspect answers, protest replies, or outliers (clearly implausible replies). This should be done with care to reduce the risk of the analyst injecting his or her own biases or expectations into the data sample. Note should be taken of extreme WTP answers such as zero replies and their true significance established if possible. Another type of sampling problem is the treatment of non-responses especially where expected to be non-random. A high proportion of non-responses *may* signify a problem with the method. In yes/no elicitation procedures, there should also be room for a 'no-reply' answer with a follow up question on the reason for this choice.

4.1.6 Testing for Accuracy

A large part of the literature on CVM is based on its accuracy. Accuracy is not easy to define. But since the basic aim of CVM is to elicit 'real' values, a bid will be accurate if it coincides (within reason) with one that would result if an actual market existed. Because actual markets do not exist, accuracy must be tested by other means.

The reliability of data and survey methodology can be checked as follows:

(i) Internal check on survey design. Certain details may be varied between different split samples to see whether systematic differences arise. The following design details may need to be checked: starting points for WTP bids; elicitation procedures, especially the open-ended versus yes/no approaches; effects of time to think; the order of questions; and the amount of information provided.

Reliability could also be checked through the use of replaceability tests — repeating an experiment using different samples to see if there is a correlation between the variable collected. Few such tests have been carried out due to their expense.

(ii) Multivariate analysis, correlating WTP with socio-economic variables suggested by demand theory (e.g., income, education, family status, housing conditions). Confirmation of *a priori* expectations of the relationship between WTP income, age and other variables is a good indication of meaningful responses. If the correlations do not follow a predictable pattern, this would be *prima facie* reason to question the survey methods.

(iii) Comparisons of CVM valuations with those obtained from other methods, where these are available and appropriate. A reasonable correspondence between estimates obtained from different methods is reassuring. However, if estimates differ widely, this is not necessarily a condemnation of CVM results since other methods are likely to have their own problems and biases. In this case, a more complex judgement needs to be made about the relative accuracy obtained by CVM and other methods. If a scheme has been in operation for sufficient time, it may also be possible to compare what people say they would be WTP with what they actually paid.

Box C4.4 WTP Versus WTA

Despite intuition to the contrary, both evidence and theory indicate that for a particular measurable change in the provision of a good, measures of WTA and WTP will not necessarily be identical. Typically, WTA is several times larger than WTP, reflecting the fact that WTA is not limited by income, and that most people place a higher value on what they already have than on something they may hypothetically acquire. In practice, WTP estimates tend to be used.

Carson (1991) suggests that differences between WTP and WTA are likely to be particularly large when examining unique environmental goods. This has led many to question the use of WTA as a measure of economic welfare in such cases.

4.2 Common Problems[13]

The valuations produced by contingent markets are 'contingent' because the values derived depend on individual perceptions of a host of background factors that influence the market being surveyed. Given the contingent nature of such a survey, a poorly designed and implemented survey may easily influence and distort individual answers. This leads to survey responses that bear little resemblance to the relevant populations' true WTP. These difficulties — or potential bias sources are listed below. Bias is any element in the study that consistently skews results in one direction, thereby leading survey results away from the population's true WTP.

Biases may arise at any stage in survey design and implementation: construction of the market scenario; sample selection; development and application of the method and vehicle for eliciting responses; survey implementation; or in the drawing of inferences from the results.

The literature on CVM has focused on overcoming the many sources of bias in CVM studies. Resolving these difficulties involves careful design and pretesting of questionnaires, competent survey administration, and the execution of econometric tests that may identify the remaining sources of bias.

Design biases

Design bias derives from the information presented to the respondent, the sequence of presentation, the bidding instrument and the starting point of such bidding.

Information bias

The quality of information given in a hypothetical market scenario almost certainly affects the responses received. Empirical evidence suggests only a weak information bias; some studies finding a threshold effect for information build up, below which no bias is detectable but above which a positive and weak effect is found. Other studies have found no significant information bias, although bid variance was found to fall as information increased (Pearce and Moran 1994).

The likelihood of ignorant or flippant answers can be reduced by offering respondents proper information about the proposed change, including graphics and photographs. Sometimes it would be beneficial to offer more time to answer, for instance by returning the following day to complete the interview. How much information to provide is a judicious decision; providing too much data may itself be a source of biases. Ideally, this should be tested by comparing the answers of the sample with a control group being offered less information. At the very least, all respondents within a sample should be offered the same information, and interviewers should be sparing in the amount of supplementary information they volunteer in response to questions.

In the context of unknown or lesser known species, the issue of information is clearly vital. If CVM is to be extended beyond well known species and ecosystems, the effects of information provision must be addressed.

[13] Based on OECD (1994) and Pearce and Moran (1994)

Some of the pertinent issues are: should uninformed respondents be informed, and how does this process affect the eventual responses to CVM questions? If there is no information provision, should the responses of uninformed respondents count, and what does this imply for the range of subjects suitable for CVM study?

Part/Whole bias

One common error is for the respondent to confuse the subject of the enquiry with other, wider, questions that arise in his or her mind. There is evidence to suggest that people have problems understanding certain kinds of questions that depend on insights into their own feelings or their memory of events or feelings. This is often so with environmental issues which evoke deeply held moral, philosophical and religious beliefs. Respondents may interpret a hypothetical offer of a specific good or service to indicate an offer for a broader set of similar goods and services. This is referred to as the *embedding problem* (alternatively as the *part/whole bias*) since the value of the good being sought is embedded in the value of the more encompassing set of goods or services reported by the respondent. If, for example, people were asked their WTP for the preservation of a particular natural habitat, their answer may betray their values for the whole of that natural habitat in the country (or even in the world, in the case of threatened species). The only safeguard against this bias is for the background information to be clear that the questions relate solely to the case in point.

This problem is indicative of an even broader problem with obtaining accurate answers. For a single individual the total amount he or she is WTP for improved environmental goods and services may be determined by the composition or components of the total set of environmental projects and policies to be funded. However, this information is unlikely to be obtained from the aggregation of values based on a set of CV studies designed to measure individuals' preferences for narrowly defined environmental goods.

Starting point bias

It is important that any hint be avoided in the questions or in the manner of the interviewer about the level of expected WTP values. If, for instance, people are asked their WTP for an ascending or descending range of values, their answers may be influenced by the starting level (starting point bias). The same problem may arise from the use of payment cards with different levels of value on them, or from using bidding games. In the interest of objectivity, respondents should be discouraged from guessing what level of WTP they are expected to produce, or the average level of other people's replies.

Payment vehicle bias

WTP replies may be biased by the choice of payment vehicle specified in the question; for example, cash price, entry charge, indirect tax, property tax supplement, voluntary donation, once and for all current charges. This is referred to as instrument bias. On the other hand, the 'bias' between various forms of payment may reflect people's genuine preferences. Thus, they should not be disregarded or corrected for.

To minimise this bias, controversial payment vehicles should be avoided and the payment method should be as realistic as possible.

Interview and respondent bias

The way interviewers conduct themselves can influence responses. Another variant of the problem is compliance bias, which arises when a respondent tries to guess the correct answer or tries to answer without giving the problem proper consideration. To minimise this problem, interviewers should be well trained, and they should follow the wording of the questionnaire exactly, with the respondents being offered a choice of prepared responses.

Hypothetical bias

Hypothetical bias measures the influence of an artificial market against an actual market on the valuations. The hypothetical nature of the market in CV studies can render respondents' answers meaningless if their declared intentions cannot be taken as accurate guides of their actual behaviour. Some writers have looked at hypothetical bias in terms of increased bid variance and low model reliability. Others view the use of hypothetical markets as having other distinct problems. Research into hypothetical markets and their predictive ability has looked at attitude-behaviour relationships, and experiments which examine substitution of real for hypothetical markets.

The Fishbein-Azjen attitude behaviour model (1975) looks at the links between stated attitudes and actual behaviour. In order to minimise hypothetical bias, this model argues that the specified attitude (WTP scenario) must closely correspond to the specified behaviour (the precise good behaviour). It argues also that predictive power will be greater the fewer the influencing relationships between a component in the model and behaviour. Finally, it notes that where a respondent is dealing with familiar behavioural situations, attitude will be a better predictor of behaviour.

Strategic bias

Strategic bias arises when respondents deliberately understate their true preference (WTP) for a good, or exaggerate the amount of compensation they would really need.

Strategic bias depends on the respondent's perceived payment obligation and his or her expectation about the provision of a good. Where individuals actually have to pay the reported WTP values, then there is the temptation to understate their true preferences in the hope of a 'free ride' (i.e., the opportunity of benefiting from the provision of a public good without contributing to it, or the chance of paying less for an environmental change than it is really worth to them). Alternatively, if the price to be charged for the good is not tied to an individual's WTP response, but the provision of the good is, then over reporting of WTP may occur in order to ensure provision. Another motive would be to use the survey to register a protest at the idea of a charge for something they would expect to enjoy free (a protest response).

Minimisation of occurrence of strategic behaviour can be achieved by framing the CVM questions in an incentive compatible way such that this type of behaviour is not induced. One particular approach is to ask respondents to make bids for a good under three scenarios - only the highest bidder gets the good; everyone gets the good if WTP is above a certain level; everyone with a positive WTP gets the good. The first scenario is assumed to give true WTP, the second has a weak free rider incentive and the third a strong one.

Empirical evidence suggests that the latter two scenarios do indeed produce WTP values below their true level. Such findings tend to come from open ended format questions rather than discrete response approaches, where free riding behaviour is likely to be minimised. Some authors suggest implementation of a property rights approach, in which respondents receive provision of a good relative to their given WTP. This removes the tendency to free ride. This is not applicable to most environmental public goods for which non-use and altruistic values act as a disincentive to free ride.

One common way of counteracting strategic bias is to ask respondents a ‘yes/no’ question about whether they would be WTP a particular sum. The sample is split into different groups (split sample), each respondent being asked whether he/she would be WTP a single sum. This sum is different for each group. The sums concerned should obviously be chosen with care, so that potential freeriders are discouraged from giving misleading, negative answers. The upper and lower bound values should be pretested so that, for WTP questions, the upper level would produce almost 100% rejection, while the lower one would elicit almost 100% acceptance. The different WTP values are then distributed randomly across the split sample.

Other precautions against strategic bias can be taken. Respondents should not be told that payment by others would be compulsory, but should be told that the provision of services would depend on the demonstration of adequate WTP. They could be told that if they exaggerate the amount they would be WTP, they may not be able to afford it if that amount were really charged. Conversely, if WTP were understated, then the service might not be provided. The latter also bring an undesired outcome.

Overall strategic bias problems have not been found to be a significant problem in practice.

4.3 Overall Evaluation of CVM

CVM is a valuation technique with great potential utility (especially due to the fact it is applicable to problems and circumstances that fall outside the scope of other methods). However, it requires very careful staging and interpretation. It is very data intensive, and the proper conduct of surveys is costly and time consuming. The design of surveys and interpretation of their results has become a specialised activity (OECD 1995).

Its greatest weakness is that it relies on peoples’ views, rather than evidence of their market behaviour. Many possible biases may arise in responses, but some of these can be controlled — if not eliminated — by survey design. CVM relies on the respondents’ understanding of the environmental issues at stake, and the likely impacts on them. This assumes a certain level of education and environmental awareness on the part of the respondents (OECD 1995)

In practice most of the empirical work has been done in developed countries on air and water quality, amenity, conservation, and existence values, where respondents are familiar with questionnaire surveys and knowledgeable about the environmental issues being raised. Many people in developing countries lack such a background, and CVM has proved to be more useful for issues of direct everyday relevance (such as water and sanitation) than for more remote issues such as biodiversity. However, a number of recent studies in developing countries — largely to do with water supply and ecotourism — are demonstrating the feasibility of applying CVM to rural natural resource issues.

4.4 Applications of CVM to Forestry Issues

CVM is potentially useful for the following types of problems related to forestry: air and water quality; recreation (including fishing, hunting, parks, wildlife); conservation of unpriced natural assets such as forest and wilderness areas; option and existence values of biodiversity. In practice, CVM has successfully been applied in estimating the direct use value of ecotourism for a particular species or the total economic value of a protected area.

Box C4.5 Guidelines for Using CVM (Arrow et al 1993)

The following guidelines were produced in a report of the Contingent Valuation Panel, co-chaired by Kenneth Arrow and Robert Solow, to the US National Oceanic and Atmospheric Administration in the aftermath of the Exxon Valdez oil spill in Alaska. The guidelines apply to estimating non-use values of natural habitats. In the USA, evidence of damage to non-use values of natural resources is admissible in the award of damages to trustees and others. Hence the CVM is becoming widely used in litigation, and substantial resources are being made available for the conduct of CV studies. This should be borne in mind when reading the guidelines below, not all of which may be entirely relevant to applications in other countries, or for other purposes.

Sample: A professional statistician should be involved in the choice, type and size of the sample. The sample size must be statistically significant, especially where split samples are used.

Non-response: A high non-response rate would make the survey results unreliable.

Interviews: Face to face interviews are usually preferable to other types, and telephone interviews are better than mail surveys. Major CV surveys should also pretest for the effect of the interviewer. The effects of photographs on the respondents should be carefully explored.

Reporting: The survey report should contain information on the population sampled, the sampling frame used, sample size, the overall non-response rate and breakdown of non-responses, a copy of the questionnaire, and all communications with respondents. Data should be archived and made accessible to interested parties.

Questionnaire design: Questionnaires should be piloted and pretested. There should be evidence that respondents understand and accept the descriptions and questions. In general, the structure of the survey should err on the conservative side (i.e., options which underestimate WTP should be preferred to those which risk overestimating it, in order to improve the credibility of results). There should be a place for ‘no-answers’, the reasons for which should be explored.

Cross-tabulations: The survey should include a variety of other questions that help to interpret replies to the primary valuation questions. These might include income and other socio-economic indicators, location, awareness of environmental issues.

Elicitation procedure: WTP format is preferable to questions about required compensation. The valuation questions should be posed as a vote on a referendum (‘yes/no’ rather than an open-ended question procedure about WTP). The mode of payment should be clear, realistic and acceptable.

Accurate description of issues: Sufficient information should be provided about the environmental issues in question, and about what remedy is being offered. Respondents should be reminded of the existence of substitute commodities or other comparable natural resources.

Expenditure implications: Respondents should be reminded that their WTP for the programme in question would reduce their ability to spend on other goods and services.

CVM could be used to value non-timber forest products, but would probably be less useful to value complex environmental functions such as watershed protection given that familiarity on the part of respondents with the environmental amenity being valued is a prerequisite for undertaking a CVM. On the other hand, CVM could be used to value the actual commodities that are supported by environmental functions (e.g., water for irrigation and household uses). However, a production function approach might be necessary to link changes in these commodities to changes in the underlying environmental services (IIED 1994).

Box C4.6 A 'Taxonomy' of Pitfalls in CVM Design and Administration

A. Survey Design Criteria

1. Scenario Criteria
   - a. theoretically accurate
   - b. policy relevant
   - c. understandable as intended
   - d. plausible and meaningful

2. Response Effect Bias
   - a. Incentives to misrepresent responses
     - (i) Strategic Bias
     - (ii) Compliance Bias
       - sponsor bias
       - interview bias
   - b. Implied Value Clues
     - (i) starting point bias
     - (ii) range bias
     - (iii) relational bias
     - (vi)importance bias
     - (v) position bias
   - c. Scenario Mis-specification
     - (i) theoretical mis-specification bias
     - (ii) amenity specification bias
       - symbolic
       - part-whole
       - geographical part-whole
       - benefit part whole
       - metric/scale
       - probability of provision
     - (iii) Context mis-specification bias
       - payment vehicle
       - property right
       - method of provision
       - budget constraint
       - elicitation question
       - instrument context
       - question order

B. Sample Design and Implementation Biases

1. population choice biases
2. sampling frame bias
3. sample nonresponse bias
4. sample selection bias

C. Inference Bias

1. temporal selection bias
2. sequence aggregation bias
   - a. temporal selection bias
   - b. multiple public good sequence aggregation

Source: Extracted from Carson (1991)

5.0 COST BASED VALUATION[14]

Cost based valuation techniques assess the costs of different measures that would ensure the maintenance of the benefits provided by the environmental good or service being valued. These cost estimates are then used as proxies for the non-market environmental benefit in question. Cost based valuation approaches include: opportunity cost based approaches; approaches which measure environmental values by examining the costs of reproducing the original level of benefits (e.g., replacement, restoration and relocation cost methods); and, the preventative expenditure approach, which examines the up front payments paid in order to prevent environmental degradation.

Cost based valuation techniques must be used carefully as they are inherently measuring values or benefits, by looking at costs. Further, because they do not actually measure the demand or WTP for environmental goods and services, cost estimates fail to reflect consumer surplus (and may also underestimate producer surplus) thus tending to underestimate environmental values.

5.1 Problems Associated with Cost Based Valuation Approaches

There are a number of problems associated with the use of cost based approaches in the valuation of environmental benefits which can be demonstrated by examining the basic underlying principles of these approaches (IIED 1994).

The first condition that must be met is that the maintenance of the benefits is worthwhile. The benefits of maintenance (Bm) exceed the costs of maintenance Cm (this would be necessary for the investment to take place), hence:

Bm > Cm or (Bm/Cm) > 1

Secondly, *in order to use the cost based method as a valuation tool*, it is necessary that the cost of investing in maintenance activities provides a level of benefit equivalent to the benefit of the original good (Bo):

Bm = Bo

Yet, the objective of cost approaches is to use maintenance cost as an estimate of the benefits provided by the original environmental good or service:

Cm = Bo

This leads to the following deduction : Cm = Bm (Bm/Cm) = 1

Clearly the benefit-cost ratio of maintenance cannot be greater than one and also unity at the same time. This logical conundrum reveals the inherent difficulty of using costs to measure benefits.

A potential cause of overestimation occurs if the first condition is not actually met i.e., if the benefits of maintenance do not exceed the costs of maintenance. If this is the case, then investment in maintenance is not a profitable use of economic resources and the cost of maintenance activities may be larger than the WTP for the original environmental benefits.

[14] Section compiled from IIED, 1994

In cases such as estimating the costs of relocating communities affected by land use changes, satisfying this condition may not be critical. Concerns over equity (ensuring just compensation) may override any economic criteria being placed on the cost of relocation.

A practical difficulty with cost approaches is actually ensuring the second condition (i.e. that the cost of maintenance will provide a benefit equivalent to the benefit of the original good). If the benefits generated by the maintenance activity exceed that of the original environmental benefits, then the costs of maintenance activity may exceed the WTP for the original environmental benefits.

The use of cost-based valuation estimates based on market prices also rests on the assumption that the supply of capital and labour for maintenance activities is perfectly elastic. Otherwise the additional demand generated by these activities (e.g., expenditures on replacement) might raise the market prices of these inputs.

Due to these difficulties, cost based valuation approaches are likely to be relatively inaccurate and are generally regarded as *second best valuation techniques.* They should not be used when other valuation methods are available. Their possible advantage over some of the first best techniques is that they are useful when there are limitations on the time and resources for detailed research or when data sets are so questionable as to reduce the advantages of using more exact but costly techniques.

5.2 Indirect Opportunity Cost

Opportunity cost is the foregone benefit (opportunity lost) from undertaking a particular activity or approach.

The indirect opportunity costs (IOC) method has been used to estimate the value of non-market environmental goods (e.g., fuelwood) based on wages foregone as a result of time (labour) spent harvesting these goods (i.e., if time was not spent collecting, it could be used for other forms of employment that might earn an income).

Such calculations require data on the time and efficiency of collection activities, and the (local) rural wage rate. This approach rests on being able to accurately identify what part of the time is spent actually gathering, and what alternative activity the gatherer would have engaged in if not gathering. A difficulty with this technique is that collectors may not ascribe a monetary value to the good collected or to the time spent collecting if the good is collected in spare time or if alternative employment opportunities are not available.

A more serious theoretical concern is the issue of using costs as a measure of benefits. For example, say the value of fuelwood, using the indirect opportunity cost approach, is estimated to be $10. This represents the *gross* value of fuelwood from which the costs of collection (i.e., $10) should be subtracted to derive *net* benefits. This leaves us with a net benefit of zero. The indirect opportunity cost approach should be used with caution, but may be used as a rough estimate of value if no other valuation route is feasible

5.3 Restoration Cost

Restoration implies re-establishing original site conditions. The restoration cost approach is based on the idea that, given a change in forest land, one measure of the benefits provided by the original intact ecosystem (or particular goods and services of such an ecosystem) is an estimate of what it would *cost* to re-create the original system (or environmental good or service). This approach assumes that the original level of benefits can be recreated through restoration.

In the case of tropical forests, this method would involve costing the restoration of original forest cover. Clearly this is a difficult, and perhaps impossible, task. Loss of biodiversity, the existence of endemic species and the rapid loss of nutrients upon initial clearing make it unlikely that an exact restoration of tropical forest ecosystems could be achieved. Furthermore, there will be a considerable time lag before the level of benefits previously enjoyed can be recreated. The restoration technique is therefore unlikely to prove useful at the ecosystem level.

It may be possible to value particular goods and services using the restoration cost technique. For example, the cost of restoring the watershed protection function of a tropical forest by replanting trees in particularly sensitive areas such as on steep slopes and along waterways. Other functions of the forest (e.g., carbon store, microclimatic stabilisation) may also be estimated individually by this technique. However, such a partial approach to restoration would no doubt provide joint benefits (e.g., wood products in the examples provided above) meaning that the cost figure would reproduce more than the benefits of particular function. Such cost estimates could, therefore, overstate the value of the function.

5.4 Replacement Cost [15]

Instead of attempting to restore the original ecosystem or function benefits, perhaps a more realistic method of recreating non-marketed benefits is to replace specific natural ecosystem functions or assets with man-made production processes and capital. When an informed choice is made to partially or fully replace the lost benefits of an original resource with an largely man made alternative, the cost of replacement may be used as an estimate of the affected resource's value and services.

This technique obviously rests on the availability of such an alternative for the original good or service, and on the assumption that replacing the original good or service is worthwhile. The alternative should — as nearly as possible — produce the same level of benefits supplied by the resource or environmental function being valued. If replacement efforts cost more than the value of the good or service being provided by the affected resource, then costs will overestimate the change in value.

The replacement cost technique has not been widely used in the valuation of tropical forests. However, as a second best method, it could be applicable to the valuation of particular direct and indirect use values of tropical forests (e.g., carbon storage and soil nutrient cycling).

[15] The difference between the replacement cost method and the substitute good method is that the substitute good method simply rests on establishing the market price of a substitute. The replacement cost approach involves actually estimating what it would cost to replace a good (or service). Thus, the replacement cost approach involves calculating not only the price of the replacement good, but the replacement quantities necessary to replace the original benefits. As noted, depending on the elasticities involved it may also be necessary to recalculate what the price level of the substitute good would actually be if additional quantities were required for replacement purposes. Thus the cost of replacing a good is different from simply using the price of a related good as value estimate for the original good.

5.5 Relocation Cost

The relocation cost approach abandons the attempt to reproduce the benefits (or introduce substitutes) at the original site and examines instead the cost of relocating (and re-equipping) communities so that they obtain a similar level of benefit in their new location as derived from their original site. Applications of the relocation cost technique to tropical forest is typically restricted to a different purpose — assessing the direct costs of establishing new protected areas which require the resettlement of forest-dwelling or forest-dependent communities. However, estimates of relocation costs could also be used to estimate the use value derived by local people. That is, one could measure the benefits of use values denied local communities by a proposed change in land use by the costs entailed in relocating the entire community to a location where similar use and non-use benefits are available. This is likely to be very difficult to achieve in practice since different sites have very different environmental resources and functions, and, hence, will differ in terms of the benefits available.

5.6 Preventive Expenditure

The preventive expenditure approach (also referred to as the ‘defensive expenditure’, ‘mitigation approach’ or ‘avertive behaviour’) places a value on environmental goods and services by estimating the costs of *preventing* a reduction in the level of environmental goods and services derived from a particular area. The preventive expenditure approach therefore examines the up front payments paid in order to prevent or avoid environmental degradation.

There are two different approaches to this type of analysis and only one of them is truly a cost-based valuation technique. If estimates of what people are willing to pay to prevent damage to the environment or themselves are elicited through the use of constructed markets, or by the examination of past events in similar circumstances through the use of revealed preferences exhibited through actual or surrogate markets, *first based estimates* of value will be derived.

Under a cost based approach, the preventive expenditure approach estimates what it *would* cost to maintain environmental benefits by investing in the prevention of their degradation. The preventive expenditure approach could be used to estimate the value of a range of indirect use values of tropical forests. For example, the benefits of watershed protection that would be lost by building logging roads for the log extraction, could be estimated based on the cost of moving to a less damaging extraction technique such as non-mechanised extraction or extraction by helicopter under a selective harvesting regime. Estimates of expenditures on soil and water conservation aimed at halting or reversing degradation could provide an estimate of the benefits generated by nutrient cycling and watershed protection function of tropical forest.

As with other cost based approaches, it is important to ensure that the preventive expenditure benefits match those originally provided by the environmental function to obtain a realistic cost estimate.

6.0 BENEFITS TRANSFER

Where data on environmental values in a specific project and/or locality are absent and/or research resources are limited, it is common to borrow unit values developed elsewhere to illustrate order of magnitude estimates for the environmental goods and services of interest. That is, estimates of economic benefits are transferred from a site where a study has already been done to the site of policy interest. This approach is known as *benefits transfer*.

The location where the data was generated is known as the *study site*, and the project or area that the benefits are transferred to is the *policy site* (OECD 1995). In some cases the methodology developed at the site can be transferred to the policy site, using the empirical data of the later. In other cases, the methodology, data and values are transferred wholesale. The benefits transferred from the study site could have been measured using any one of the valuation techniques summarised in Table B7.1.

Benefits transfer entails a careful review and interpretation of the existing literature that reports the findings of primary research efforts. These research results must then be adapted according to the parameters of the situation under analysis. A clear understanding of the project site is therefore required (this may be obtained through existing literature or surveys).

While benefits transfer has been widely and successfully used in policy analysis and decision making, this approach to valuation is only as accurate as the values employed. The larger the difference between the conditions at the study site and the policy site, the greater the likelihood of a poor approximation.

Benefits transfer may be the only feasible option in some cases. However, it is no substitute for primary data collection and analysis, which may be unavoidable for large projects, projects with potentially large (and irreversible) consequences, or for particularly complicated or politically sensitive projects.

Box C6.1
When is Benefits Transfer Appropriate?

Benefits transfer is most appropriate when:

1. Funds, time, or personnel are insufficient to undertake a satisfactory new study
2. Study site is similar to the policy site
3. Issues (e.g., proposed policy change, or nature of the project) are similar in the two cases
4. Original valuation procedures are theoretically sound

Source: OECD, 1995

6.1 Methodology

6.1.1 Select literature

An extensive body of literature exists from which values and estimates of environmental goods and services may be obtained. Many studies synthesise other studies and are useful surveys of value estimates. In selecting literature, several common-sense guidelines should be followed (ADB 1996):

i. the expected environmental changes should be similar in magnitude and type in the project being appraised and those study projects from which data are obtained;

ii. if possible, studies that analyse locations and population similar to those being evaluated should be used;

iii. the cultural differences between the project location and the source of data should be considered; and,

iv. the technical quality of the study should be assessed — the original studies must be based on adequate data, sound economic and scientific methods, and correct empirical techniques.

6.1.2 Adjust Values[16]

Empirical estimates of values such as recreation, noise, and clean air vary greatly. This is because such values will differ from region to region, and are dependent on baseline conditions and expected environmental changes from the baseline. The variation in estimates will also reflect variations in study methodology, and researchers' judgement in the selection of sample size, determinants of WTP, data proxies, econometric specification, and other factors. Differences may also arise because of differences in study quality.

The most basic adjustment that is usually required is to quantify the differences in baseline conditions and/or the magnitude of the economic impact (i.e., change from baseline). The more information available in the study and appraisal areas, the easier it will be to adjust the study area values to reflect the proposed project area conditions.

In addition, the average monetary values reported in the research study will have to be adjusted to account for differences between the project and the primary research case study. This is done in the following ways:

(i) when several values are reported for one study, values from the original study that are deemed most appropriate or applicable may be used.

(ii) a range (or an average) of reported values from several studies may be used.

For example, consider transferring the benefits of recreation. It is assumed that the change in well-being experience by the average individual at the existing site is equivalent to that which is being experienced at the new site being valued. Therefore, aggregate economic benefits from recreational activity at the policy site = average WTP of individuals for similar recreational activity at study site * number of days of such activity forecast at policy site as a result of environmental change.

[16] Based on ADB (1996) and Pearce and Moran (1994)

The mean unit values from the study site should be adjusted for any kind of biases that are thought to exist, or they can be adjusted to reflect better conditions at the policy site. Potential differences that should be looked for between the study and policy sites are: the socio-economic characteristics of households; the environmental change of concern; and, the availability of substitute goods and services.

The problem is that individuals at the policy site may not value recreational activities at the site in the same way as the average individual at the study site. A more sophisticated approach might therefore be needed.

(iii) a benefits function transfer may be used. In this approach, instead of transferring adjusted unit values, the entire demand function estimated at the study site could be transferred to the policy site. More information is transferred in this way.

For example, consider a zonal travel cost model, with a demand function of the form (Loomis 1992):

$$X_{ij} / POP_i = b_O - b_1 C_{ij} + b_2 TIME_{IJ} + b_3 Psub_{ik} + b_4 I_i + b_5 Q_j$$

where:

Xij	number of trips from origin *i* to site *j*
POPi	population of origin *i*
Cij	travel costs from origin *i* to site *j*
$Psub_{ik}$	a measure of the cost and quality of substitute site *k* to people in origin *i*
Ii	average income in origin *i*
Qj	quality of site j for recreational users

The approach requires that estimates of the parameters b_o, b_1, b_2, b_3, b_4, and b_5 are found. Data therefore needs to be collected on:

(i) population of zones around the policy site

(ii) travel costs from these zones to the policy site

(iii) the cost and quality of alternative recreational sites available

(iv) the average income of these people in these zones; and

(v) a measure of the quality of the policy site for recreational uses.

The values of these independent variables from the policy site and the estimates of b_0-b_5 from the study site would be replaced in the travel cost model, and this new equation could then be used to estimate both the number of trips from the designated zones to the new site and the average household WTP for a visits to the new site.

Table C6.1 The Benefits Transfer Method: Study Selection Criteria

Criteria for selection	Advantage	Disadvantage
Environmental impacts similar in magnitude and type	More credible for transfer of physical impacts because values associated with large changes may not be applicable to smaller ones	May be difficult for non-scientists to find truly similar impacts
Primary study incorporates socio-economic characteristics of the population	Easily allows for adjustments to be made from primary study site to populations affected by the project being appraised	May rule out the use of otherwise very good studies when the authors merely failed to report these characteristics
Regions similar in population size and composition, geography, and environmental characteristic	Impacts and people affected may be similar, allowing for easier adjustment	Assumes that the primary determinants of values have these similarities, when they in fact may not be significant factors
High quality, up-to-date studies	Most defensible for transfer of economic values; recent studies most likely to incorporate current economic conditions; may use state-of-the art techniques	May be too specific and narrow in focus to be of use and difficult to understand Up to date studies may be difficult to obtain because such studies may not yet be published.

Source: ADB, 1996

6.1.3 Calculate Values Per Unit of Time

The values are multiplied by the number of affected individuals to obtain total values for the impacts per unit of time. If the impacts change with time, they should be estimated for each future time period in which effects are expected to persist (ADB 1996).

6.1.4 Calculate Total Discounted Value

Because costs and benefits from a project may occur at different times, the period over which the impacts are expected to occur must be identified (see Section B9). The total discounted annual damages and benefits need to be calculated using the recommended discount rate (and other rates that may be appropriate for sensitivity analysis).

6.2 Overall Evaluation

In situations where research resources are limited, benefits transfer may be the only practical course available for estimating the value of a project's environmental impacts. In particular, benefits transfer offers a means of providing an order of magnitude estimate for non-market values, such as air and water quality, or recreation, which although typically significant are often difficult to assess.

Box C6.2
Steps for Performing a Benefits Transfer

(i) Select literature
(ii) Adjust values
(iii) Calculate unit values per unit of time
(iv) Calculate total discounted values

Source: ADB, 1996

In relation to tropical forests, NTFP values have been estimated from detailed surveys in the Amazon, West Africa and Southeast Asia. They have been widely quoted to illustrate the potential values of other tracts of forest. Also, a number of studies have used empirical relationships on afforestation and soil fertility, or soil erosion and crop yield, developed in specific areas, in cases where local empirical data is not available.

All benefits transfer studies are subject to uncertainties (in addition to those associated with the results of the original valuation studies). Whether the uncertainties in a benefits transfer are so great that the transfer should not be attempted is a decision to be taken by the project analysts (ADB 1996). Inaccuracies and/or distortions will result if care is not applied. Furthermore, there will be times when the available data will not be of sufficient technical quality or comprehensiveness to be useful. Should this be the case, an agenda for primary research should be proposed.

***General cautions*:**

(i) The use and non-use values reported in the current body of literature sometimes vary greatly. Also, some types of benefit estimates are considered more accurate than others.

(ii) The nature of nonmarket goods and services typically precludes the application of values without modification. Sound judgement is essential to ensuring a fit between values from the study sites and those at the new project site.

(iii) Projects that are large or projects with serious environmental impacts, may require a more rigorous analysis than a benefits transfer approach can offer.

(iv) More generally, valuation of the environment is still in its infancy, and so procedures for dealing with many common issues have not been standardised. Most of the work on valuing environmental resources has been conducted in developed countries. The adaptation of these studies to developing countries should take into account major differences with respect to personal income, property rights, land prices, institutions, cultures, natural resources, and a range of other factors. Such differences raise additional qualifications to the direct transfer of estimates.

SECTION D

Valuing the Characteristics of a Tropical Forest

1.0 DIRECT USE VALUES[1]

1.1 Timber

Timber extracted from the forest is typically marketed, and therefore *market prices* can be used for valuation purposes. Market prices are usually available for roundwood delivered at the processing plant or point of export (Gregerson *et al* 1995). Total value is derived by applying the price for a unit of timber to the estimated quantities that could be *sustainably* harvested from the area of forest under consideration.

A number of issues need to be covered when using market prices to value timber (see Box D1.1).

The costs of harvesting and transporting the timber must be deducted from the market price to arrive at the *net* value of standing timber in the forest.

Box D1.1 Valuation of Environmental Products Using Market Prices

For environmental products that have a market price, their monetary value may be estimated as follows:

Total Value = Unit Market Price * Quantity

Where:

Market Prices are corrected for any known market and policy failures (e.g., externalities, taxes and subsidies)

Harvesting and transport costs are deducted from the gross value in order to derive the net value of a product

Account is taken of seasonal changes in market prices

Quantity harvested is based on maximum sustainable yield (MSY)

Market price analysis will tend to underestimate value since it does not account for consumer surplus.

Obtaining Data on Market Prices

Market prices may be derived from a variety of sources including: existing literature on economic and social studies; published or privately held statistics; socio-economic surveys; and, consultations with agricultural extension officers, forestry service personnel, government market specialists and statisticians (IIED 1994).

[1] This Section discusses the valuation approaches which could be used to value each individual characteristic of a tropical forest. Some results from previous studies are presented. Reference should be made to Section C of this manual for a more detailed discussion of the different valuation techniques.

For economic assessment purposes, efficiency prices must be derived (see Section C1.2). This may have to take account of external costs (externalties) arising from damage caused by logging activities. For example, if logging increases sediment loads to nearby rivers and adversely affects the water supply and fish productivity, this should be reflected in the costs of timber production. The prevailing market price will distort true market values if taxes, subsidies or quantitative restrictions exist. For example, an embargo on log exports to encourage local processing, could depress local log prices below world market levels. Price distortion as a result of market and policy failures should be corrected (alternatively, world market price could be used).

Ideally, the valuation of timber should take account of the variations in market values from species to species, and the variation in residual values with location and topography. However, this usually requires more detailed and accurate information than is generally available. Values are also likely to change over time as technological advances and changes in supply and demand allow previously unused species to be marketed. Timber values may therefore require periodic revision (Gregerson *et al* 1995).

If the physical scale of the land use in question is large relative to the local/national economy, the analyses of the potential changes in the output of marketed products is complicated by possible price effects. In such cases, prices should be adjusted using estimates of the price elasticity of demand with respect to changes in quantity.

Market prices will undervalue tropical timber if based on unsustainable harvesting practices. In such cases the quantity harvested should be based on an estimated of the maximum sustainable yield for the area under study (see Section B14.2).

1.2 Non-Timber Forest Products

The term non-timber forest products (NTFP) may be defined as the variety of physical goods, other than timber, that are derived from forests and that are used either for subsistence purposes or traded or sold. NTFP include plants and plant based products (fruits, latexes and medicines) as well as animals and animal based products. Table D1.1 summarises the various NTFP categories.

Traditionally, forest value has been based on timber production, while NTFP values have been largely neglected, if not ignored. The omission of NTFP benefits from the analysis means that the forest resource is undervalued. This can result in unsustainable paths for timber extraction or to the conversion of forest land to alternative land uses, since both of these options *appear* financially more attractive.

Greater attention is now being paid to the importance and value of NTFP. A number of economic studies have been undertaken in order to measure, in monetary terms, the value of NTFP. These studies have demonstrated that the real (or potential) magnitude of NTFP in many cases is substantial. A study in the Amazon forest indicated that the economic value of NTFP was in fact bigger than that of the timber in the long run (Peters *et al* 1989). Other studies have shown that NTFP are important sources of fuelwood, building materials, fodder, food and income to the rural people. A number of NTFP (e.g., rattan, bamboo, resins and medicinal plants) have shown potential economic value for further research and development. It has also been highlighted that higher economic values can be derived if forest management emphasises the production of both timber and NTFP (Panayoutou and Ashton 1992).

Table D1.1 A Characterisation of Non-Timber Forest Products

Category	Examples
Food	bushmeat, fish, fruit, edible oils, edible plants, honey
Medicinal products	
Fuel	fuelwood, charcoal
Structural Materials	rattan, bamboo, wood poles, various fibres
Animal products	honey, eggs, birds nests, reptile skins, feathers and other decorative wildlife products
Live animals	
Ornamental plants	

1.2.1 Obtaining Information on NTFPs

Identifying the range of goods harvested from the forest will typically require a local survey. When time is short, the survey can be conducted informally, by going from house to house, or alternatively by going to the local markets and identifying the set of forest products being traded. A more time consuming alternative is to accompany foraging parties into the forest and to directly observe the goods being gathered. This has the advantage of allowing the researcher to observe harvesting practices and to determine whether the good is being harvested sustainably (Lampietti and Dixon 1995).

Ideally, the survey should be conducted in such a way that the results can be extrapolated to the entire population concerned.

1.2.2 Valuing NTFPs

After identifying the set of goods, an appropriate price must be determined for each good. If the good has a well established market value, then its price can be determined at the local market or during an interview (Lampietti and Dixon, 1995).

The problem is that many NTFP are not marketed. The value of non-marketed goods must be imputed by either observing a barter transaction for another good, or by identifying a close substitute for the good that has a price. If neither of these alternatives is feasible, then the value might be imputed based on the amount of labour (time) spent harvesting (Lampietti and Dixon 1995).

Regardless of whether the good is marketed or not, value estimates should be net of the costs of labour (based on local wage rates) and materials (for example, bullets and arrows) used for foraging and processing and transport costs (i.e., net values should be derived).

Table D1.2
Non-Timber Forest Products' Possible Valuation Approaches and Data Requirements

Possible Valuation Methodology	Data Requirements
Market price where Net returns = market price * annual sustainable harvest - harvesting and transport costs	*Biophysical data* Types of products (e.g., types and number of tree species, types and number of tree species yielding marketable products such as fruit and latex, types and quantity of wildlife, and, types and quantity of plant species). Different uses of products Rates on biological productivity Data on harvest rates *Cost of Inputs* Purchased (cash) inputs: equipment, hired labour, licence fees Own (non-cash) inputs: equipment, labour Prices of possible substitutes for non-cash inputs *Use Rates of Inputs* Labour time per activity Amount of equipment and supplies used Rate of depreciation of capital equipment *Prices of Outputs* Market Prices Cost of transport Cost of harvesting *Other information* Seasonal harvest rates Price trends Level and types of employment
Direct substitute approach	Additional data: Degree of substitution between the two goods Market price of substitutes
Indirect substitute approach	Additional data: Degree of substitution Physical change in output caused by a change in input of substitute good in the production process Monetary value of change in output
Indirect Opportunity Costs Approach	Additional data: Time and efficiency of collection activities Local rural wage rate
Barter Exchange Approach	Additional data: 'Rate of exchange' between the two goods

Estimating the time spent collecting forest products is complicated because not all the time in the forest on any given trip will be spent necessarily hunting and gathering.

The *quantity* of a good extracted from the forest can be determined by directly counting or weighing goods collected when foraging parties return from the forest, or by interviewing product collectors and asking them how much of each good they collect, on average, per trip and then multiplying this by the number of trips.

1.2.2.1 *Marketed* Non-Timber Forest Products[2]

A variety of NTFP are traded or sold (e.g., fruits, medicinal plants, fibres, canes). For NTFPs extracted for sale, valuation can be based on market prices, following closely the procedure described for timber (see Box D1.1). A marketed NTFP value is therefore equal to its market price minus the costs of collection and transportation, multiplied by the quantity collected.

In addition, information on any seasonal variations in the goods harvested is important, since this can be significant and will thus impact benefits, especially locally. For example, a study in Combu Island, Brazil estimated the annual revenue from the sale of acai fruits, cacao and rubber over a five year period (1984-88) to be approximately $3,100 per household. However, there can be as much as an eightfold difference in seasonal income from the sale of these products. If the data from November or December (about $50 per month) were used to calculate household revenue, annual revenue would be $600 (an underestimate of about $2,500). This underestimation would lead to the incorrect conclusion that NTFP extraction does not compare favourably with alternative land uses such as agriculture, which produces annual revenues of about $1, 828 per household (Anderson and Ioris 1992). The average monthly revenue should therefore be calculated (average monthly revenue = total annual revenue / 12).

The approach presented in Box D1.1 is convenient if information about prices, costs of extraction, and quantity extracted is available. However, it is likely to be considerably more difficult to apply this to NTFP because of the nature of the markets involved.

Only a few NTFP such as rattan, enter world trade in quantities and at prices that are reasonably well documented. The majority are traded in local market systems, escaping formal monitoring and recording. Many forest products used by rural populations involve some form of preparation or processing, typically by small enterprises located in the rural sector. When rural people migrate to urban centres they often continue to use some forest foods, medicines, and products, so that the trade in the latter increases. However, trade tends to remain almost exclusively within the informal sector. As a consequence, data on quantities and prices are often not readily available and markets are poorly understood.

Market prices for NTFP often reflect conditions that are unique to a narrow situation. The prices obtained in isolated rural markets do not necessarily reflect the value that a broader consumer population would be prepared to pay or incorporate the costs of bringing products to a wider market. Access to markets and transport infrastructure may limit a location's ability to place products on the market competitively.

[2] Compiled from Gregerson *et al*, 1995

Other factors also affect the potential for NTFP expansion into modern sector markets. For example, the seasonal nature of supply of many products can result in supply/demand imbalances and a collapse in prices at certain times.

Often, open access to forest areas and lack of management means that harvesting is unrestricted, leading to excessive harvesting and output. Substantial increases in production of many products could create imbalances and a fall in prices below levels that would be profitable.

1.2.2.2 Valuing *Non-Marketed* Forest Products[3]

People acquire many forest goods, such as fruits and fuelwood, not through the market but by gathering or producing them themselves. Non-marketed NTFP may be valued using one of the following approaches: barter exchange approach; direct substitute approach; indirect substitute approach; or the indirect opportunity cost approach. Examples are presented below.

Fuelwood could be valued using the direct substitution approach, by referring to the price of purchased fuelwood, or to other purchased fuels such as charcoal or kerosene. This can be complicated because the different fuels have to be expressed in the same delivered energy terms if they are to be compared. Also, the approach is likely to overvalue subsistence supplies if the users would not purchase fuel when unable to gather fuelwood (i.e., if they would adopt an alternative such as switching to other gatherable fuels). The value of traditional medicine could be based on the cost of purchasing equivalent medication at local stores or pharmacies.

If substitute goods are also unmarketed, the indirect substitution approach might be used. For example, fuelwood may be valued by referring to the value of other locally available gatherable fuels (e.g., crop residues, dried dung). As these do not have market values, they have to be valued in terms of their value in an alternative use. The alternative use for dung is usually fertiliser, and its value in use is calculated in terms of increased crop yields foregone by diverting it to use as fuel (i.e., the production function approach).

Gathered products such as fuelwood and fruits could be valued by reference to the opportunity cost of the time that household members spend collecting these products. This approach rests on being able to accurately identify what part of the time is spent, say, in walking to and from the household's outer fields and gathering on route is attributable to the latter, and what alternate activity the gatherer could have engaged in if not gathering the forest product.

A more serious theoretical concern is the issue of using costs as a measure of benefits. For example, say the value of fuelwood, using the indirect opportunity cost approach, is estimated to be $10. This represents the gross value of fuelwood from which the costs of collection (i.e., $10) should be subtracted to derive net benefits. This leaves a net benefit of zero. The indirect opportunity cost approach should therefore be used with caution, but may be used as a rough estimate of value if no other valuation route is feasible. However, understanding this approach is important for valuation purposes, since this type of calculation is likely to be necessary for most NTFP (regardless of the valuation technique used) in order to estimate *net* benefits. This is because most NTFP are harvested through the expenditure of human effort with only minor investment in capital equipment.

[3] Based on Gregerson *et al*, 1995

Some subsistence goods can be considerably more difficult to value. For example, most foods from the forest complement other parts of the diet, (e.g., by providing essential vitamins or proteins) and many medicinal plants are used not individually but in combination with other plants and products. It is therefore difficult to separate out their effect. If that were possible it would probably have to be expressed in nutritional or health terms rather than economic values. *It should be noted that all the issues concerning marketed non-timber forest products identified above, apply equally to non-marketed products.*

The NTPF values from previous studies ranged from a low of US$5 per ha/year in the Brazilian Amazon (Schwartzman 1989, and Hetch 1992), to a high of over $422 per ha/year (Peters *et al* 1989). However, the majority of the values are clustered around $70 per ha/year. The range in values can be explained by differences in study methodology, study assumptions, site biology, and the number of goods valued. Study methodologies are frequently not comparable. For example, Nations (1992) takes the total value of production of a forested area in Guatemala and divides it by the area of forest, yielding a value of $10 per year. Abeyunawarenda and Wickramsinghe (1992) sampled 50 households in Sri Lanka and then extrapolated a value of $50 per ha/year.

Another explanation for the wide range in results is that some studies measure maximum sustainable yield, whereas others measure only that portion of the goods that are consumed. In Iquitos, Peru, the *potential* maximum sustainable yield of one hectare of tropical forest was valued at $422 per year (Peters *et al* 1989). Potential returns may not be a good indication for NTFP value in situations where limitations on marketing, postharvesting, processing, and export prospects are evident. The goods *actually* consumed from a similar one-hectare plot of a neighbouring watershed were valued at only 5 percent of this amount — US$20 per year (Pinedo-Vasquez *et al* 1992).

Wildlife and fish may be valued using market prices, the barter exchange approach, the direct substitution approach, or as a last resort, the indirect opportunity cost approach. Fish may also be valued using the production function approach.

The values in the studies presented range between $1 and S416 per ha /year, with a median of $5 per ha/year.

1.2.2.3 Valuation of NTFP and the Issue of Transferability [4]

While a number of estimates on the value of NTFP exist, there are a number of reasons why these estimates may not readily be transferred to other sites. Firstly, values obtained by an assessment of the local market (e.g., for medicinal plants) will reflect supply and demand in that particular context. Those conditions will vary in other contexts.

A second problem of transferability arises in the context of generalising values to wider areas. For example, the study by Peters, Gentry and Mendelsohn (1989) on the returns to the sustainable use of land in Peru cannot be used to argue that such values are typically of *all* tropical forested sites, even in the same region. This is because:

(i) the values of the non-timber products in question will be related to the existence of the market place. The further from the market, the lower such values can be expected to be.

[4] Compiled from Pearce and Moran, 1994

Box D1.2
Characteristics that Make the Valuation of Non-Timber Forest Benefits (i.e., NTFP and Non-Use Values) Difficult

(a) Information

There is inadequate information about their price and quantity. Almost nothing is known about many non-timber products, many of which are extracted by indigenous populations and not traded in formal markets. This is also true of forest services, for example. Although it is evident that forests provide a valuable service by regulating water flows, little is known about how much people are willing to pay for this service.

(b) Non-excludibility

Forests produce many products that are non-excludable. An example is a scenic view. Once provided, the marginal benefits from supplying the scenic view to an additional individual are very hard to capture. Typically this causes the forest to be undervalued, because only the values that can be easily captured, like timber, are taken into account in the decision making process.

(c) Biological dimensions

Biological dimensions are poorly understood. The quality and quantity of goods and services produced by a forest is related to tree species, tree age, trees density, soil type, rainfall, and contiguity of forest area (among others). However, very little is known about how the production of goods and services changes with a change in any of these variable. This makes it extremely difficult to predict how different management practices will effect benefits.

(d) Planning horizon

Forest take an extremely long time to produce certain types of benefits. The discount rates used in conventional economic analysis results in very small present value that are realised many years into the future.

Another factor affecting the planning horizon is that forests are both an asset and a commodity. They are an asset (or stock resource) because from year to year they grow and increase in value. They are a commodity because they can be partially or entirely liquidated at any time (and hence are a flow resource). Since timber is the most well developed (greatest value) forest product, forest management decisions are the most likely to be based on optimal timber harvesting schedules. Rotations that optimise timber production will effect the flow of benefits.

(e) Joint production

Forest produce joint goods and services. Even when extensively managed for timber production, forest produce positive externalities such as watershed functions and carbon sequestration. The multitude of interlinked and indirect benefits produced by forests are hard to value even without double counting or omitting some of them. Careful judgement must be exercised to identify and value only the most important goods and services. There are a multitude of ways in which a forest can be managed that will result in the same overall level of benefits.

Valuation can be simplified by only including the functions with the most important economic impacts in the analysis.

Source: Derived from Lampietti and Dixon, 1995

Table D1.3 NTFP Results from Previous Studies

Location/Product	Value $/ha/year	Comments	Source
Brazil (Amazon) Brazil nuts and rubber	5*	Gross value for brazil nut andrubber calculated	Schwartzman, 1989
Guatemala (Maya Reserve) Chicle, xate, and allspice	10*	Gross value for chicle, xate, and allspice;550,000ha = $5.5 million/year in exports	Nations, 1992
Sri Lanka (Sinharaja)	13*	Survey of 135 households over 3 months, extrapolated to entire forest area	Weahera and Abeygunawardena,
Brazil (Western Amazonia)	5-16*	Gross value varies by size of the extracted area	Hecht, 1992
Peru (Iquitos)	16-22*	Samples from 2 forest gardens	Padock and de Jong, 1989
Peru (Iquitos) Latex and fruit	20	Latex and fruit only	Pinedo-Vasquez *et al,* 1992
Belize Medicinal plants	36-162*	Annual sustainable harvest of medicinal plants, 5% discount rate	Balick and Mendelsohn,1992
Malaysia Rattan and bamboo	48	Rattan and bamboo only	Kumari, 1994
Sri Lanka (Hantana)	50*	Gross value data from 50 households in three villages CVM and opportunity cost	Abeyunawardena & Wickramasinghe, 1992
Indonesia (Kalimantan) Rattan	53	NPV of rattan $529/ha over 25 years and 10% discount rate	Godoy and Feaw, 1989
Brazil (Amazon) Kernal, charcoal, and babassu palm	59*	Unclear if net or gross	Anderson *et al*, 1991
Ecuador (Amazon) Fruit and medicine	63-147	Potential extraction from 3 ha of primary forest	Grimes et al, 1993
Brazil (Combu Island) Wild cacao, acai, and rubber	79*	Gross value of wild cacao, acai, and rubber; $3171/yr/household, assumes 40 ha/ household forest	Anderson and Ioris, 1992
India (Tamilnadu) Fuel and fodder	80*	Fuel and fodder	Appasamy, 1993
Brazil Brazil nuts	97*	Gross value of Brazil nuts only	Mori, 1992
Brazil (Para) Acai	110*	Value after thinning and pruning acai	Anderson and Jardim, 1989
Mexico (Veracruz) Fruits, housing materials and medicine	116*		Alcorn, 1989
India fruits, herbs and medicinal plants	117-114*	Gross value calculated	Chopra, 1993
Peru (Jenaro Herrera) Wild camu-camu	167	Values only of wild camu-camu, unclear if net or gross	Peters quoted in Vasquez and Gentry, 1989
Peru (Iquitos) Fruit and lates	422*	Net value of the inventory in one hectare	Peters *et al*, 1989

* derived

Source: Lampietti and Dixon, 1995

(ii) The expansion of NTFP supply across all feasible sites would result in price falls for the commodities in question.

Godoy *et al* (1993) in a review of 24 NTFP valuation studies point out that such studies lack consistency in the examination of extraction costs, methods for ascertaining household uses, and in determining the correct 'forest gate' or alternative shadow price to be assigned to marketable quantities. Furthermore, there is no evidence that valuation estimates are compatible with sustainable extraction.

Hall and Bawa (1993) discuss methods for assessing biological sustainability of plant extraction, but few studies attempt to gauge the sustainable hunting yields. In the absence of more detailed analysis, therefore, sustainability of forest use is at best case specific.

When extraction is known to be non-sustainable, this can be indicated in an appraisal by deduction of depletion premium from the value of forest products. This would depend on how long the present extraction can continue and on the discount rate (Godoy *et al* 1993)

1.3 Tourism and Recreation

When information on the number of visitors to a site and the cost of either entrance fees or permits is available, it can be used to estimate a minimum level of benefits from park use. However, information on the demand for the recreational services of the forest is usually not available from markets, because many forest areas are accessible to the public free of charge.

Table D1.4 Hunting and Fishing: Results from Previous Studies

Location	Value per hectare per year	Comments	Source
Venezuela	1*	Estimate net harvest for caiman harvest	Thorbjarnarson, 1991
Cameroon (Korup National Park)	1*	NPV foregone benefits from hunting =$2,700,00 at a 5% discount rate, area = 126,000ha	Ruitenbeek, 1998 Infield, 1988
Zaire (Ituri Forest)	1-3*	Gross value 318 kg game/km^2 primary forest or 50 kg/km^2 in climax forest at $1/kg	Wilkie 1989; Wilkie and Currran, 1991
Malaysia (Sarawak)	8*	Wildlife in one square kilometre	Caldecott, 1987
Malaysia	12	Fish only	Kumari, 1994
Nigeria (Cross River Park)	16*	Gross value from hunting, gathering, and trapping = $108 per person, population = 38,300, area = 250,000ha	Ruitenbeek, 1989

Source: Lampietti and Dixon, 1995

When market prices are not readily available, the assessment of forest-based recreation values requires the application of the travel cost method (TCM) or Contingent Valuation Method (CVM). Both of these WTP techniques estimate demand curves and consumer surplus to forest users. A limitation of TCM is that it captures only part of the value to the user (i.e., it does not account for option and existence values). A concern with CVM is the assumption that people's stated assessment of what they would be WTP accurately reflects what they would actually spend to enjoy that recreational experience. There has been limited experience to date of trying to apply either method to recreational use in tropical forest areas due to their considerable data requirements.

In certain cases, even when price data are available these may be unreliable or insufficient for research purposes. In such circumstances, a non-market valuation technique has to be applied. For example, Tobias and Mendelsohn (1991) used the travel costs method to estimate the value of Monteverde Cloud Forest Reserve in Costa Rica for ecotourism. While revenue data for the reserve were available, the authors felt that peoples WTP for the amenities of the reserve far exceeded the amount actually charged to enter the reserve. This hypothesis was upheld by the application of the TCM, which allowed a more complete assessment of consumer surplus (IIED 1994).

Table D1.5 Tourism and Recreation: Possible Valuation Approaches

Valuation Method	Data Requirements	Value Estimate Derived
Benefits transfer - based on primary research for an alternative site	Literature review Information on characteristics of site under valuation	Only provides an 'order of magnitude' estimate Should be used with caution
Aggregate expenditure data obtained in national accounts	Survey of national accounts	Does not measure consumer surplus
Average tourism expenditures per person	Data on expenditure (i.e., accommodation, gate fees, food transport and guide services) Annual number of visitors	Does not measure consumer surplus
TCM	Data intensive	Measures WTP Does not account for non-use values
CVM	Data intensive	Measures WTP

Table D1.6 Tourism and Recreation: Some Results From Previous Studies

Study Area	Result	Valuation Technique	Source
Costa Rica's Monteverde Cloud Forest	Average visitor valuation $35 (1988), producing a present value for trips assuming constant flows of $2.5m, or extrapolating for foreign visitors $12.5m. This gives a value per hectare in the reserve of $1250 relative to the market price of local non-reserve land of $30-100/ha	TCM	Tobias and Mendelsohn, 1991
Khao Yai, Thale Noi and Khao Dao Protected Areas in Thailand	Khao Yai: related expenditures amount to 100-200 m baht ($ 4-8m) per year. Consumer surplus is estimated to be 10-25m baht ($400, 000 - 1m) per year	Benefits Transfer Tourism related expenditure (i.e., expenditure * no of tourists) based on previous study by Dobias (1988). Consumer surplus estimate based on TCM study performed by Eutrirak and Grandstaff (1986) for Lumpinee Park in Bangkok.	Dixon and Sherman, 1990
	Thale Noi: related expenditures range from 5m baht ($ 200, 000) in the local community to 50m baht ($2m) in total	Based on 1981 estimate of visitor expenditures	
	Khao Soi Dao: total expenditures range from 3-10m baht ($ 120, 000 - 400, 000)	Based on visitor expenditures elsewhere in Thailand	
Korup National Park, Cameroon	US$19/ha	Based on assumptions made on the number of visitors to the park, and typical expenditures and itineraries elsewhere	Ruitenbeek, 1989
Kenyan National Parks	WTP for current levels of elephants in Kenyan parks estimated at US$25 million (the mean WTP - US$100 per person)	CVM Focused on the direct use value of valuing elephants. The object of the valuation study was to estimate a permit price for elephant viewing	Brown and Henry, 1989

1.4 Research Benefits

Protected forest areas can be used as research and education facilities. Valuation of forest research and education benefits could be based on specific expenditures within the park. Although such expenditures do not represent economic values *per se*, they do indicate a minimum WTP to take advantage of the park resources (IIED 1994).

Furthermore, foreigner researchers may add to the overall tourism statistics for a country and bring in foreign exchange, while some projects provide employment and training opportunities for locals.

While revenues from people who go to the park to learn about nature would be included in tourism benefits, an additional but non-quantifiable value would be the effect of education on the future actions of visitors. Environmental sensitivity gained by visiting a park would tend to promote greater awareness of the importance of natural resources and encourage conservation. This benefits could be measured by a survey inquiring about visitor's knowledge and opinions before and after their visit.

Table D1.7 Estimated Research Benefits for a Protected Area in Thailand

Study Area	Result	Valuation Technique	Source
Khao Yai Protected Area, Thailand	1-2 million baht ($40, 000 - 80, 000) per year	Based on scientific expenditures within the park. Research activities have mainly focused on gibbons, hornbills, and elephants, and have involved expenditures of more than 3.6 m baht ($144, 000). The research- cum-demonstration projects totalled more than 7.1 m baht ($284, 000) in expenditures (not all in Khao Yai).	Dixon and Sherman, 1990

2.0 INDIRECT USE VALUES

2.1 Watershed Effects

The impacts of change in forest cover on watershed functions include soil erosion, disturbance to downstream water flows and flooding, with consequent damage to agriculture, fisheries, dam storage, and power generation. In principle, many of these effects can be valued using the *change in productivity approach* (e.g., in terms of loss in crop yields due to soil erosion, sedimentation, flooding, or dry season water shortages on downstream agriculture) (Gregerson *et al* 1995).

Table D2.1 Watershed Functions: Some Results from Previous Studies

Watershed Protection Function/ Study Area	Results	Valuation Technique	Source
Protection to onshore and offshore fisheries The Korup National Park, and Oban National Cameroon Park	NPV $6.8M or $54 per hectare assuming that the benefits start to accrue in 2010 and beyond	Two independent methods are used to derive fishery value: 1) Fish productivity - productive capacity multiplied by average fish prices 2) Economic activity: population dependent on fisheries multiplied by the average per capita income	Ruitenbeek, 1989
Flood control The Korup National Park, and Oban National Cameroon Park	NPV of $2.8M or $2.3 per hectare	Expected Net Present Value of Benefits. The expected value of loss of flooding in any one year t were the Korup forest to disappear is estimated as: Nfc * (Ad/A) * V * S/T where Nfc - number of people expected to be affected by the flood event Ad/A - the proportion of the deforested area of the forest to total area V - per capita income per region S - the share of income lost due to the flood event	Ruitenbeek, 1989
Soil fertility maintenance The Korup National Park, and Oban National Cameroon Park	NPV $958,000 or $8 per hectare	Change in productivity	Ruitenbeek, 1989
Watershed protection function Bacuit Bay, Palawan, Philippines	Reduction in the NPV of fish catch between 1987-96 from US$17 to US$9 million (if tuna is excluded from the analysis on the basis that the extent to which tuna are biologically dependent on coastal waters has not yet been proven) and from US$28 to US$15 million (including tuna). With continued logging, tourism will 'decline steadily by 10% per year due to declining tourist amenities. The NPV for all dive-based tourism is estimated to fall from US$25.5 million in 1987-91 to US$6.3. million in 1992-1996.	Variant of production function method. The valuation is based on the idea that the damages from logging and watershed degradation - as revealed by losses in fishing and tourism revenues - are a measure of the benefits of intact watershed. The value of fishing is estimated using information on fish catch, market price of fish and cost of fishing. A reduction in fish catch over time resulting from sedimentation is estimated through regression analysis using information on coral cover, species diversity and fish biomass. The value of dive based tourism is based on information on average length of stay, average occupancy and advertised daily rates plus any additional lump sum fees. The economic value of tourism is expected to be seriously affected by sedimentation, because the main tourist attraction for divers is the pristine coral reefs and clear waters.	Hodgson and Dixon, 1988

As an example, soil erosion can result in sedimentation of downstream reservoirs. Sedimentation in reservoirs reduces the water storage capacity of the reservoir, impacting its function as a supply of water for agriculture irrigation and power generation. To estimate the loss in reservoir benefits associated with increased sedimentation, data on annual erosion rate in the watershed, channel and bedload erosion, and the sedimentation delivery rates are needed. The base case would first estimate the effects of existing erosion rates. With increased loss of forest cover, erosion and sedimentation would increase. Costs associated with this increased rate of erosion are the effects on downstream structures and water users affected by the increased sedimentation. Increased costs associated with the increased erosion and sedimentation rates could then be used to value the forest's watershed function of the forest (IIED 1994).

Soil erosion could also be measured by the cost of replacement approach (i.e., the cost of fertiliser required to restore nutrients lost due to soil erosion).

The replacement cost method is also useful for estimating flood protection and water regulatory services supplied by the forested watershed which provides natural barrages (e.g., the costs of building flood prevention structures to prevent such damage).

In practice, the difficulties and costs of tracing and quantifying the physical impacts of watershed disturbance both on and off site, mean that economic analysis is often limited if not impossible.

2.1.1 Case Study: Nigeria, Shelterbelts and Farm Forestry (Anderson 1987)

This study is a cost benefit analysis of the tree planting programme already underway in the arid zone of northern Nigeria. Unsustainable use of fuelwood in the area (used by 90% of the population for cooking) is leading to a sharp decline in farm tree stocks, increased encroachment by farmers on public reserves, and the non-sustainable harvesting of trees in the more humid southern belt. These activities are reducing *soil fertility* through gully erosion, loss of top soil, surface evaporation, reduced soil moisture, and the use of dung and residues for fuel rather than fertiliser.

The two main components of the afforestation project are shelter belts and farm forestry. Shelterbelts consist of lines of trees (usually eucalyptus and neem) arranged in 6 to 8 rows up to 10 km long. Farm forestry is undertaken by farmers on their own land, and typically 15-20 trees/ha are planted with the aim of providing useful products (fodder, fruit, fuel, shelter) for the household.

The analysis compares the financial and economic returns to shelterbelt and farm forestry projects to a 'without project' base case. The benefits from afforestation include halting declines in soil fertility (plus any increases in soil fertility as a result of improved moisture retention and nutrient recycling), increased outputs of livestock products, and the value of tree products.

The benefits of livestock and tree products are valued directly by multiplying increase in quantity by the market price to derive their *financial* value and then adjusting this to reflect the *economic* value as appropriate. The value of wood and fruit from the new trees is estimated to be $22/ha for the shelter belts and $7 for the farm forestry, net of labour costs.

Estimation of the environmental benefits of the rural afforestation programme are undertaken using the *production function approach*. The two main steps to this approach are discussed below.

1. Estimating the effect of the afforestation programme on soil fertility.

Estimates of the changes in soil fertility due to the afforestation programme were difficult to make due to insufficient data on soil fertility and on the direct and indirect impact of tree stock decline on soil erosion. Through discussions with agronomists and other soil experts, a rate of soil fertility decline of between 1%-2% per year was adopted in the analysis. These rates are applied to the gross value of farm output but not to costs (costs could increase over time if it becomes harder to work the land).

Following a review of the international research on the topic, it is assumed that the shelterbelts would increase the net yield of crops in the area by 15%-25%. The main mechanisms for this would be increased soil moisture retention and reduced crop losses from wind due to reduced wind speeds. For farm forestry, the increased yield is taken to be a more modest 5%-10%.

In the with project case the decline in soil fertility is gradually stemmed and soil fertility is enhanced as the afforestation programme begins to take effect (after 7-10 years for shelterbelts and 7-15 years for farm forestry). These 'with project' benefits are compared with the assumed trend 'without', which is a decline in soil fertility of 0%-2% per annum. This decline would be halted after 8 years with the project.

2. The benefits derived from changes in soil fertility are calculated by estimating the value of the changes in agricultural output. The estimates of financial and economic values of crop output under the three systems are made from traditional agricultural cultivation on a typical three-hectare farm, using information from local surveys undertaken during preparation of rural development projects and border price information from World Bank data.

The main investment costs of the programme included in the analysis are:

i. fencing and planting expenses — $150/ha for shelterbelts and $40/ha for farm forestry;

ii. the opportunity cost of the farm land occupied by trees, taken to be proportional to the area taken up by the trees — 12% for shelterbelts, 2% for farm forestry;

iii. other farm forestry costs (e.g., setting up seedling nurseries, distributional facilities and an extension network).

Results

The NPV of alternative land uses under a 10% discount rate and 50-year time horizon, are presented in Table D2.2. For shelterbelts, a base rate IRR of about 15% was estimated. Sensitivity analysis on yield costs, and underlying erosion produced a IRR within the range of 13%-17%, while a consideration of the wood benefits only showed an IRR of 4.7%. The base case for the farm forestry programme was an IRR of 19%, with a range of 15%-22% in the sensitivity tests. The IRR for wood and fruit benefits was 7.4%.

The timing of benefits is significant to the results. After Year 17, net farmer income without the shelterbelt programme declines to zero and it is assumed that the land is abandoned at this point. However, for the first 9 years of the shelterbelt programme gross farmer income with the project is less than 'without', because of the effect of taking land out of production to plant the trees.

Table D2.2 Cost Benefit Analysis of Shelterbelts and Farm Forest Project, Nigeria (NPV in Naira/ha)

	Shelterbelts	Farm Forestry
Base Case	170	129
Wood (and Fruit) benefits only	-95	-14
Low yield / High cost case	110	70
High yield case	221	na
No erosion	108	75
More rapid erosion	109	60
Soil restored (plus yield jump)	263	203

Conclusion

Traditional CBA typically does not provide an economic justification for planting trees. This is because the environmental benefits are normally omitted and trees grow so slowly their benefits arise a long time into the future. Applying conventional discount rates to their stream of benefits tends to yield a low economic rate of return. As a result, afforestation schemes are usually undertaken in response to tax incentives, or are subject to special low discount rates (exceptions include rapidly growing species and trees planted for social and amenity purposes).

However, an environmental CBA can show very different results if it attempts to place economic values on the full range of forest benefits excluded in traditional CBA (e.g., indirect benefits of shade, windbreaks and soil retention). The above study was one of the first to demonstrate that afforestation can be justified according to conventional cost benefit criteria when the wider non-timber benefits of the forest are considered, despite the lags involved in the appearance of benefits. Merely considering wood benefits would not justify proceeding with the scheme.

The study is also an example of using the production function approach to estimate tree planting's soil fertility maintenance function. The estimates are based on a number of assumptions sensitive to local conditions and project parameters. These cannot be uncritically transferred from elsewhere and the study indicates what kind of information needs to be collected for appraisal purposes, and the importance of such analysis to the final results.

2.2 Biodiversity[5]

Biodiversity includes direct and indirect use values, option and existence value.

The valuation of preferences for biodiversity is perhaps the most challenging issue in the context of economic valuation.

'Biological diversity' (biodiversity) is an umbrella term used to describe the number, variety and variability of living organisms in a given assemblage. Biodiversity may be described in terms of genes, species and ecosystems, relating to the three fundamental and hierarchically-related levels of biological organisation. It therefore embraces the whole of 'Life on Earth'. Declines in biodiversity includes all those changes which will reduce or simplify biological heterogeneity, from individuals or regions.

It is hard to use the term *biodiversity* for valuation. Diversity valuation requires some idea of WTP for the range of species and habitats. In reality, what economic studies are normally measuring is the economic value of *biological resources* rather than biodiversity.

Biological resources are a more anthropocentric term for biota such as forest, wetlands and marine habitats. They are simply those components of biodiversity which maintain current or potential human uses. This anthropocentric view of biological resources is much more convenient for economic analysis compared to alternative value paradigms such as intrinsic values (values in themselves and, nominally unrelated to human use). Intrinsic values *are* relevant to conservation decisions, but they generally cannot be measured. Studies of biological resources may capture diversity values; for example, studies valuing habitat may capture perceptions of biodiversity (i.e., valuations may be high simply because the area is known to be rich in diversity) but such effects are difficult to assess.

There are other reasons why it is difficult to put a monetary estimate on biodiversity. The lack of consensus on the rate of biodiversity loss and biodiversity indicators, and of any baseline measurements of biodiversity also has important implications for economic valuation. Fundamental to any monetary measure of value is some index or set of indices of biodiversity change.

The projected loss of species over the next century might be as high as 20%-50% of the world's total which represents a rate between 1000-10, 000 times the historical rate of extinction (Wilson 1988). The implications of species depletion on the functioning of vital ecosystems are not clear. Possible worst case scenarios involve the existence of depletion thresholds and associated system collapse. Such outcomes clearly indicate the interaction between the environment and the economy. More immediately, the loss of biological resources might be apparent in decline in cultural diversity, indices of which are provided in diet, medicine, language and social structure.

2.2.1 Valuing Biodiversity

Contingent valuation approaches are perhaps the most promising in terms of valuing biodiversity. Individuals can be presented with different ranges of species and habitats to see which they prefer. Information is obviously crucial for the success of such approaches. Many scientists believe that biodiversity is fundamental to human well-being while others argue that the functions of diversity are simply unknown. As such, individuals may not be well informed of the potential value of biodiversity.

[5] Based on Pearce and Moran, 1994.

WTP studies relating to the conservation of biodiversity *per se* have not yet been attempted in the developing country context. In developed countries, direct questioning on biodiversity preferences has focused on the preservation of well-known or charismatic species and ecosystems. The few attempts that have been made to elicit preferences for less familiar biodiversity have encountered response difficulties when the subject good is difficult to explain or unknown to respondents, or where respondents lack experience of making similar transactions (Stevens *et al* 1991; Hanley and Splash 1993). In any event, contingent valuation studies on the WTP for biodiversity *protection* do not provide information on the inherent value of biological diversity and are likely to underestimate economic value.

Travel cost and discrete choice studies might also be used for diversity valuation if it is possible to look at choices between alternatives that vary in their degree of diversity.

Even if the intrinsic value of biodiversity cannot be measured, there is still a very good reason for measuring the *direct use values of conservation:* biodiversity will be more prone to loss when direct use values are not appreciated.

There are many sustainable use values of habitat, such as ecotourism, and the collection of medicinal plants and non-timber forest products which might be valued. In addition, surveys measuring the foregone local use benefit as a result of designating a protected area, or tourists' willingness to pay for park maintenance provide some estimate of conservation values (Merceur *et al* 1993; Moran 1994). Such conservation studies may include incidental diversity benefits if subjects (biological resources studied) are considered central to the system as a whole. There is then considerable scope for at least securing minimum values for biological diversity through the use of approaches focused on market values.

Methodologies for estimating the economic value of medicinal plants and plant genetic resources for agriculture are presented in more detail below.

2.2.2 The Economic Value of Medicinal Plants

The *potential* returns from commercial drugs derived from plant species is one strong argument for identifying and preserving the world's biodiversity (particularly of species rich ecosystems such as tropical forests).

About 25% of all Western prescription drugs and 75% of developing world drugs are based on plants and plant derivatives (Principe, 1991)[6]. The pharmaceutical industry based on rainforest related drugs is estimated to generate about US$43 million in annual revenues. Clearly, medicinal plants are relevant to *use value* arguments for conserving biological resources. How far they have relevance in justifying conservation of biodiversity as such is more problematic.

Quantitative assessment of the medicinal benefits of plant species are highly speculative. Their value typically lies in undiscovered species of unknown uses that might have potential commercial value in the future. A difficulty then in valuing the potential returns from such species is that of assigning *ex ante* values to properties or products that have not yet been identified.

[6] Plant species are used for commercial medicine (prescription or over-the-counter sales) and, as traditional medicines which are not always marketed. Work to date has focused mainly on the potential commercial value of medicinal plants.

A further consideration is that because of the potentially significant *global importance* of uniquely rich tropical forest systems, the issue seems to be as much about what other, wealthier, countries are prepared to contribute to conserve biodiversity, as it is about their values within and for the countries where these resources occur. Valuation of such global values are at present highly speculative.

Valuation Methodologies

Economic valuation of medicinal plants can be undertaken at two levels. Firstly, relating to the use value for commercial and traditional medicine. Secondly, relating to option value, the extent to which conservation is required to protect future use values of medicinal plants. Option value is reinforced by the extremely limited knowledge that exists about the medicinal properties of plants, and will partly depend on the nature of future research in the medicinal drugs sector with respect to the base materials that are likely to be used. There is some debate over the merits of natural product screening relative to biotechnology and chemical synthesis (some scientists believe that genetic engineering of micro-organisms will eventually displace plant-based research).

Notwithstanding the current difficulties surrounding the valuation of biodiversity, Pearce and Moran present a model for determining the medicinal value of a unit of land as biodiversity support.

The medicinal value of a given area, say a hectare, of 'biodiversity land' is:

$$V_{mp}(L) = p \cdot r \cdot a \cdot V_i(D)$$

where:

- *p* — the probability that the biodiversity supported by that land will yield a successful drug D
- $V_i(D)$ — the value of the drug where the subscript *i* indicates one of two ways of estimating the value: the market price of the drug on the world market (i = 1), or the shadow value of the drug which is determined by the number of lives that the drug saves and the value of statistical life (i = 2)
- *r* — the royalty that could be commanded if the host country could capture the royalty value
- *a* — the coefficient of rent capture

Each of these factors are described in more detail below.

The probability of success (*p*)

The probability of success, *p*, is based on discussions with drug company experts. Principe (1991) estimates that the probability of any given plant species giving rise to a successful drug is between 1 in 1000 and 1 in 10,000.

Estimates of the number of plant species likely to be extinct in the next 50 years vary, but a figure of 60, 000 is widely quoted (Raven 1980). This suggests that between 6-60 of these species could have significant drug values. Therefore conservation of tropical forest land might realise a benefit in terms of medicinal drugs equal to the economic value of these 6-60 species. Thus, 30 could be taken as the mean value of plant based drugs lost.

Table D2.3 Some Values of Plant-based Pharmaceuticals

	$ billion 1990 (bracketed number refer to year to which estimate relates)		
	USA	OECD	WORLD
Market value of trade in medicinal plants (1980)	5.7 (1980)	17.2 (1981)	24.4 (1980)
Market or fixed value of plant-based drugs on prescription	11.7 (1985) 15.5 (1990)	35.1 (1985)	49.8 (1985)
Market value of prescription and over-the-counter plant based drugs	19.8 (1985)	59.4 (1985)	84.3 (1985)
Value of plant-based drugs based on avoided deaths:	120.0 (anti-cancer only) 240.0 (+ non cancers) (1985)	360.0 (anti-cancer only) 720.00 (+ non cancers) (1985)	

Source: Pearce and Moran, 1994

Approaches to valuation (V_i(D)

Three approaches to valuation might be used: (i) the market value of the plants when traded; (ii) the market value of the drugs (based on plant material)[7] ; or, (iii) the value of drugs in terms of their life saving properties, using a value of a *statistical life*.

Each of the above valuation methods will give different estimates. Valuation based on life-saving properties give the highest values (using the value of a statistical life of $4 million (Pearce *et al*, 1992)), while the market price of traded plant material give the lowest values.

In the 1980s, an estimated 40-plant species accounted for plant-based prescribed drug sales in the USA. Based on the prescriptions values reported in Table D2.3, each species can be estimated at $11.7 billion/40 = $290 million on average. Principe (1991) suggests that USA 1990 prescription plant-based medicines have a retail value of $15.5 billion, which would raise the value per plant to $390 million. Assuming that all life saving drugs would be on prescription, use of the value of avoided deaths suggest a value per plant of $240 billion / 40 = $6 billion per annum.

[7] The price of drugs reflects much more than the costs of the plant source material. In this respect, the drug price overestimates the value of the plant. However, market prices are also likely to understate true WTP for drugs, (i.e., there will be individuals WTP more than the market price for a given drug). Given that such drugs tend to be price inelastic, this 'consumer surplus' could be substantial. Thus, although there is no empirical basis for supposing that these biases offset each other, the two factors do work in opposite directions.

By using these average estimates, it is possible to get some idea of the lost pharmaceutical value resulting from species loss, using 30 as the estimate of lost species of pharmaceutical potential.

Using market-based figures, annual loss to the USA alone would be 30 * $292 million = $8.8 billion, and to the OECD countries perhaps $25 billion. Based on the value of life approach the annual losses would be 30 * 6 billion = $180 billion for the USA, and over $5000 billion for the OECD countries (these figures might be compared to the GNP of the Brazilian Amazonia which is estimated at $18 billion per annum).

It should be noted that these figures assume that substitutes would not be forthcoming in the event that the plant species did become extinct.

The royalty (*r*)

Potentially useful medicinal products only acquire significant value after commercial processing in modern laboratories making it difficult for developing countries to realise these values. An important question is "What percentage of the eventual value should be attribute to their origins in the forest?"[8] Historically, international patent systems have provided little protection for products based on natural goods. Thus, while indigenous knowledge of the medicinal value of plants and animal species is often fundamental to the development of commercial drugs, little economic benefit is returned to the indigenous communities.

Drug companies typically use specialist plant gathering agencies (e.g., botanical gardens and private companies) who in turn employ local institutions and people to collect and ship the products. Payment to the gathering companies is often by contract or weight of material, but there are examples of agreements involving royalties in the event of successful exploration which are divided between the gathering company and the source countries (these agreements provide for the sharing of rents as intended by the Rio Biodiversity Convention).

Royalties are usually based on the value of the drug to the drug company (ranging between 5-20%). Royalties are generally higher for plant materials to be used in a drug nearer to being marketed, as opposed to material destined for screening and longer term development. Based on existing royalty agreements of 5%-20% and given that royalties will be low for drug development some way into the future, a value of $r = 0.05$ is adopted in the model.

Rent capture (*a*)

The amount that a developing country can capture of the total value of biodiversity, in reality is significantly less than its total value. Historically the *capturable boidiversity benefit* was essentially zero but a number of recent institutional arrangements have made it now more likely that countries can capture some of the biodiversity benefit by attracting foreign funding for projects which promote conservation initiatives.

[8] Pharmaceutical prospecting is a growing industry in which plant and microbial organisms are screened for compounds active against disease agents such as AIDS.

When using valuation approaches (i) and (ii) the *institutional capacity* of the host country to capture the values in the discoveries should be accounted for. Failure to so is likely to result in an exaggerated value to the host country. A factor representing the institutional framework should therefore be applied to the *ex-post* discovery valuation.

Ruitenbeek (1989) uses a "Rainforest Supply Price" to estimate biodiversity. This estimates the amount a developing country can capture, either through genetic product development or transfers from the international community, to justify saving a particular rainforest. The factor will depend on: the licensing structure in the host countries; whether research in the host country causes other leakages in the economy; and, whether the ability exists domestically to follow out the research. This factor is therefore expected to be low in tropical low income countries.

$$CPE = a.\ EPV$$

where CPV is capturable production value, EPV is expected production value, or the patent value of the discovery. If host countries could capture rents perfectly then a = 1. In reality a tends to be as low as 10% explaining why developing nations feel that the benefit of their efforts to conserve biodiversity is captured more by others. Therefore, a can be thought of as the coefficient of rent capture. A range of a = 0.1 to 1.0 is adopted in the model.

The value of land for medicinal plants

Based on the above figures, an estimate of the value of a representative hectare of land is derived, using the following model:

$$V_{mp}(L) = \{N_R.\ p.r.a.\ V_i / n\} / H \text{ per annum}$$

Where:

NR = number of plant species at risk
n = number of drugs based on plant species
H = number of hectares of land likely to support medicinal plants

and

NR = 60, 000
p = 1/ 10, 000 to 1/ 1000
r = 0.05
a = 0.1 to 1
V/n = 0.39 to 7.00 billion US$
H = 1 billion hectares, the approximate area of tropical forest left in the world

The resulting range of values is $0.01 - $21 per hectare. If a=1, then the range is $0.1 - $21/ha. The lower end of the range is negligible, however the upper end of the range would, at a 5% discount rate and a long time horizon, amount to a present value of around $420 ha.

Pearce and Moran conclude that despite the formidable data problems and the difficulties involved, the model developed indicates that values range from very low to around $20 per hectare.

Estimates relating to other studies of biodiversity values are summarised in Table D2.4.

Table D2.4 Biodiversity: Some Results from Previous Studies

Study Area	Result	Valuation Technique	Source
Land for medicinal plants in general	\$0.01 - \$21 per hectare	Based on: $V_{mp}(L) = \{N_R . p.r.a. V_i / n\} / H$ p.a where: *p* - probability that the biodiversity 'supported' by that land will yield a successful drug V_i - the value of the drug NR = number of plant species at risk n = number of drugs based on plant species H = number of hectares of land likely to support medicinal plants and NR = 60, 000 *p* = 1/ 10, 000 to 1/ 1000 *r* = 0.05 *a* = 0.1 to 1 V/n = 0.39 to 7.00 billion US\$ H = 1 billion hectares, the approximate area of tropical forest left in the world	Pearce and Moran, 1995
Korup National Park, Cameroon	Annual value of \$85, 000, and per hectare values of \$0.2 - \$0.7	Expected Production Value Analysis (EPV) EPV = (value of research discovery) * (number of capturable research discoveries) CPV = k * EPV, 0 > k <1 where: CPV = Capturable production value; k = 10% The value per research discovery is based on patent values reflecting the expected gains to industries doing research in the area. It is assumed that the Cameroon will only be able to capture 10% of the genetic value through the licensing structure and the institution in place.	Ruitenbeek, 1989
Mangrove resource in Buntuni Bay, Indonesia	\$ 1, 500 / km^2 per year	Capturable biodiversity benefit if mangrove maintained intact	Ruitenbeek, 1992
Capturable benefit for ecologically important and diverse ecosystem such as a tropical forest	\$3, 000 / km^2 per year	Analysis of transfers over the period 1987-1990	Ruitenbeek, 1990
Local medicinal plant use in Belize	Annual net revenues of \$9-61 per hectare	Based on study of plant harvesting. Note that local values could become quickly depressed, if large tracts of land were devoted to medicinal plants.	Balick and Mendelsohn, 1992

2.2.3 The Value of Plant Genetic Resources for Agriculture

Genetic and species diversity can be of great benefit to agriculture in offering the possibility for plant improvements and increases in yield, and as a form of 'natural insurance' against yield unpredictability of homogenised systems. In terms of assessing the benefits of conserving species-rich tropical forest lands, the question arises whether such functions are maximised as a result of *in situ* recombination, in farms or in the wild. Related to this question, as for medicinal plants, is the issue of the distribution of benefits resulting from the global adoption of new agricultural varieties originating in developing countries.[9]

Valuation methodologies

Measurements of the benefits of germplasm diversity to crop development are a difficult task (Evenson 1991). Genetic resources are rarely traded in markets and common landraces based on wild species are often the product of generations of informal and formal innovations by international research centres. Identifying the contribution of an original landrace to the success of a particular modern variety is therefore extremely difficult. Furthermore, the base materials used for breeding are themselves the result of a production process which includes labour and on-farm technology. Attributing the returns to respective complementary inputs with any accuracy, including a return to all historical intellectual inputs, is highly improbable.

Netting out human and technological contributions to agricultural production is complex, since an accurate picture of the contribution of genetic resources requires assessment of the net incremental yield value at every stage of recombination. Information on parentage and genealogy of many common landraces is available at agricultural research centres. However, an accurate catalogue of yield effects of successive breeding stages and the necessary input cost information is not.

Cervigigni (1993) shows how the benefits of genetic material might be estimated, using the difference between the benefits of an improved variety — measured as the price multiplied by the yield increase — and the costs of all the other factors employed in breeding operations (e.g., capital and labour). Data limitations mean that some degree of generalisation of input cost is necessary.

Evenson (1991) employs a hedonic approach to establish the value of conserving the gene pool of major agricultural crops. The value can be arrived at by reference to the value of that part of the species range that is currently used commercially, the value of improvements in the properties of that crop already achieved through breeding, and the cost incurred in collection and maintenance of the gene pool used in that breeding. This approach has yet to be attempted for forest tree species. Such an approach may be particularly useful in illustrating the relative contribution of genetic materials conserved *ex situ* to the development of recent 'successful' varieties. The incidence of success would also be indicative of the returns to wild species collections compared to developments based on existing genetic materials.

[9] The concept of 'farmer rights', was first adopted by the UN Food and Agriculture Organisation on Plant Genetic Resources, and is implicit in the terms of the Convention on Biodiversity. The concept recognises a historically unrewarded contribution to crop improvement and the need for compensation framework. Whether such retrospective claims will be addressed remains to be seen.

The complexity of modern and traditional breeding practices means that only the broadest approximations of plant genetic value for the most common crops is possible. This uncertainty is reflected in available estimates of the contribution of South germplasm to the value of food production in the North (via crop research centres like CIMMYT - the International Maize and Wheat Improvement Centre). For wheat and maize, estimates range from: US$ 75 million per annum for Australia; $500 million for the US; and, 42.7 billion per annum for the OECD in general (Mooney 1993). How much *ex situ* value-added is included in these estimates, or how much they might be assigned on a per hectare basis to agriculture in developing countries is not clear.

2.3. Micro Climatic Functions

In principle, the value of tropical forest in terms of micro climate, climate, and the atmosphere could be assessed through the effects on production (or preventive expenditure costs) resulting from climatic and atmospheric changes associated with alterations in the extent or composition of tropical forests. In practice, the relationship between forest changes and atmospheric change is as yet imperfectly understood. For example, it is known that transpiration from tropical forest accounts for a substantial part of the recycling of moisture back into the atmosphere; but empirical evidence as to the impact of disruption of this flow through forest removal is limited and inconclusive. Therefore, valuation of the micro climate benefits of tropical forests is rather speculative.

However, it may be possible to measure the local and immediate effects of forest removal. A falloff in crop yields on adjacent lands, for example, could be assessed in terms of the costs of compensatory inputs of fertiliser, or of the investment in windbreaks that prove necessary to offset the loss of protection previously afforded by the forest.

2.4 Carbon Storage[10]

All forests store carbon. Consequently, clearing and burning of forest releases carbon dioxide into the atmosphere which will contribute to the greenhouse effect and to global warming. Valuing the benefit of the carbon storage function of forests is complicated for a number of reasons:

(i) it is not clear what share of the total emissions of carbon is due to deforestation and how much is due to other sources (primarily fossil fuel use).

(ii) there are a variety of ways in which carbon dioxide emissions could be curbed or reduced (e.g., replacing the forest with carbon dioxide-absorbing plantations or crops, or establishing compensatory fast growing plantations elsewhere). The value of retaining or managing tropical forests as a carbon store would need to be compared to the efficiency of alternate forms of carbon capture or storage, and with the opportunity cost of not exploiting other forest values such as timber.

(iii) the scientific evidence on climate change and the likely impacts of rising carbon dioxide levels in different parts of the world is not yet clearly understood.

Notwithstanding these issues, methodologies for valuing the carbon storage function of forests and some estimates of this value are available.

[10] Based on Pearce and Moran, 1995

Valuation Methodology

A methodology for deriving carbon credits, or credits that should be ascribed to an intact tropical forest developed by Pearce and Moran (1995). It is summarised below.

To derive a carbon credit, the following must be known: (i) the net carbon released into the atmosphere when forests are converted; and, (ii) the economic value of one ton of carbon released.

(i) Estimating carbon released through forest land conversion

One important consideration is that carbon is released at different rates according to the method of forest clearance and the subsequent use of the land.

If the forest is burned, CO_2 is immediately released into the atmosphere, while some remaining carbon is locked in ash and charcoal. This charcoal and ash will typically decay over a 10-20 time horizon releasing most of its carbon into the atmosphere. Studies of topical forest indicate that significant amounts of cleared vegetation become lumber, slash, charcoal and ash. The proportion differs for closed and open forest; generally the smaller stature and drier climate of open forests means that a higher proportion of vegetation is burned.

If tropical forest land is converted to pasture or permanent agriculture, then carbon will be stored in the biomass of the grass grown or crops planted. If secondary forest is allowed to grow, carbon will be accumulated, and maximum biomass density is attained relatively quickly.

Table D2.5 presents the net carbon store of land which has been converted from tropical forests (closed primary, closed secondary, or open forests) to shifting cultivation, permanent agriculture, or pasture. The negative figures indicate emissions of carbon. For example, when closed primary forest is converted to shifting agriculture an estimated 204 tC/ha are lost. The greatest loss of carbon occurs when land use is changed from primary closed forest to permanent agriculture. The data suggests that allowing for the carbon fixed by subsequent land uses, carbon released from the deforestation of secondary and primary tropical forest is around 100-200 tC/ha.

Table D2.5 Changes in Carbon with Land Use Conversion (tC/ha)

	Original C	Shifting agriculture*	Permanent agriculture	Pasture
Original C		79	63	63
Closed primary	283	-204	-220	-220
Closed secondary	194	-106	-152	-122
Open forest	115	-36	-52	-52

* Shifting cultivation represents carbon in biomass and soils in second year of shifting cultivation.

Source: Brown and Pearce, 1994

It should be noted that the above estimates represent the "once and for all change" in carbon storage as a result of land use conversion. Further refinement would require estimating the present value of the carbon releases by discounting future releases of carbon (i.e., if not all the carbon is released in the initial burning of the forest, subsequent burnings and the associated quantities of carbon released over time would need to be accounted for).

(ii) Estimating the economic value of one ton of carbon

The carbon released from burning tropical forest contributes to global warming. There are several estimates of the minimum economic damage caused by global warming (not including catastrophic events). Fankhauser (1994) suggests a *central* value of US$20 of damage for every ton of carbon released between 1991-2000. Nordhaus (1991) estimates the damage from a rise in sea level due to global warming at $13 per ton of carbon.

Taking US$20 as an estimate of damage and applying this figure to the data in Table D2.3, the cost of global warming damage as a result of converting an open forest to agriculture or pasture is estimated at $600-$1,000 per hectare. Similarly, conversion of closed secondary forest would cause damage of $1,000-$3,000 per hectare; and conversion of primary forest to agriculture $4,000-$4,400 per hectare. These figures allow for carbon fixation in the subsequent land use.

These damage estimates (carbon credits) can be compared to the development benefits of land conversion. For example, Schneider (1992) reports a value of $300 per hectare for land in the Amazon, Brazil. In this case, carbon credit values are two to fifteen times the price of land. These carbon credits also compare favourably with the value of forest land for timber. In Indonesia for example, estimates are $2,000-$2,500 per hectare[11] .

Other approaches to valuation

The replacement cost approach could also be used to value the carbon store function of tropical forest based on the idea that the carbon store function of tropical forest might be replaced by plantation forest. There are two difficulties with this approach. First, evidence from the Amazon suggests that even more carbon is stored underground as above ground due to the forest's deep root structures (Woods Hole Research Centre). Strictly speaking, measurements of the carbon replacement also require an analysis of the carbon stored underground. Secondly, such an approach measures 'benefits' in physical terms (e.g., in tons of carbon). The question of what are the monetary benefits of carbon storage is therefore side-stepped by assuming that replacement of physical quantities is worthwhile (IIED 1994).

Although not comparable, estimates have been made on the size of a carbon tax needed to induce changes in behaviour that would lead to major reductions in $C0_2$ emissions. Rothjman and Chapman (1991) calculate that a tax of $40 per ton of carbon would be needed to reduce emissions in the US by 20% from 1990 levels to the year 2005. Others have suggested that the carbon tax should be much higher ($275-600/ton) in order to achieved a 20% reduction in US emissions from 1990 to 2020 (Manne and Richels 1990 and 1991).

[11] These estimates suggest that there are mutual gains to be made from a *global bargain*. The land is worth $300 per hectare to the forest colonist but between $600-4000 to the world in general. If the North can transfer a sum of money greater than $300 but less than the damage cost from global warming, then both parties gain. If the transfers did take place at, say, $500 per hectare, then the cost per ton of carbon would be roughly $5 tC ($500/100t C/ha). These unit costs compare favourably with those achieved by carbon emission reduction policies through fossil fuel conversion.

Table D2.6 Estimates of Value of Carbon Storage Function of Tropical Forest: Some Results from Previous Studies

Value Estimates	Valuation Technique	Source
$1.2b-$3.9b /year	Crediting forest with *damage avoided* from adverse climatic change. Assumptions: i) damage estimate per ton of carbon - US$5-13 ii) amount released, itself dependent on assumptions of per hectare sequestration and annual deforestation rates.	Pearce, 1991 Scheider, 1991
$1,300-$5,700 per hectare/year		Pearce, 1990 Schneider, 1992
$46bn (Total carbon storage of theAmazon)		Solorzano and Guerrero, 1988
US$ 1,300 per ha (one time opportunity cost)	Based on damage estimate of US$13 per tons of carbon Assumes that one hectare of deforestation contributes 100 tons of carbon to atmosphere in a single year	Pearce and Warford, 1993
US$1, 625 per ha for land in Amazonian forest	Based on damage estimate of US$13 per ton of carbon Assumes that Amazonian forest would contribute 125 tons of carbon per year, given its rich biomass	World Bank
'carbon credit' estimates based on damage costs of forest land conversion per hectare: Open forest-agriculture: $600-$1,000 Closed Secondary forest –agriculture: $1,000-$3000 Primary forest -agriculture: $4,000-$4,400	Based on: damage per ton of carbon of $20 Data on carbon released for various types of land conversion.	Pearce and Moran, 1995 (see text)

2.5 Soil Nutrient Cycling[12]

Some studies have used the replacement cost approach to value the soil nutrient cycle function of tropical forests. For example, Stocking (1986) valued the benefit of naturally-occurring soil nutrient cycling by examining the costs of replacing such nutrients with commercially available plant fertiliser.

Maltos, Uhl and Goncalves (1992) implicitly use the replacement cost approach in suggesting that the *social costs* associated with the leaching of nutrients due to the conversion of forest pasture in the Eastern Amazonia can be valued at $3,480 per hectare per decade. In this case, one of the benefits provided by intact forest is measured in terms of the cost of replacing the nutrients lost through conversion and subsequent ranching activities.

In the eastern Amazonia case the net present values for ranching (for a comparable period of time as the nutrient loss) are estimated to vary from $5/ha to $541/ha depending on the size of the ranch and the management regime employed. Such a discrepancy between the value of production realised under ranching and the social costs of nutrient leaching may indicate the need for reassessment of the assumption that the level of benefits is being reproduced exactly by replacement activity. In particular, it is important to ask what economic benefits, if any, are produced by the existence of these nutrients within an intact forest ecosystem and how do these benefits differ from the benefits generally produced by the application of commercial fertilisers. If the benefits are not equivalent then it may be inappropriate to suggest that the cost of obtaining commercial fertilisers is an estimate of the benefits produced by these nutrients in intact forest.

3.0 OPTION AND EXISTENCE VALUES

Option and existence values are rarely included in CBA despite the fact that there is evidence to suggest that these values can be very high. One reason for this is that CVM is the only approach which can estimate option and existence values and this is a time consuming and expensive research technique.

Other possible routes to obtaining ‘rough and ready’ estimates of option and existence value are (Pearce and Moran 1995):

(i) Lower bound estimates of *option value* may be inferred from the current market value or foreign exchange earning potential of plant based pharmaceuticals.

(ii) The extent of *existence values* might be approximated from the value of vicarious tourism — the consumption of books, films and TV programmes — particularly in developed countries.

(iii) Donations to charitable funds may be one way of placing CVM evaluations in context. However, there may be a dichotomy between the observed reason for giving money and the actual use of funds. It is also difficult to identify organisations involved uniquely in forest protection.

[12] Compiled from IIED, 1994

(iv) The value of debt for nature swaps may provide an approximation of a WTP reflecting a non-use value. The implicit value of different sites is reflected in the price paid by conservation bodies involved. Some swap transactions have aimed to preserve tropical forest ecosystems[13] .

(v) Values could be extrapolated from WTP information on visitors to wildlife sites in substitute countries (i.e., Benefits Transfer Approach).

Some estimates on value and existence value from previous studies are presented in Table D3.1. The Dixon and Sherman (1990) study illustrates a difficulty in survey design related to valuing wildlife species. Although the object of the valuation exercise was to generate information about the value of elephants in Kaho Yai, the questions actually posed to respondents pertained to all elephants living in the wild in Thailand. As a result, the authors needed to make a number of assumptions to relate the data back to their original policy target — an evaluation of Khao Yai. As a result, geographical sequence aggregation bias may creep into the analysis. For example, the authors assumed that 10% of the WTP for the continued existence of elephants in the wild in Thailand is attributable to Khao Yai park as 10% of the elephants in Thailand are found in the Park. However, it is unlikely that respondents would value more highly a policy choice to conserve the last 10% of elephants under threat than the first 10%. Thus, inferring from a response to a question about all elephants in Thailand to the elephants specifically in Khao Yai may be problematic. In addition, it is unclear why the results are cited as evidence of option and existence value and not total economic value. As respondents are indicating their WTP to conserve elephants, this must include use, option and non-use values (IIED 1994).

Table D3.1. Option and Existence Value: Some Results from Previous Studies

Study Area	Results	Valuation Technique	Source
Existence value for the Brazilian Amazon	$30b	Calculated using an arbitrary WTP figure (observed from various CVM studies) aggregated across OECD adult population	Gutierrez and Pearce, 1992
Khao Yai National Park, Thailand	US$7 (individual WTP to preserve elephants)	CVM survey used to elicit park users maximum willingness to pay to ensure the continued existence (for use or non-use purposes) of elephants residing in the park. Unfortunately the survey design does not allow the disaggregation of this 'preservation' value into existence and option components.	Dixon and Sherman (1990)

13 A debt-for-nature swap involves an organisation, typically a conservation organisation in a rich country, buying some of the foreign debt of an indebted developing country. This can be done by buying debt in secondary debt markets at a price heavily discounted relative to its face value. The debt is then offered back to he developing country in return for an agreement to conserve some environmental asset, e.g., a tropical forest.

4.0 DISTRIBUTIONAL IMPACTS

Only a few studies of tropical forest land use options attempt to quantify the distributional costs and benefits among different groups. Generally, this is an area which requires more attention in the evaluation process given that distributional issues may be central to decisions to utilise forest land for commercial production, particularly in remote forested areas.

One example is provided by Loomis *et al* (1989), in a study of the economic benefits of hunting and viewing deer in California, including land use trade offs with housing and ranching. In addition to estimating the WTP of hunters and deer viewers using TCM and CVM, the authors also estimate total personal and business income generated in the State of California for deer hunting and viewing, as well as total employment impacts.

Relocation costs could be used to estimate subsistence values lost with the loss of forest or, the costs that would be incurred in moving the population concerned elsewhere. However, communities lose more than just their subsistence supplies when they are relocated (e.g., cultural heritage may also be lost). Cost should therefore also reflect these other values (IIED 1994).

5.0 COMPARATIVE ANALYSIS OF THE ALTERNATIVE USES OF TROPICAL FOREST LAND[14]

There are a number of alternative land uses which might be managed sustainably. For example: sustainable forestry regimes; the sustainable exploitation for minor forest products; and a number of agricultural regimes. Typically, sustainability will be consistent with limited exploitation of use values, and the maximisation of non-use values. Land uses that *do* alter the ecological profile of the forest are permanent agriculture, clear felling of timber, and industrial/residential land uses.

This Section discusses the problems associated with the economic evaluation of two important development alternatives for forest land — agriculture and commercial forestry— and presents order of magnitude estimates for these two activities derived by Pearce and Moran (1994). The results of some previous studies which have compared different forest land use options are summarised in Table D5.4.

5.1 Agriculture

An important activity encroaching on tropical forest land is agricultural development. It may be important therefore in an economic analysis of alternative forest land use for the analyst to estimate the economic return from agriculture.

Estimating the economic returns from agriculture requires some idea of farm budgets so that 'typical' returns and costs (shadow priced where necessary) can be compared. Such data is generally not available on any systematic basis. Furthermore, data needs to be in a form that permits some kind of extrapolation of net returns through time if any insight into the *sustainability* of the agriculture activity is to be gained. In general, data on the comparative rates of return to agriculture do even not permit very confident statements about 'static' returns.

[14] Compiled from Pearce and Moran, 1994

One problem in deriving estimates is that production cost data are rarely allocatable to individual products in any meaningful way (Brown and Goldin 1992). Farm cost data exist for OECD countries, but there are no reliable comparisons for developing countries.

Given the absence of cost data, one approach is simply to look at agricultural yields and value these at ruling border (world) prices. The resulting figures then represent upper bound estimates since costs will not have been deducted. Furthermore, the rate of return for subsistence agriculture is not captured, and returns are likely to be distorted by the existence of agricultural subsidies and price supports.

Table D5.1 presents some data on agricultural yields, border prices and revenues per hectare valued at border prices. The data should be treated with caution given that they relate to national averages for yields across different types of crops. However, the results suggest that alternative land uses will need to achieve benefits *of the order* of: $200-$400/ha in South America; $250/ha in India and Pakistan; $600 in China; $700 in Indonesia and $300 in North America.

Table D.5.1. Upper Bound Estimates of Economic Revenues per Hectare from Crop Production in Selected Countries

Country	Cereal yields (tons/ha)	Border prices US$/ton	Shadow revenues US$/ha, 1987
Wheat			
Argentina	2.26	91	206
Bangladesh	2.48	164	407
Canada	2.20	139	306
Chile	3.69	126	465
China	4.05	151	611
Egypt	5.25	89	467
India	1.86	138	257
Japan	5.66	184	1041
Nigeria	1.12	142	159
Pakistan	1.75	153	268
Turkey	2.05	95	195
USA	4.34	70	304
Rice			
Indonesia	3.71	192	712
Kenya	1.72	255	438
S. Korea	5.93	264	1565

Source: Pearce and Moran, 1994

These figures represent gross receipts. To obtain net receipts, the costs of production must be deducted. Specific data are generally not available. However, Alexandratos (1988) provides estimates of the proportion of agricultural revenues that could broadly be considered as the costs of 'off-farm' inputs (Table D.5.2).

Table D5.2 Percentage of Agricultural Revenues Representing 'Off-Farm' Input Costs

	1982/4 (%)	2000 (%)
93 developing countries	24	27
Africa (SSA)	10	11
Near East / N. Asia	36	40
Asia (excl China)	24	28
Latin America	25	29
Low income countries (excl China)	22	25
Middle income countries	25	29

The figures in Table D5.2 suggest that one might take 75% of gross revenues as representing profit in most developing countries (60% for Near East/North Asia, 90% for Sub-Saharan Africa). Based on this, summary figures for the NPV of traditional development uses might be:

South America	\$150-300 /ha
India/Pakistan	\$190/ha
North America	<\$300/ha
China	\$480/ha
Indonesia	\$520/ha
Korea	\$110/ha

These figures are still likely to overstate the competition faced by sustainable land uses as they do not consider the environmental costs of conversion. Also, these are 'one off' annual values and not present values.

Pearce and Moran conclude that crop production uses of land probably yield economic returns of the order of \$150-300/ha in the developing world and the USA, but \$350-\$600/ha in terms of the private financial rate of return (allowing for a rough estimation of costs). In Japan and some of the newly industrialising countries, the difference between economic and financial returns is substantial, with economic rates of perhaps \$750 /ha and financial returns of \$12,000-\$14,000/ha. These figures conform to the widely held view that subsidies in agriculture are prevalent and seriously distort the way in which land is used (Pearce and Warford 1992; Repetto 1986).

5.2 Forestry Values

Land clearance for timber production is also a major cause of tropical forest land loss. As for agriculture, estimates of the rates of return to forestry are inexact. Table D 5.3 reports estimates of rates of return to timber in terms of per hectare values and values per cubic meter roundwood equivalent. Taking a yield of 30-60 cubic meters per hectare (Vincent 1990), the per cubic meter values shown are consistent with the per hectare values ($900-$2500) although returns over $1500 ha are likely to rely on optimistic assumptions about yields.

Table D5.3. Rates of Return to Timber Production

Forestry Regime	Selective (NPV $/ha)	Clear (NPV $/ha)	Sawtimber (NPV $/ha)
(a) Indonesia 1986 $			
at 5%	2705	2690	na
at 6%	2409	2593	2165-2419
at 10%	2177	2553	2130-2278
(b) Indonesia 1994 $		1479-1642 (actual) 1873-2257 (potential)	
	Logs ($ rent per cubic metre)	Swanwood ($ rent per cubic metre)	Plywood ($ rent per cubic metre)
(c) Indonesia 1983 $	53	23	-24
(d) Sabah 1983 $	30	18	n.a
(e) Philippines 1983 $	34	49	-34

Source: Derived from Pearce and Moran, 1994. Studies: (a) Sedjo (1987); Pearce and Barbier (1987); (b) Ruzicka quoted in Gillis (1988a); (c) Gillis (1988a); (d) Gillis (1988b); (e) Boado (1988).

Leslie (1987) argues that sustainable natural management of tropical forest is only financially viable if non-timber values are allowed for. Otherwise, clear-felling systems that ignore damage done by felling selected trees, are financially more attractive. Vincent (1990) suggests that sustainable management is in fact more feasible than Leslie suggests if timber is valued at stumpage value and allowance is made for rising real prices of hardwood timber. High cost low yield cases produce positive NPVs in a few cases and in most cases where low costs and high yields prevail. Vincent's analysis also indicates a maximum obtainable NPV for Malaysian forests of around $230/ha at a 6% discount rate, about one-tenth of the value shown for Indonesia. Vincent's analysis is for sustainable forestry, whereas the selective cutting referred to could be sustainable, but is more likely not to be. Vincent's highest return is $850 for a 4% discount rate, high yields and low costs.

Based on the limited data available Pearce and Moran conclude that *sustainable* forestry systems may yield NPVs for timber ranging from negative to $2-$500/ha. Less sustainable systems appear to yield $1,000-2,500/ha. **Clearly, the focus for sustainable systems has to be on non-timber products and functions.**

Table D5.4 Summary of the Comparison of Estimates for Different Land Use Options

Location/Study	Result	Source
Peruvian Amazon Comparison of the NPV of three land use options: sustainable fruit and latex harvest only; clear cutting of timber; periodic selective timber harvesting combined with sustained fruit and latex harvest.	Periodic selective timber harvesting combined with sustained fruit and latex: $6,820/hectare Clear cutting of timber: $1,000/hectare Plantation for timber and pulpwood: $3,184/ha Cattle ranching: $2,960/hectare **Caution** Results probably overestimate returns relative to other areas of Peruvian Rainforest for a number of reasons: Results relate to land near well-developed local market; If many plots were utilised for forest products the market would probably become quickly saturated which would affect prices and rates of return; Estimates based on quantified inventory rather than sustainable flow; Analysis assumes that there are no subsequent uses for land after clear-felling, whereas clear-felling is typically followed by 'nutrient mining' activities such as crop production and finally cattle ranching. From the private farmers' point of view it is the sum of the returns from this sequence which defines the comparison with sustainable options.	Peters, Gentry and Mendelsohn, 1989
Malaysia	Forest production: $2,455 present value/ ha Intensive Agriculture: $217/ha	Watson, 1988
General estimates based on a synthesis of available data and information	Estimated economic returns from agriculture in developing countries - $150-$300/ha; Financial rate of return from agriculture - $350-$600/ha Sustainable forestry - $200-$500 NPV Unsustainable - $1,000-$2,500 NPV	Pearce and Moran, 1994

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