Valuation Methods for Environmental Benefits in Forestry and Watershed Investment Projects

Romina Cavatassi

ESA Working Paper No. 04-01

January 2004

Agricultural and Development Economics Division

The Food and Agriculture Organization
of the United Nations

www.fao.org/es/esa

ESA Working Paper No. 04-01
www.fao.org/es/esa

Valuation Methods for Environmental Benefits in Forestry and Watershed Investment Projects

January 2004

Romina Cavatassi
Agricultural Sector in Economic Development Service
Agricultural and Development Economics Division
Food and Agriculture Organization
e-mail: romina.cavatassi@fao.org

Abstract

The understatement or omission of the environmental costs and benefits associated with forest management options results in project evaluations and policy prescriptions that are less than socially optimal. The aim of this paper is to examine the full range of costs and benefits associated with forests, distinguishing between how these should, and actually are, included in economic analyses. The paper first describes the economic analysis undertaken in the project evaluation procedure of the World Bank. The second section deals with all costs and benefits that typically occur in forestry projects. Costs and benefits are classified as on-site private, on-site public or global according to their nature and area of impact and according to the Total Economic Value approach. The third section illustrates valuation techniques and how these are employed to estimate all forest values. The purpose of the fourth section is to examine how analysis is implemented in project evaluation, focussing on five case studies undertaken by the FAO Investment Centre. The analysis reveals that the main determinants of the economic viability of forestry projects are the on-site private benefits, while a major weakness of project evaluations is the difficulty in including and evaluating on-site public benefits, mainly associated with externalities. Global environmental benefits associated with carbon sequestration proved to be significant for the economic viability of forestry projects.

Key Words: economic analysis, forest values, global environmental benefits, externalities, carbon sequestration

JEL: D61, D62, Q51, Q57, 013

Acknowledgements
The author is very grateful to Daud Khan, John Weatherhogg and the FAO Investment Service Asia and Pacific for information and encouragement provided, and would like to thank Arild Angelsen, Astrid Agostini, Alberto Zezza, Marco Stampini, and Jil M. Blockhus for insightful comments and suggestions. A special thank you to Leslie Lipper for encouragement, advice and insightful comments and to Kostas Stamoulis for his support.

This paper is a joint publication of the Agricultural and Development Economics Division and of the Investment Centre Division of FAO

TABLE OF CONTENTS

INTRODUCTION

Forests serve important ecological and environmental functions and provide an important resource base, if they are managed in a sustainable manner. Sustainable forest management can provide a reliable source of income and subsistence products through the supply of direct economic goods such as timber and other wooden forest products and a whole set of non-timber forest products (NTFPs)[1]. In addition, forests may indirectly support other economic activities, such as fisheries and agriculture, by means of ecological services and functions like watershed and soil protection and climate regulation. Despite these values associated with maintaining forests, we have witnessed high deforestation rates in many developing countries, complemented by a depletion of forest resources and the services they provide.

Management of forests and of forest resources entails making decisions that involve important trade-offs, as with many other economic or environmental decision-making processes. To maintain intact or improve forest resources may require sacrificing some types of economic development, whilst desired economic development may cause forest degradation and a whole set of related problems (Ekins, 2000).

Causes of deforestation, particularly the roles of poverty and economic growth, have been the subject of many studies and debates over the past decade (Brown and Pearce, 1994; Sandler, 1992; Vosti, Witcover and Carpentier, 1998; Kaimovitz, 2002; Angelsen and Wunder, 2003; Arnold, 2001). No set group of factors was found to be the universal determinant of deforestation. Instead, a wide diversity of factors have been found to be relevant, with their importance in any particular situation depending on prevailing socio-economic and environmental conditions. Deforestation and forest degradation (DFD) may be linked to poverty, where poor people migrate to forest margins and convert lands to agricultural production. Conversely, deforestation has also been linked to political and economic elites who liquidate forest resources for their own benefit, often under economic incentives from national governments (Heath and Binswanger, 1998; Hecht and Cockburn, 1989; Kaimowitz, Byron and Sunderlin, 1998). Budgetary pressures on national governments have also been cited as a cause of deforestation, as has trade in wood products.

Perhaps even more importantly, many of the costs associated with DFD are paid not by those who make decisions on forest management (who are frequently the main beneficiaries of such decisions). Many of the values associated with sustainable forest management are externalities, defined as economic benefits or drawbacks generated through the actions of one economic agent which impacts on other agents. For example, those who clear forest lands are not likely to consider the impact of their decisions on local watershed functions, even though these may be very important to downstream farmers. Some values are not taken into account when forest management decisions are taken, which may lead to an overall loss to society, as well as to inequitable distribution of costs and benefits.

Undervaluation of the benefits arising from sustainable forest management has been thought to be a significant cause of DFD, especially for internationally-funded development projects which undergo a detailed economic appraisal process before approval. This shortcoming is due mainly to a lack of understanding and expertise in the monetary valuation of environmental impacts to be included in the appraisal process, as well as to the expense and difficulty of doing so. Therefore, decisions on forest land management are likely to have been biased in favour of development options that would have been rejected if all the relevant environmental costs were taken into account (Bann, 1997; Andersen, 1997).

[1] NTFPs include products like fruits, nuts, oils, latex, medicinal plants and others.

As a response to the increasing concern of stakeholders and the public about how best to manage forest resources, forestlands and watersheds, attempts have been and are being made to rationalise the decision-making process. In the 1980s, the World Bank, as well as the Inter-American Development Bank and other major international institutions, elevated the environmental analysis of forestry and other investment development projects to a mandatory level (Vaughan and Ardila, 1993; Belli *et al*., 1997; Munasinghe and Lutz, 1993). In response, economists have developed a range of valuation techniques that facilitate the use of monetary values for environmental goods and services in the economic appraisal framework. Many forest valuation studies have been done over the past years (Bann, 1997; Gregersen *et al.*, 1995; Kengen, 1997) although rigorous quantitative studies (Cavendish, 2000, 2002; Campbell *et al*., 2002; Fisher, 2002) are only recent and very rare (Angelsen and Wunder, 2003).

A primary objective of this paper is to investigate how the inclusion of environmental externalities could have affected project investment decisions through the analysis of *ex post* appraisals of World Bank-funded projects which included considerations of environmental externalities. Since the World Bank has been a major donor in the field of forestry and watershed protection, investigating and summarising their findings could help give an idea of the impact of externalities, compare the methods applied and draw important lessons to ensure that environmental issues are adequately considered in the design of future projects.

A secondary objective is to provide an overview of the methodologies and techniques used in the analyses of forest values and their distribution across different members of society at local, national and global levels of analysis. The paper commences with an explanation of the economic analysis undertaken in project evaluation, followed by a description of costs and benefits that typically occur in forestry projects and of valuation techniques employed. Data requirements are thereafter highlighted, followed by a report of the *ex post* evaluation applied to five case studies implemented by FAO Investment Centre. Conclusions and an Annex providing further details on the case studies presented complete the paper.

The analysis of the *ex post* appraisals reveals that given the valuation techniques employed in the studies, the main determinants of the economic viability of forestry projects are the on-site private benefits from increased production of timber, fuelwood and non-timber forest products. In contrast, the handling of local externality values reveals one of the main weaknesses of the appraisal, since their inclusion did not make a major difference in the economic viability of the project. However, whether this is due to the benefits being small or rather to the difficulty or high cost of their assessment is a question open to investigation and debate. Finally, global environmental benefits resulting from carbon sequestration tend to be large and have a substantial impact on the economic rates of return, while benefits deriving from biodiversity conservation, although considered significant, were not included in the analyses.

ECONOMIC ANALYSIS

Many forestry and environmental values are not automatically reflected in market prices, mainly because their public nature involves at least some elements of *non-excludability* and/or *non-rivalry.*[2] Their inadequate recognition and underestimation at the local, regional, national and global level is declared to be one of the main reasons for the widespread failure to practice sustainable forest management, as well as for deforestation and the transfer of forests to other land uses (as also recognised in Chapter 11 of Agenda 21, UNCED 1992).

However, the difficulty of valuing such goods and services should not preclude at least an attempt to measure these values and include them in decision-making. To the extent possible they need to be explicitly assessed, quantified and incorporated into the decision-making process. The use of money as a standard is a barrier to wide acceptance, as most people believe that there are some things that cannot be priced (Adams, 1993) and that natural resources are rights upon which it is immoral to place a monetary value (Kelman, 1982; Swartzman, 1982). In support of valuation procedure Abelson (1979), Jacobs (1991) and Pearce (1998) argue that the choice of monetary units reflects convenience and practicality, not materialism, and that the process of valuation is based on economic theory and on a systematic approach. Moreover, the purpose of valuation is to make the value of each forest use explicit, rather than to put a monetary value on nature (Michael, 1995).

Forest values can be measured by using methodologies that imply physical approaches, such as environmental impact assessment, or financial and economic methods, like cost-benefit analysis (CBA) and cost-effective analysis. This document focuses on the economic valuation of forestry projects, applied at the evaluation and appraisal stage of a World Bank systematic style,[3] and attempts to highlight considerations included in the analysis to ensure that projects are environmentally sustainable once technical, institutional and social viability have been ascertained (Belli *et al*., 1997). The methodology presented is consistent with the framework of cost-benefit analysis (CBA) used in the evaluation as well as in the appraisal stage of World Bank development projects analysis. CBA involves the economic assessment of a wide range of goods, services and attributes provided by the forest, with the purpose of calculating an overall index by which project feasibility and achievements can be judged comparing the "with project" and "without project" situations (Munasinghe and Lutz, 1993; Markandya *et al*., 2002).[4] Activities performed under the project are considered optimal when the marginal cost of the investment equals the marginal benefit yielded.

---

[2] *Non-excludability*: difficulty or impossibility of excluding other individuals from the benefits of a given good or service; *Non-rivalry*: the consumption by one individual does not preclude consumption of the same good by one or more other individuals (e.g. national parks or other recreational amenities) (Baumol and Oates, 1988).

[3] The successful completion of forestry as well as other kinds of development projects involves several well-defined analyses that, in the systematic methodology employed by the World Bank, incorporate:

1) *identification,* whose purpose is to elaborate project ideas in order to use a country's resources to achieve development. A preliminary test of feasibility is requested at this stage;
2) *preparation and analysis*, entailing a refinement of technical, economic, environmental, financial, social and institutional aspects of the project;
3) *appraisal,* to assess the global accuracy and feasibility of the project in order to validate and allow its implementation;
4) *implementation,* involving the actual project development. It includes also monitoring and supervision; and
5) *evaluation*, which refers to project *ex post* appraisal to determine the extent to which a project's objectives have been accomplished (Munasinghe and Lutz, 1993; Belli *et al*., 1997).

Recently a new four-phase project cycle has been proposed to give more flexibility in the appraisal of projects. The steps are: listening, piloting, demonstrating and mainstreaming (Picciotto and Weaving, 1994).

[4] The "with vs without" project analysis (which should not be confused with the "before vs after" analysis) is particularly useful in estimating the environmental impacts of projects – although defining the baseline and the potential impacts is not an easy task because, for example, some mitigation measures could take place spontaneously. Consideration of interdependence and divisibility of project components is thus fundamental since different project components may damage the environment but their synergy could either mitigate the impacts or even worsen them.

Economic analysis differs from financial analysis in that the former considers "social prices" that are costs and benefits from the point of view of the society as a whole, while the latter considers costs and benefits from the point of view of individual agents. When there is perfect competitive equilibrium on the market, social and market prices coincide. However, in essentially three situations a competitive equilibrium does not exist. These are: 1) when a market is distorted by monopoly, externalities or by government interventions such as taxes or subsidies; 2) when no market for the good exists; or 3) when a good is associated to a non-market benefit such as enjoyment value (Carlson, Zilberman and Miranowski, 1993).

To carry out an economic analysis, the first step is to measure the financial profitability of a project through the assessment of monetary costs and benefits from a private investor's point of view; that is, costs and benefits are based on actual market prices without any consideration of distortions or market failures. Various adjustments to the financial results are needed thereafter in order to correct for the presence of market imperfections, price distortions and distribution inequalities and to consider the social values associated with all potential economic impacts, including environmental ones. To correct for these imperfections, shadow prices – estimates of the prices that would prevail if all resources in the economy were optimally allocated – are used (Barbier *et al.,*, 1994). Benefits are defined relative to their effects on the improvements in human well-being measured through the consumer's surplus, determined by the difference between the Willingness To Pay (WTP), which is the maximum amount of money that people would sacrifice to buy a good or service, and the amount of money actually paid.[5] Costs are defined in terms of their opportunity costs (benefits forgone by not using these resources in the best alternative application) or in other words, the benefits of the next best alternative.

Once all goods and services to be included in the analysis have received a "social value", some adjustments still have to be made, especially when more than one country is involved in a project. This is often the case when the lending agency financing development projects is an international one such as the World Bank. Four steps are followed (described in detail in Box 1) in the final effort to convert market prices to social prices (IIED, 1994):

1) adjustments for direct transfer payments;
2) corrections for price distortions in traded items;
3) adjustments for price distortions in non-traded items; and
4) corrections for foreign exchange premiums.

[5] For more information see Markandya *et al.* (2002); Pearce and Turner (1990); Gittinger (1982).

Box 1: Steps to be followed in converting market prices to social prices

1. *Adjustments for direct transfer payments:*
   Payments made to agents who do not take part in any exchange of goods and services (i.e. taxes or revenues) are removed from the accounting procedure.
2. *Corrections for price distortions in traded items:*
   Any indirect transfer payments that operate through changing market prices of traded goods and services are removed. Basically the border price of the good and service must be adjusted for domestic transport and marketing costs incurred between the project boundary (or farmgate) and the border. If border prices are distorted these must be adjusted first.
3. *Adjustments for price distortions in non-traded items:*
   When the market price of the non-traded good or service is distorted because of market and policy failures, the value of a non-traded good cannot be derived from market prices and the shadow price needs to be determined.[6]
4. *Corrections for foreign exchange premiums:*
   A foreign exchange premium occurs when national trade policies restrict the free flow of internationally-traded commodities[7] and over- (or under-) value exchange rates, leading individuals to pay a premium on traded goods above (or below) what they pay for non-traded goods. To incorporate this into the economic analysis there are two approaches:
   - 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).
   - Derive a standard conversion factor 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*,[8] and this reduces them to their appropriate economic values (again, assuming a positive exchange premium).

When the true values of benefits and costs accruing to the society have been assessed, the final phase of measuring a project's feasibility and profitability can be handled by using one of the following techniques: Net Present Value (NPV), Economic Rate of Return (ERR) and Benefit-Cost ratio (B/C).

The NPV is the value at t = 0 of the flows of benefits over the life of a project, after deducting the costs, both discounted at an "appropriate" rate, which usually reflects the opportunity cost of the capital or the social rate of time preferences.[9] For a project to be viable, the NPV must be zero or positive. The ERR is the discount rate at which the stream of net benefits is equal to that of net costs or, in other words, the discount rate at which the net present value for the project is zero. The project is feasible if the ERR equals or exceeds the "appropriate" discount rate. The B/C is a variant of the NPV but is very rarely used in a developing

6 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.
7 Such as bans on roundwood exports, quotas on timber imports, tariffs on imported goods, subsidies on exported goods.
8 A conversion factor is the ratio of an item's economic price to its financial price (Belli *et al*., 1997). Whether the analyst uses conversion factors or economic prices does not alter the conclusion of the analysis but conversion factors are usually more convenient to use. As several non-traded inputs occur in nearly all projects here considered it is therefore desirable to calculate specific conversion factors for these commonly-occurring inputs on a country basis so that consistent values are used across different projects in the same or similar countries.
9 For more details see: Pearce and Turner, 1990; Neumayer, 1999; Swartzman, 1982; Hanley and Spash, 1992; etc.

country context. It is the ratio between net benefits and net costs, both discounted at the "appropriate" rate. If the B/C ratio exceeds or equals unity, the project is viable (NPV is positive or zero) (Baum and Tolbert, 1985).

In most cases all three indices lead to the same result: if the NPV of a project is greater or equal to zero (and thus B/C is equal or greater to one) at a certain discount rate, it means that the ERR is greater or equal to that discount rate and the project can be accepted regardless which index is used. However, the ERR presents some traps that can lead to erroneous conclusions. Careful attention should be paid when using it for making decisions, especially when comparing mutually exclusive alternatives.[10]

First, there are cases in which the ERR does not exist. An ERR of a series of values can exist only when at least one value is negative: if all values are positive, no discount rate can make the value of the cash flow equal to zero. This happens, for example, when net benefits of the project start so soon that there is no negative net benefit in any year.

Second, a project can have more than one ERR when the project's net benefits change signs more than once during the life of the project.

Third, in comparing mutually exclusive projects that have a different lifetime or a different initial cash flow, direct comparison of ERR can lead to erroneous conclusions unless the ERR is applied to every incremental unit of investment. This might happen, for example, in a case where undertaking a small but highly remunerative project precludes choosing a moderately-paying but larger option. In these cases, in order to use the ERR, the cash flow of the smaller alternative must be subtracted year by year from the cash flow of the larger alternative. The resulting stream of difference needs then to be discounted to determine the ERR. However, this procedure can be applied only to a single pair of alternatives. If there is more than one pair of possible projects, the procedure should be repeated for each pair of alternatives.[11]

The use of NPV, on the other hand, presents two main problems: it is not scale invariant and it requires the application of an "appropriate" discount rate. Scale invariance means that a large NPV could be due either to the project being big or to it being a very beneficial project. Therefore comparing two projects with a different scale through the use of NPV could be misleading.

How to choose the "appropriate" discount rate is a largely debated question. One of the most widely used is the *opportunity cost of capital,* which is the rate that would result if all capitals within an economy were invested in activities that pay the best return possible. If it is adequately settled, it reflects the choice made by the whole society between present and future returns and therefore its meaning represents the total amount the society is willing to save. Despite its concept being quite straightforward it is rather difficult to apply as a working tool, since no one knows what the opportunity cost of the capital really is (Gittinger, 1982). A second option is offered by the *borrowing rate that a nation should pay to finance the project,* which might mislead the selection process since only financial terms will be taken into account instead of considering the relative contribution of the project to the national income.

A third option is offered by the *social time preference rate* which implies taking into account that the discount attached to the future by the society as a whole is lower than that of single individuals and therefore the discount rate used for public investment should be lower than that of private investments (Gittinger, 1982). Many important benefits, particularly in the case

[10] Mutually exclusive projects are such that implementing one necessarily precludes implementing another (Gittinger, 1982).
[11] For further details see Brealey and Myers, 1988; Gittinger 1982.

of forestry projects, accrue far in the future, to the advantage of future generations. Intergenerational considerations are, therefore, an essential aspect to take into account, since future generation preferences cannot be expressed today. The higher the discount rate the easier to select projects with high net benefits in the short run; the lower the discount rate the easier to select projects with high benefits in the long run. Many authors[12] argue that since high discount rates may discriminate against future generations, they should be lowered to reflect environmental concerns and issues of intergenerational equity. Some claim that it should eventually be reduced to zero.[13] However, employing a zero discount rate is inequitable, since it would imply a policy of total current sacrifice, which runs against the proposed aim of equity not only for those living in the future (intergenerational concern) but also for the low-income and economically-deprived members currently present in society (intragenerational concern) (Neumayer, 1999).[14]

Which discount measure the analyst chooses depends on the practice in the country in which the project is to be implemented or on the preferences of the financing agency that is asked to fund the project. Many analysts prefer the NPV for its straightforward concept and unambiguous quality and application. Some other analysts like the ERR better because it is easier to understand and does not need to calculate an opportunity cost of the capital (although a comparison with some sort of rate should also be made). The Benefit Cost ratio is very rarely used in developing countries (Gittinger, 1982). The World Bank tends to use the ERR because it avoids the necessity to make a comparison between opportunity costs of capital in different Bank member countries and at the same time does not require setting up a worldwide opportunity cost of capital. In practice, the procedure is to run a project and make the best estimates of the results expressed in one discounted measure and thereafter select the project if it has a NPV of zero or more or if the ERR is equal or above the opportunity cost of the capital.

For the purposes of the present paper, the economic analysis procedure just described is applied to forestry or agro-forestry projects. The next step is to describe and identify the type of values held by forests.

[12] For example, Munasinghe, 1993; Jacobs, 1991; Broome, 1992; Azar and Sterner, 1996.
[13] Ramsey, 1928; Pigou, 1932; Rawls, 1972; Broome, 1992; Cline, 1992; Azar and Sterner, 1996.
[14] For further information on social discount rates, see Markandya and Pearce, 1991.

FOREST VALUES

The valuation of forest resources has been a central issue in forestry for quite a long time. Until recently, however, most valuation studies were basically concentrated on wood products and little attention was given to developing a comprehensive valuation of all different goods and services supplied by forests (Kengen, 1997a).

There is an extensive literature in environmental economics concerning assigning economic values to the environment on the basis of the *Total Economic Value (TEV)* concept, which is intended to encapsulate the full range of economic values[15] that people attach to each type of land use[16].

The Total Economic Value concept is defined as:

TEV = {***Use Values***} + {***Option Values***} + {***Non-use Values***}

and further:

TEV = {***Direct Use V. + Indirect Use V.***} **+** {***Option V.***} **+** {***Existence V. + Bequest V.***}

where:

Use Values: *Direct Use Values* are those values directly related to the use of forest goods or services such as timber, poles, fuelwood (hereafter referred to as "wooden forest products"), Non-Timber Forest Products (NTFPs), recreation, education, tourism, etc. that normally involve private benefits. *Indirect Use Values* refer to benefits that people derive indirectly from the "ecological functions" performed by the forest, such as watershed protection, fire prevention, water recycling, carbon sequestration,[17] biodiversity conservation,[18] soil fertility and agricultural productivity enhancement.

Option Value refers to preserving the possibility of future direct or indirect use of the forest. It represents the insurance premium people are willing to pay today to secure that the forest, its biodiversity and ecological services be available in the future.

Non-use Values are those benefits totally unrelated to any personal use of the forest. People may value a forest for a number of reasons without ever visiting it. These can be distinguished in: *Existence Value*, which is the perceived value of the forest, unrelated either to current or optional use: its value simply because it exists. It is measured by the willingness to pay (WTP) to secure the survival and well-being of biodiversity, endangered species, habitats and so on. *Bequest Value* accrues from the desire to conserve forests for the future generations.

The following figure represents all components of the TEV just described, proceeding from more tangible to less tangible ones.

---

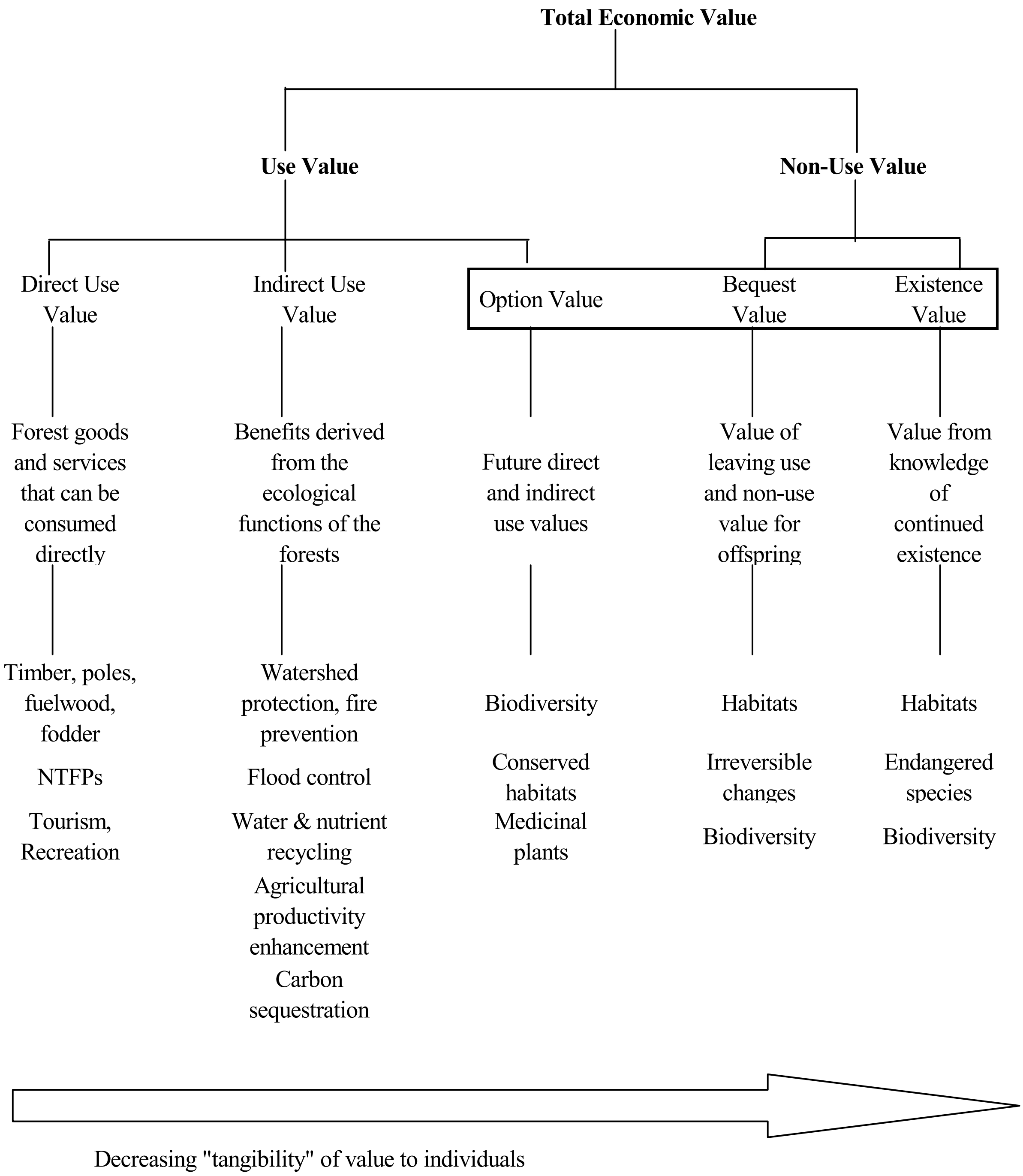
[15] In the following discussion benefits and costs are taken into account as from the environmental economic literature, which means that a benefit is either a direct benefit or an avoided damage and thus an avoided cost (Casoni, 1994).

[16] See for example Pearce, 1993; Johanssen, 1990; Barbier, 1989; Pearce and Turner, 1990; Munasinghe and Lutz, 1993; Ayres and Dixon, 1995; Kumari, 1995; Adger *et al*., 1995; Kengen, 1997[a or b?]; Hearne, 1996; Andersen, 1997; Markandya *et al*., 2002.

[17] The concept of carbon sequestration normally encompasses the idea of conserving stocks of carbon in soils, forests and other vegetation, where these are in imminent danger of being lost; and the enhancement of carbon sinks by establishing new forestry plantations, agroforestry systems and rehabilitation of partly degraded forests (Tipper, 1996).

[18] Biodiversity is used to describe the number, variety and variability of living organisms (Pearce, 1995).

Figure 1



Adapted from: Munasinghe, 1995

Usually the use values of forests such as timber products and NTFPs affect only the population in the country in which the forest is located and, as a consequence of their predominantly private nature, may be directly traded on markets. On the other hand, a number of the environmental goods and services provided by forests, such as the safeguarding of major watersheds, may also have transboundary spillover effects downstream or into more than one region or country, and because of their partial or total public nature cannot be directly reaped or identified. Furthermore, the world's forests are increasingly considered to produce important "global benefits" in the form of carbon sequestration[19] and preservation of the world's biological diversity. Forest alteration and degradation thus have potential consequences for human welfare at the local, regional and global level (Brown and Pearce, 1994).

Along with the area of influence of people affected and of the private or public nature of the benefit concerned, forest values can also be classified as on-site private, on-site public and global (off-site) according to where and how their impact is felt, wherein:

On-site private benefits are mainly those local private benefits tangible at the project area level (or direct-use benefits produced essentially at that level). They consist of profits derived from the forest for the project area people and are reaped directly by the agent who undertakes the action. Examples of on-site private benefits include wooden forest products (timber, poles, fuelwood, pulpwood, etc); non-timber forest products (NTFPs) (mushrooms, medicinal plants, honey, fruits, nuts, biochemically active plants and others); tourism, education and recreation (jungle cruises, tour guiding, entrance permits and all profits that can be gathered through the organisation, management and implementation of tourist activities) and agricultural products (when the project involves agro-forestry or other sorts of agricultural activities).

On-site public benefits are those externalities essentially related to the ecological function of the forest which produces on-site effects as well as transboundary effects at a larger level (off-site). They are mainly represented by indirect use values or non-use values, which means that there are benefits (or costs) reaped (or borne) by one agent despite the action being undertaken by another agent. Although the importance of the ecological functions of forests is widely recognised (Angelsen and Wunder, 2003; FAO, 2003), those functions are not easy to document. Among the most significant functions are the values of nutrient cycling, watershed, soil and flood protection (which also enhance agricultural productivity) and protection against fire. Other examples of on-site public benefits include cultural, aesthetic and spiritual values.

Global benefits refer to all benefits that are, or can be, reaped from everybody including local, national and international communities. They can be either direct benefits or externalities, and include:

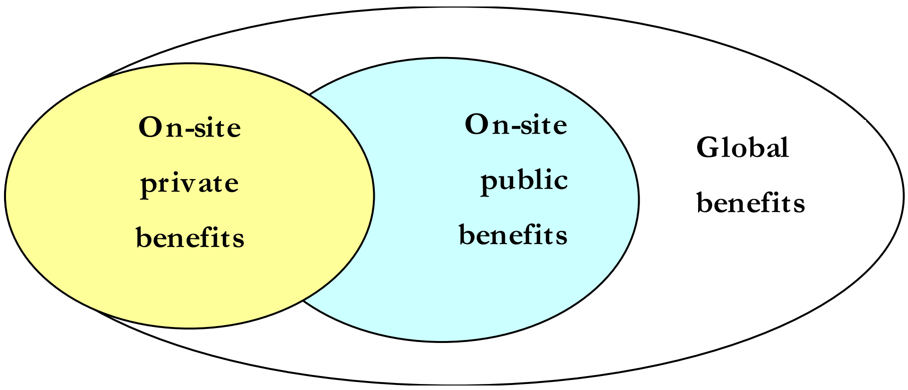
- direct use values from recreation, tourism and from the provision of genetic material and varieties for forest management and agriculture;
- indirect use value in the form of carbon sequestration;
- option values in the form of unknown genetic material which can be used for medical purpose in the future; and
- an existence value as biodiversity conservation from the mere satisfaction of the forest's existence (Andersen, 1997).

[19] According to the Global Environmental Facility (GEF), global environmental benefits are obtained whenever a global environmental objective is met. The Global Environment Facility was established in 1991 and restructured after the Rio Summit to forge international co-operation and finance actions to address four critical threats to the global environment: biodiversity loss, climate change, degradation of international waters and ozone depletion (see http://www.gefweb.org/What_is_the_GEF/what_is_the_gef.html).

Where global benefits can be reaped by all members of the global community, on-site public benefits refers to externalities and spillover effects which affect any people living in the project area or relatively close to it, while on-site private benefits are principally direct-use benefits to the communities at the project area level. The classification of values into on-site private, on-site public and global is also useful in providing some indication of what transfers should take place to obtain the optimal amount of forest protection, especially in light of the Clean Development Mechanism (CDM)[20] and similar forms of compensation[21] set up under the Kyoto protocol and other Multilateral Environmental Agreements (MEAs).

The figure below shows that the concept of global values incorporates also that of on-site private and public, but not vice versa. Moreover there is also an area of overlap between private and public on-site benefits, as for example in the case of agricultural products or tourism. When the project entails agro-forestry activities, products obtained are directly reaped at the private level. However, an increase of agro-forest production can also result in favourable impacts on downstream farmers through the ecological functions of a forest. Similarly, tourism produces two types of benefits: those of a direct private nature in terms of income or employment generation, and those of a public nature at the national or international level in the form of actual or potential enjoyment of the forest.

Figure 2
On-site private, on-site public and global benefits



In the following table forest value categories are analysed with respect to type of benefit.

20 The CDM is a system set up under Article 12 of the Kyoto Protocol that allows investors from Annex B countries (industrialized countries with legally binding emissions reduction commitments) whose greenhouse gas emissions surpass their commitment levels to obtain a carbon credit for emission abatement from developing countries who in return cut their emissions or increase carbon sinks through actions such as conserving forests or investing in clean technologies (Olsson and Ardö, 2001). Ostensibly, the CDM would result in investment on the part of industrialized countries in projects which promote sustainable development as well as carbon sequestration in developing countries (Brown and Pearce, 1994). Carbon emission abatement costs are substantially lower in developing countries than in industrialized ones, which is the basis for establishing the market. The vision is that payments for emissions offsets to developing countries could be used to finance sustainable development, although the rules under which this will take place are still uncertain.

21 The Biocarbon Fund, recently established by the World Bank with a capitalization of US$ 100 million for the first phase, is one important source of funds for sequestration payments. The fund is divided into two separate windows for financing: one which will be targeted to land use changes that qualify for credits under the CDM and another which allows a broader menu of land uses to be considered, including avoided deforestation and soil carbon sequestration. The Fund explicitly requires that projects contribute to improved livelihoods for local populations, as well as cost-effective emissions reductions and local environmental benefits. The source of funds for the Biocarbon Fund are a mix of private sector entities and development agencies, with the former receiving emissions reduction credits for their participation. For further information see Lipper and Cavatassi, 2002.

Table 1
Forestry value categories and types of benefits[a]

	Direct use value	Indirect use value	Option value	Non-use value
On-site private benefits	Timber, poles, and other wooden forest products Non-timber forest products (NTFPs) Education, tourism and recreation income Some medicines and agricultural germplasm Agro-forestry products			
On-site public benefits		Watershed, soil and flood protection Water and nutrient recycling Soil fertility Protection against fire Agricultural productivity enhancement		Aesthetic, cultural and spiritual values
Global benefits	Recreation, tourism	Carbon sequestration	Genetic material which can be used for medical purposes in future	Biodiversity conservation and species preservation

[a] Most of the benefits are at all three levels, but in order to avoid rendering the table meaningless, it is the *main* benefits that are indicated.

Identifying and defining the values of goods and services a forest can provide, and how those values can be distinguished according to the affected areas and people, is not sufficient to complete the economic analysis, since a price should be attributed to each of them. This requires applying appropriate techniques from among those available and described in the next section.

EXISTING METHODOLOGIES AND DATA PROBLEMS

METHODS FOR MEASURING FOREST VALUES

To determine the appropriate measures of value for each forest's product, various techniques have been developed over the years. These techniques can be grouped into three broad categories, based on their reliance on: a) direct market prices; b) indirect market price*s* or values; and c) hypothetical values (Kengen, 1997b).

a) **Direct market prices** techniques are based on actual market estimates such as direct observation, market surveys and so on. They are used for the purpose of financial analysis, as they capture private benefits and costs representing also the first step of the economic valuation. Obviously, in the absence of market distortions, they can also be taken as a measure of social value.

Direct market prices	Source	Example
Prices existent in market place	Direct observation Market surveys Use of statistics	Used to value all market goods and services from the forest in the absence of market distortions.[22]
Residual values	Use of market prices for final goods and intermediate inputs plus some measure of profit to arrive at residual value.	Timber stumpage value is derived by taking market prices for finished lumber and subtracting costs, from harvesting through processing to lumber sale.

Most forest project decisions are based primarily on financial analysis results that consider only direct market costs and direct benefits. It is indeed difficult to find forestry project decisions that have considered quantitative estimates of the non-market environmental services associated with forests, such as biological diversity protection, watershed protection, carbon sequestration and so forth (Kengen, 1997b). Therefore, as previously emphasised, some adjustments to market prices need to be made within the financial analysis in order to obtain shadow prices for the purpose of the economic analysis. Indirect market prices and non-market values are examples of estimates that reflect some social values.

Indirect market prices techniques rely on inferences about the value of environmental goods based on people's actual behaviour and on how it changes as the environmental quality level changes.

Indirect market prices[23]	Source	Example
Surrogate prices and replacement or avoided costs	Use of market prices for close substitute as a proxy measure of value for the unpriced good or service being valued. Both are converted to a common denominator (e.g. protection value).	The maximum value of a watershed management programme focused only on containing sediment in a downstream reservoir is equal to the alternative market cost of dredging the reservoir of the additional sediment that would occur without the programme.

[22] The most common cases of distortion occur when there are imposed minimum prices or ceilings on goods and services.
[23] Value inferred from other market prices. Used for both non-market-priced and market-priced outputs and inputs.

Opportunity cost	Use of market prices for the best foregone alternative provides a measure of the minimum value for a good or service, and is useful for making a decision about approving or rejecting a project.	The minimum value of a wilderness park is estimated on the basis of market-priced value of the goods and/or services forgone (e.g. timber, mineral, grazing).
Travel costs	Per capita measures of participation from different distance zones are used to derive estimates of the value of an area, facility or activity.	Differences in market-priced costs of trips by different users to a reserve, a park or a recreational area are used to value those sites on the basis of differences in use rates in relation to differences in trip costs.
Hedonistic price	Based on the idea that people value a good because they value the characteristics of the good rather than the good itself.	Housing prices will be related to a variety of characteristics including attributes of the house itself (number and size of rooms, quality of construction and so on) and attributes of the neighbourhood (air quality, noise level, level of crime, distance to employment centres and so on).

b) **Hypothetical values** techniques adopt a surrogate market approach by directly asking people for their preferences and valuation or making assumptions regarding proxy market conditions and how market agents will behave under different circumstances (Dixon *et al*., 1994).

Non-market value estimates	**Source**	**Example**
Contingent valuation method	Surveys of stakeholders' willingness to pay for a given event, area, facility or activity.	Value of a certain endangered species is inferred from a survey on people's willingness to pay to save it.
Conjoint analysis	Determines valuations by asking people questions across a range of features or attributes of a forest, protected area, event, etc. Allows an analysis of trade-offs involved in each good or service in order to determine the combination of attributes that will be most satisfying or valuable.	The valuation of a protected area can be inferred from the answers given with respect to different attributes and features of the area.

Source: Adapted from Gregersen *et al*., 1995.

One or more of these techniques can be used to estimate each of the forest values presented in the previous section. The next table shows which techniques can be applied to measure various aspects of forest values. In the following section a description of valuation techniques and values applied to each forest product is presented.

Table 2
Techniques commonly used to value components of a forest[a]

TEV	On-site Private	On-site public	Global	Valuation Technique
Direct use value	Timber and other wooden products NTFPs Agricultural products[24]		Biodiversity conservation	Market analysis Price of substitutes Surrogate prices and indirect substitution approach Opportunity cost approach Value of changes in production
Indirect use value	Educational, recreational and cultural uses			Travel cost method Hedonic prices
		Watershed protection Nutrient cycling Air pollution reduction Microclimate regulation Agricultural productivity enhancement	Carbon sequestration	Damage costs avoided Preventive expenditure Value of changes in production Relocation costs Replacement costs
Option Value **Existence Value**	Spiritual, aesthetic, cultural values	Genetic material	Biodiversity conservation	Contingent valuation method Indirect cost approach

[a] Here again, some values could be presented in more than one cell; for example, biodiversity has both on-site private and public indirect use value. However, in this analysis the focus is on the most difficult values or on the most difficult aspects of a value to be captured.

On-site private benefits

Wooden forest products (timber, poles, fuelwood, pulpwood)
Nearly all kinds of timber, poles, fuelwood and other wooden products are marketed, and consequently have market prices that may be used in an analysis. In the evaluation process the first step requires determining the amount of timber (or other wooden products) that can be harvested in a sustainable manner over a consistent amount of time; this varies according to the type of timber or forest good. The second step is to apply a stumpage price. A common way to determine stumpage price is to deduct the costs of extraction and transport from international market price per unit of output (Andersen, 1997; Kengen, 1997a; Gregersen, 1996).

Agricultural and other agroforestry products
When the project under consideration involves agroforestry activities, on-site direct private benefits connected to the products obtained should be considered, using market prices.

[24] Agricultural products here refer to private (on-site) benefits produced through the project when this involves agroforestry activities. Agricultural products are on-site public benefits when agricultural productivity enhancement is provided indirectly through hydrological features of watershed, soil protection, etc.

Non-timber forest products (NTFPs): mushrooms, medicinal plants, honey, fruits, nuts, biochemically active plants and others

Besides timber and other wood forest products, it is possible to extract a wide range of NTFPs from a standing forest, such as mushrooms, medicinal plants, honey, fruits, nuts, biochemically active plants and many other products. Valuation of NTFPs has received great attention because these are major sources of food and income for forest-dependent people, and they may also play a significant role in forest conservation and even in development[25] (Myers, 1988; Godoy and Feaw, 1989; Roche, 1989; Gentry and Blaney, 1990). In a study conducted on forest communities in Orissa (India), Mallick (2000) found that about 20 percent of total annual household income derives from NTFPs and that 36 percent of labour activities are related to NTFPs. There is certainly a strong correlation between dependence on NTFPs and poverty, as documented by Angelsen and Wunder (2003) in their recent analysis of linkages between poverty and forests. In their analysis, NTFPs can either act as safety nets or as poverty traps. They operate as traps only in those cases in which existent alternative development options are not implemented due to exogenous forces such as political will (Angelsen and Wunder, 2003).

Many reports and studies conducted to estimate values of NTFPs can be used in analysis. These include IBGE (1994) for rubber, Brazil nuts, bassau oil and palmito; Anderson, May and Balick (1991), as well as IBGE (1994), for many Amazon NTFPs; research of the Ministry of Environment and Forests in India (in Mukherjee, 1994); Knowler and Canby (1998); Mallick (2000); Gupta, Banerji and Guleria (1982), etc. However, while some NTFPs have a high commercial value for people involved in their production, as documented by CIFOR in their recent comparative analysis of 61 cases of commercial NTFPs production and trade (Ruiz-Pérez *et al*., 2003), many analysts argue that most NTFPs produce low returns both per hectare as well as per labour unit (Byron and Arnold, 1999; Neumann and Hirsch, 2000; Angelsen and Wunder, 2003). Bann (1997) maintains that there can be as much as an eightfold difference in seasonal income from the sale of these products and that all estimates are site-specific and must be handled with great caution. Bettencourt (1992) claims that, since only a minor part of the products consumed are traded in the market, any full valuation that relies on prices and quantities originated at the market level will underestimate the true economic value of the resource. Moreover, most of the studies on NTFPs are carried out on a per-plot basis although not every hectare of tropical forest has the same market value and not all resources on a plot with potential uses are actually exploited.

Finally, despite the fact that market prices exist for some NTFPs, it is likely to be quite difficult to apply a market approach to less-traded NTFPs because of the nature of the market involved, which is very much locally-based and contingent on seasonal trends. However, FAO (1997) reports that at least 150 NTFPs are significant in international trade. Among these, plants used in pharmaceutical applications, nuts, ginseng roots, cork and oils each have an annual trade value of more than US$ 300 million. Chopra (1993) estimates that the total present value of NTFPs from a deciduous tropical forest in India varies from a minimum of US$ 219 to a maximum of US$ 317 per hectare annually. In 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 US$ 3 100 per household.

In carrying out an economic analysis, NTFPs must be included because they are or could potentially be traded in significant amounts. Moreover, opportunity costs related to

[25] Rather than extracting timber, income can be derived from the extraction of NTFPs. However this assumes implicitly that NTFP extraction would not have ecological impact on a forest, a questionable assumption (Gunatilleke, Senaratane and Abeygunawardena, 1993; Peters, 1994).

alternatives foregone must always be considered so that their value as safety nets or cost as poverty traps is included in the analysis.

Recreation and tourism
As mentioned earlier, recreation and tourism must be considered from two different points of view: as an income source at the local level for those who provide and supply tourism activities; and as an indirect benefit associated with recreational services provided by the forest for actual or potential users who could be local but could also be international residents.

Recreational services of the forest tend to be more valuable to urban wealthy people than to poor people in developing countries who fight to survive (Kengen, 1997b). Tourism as an active, enjoyable activity is measured as the value people attribute to the forest through methodologies like the Travel Cost Method (TCM) or the Contingent Valuation Method (CVM).[26] At the local level tourism can trigger cash flows for on-site expenditures on tourism goods and services. These are measured in terms of employment and income generation[27] (hotels, tour guides, licenses, permits and fees to pay for visiting, sport or hunting and so on). Unfortunately, the economic potential for local income-generation from tourist-related activities is very often ignored (Angelsen and Wunder, 2003).

On-site public benefits

Benefits under this category include mainly those linked to the ecological function of forests. Documenting them is not easy (Bruijnzeel, 1990), but the main ones include watershed, soil and flood protection, water and nutrient cycling, soil fertility, protection against fire and other connected benefits such as enhancement of agricultural productivity. All these can be seen as benefits generated through a forestry project or as cost in case of deforestation (and therefore avoided cost if deforestation is avoided). Aesthetic, cultural and spiritual values are non-use values of the public type which also fall into this category.

Watershed protection
Watershed protection is a key determinant of soil and water conservation, yielding local, national and transnational benefits. Forest management or a reforestation/afforestation project may provide many positive externalities in the form of: a) reduced soil siltation, resulting in decreased on-site and off-site sedimentation; and b) decreased water run-off which could otherwise lead to localised flooding and could have critical consequences for downstream fisheries and reservoirs. The literature usually suggests using costs of mitigation, reparation and watershed rehabilitation as a basis for assessing externalities and spillover effects (Kengen, 1997; Andersen, 1997). These costs give a surrogate measure for estimating the value of the protective forest function. In a study conducted by McGinnis (1995) in a Colombian river basin, a rough value of about US$ 3 per hectare per year was assessed. However, it must be stressed that such estimates are site-specific. Some of the above-mentioned effects can also be valued in terms of the effects on production or of preventive expenditure methods, e.g. in terms of crop yield *gains* due to reduction of damage from sedimentation, flooding or dry season water shortages; or conversely, to crop productivity *losses* due to sedimentation, flooding, water shortage, reduced evapotranspiration and so forth.

Agricultural productivity enhancement (increased crop production, etc.)
Agricultural productivity can increase due to positive externalities associated with good forest management, such as watershed, soil and flood protection, nutrient cycling and soil fertility.

[26] In this respect, tourism is not a benefit in itself but becomes a cost in the case that access to the forest is denied.
[27] Although they may have imposed a restriction on forest use which represents an opportunity cost.

Productivity can be reaped as an indirect private benefit and it is valued on the basis of the increased crop production at crop market prices (usually a farmgate price is considered), but it can also be a direct on-site private benefit when the project involves agroforestry or agricultural activities as previously discussed. To assess the correspondent value, market prices may be applied to the increased production.

Nutrient cycling
The relationship among forests, atmospheric moisture and water yield has always been quite controversial (FAO, 2003). During the 1980s, Lee noted a coincidence between forest cover and higher precipitation which led to the conclusion that forests attract rain, although this does not hold at a global level (Calder, 1999). Fearnside (1995) observed that the leaf area is roughly proportional to evapotranspiration and therefore is directly connected to water recycling, precipitation and water recharge. Thus, reforestation or sustainable forest management can lead to increased hydrological cycling, evaporation, precipitation and recharge of groundwater and water courses which, in turn, can avoid dry seasons and entail an increase in crop production while diminishing the possibility of drought problems that would kill many plants and trees of susceptible species. Here again, avoided costs of restoration, reparation or of agricultural production loss may be considered as estimates.

Biomass[28] and nutrients
Biomass above ground includes most of the soil and plant nutrients as well as a good quantity of carbon (Andersen, 1997). Reforestation or afforestation projects may lead to an increase of nutrients and carbon located in the biomass above ground.[29] The value of nutrients can be calculated in relation to the market price of fertilisers; in a study carried out in Brazil, Uhl, Bezerra and Martini (1993) estimated them at about US$ 3.480 per hectare. However, this value cannot simply be added on to other values, as its appropriation would mean the elimination of other values (Andersen, 1997). The amount of carbon stored in biomass can be also estimated and evaluated; as this is more of a global benefit, it is treated extensively in the following section.

Microclimate regulation
Rain forests, with their humid microclimate, provide natural protection against fire. The fire prevention service provided by forests has not yet been calculated, but it can be estimated considering the probability of wildfire on cleared land in comparison to an intact forest and the consequent loss in terms of all the products and services provided by forests. Assuming that in an intact forest the probability of fire is 0.2 percent per year, while on cleared land it is 2 percent per year, Andersen (1997) estimated a value of US$ 6 per hectare per year in Brazil.

Despite the fact that these environmental attributes may be highly significant, every one of them is controversial and site-specific as well as scale-specific. They are often extremely difficult to value and depend crucially on which land use alternatives are used for comparison (Angelsen and Wunder, 2003). Moreover, it is not easy to distinguish on-site and On-site public benefits and costs and thus attribute the correspondent value to the appropriate agent. This is in part because the interest of upland inhabitants may not coincide with that of downstream farmers: something that could be a benefit for upland inhabitants could be a cost for downstream farmers and thus considered as such in the analysis of downstream farmers. It is also frequently the case that political boundaries do not coincide with geographical ones.

---

[28] Biomass is all nonfossil organic materials that have an intrinsic chemical energy content. They include all water- and land-based vegetation and trees, or virgin biomass, and all waste biomass such as municipal solid waste (MSW), municipal biosolids (sewage) and animal wastes (manures), forestry and agricultural residues, and certain types of industrial wastes. Unlike fossil fuels, biomass is renewable in the sense that only a short period of time is needed to replace what is used as an energy resource.

[29] It must be kept in mind that a mature forest is in nutrient balance and therefore does not provide any nutrient recycling value to surrounding areas.

Two or more public administrations may make different decisions related to the same watershed or forest, thereby making the valuation process even more difficult. In the same forest different decisions could lead either to costs or benefits to be considered in the analysis of different administrators.

Furthermore, many of the derived benefits cannot be easily priced in the market place and there is uncertainty about timing of sedimentation and related events. In carrying out an economic analysis, it must be kept in mind that the role of the analyst is different from that of the researcher and that a cost or benefit must be included only if it would change significantly the final decision. To date, relatively few studies have been conducted on these values. While some of these valuation procedures sound quite speculative, when a project would have considerable impact (positive or negative) on one or more of the above-mentioned elements, it would be worth spending time and money to include their valuation in the analysis.

Aesthetic, cultural and spiritual values; education
The cultural, spiritual, religious and aesthetic values associated with a forest are particularly difficult to assess. One methodology that tries to ascribe monetary values to them is the Contingent Valuation Method (CVM), a common method used to assess non-use values. It does so through the elicitation of the Willingness to Pay (WTP) to conserve the forest,. Similarly, hedonic prices could be used to assess how much house-buyers are willing to pay for a good view or for being close to a forest/recreational area.

Global environmental benefits

As mentioned earlier, this category refers mainly to carbon sequestration and biodiversity conservation, whose importance at the global level has increased with the ratification of the Convention on Biological Diversity (CBD), the Kyoto Protocol and the establishment of the Global Environmental Facility (GEF),[30] which made a distinction between resources that provide benefits at the global level and those which generate benefits only of local or national concern.

Carbon sequestration
Given the great concern about climate change and the ability of forests to sequester from 20 to 100 times more carbon per unit area than croplands (Cielsa, 1995), carbon sequestration has become one of the most important externality values of a forest (Gregersen, 1996).

Many efforts have been made to value forests as a source of carbon sinks and for their contribution to reducing global warming. Developing countries can benefit from the provision of this service through the CDM or other similar mechanisms such as the Biocarbon Fund or GEF or private sector Joint Implementation (JI) schemes which operate under the principle that emission trading allows the achievement of a given mitigation target at the lowest cost while promoting sustainable development. Carbon offsets from reforestation and afforestation projects[31] can be sold to those whose carbon emissions are constrained as a result of policy decisions to limit global carbon emissions. Rich countries can buy credits from poor countries for green political purposes, while poor countries gain in terms of project development, money and compensation for the limited access to forests for other land use.

[30] See note 19 above
[31] Yet, in October 2003, immediately preceding the 9th session of the United Nations Framework Convention on Climate Change, forestry activities under the CDM are limited to reforestation and afforestation, while activities to reduce deforestation are not included. The same approach is valid for the Biocarbon Fund and most JI schemes.

One condition for the success of trading carbon credits is the ability to measure or estimate the amount of carbon actually sequestered under different forest systems and land management, while the other condition is the economic value per tonne of carbon released to the atmosphere (Dumansky, Von Grebmer and Pieri, 1998). Several methods are available to estimate the quantity of carbon stored in forests, such as extrapolation from experimental plots or modelling from inventory data. Meanwhile, criteria to consider when selecting and assessing carbon sequestration are the type of project, the size of the forest, forest age, the type of trees, the way they are used afterwards, the geographical area where forest is harvested and so on. These different approaches and criteria used in analysis generally give different figures. However, while the valuation process is site-specific, the value itself is completely interchangeable, since one atom of carbon stocked in the Amazon forest is exactly like one atom stored in a Malaysian forest (Fearnside, 1997).

The Total Economic Value of carbon sequestration can be obtained from estimates of discounted costs and benefits of CO_2 emissions. However, as the future environmental impact of global warming is difficult to predict, such costs are inevitably speculative. Nordhaus (1992) recommends a marginal economic cost of US$ 5 per tC. On the other hand, Fankhauser (1995), who tried to account for the intrinsic uncertainties in climate change impacts by including random variables into key variables such as damage functions and discount rates, derived a central estimate of US$ 20 per tC.

In considering all the methods and estimates developed over the years, the economic value per ton of sequestered carbon has been estimated with values that range from US$ 5 to US$ 125 per tC. Obviously, emerging markets for carbon are a concrete guide for value; they also provide opportunities for not only demonstrating the value, but also capturing it. With regard to the developing CDM market, there is still considerable uncertainty over the final form the CDM will take and how land-use-based sequestering changes will be treated. The Marrakech Accords established a CDM board which is developing guidelines and best practices. Meanwhile, there is considerable interest in harnessing carbon credits to promote sustainable agricultural development. Over 30 carbon-offsetting land use change projects have been developed on a bilateral payment basis, although it is still unclear whether they will qualify for CDM-based credits (Nasi, Wunder and Campos, 2002; Bass *et al.,* 1999).[32]

The latest estimates of the CDM market take into account a great drop in the demand as compared to what was originally envisioned, due to the withdrawal of the United States from the Kyoto Protocol, a move which entails a loss in potential demand of between 40 and 55 percent. The consequent potential reduction in carbon emission reduction credits (CERs) is expected to be up to approximately 70 percent (Black-Arbelaez, 2002). Another major issue which could reduce the demand for CERs is the degree to which Russia will enter the market as a supplier and at which time. A full-scale and immediate entrance of Russia into the market could drive market prices down by a third (Black-Arbelaez, 2002) leading prices for CERs to drop as low as US$ 3.60 per tonne of carbon. The most recent developments of the emerging CDM market indicate figure from US$ 5 per tonne of carbon up to US$ 15 per tonne of carbon sequestered, with a central figure of US$ 10 per tonne. Considering that the market for carbon offset is strongly emerging and that connected prices are roughly defined, it is certainly advisable to include carbon values in the analysis of forest resources.

[32] These include some projects which specifically target smallholders and limited-income producers. The Scolel Té Project in Chiapas, Mexico is one such example, as is the Profafor project in Ecuador and the TIST project in Tanzania, both of which involve smallholder provision of forestry emission credits. For further details see Lipper and Cavatassi (2002).

Biodiversity conservation

"Biological diversity" (biodiversity) is an umbrella term used to express the number, variety and variability of living organisms, thereby embracing "life on earth". Declines in biodiversity include all those changes that will reduce or simplify biological heterogeneity, between individuals or regions. Maintenance of biodiversity is an environmental service for which many beneficiaries around the world might be willing to pay, but its measurement is perhaps the most challenging issue in the context of economic valuation.

The greatest difficulty in attributing value to biodiversity conservation is due to its many components: in addition to the supply of direct benefits, such as the stock of genetic material and nutrients for plants and animals needed to forest management and agricultural systems, the benefit of biodiversity arises from its option and existence value. Biodiversity is a stock of resources for current uses but also for future potential uses in medicine, agriculture or genetic engineering applications. Therefore, in addition to a high degree of uncertainty about the current possibilities of its uses, the value of its potential for future uses is difficult to measure and so despite its importance it is very underestimated. While it is clear that biodiversity is very valuable, the lack of willingness to pay for its preservation is a limiting factor on how much of its value can be translated into monetary flow.

In trying to place a value on biodiversity conservation, direct use values, option and existence values should all be considered. With regard to direct use values, since many of the goods and services directly provided by the forest for current use are either sold or used in support of the production of other goods and services, they might be valued by investigating particular markets (and this has been done in part in attributing value to some forest products previously highlighted).

Pharmaceutical applications present a special case, as market value understates the true WTP and some correction has to be applied. CSERGE (1993) reported that about 250 plant species are used for medical purposes in the West, with approximately 120 pharmaceuticals being based on plant substances, and that over a quarter of the United States prescriptions are plant-based. At 1990 prices the estimated prescription value was about US$ 50 billion. However, market prices understate the true willingness to pay for drugs since the value of lives that could be saved is greater than the market value of pharmaceuticals. Multiplying the number of lives saved through these plant-based medicines by the value of a statistical life, part of the consumer surplus not incorporated into the previous value can be valued and included. For a statistical life an average value of US$1 million can be assumed (Pearce, l993; Cline, 1992), taking into account the average number of lives saved.[33] Once all the costs of production are subtracted, and considering the loss of value of 1 percent deforestation, a marginal value of US$ 0.77 per hectare per year is found (Pearce, 1993; CSERGE, 1993).[34]

To the market value of pharmaceutical products derived from plants and forest products must be added the option value connected to the likelihood of discovering new species of plants which can become sources of new medicines to fight illness. A major issue in measuring the option value of biodiversity is linked to the probability of finding something valuable to use, but also the degree to which this can be substituted with other products either wild or chemical. Repetto (1990) claims that less than one percent of all tropical plant species have been screened for potentially useful medical properties. However, according to Simpson, Sedjio and Reid (1996), because of the high degree of substitutability between various life

[33] Pearce (1993) considered about 126 000 lives saved.

[33] This implies a net present direct use value of biodiversity of about US$ 40 per hectare at the 2 percent discount rate, and US$ l3 per hectare at the 6 percent rate. Notice that this value will increase dramatically with a deforested area. At around 25 percent deforestation, the net present direct use values of biodiversity will have increased to US$ 4 800 per hectare (with a 2 percent discount rate), and at around 50 percent deforestation it will be approximately US$ 265 000 per hectare.

forms and of the low probability of finding a useful application for newly discovered plants, the value of biodiversity, at the margin, is almost zero.

In other words, the value of the "marginal" species is the contribution provided by an additional species to the probability that researchers find what they are looking for. In addition, within the infinite set of living organisms many species are likely to be adequate substitutes as "leads" for potential commercial products, since each represents a research opportunity and substitutes another because resources required for researching one could not be devoted to another (Simpson, 1997). Therefore the value of the marginal species is close to zero.

In opposition, Rausser and Small (2000) demonstrate that this theory holds true only in the "degenerate" case in which no prior information is available. They argue that scientific research efforts are based on leads for which the expected productivity of discoveries is highest and with technologies and new discoveries to lower the search costs, the bioprospecting[35] value of certain genetic resources could be large enough to support market-based conservation of biodiversity. Conversely, Randall (1991), Principe (1991) and Winpenny (1992) claim that emerging technologies of bioengineering will lessen the interest of pharmaceutical industries in plant- based genetic material, as it will be more often produced synthetically in the laboratory.

Others have tried to measure the option value of biodiversity through empirical work based on sometimes very speculative assumptions. For example, Principe (1991) and Pearce (1993) assumed that the probability of a specified plant species giving rise to a successful drug falls between 10^{-3} and 10^{-4}. Taking a mean value of $0.5*10^{-4}$, using the same assumptions as in the previous section, and the expected extinction of about 60 000 plant species in the next 50 years (CSERGE, 1993) the resulting value will be US$ 30 per hectare per year (Andersen, 1997).

Apart from expectations of drug discovery and genetic pools for agriculture, biological diversity conservation has been advocated also largely on the basis of its existence value, assessed through asking people how much are they willing to pay to conserve the forest intact regardless of whether they are going to make use of it. Excluding all the controversies around the use of CVM that are not addressed here, some guesstimates of the existence values based on studies for other endangered species and natural assets are presented. Pearce (1991) proposes a conservative average figure of US$ 6.4 per hectare per year, taking into account that the existence value may not be as high for the first hectares to be removed. Because most people are not familiar with the uniqueness of each single hectare, an existence value per hectare close to zero at relatively low levels of deforestation, but exponentially increasing with the level of deforestation, is considered. Cartwright (1985) made a different attempt to value biodiversity on the basis of the opportunity cost of avoiding deforestation and came out with a total value of US$ 20 per hectare per year as the amount needed to convince tropical countries to enter into agreements for biodiversity maintenance.

From the previous discussion it seems quite clear that measuring biodiversity is a very difficult task requiring time and resources and based on assumptions that make the estimated results subjective and speculative. Moreover, an inclusion of all values will make the forest appear astronomically valuable, impeding people's use of it. This leads also to ethical

35 Scientific research that looks for a useful application, process or product in nature. In many cases, bioprospecting is a search for useful organic compounds in microorganisms, plants and fungi that grow in extreme environments, such as rainforests, deserts and hot springs (NPS, 2002).

concerns, especially in a developing-country context where people who are struggling to survive will bear the cost of denied access to the forest, while rich countries reap most of the benefits.

In summary, while inclusion of biodiversity values is difficult and speculative and the necessary data are often lacking, it is important to consider, especially when biodiversity conservation is one focus of the project or when the project generates significant impacts on biodiversity.

APPLYING ECONOMIC ANALYSIS TO FOREST VALUES

Once all forest values have been identified and classified and a value has been attributed to them, the economic analysis may be carried out. A forest can be used in many different ways: for commercial timber extraction, converted to agriculture, for traditional subsistence activities such as agroforestry or extraction of NTFPs or protected as a national park, a wildlife sanctuary or a protected area (IIED, 1994). Each use can produce some on-site private, on-site public and global benefits, but obviously some trade-off between those benefits and the consequent opportunity costs for benefits foregone should also be considered.

For example, if the forest is cleared for agriculture, the evaluation process should consider the *direct costs* of conversion (clearing and burning the forest and establishing crops) but also the *foregone values* of the forest that has been converted, such as the value of the important environmental functions lost (watershed protection, micro-climate maintenance and biodiversity) as well as the value of resources lost (e.g. commercial hardwoods, non-timber products and wildlife).

On the other hand, forest preservation produces on-site private benefits (tourism and recreation), on-site public benefits (watershed protection, soil and fire prevention) and global benefits (carbon sequestration and biodiversity conservation). In addition to the direct costs of preservation such as for setting up a protected area and paying forest guards or perhaps rangers to protect and maintain the area, development options – such as the use of the forest for commercial timber exploitation or conversion of forest land to agriculture, mining or hydroelectric power generation – are sacrificed. Moreover, local people may find access to the forest denied, even for traditional agricultural practices. These foregone development benefits are therefore additional costs associated with the preservation option. The decision of what land use option to engage for a given forest area can only be made if all the gains and losses associated with each land use option are properly evaluated (Bann, 1997; Lipper and Cavatassi, 2002).

Ideally, all the benefits and costs associated with each land use option should be estimated. However, the analyst's ability to estimate environmental values is constrained by data limitations, finances, time and skills. Thus it is extremely important, when designing an analysis where data are scarce and costly to obtain, to identify the potentially important environmental benefits. The aim of the assessment is to provide the best information possible to aid decision-making. It is, therefore, crucial to judge the relative importance of the different value components and to determine the cost-effectiveness of getting 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, giving priority to estimating value components with the highest ranking. There may be constraints impeding or obstructing the valuation of important components. Resource and data limitations will influence the choice of valuation technique selected. Proper valuation of forest goods and services depends on reliable information and data, whether quantitative, qualitative, scientific and/or socio-economic. Lack of basic and consistent scientific information on many aspects of forest production, excluding timber, is among the principal barriers to accurate forest valuation (Kengen, 1997a). The main constraints and deficiencies of resource valuations are connected to methodological difficulties, the high costs of undertaking full resource valuation, their minor role in actual resource-allocation decisions and indirect or opportunity costs of diverting policy research and development from other determinants of sustainable forest management such as land tenure.

In performing a CBA, each analyst should first undertake an *ex-ante* analysis regarding which aspects should be included. The analyst should first consider the type of project to be evaluated, the main objectives and the main impacts (positive or negative) produced by the project, as well as opportunity costs and alternatives foregone. All values connected to these elements must then be included in the evaluation, in accordance with data availability and analysis feasibility, without using exaggerated speculation. When the project is not feasible, the analyst should consider whether inclusion of the concerned values would make a difference to the final decision. If so, time and money should be devoted to getting the necessary data, or alternatively a detailed qualitative descriptive assessment should be undertaken and presented along with justification of why the concerned value was not included in the analysis.

The following section will provide a summary of *ex post* evaluation analysis applied to five projects carried out by the FAO Investment Centre Division, which attempted to include and value some non-market benefits like carbon sequestration and some on-site public benefits.

CASE STUDIES

The FAO Investment Centre works closely with donors in the identification, preparation and evaluation of investment projects in forestry, agriculture and rural development. As part of its regular work with the World Bank, the Asia and Pacific Service of the Investment Centre has been involved in the evaluation of completed World Bank forestry projects, some of which are reported here thanks to the availability of Implementation Completion Reports (ICRs). Attempts have been made in these analyses to quantify and incorporate the economic value of "environmental benefits" in order to evaluate the nature and magnitude of the main benefits, assessing their impact on the economic viability and drawing conclusions about how investment decisions could be improved in view of these environmental benefits.

Three of the projects presented here were implemented in India (hereafter referred to as Maharastra; Gujarat, Orissa and Rajasthan; Andhra Pradesh), one in Nepal and one in the Philippines. While focusing on biodiversity conservation and productivity of forests and wastelands, their main aim was to slow environmental degradation through the establishment of significant plantation areas, the rehabilitation of degraded forests and the establishment of vegetative cover on waste and community lands. The projects were implemented through a menu of land treatments, emphasising soil and moisture conservation and introducing more sustainable land management systems, including seeking long-term, community-based management solutions for public non-arable lands. One of the projects (Gujarat, Orissa and Rajasthan) also involved many kinds of agroforestry activities.

The measure used in the economic analysis of the projects and reported in the ICRs is the Estimated Rate of Return (ERR), which is the preferred measure of the World Bank analysts because it is expressed in percentage terms and does not depend on any monetary unit. Thus it is comparable across different projects and different countries and years. The ERR is certainly a useful summary statistic to present the result of analysis, but an analyst should be aware of its limitations in making decisions, as highlighted in Section 2 of this paper. The ERRs of the projects here reported have been undertaken at the aggregate level, summing up all the incremental benefits and costs. All project financial costs and benefits have been included in the stream for calculation, but for the economic valuation they needed to be revised to correct for any market and policy failures in order to better reflect the opportunity costs of resource use to society and any distributional objectives.

In the projects reported here, parity prices for major tradable goods have been calculated on the basis of price projections made by the World Bank. All prices were converted into 1999 or 2000 prices. A Standard Conversion Factor (SCF) of 0.9[36] was applied to non-tradable items. Assumptions had to be made regarding the "without-project" situation in order to compare it with the "with-project" situation, as did estimates of increased production and its incremental rate and opportunity costs of labour. A more detailed report of each project and the assumptions made is available in the appendix.

Below are attempts at the quantification of forest values. For some of the projects an attempt was made to quantify benefits from the harvesting of non-timber forest products and environmental benefits, including carbon sequestration, and reduced erosion/flooding resulting from improved forest quality. Consequently the ERR was first determined using just direct on-site private benefits. On-site public and global benefits were added at a later stage to determine their contribution to the economic value of the projects.

[36] The World Bank provides index as well as opportunity cost of the capital and the Standard Conversion Factor for each country in which the project is based and analyses must be carried out UNCLEAR. For more details see Section 2, Box 1.

On-site private benefits

Maharastra
The project developed and/or rehabilitated about 330 000 ha over the project period, increasing the production of timber, poles, fuelwood and fodder. This increased production was estimated by using 16 forest plantation models. Models included all physical input and output over the period of 30 years (the rotation period of plantation). Incremental production of timber, poles, fuelwood and fodder was estimated by aggregating all forest models with corresponding areas planted over the project period.

Regarding the increased availability and collection of NTFPs, such as fruits, medicinal plants and mushrooms, the analysis assumed conservatively that an incremental benefit of US$ 2 per hectare per year was produced. This was based on reports of some villages in the project area, since there was little data available on the quantity of NTFPs collected.

Apparently lack of data did not permit systematic quantification of agricultural benefits, although positive impacts on agricultural and livestock production – such as increases in crop yields and cropping intensities and shifts in cropping patterns towards more high-value crops – were evident in some areas and more effort should probably have been devoted to gathering additional data.

The ERR, calculated taking into account only on-site benefits, was estimated to be 6.9 percent.

Gujarat, Orissa and Rajasthan
On-site private benefits resulted from three main activities: establishing new pasture areas, silvi-pasture, and mixed forest plantations (multi-tier canopy). Products generated from these activities included timber, fuelwood, and NTFPs such as gum and fodder. Depending on the type of crop models formulated to capture the benefits and costs of these activities, their incidence to the overall direct benefits of the projects was about 11 percent to 27 percent.

Increased fodder availability, combined with project intervention in animal husbandry, would have a beneficial impact on livestock production, most importantly on milk production. However, to represent the benefit to the animal husbandry component only the value of fodder production was used, since systematic data on increased milk production were not available.

A positive impact of the project on rainfed crop yields was estimated on the order of 10 percent over the without-project situation. The total area benefiting from farm forestry was 64 105 hectares over the project period. The ERR was measured at around 13.5 percent, considering all the on-site private benefits described here.

Philippines
The report states that financial and economic evaluation analysis was not considered applicable owing to lack of data. However, the mission considered it useful to provide an indication of the financial viability of activities supported by the project as a key determinant of sustainability and replicability.

Based on data provided by the Project Management Office (PMO) and information collected in the field and in interviews with farmers, one-hectare models of a typical reforestation site and an agroforestry model farm were developed. The elaborated models indicated that both activities would be viable and attractive for farmers even in the absence of subsidy payments.

Reforestation activities, based on *Gemelina arborea,* gave an astonishing ERR of 43 percent. In order to assess returns to typical on-farm activities, a one-hectare model farm cultivating eucalyptus, fruit trees and cash crops was analysed, generating a rate of return of 48 percent.

Nepal
Direct benefits were quantified in terms of per-hectare offtake of poles and timber, fuelwood, leaf, grass fodder and leaf litter. Incremental production was derived based on those parameters. The annual value of NTFPs in Nepal was estimated at roughly US$ 2 per hectare (Knowler and Canby, 1998). This estimate was based on the value of annual exports of NTFPs, divided by Nepal's forest area. This project's analysis assumed that the annual incremental value of NTFPs is US$ 1 (NRs60) in Years 1–10, and US$ 2 thereafter; the without-project continuation of open access would significantly reduce opportunities for harvesting NTFPs.

On-site private benefits resulted in an ERR of 14 percent.

Andhra Pradesh
On-site private benefits included incremental production of timber, poles, fuelwood, fodder, forest fruits, bamboo, a variety of horticultural products for household consumption and several NTFPs. The aggregate production arising from treatment practices was measured for the first 20 years for bamboo, eucalyptus and other fast-growing species, and 30 years for hardwood species based on 17 forestry treatment practices models. The ERR calculated with the inclusion of on-site private values was 22 percent.

On-site private benefits included in the calculation produced the following ERR:

	Maharastra	**Gujarat, Orissa and Rajasthan**	**Philippines**	**Nepal**	**Andhra Pradesh**
ERR with only on-site private benefits	6.90%	13.50%	Reforestation 43% Agroforestry 47.6%	14%	22%

On-site public benefits

In the Maharastra and Andhra Pradesh projects, on-site public benefits were not included in the analyses, although conserving biodiversity and slowing environmental degradation were considered to be the main objectives of the projects.

Gujarat, Orissa and Rajasthan
It was assumed that 0.5 percent of production would be saved through project intervention compared to the non-project situation, thanks to prevention of soil erosion, reduction of water run-off, reduction in soil-loss, improvement in soil fertility and rise in the groundwater table. Therefore the avoided damage cost estimate was used for estimating these benefits, while the agricultural production enhancement (also included in the analysis) was estimated on the basis of market prices of increased crop production.

Philippines
A more detailed analysis was carried out to assess benefits but it was based more on assumptions rather than on actual data available:

– Irrigation system estimates were based on the loss of value of production from a reduction in irrigable area owing to soil erosion/sedimentation in terms of gross value added (GVA) from *palay* production.

– Dam system estimates were calculated on the basis of the total cost of damages from sedimentation owing to the decrease in service life on amortised capital cost of the four reservoirs most affected by sedimentation problems.

– Fishery benefit estimates employed a survey analysis which considered the benefits of a regeneration of fishery yields resulting from reduced upstream soil erosion, offering fish at discounted prices to upstream farmers in compensation for their application of agroforestry practices. This estimate reflected a lower boundary of the willingness to pay to avoid soil erosion upstream in order to protect downstream fishery resources.

Nepal
Reduction in downstream sedimentation, flooding and landslides, as well as the regulation of water flow, were considered in the analysis undertaken. A conservative estimate of US$ 2 per hectare per year was assumed on the basis of previous empirical analyses and examples rather than on a more direct analysis and investigation.

None of the project analyses included any values relating to the spiritual, cultural or aesthetic aspects of the projects. In some cases they were included in the general descriptive and qualitative consideration of positive benefits.

The inclusion of on-site public benefits did not make a big difference in the determination of the ERR, and they were included in only three of the five projects reported. The comparison is as follows:

	Maharastra	Gujarat, Orissa and Rajasthan	Philippines	Nepal	Andhra Pradesh
ERR with only on-site private benefits	6.90%	13.50%	Reforestation 43% Agroforestry 47.6%	14%	22%
ERR including On-site public benefits	Not available	14%	Reforestation 43.4% Agroforestry 47.8%	17%	Not available

Global environmental benefits

Carbon sequestration

Maharastra
The capacity of forests to fix carbon was assumed at 4 tonnes of carbon per hectare per year, based on the incremental production of poles and timber. The valuation of carbon is a controversial issue, and various values have been quoted and estimated. For this analysis, a figure of US$ 10 per ton was adopted.

Gujarat, Orissa and Rajasthan
Carbon sequestration was not taken into account, even though necessary data was available or could have been gathered through the project.

Philippines
Carbon sequestration benefits assumed an estimate of US$ 24/tC and incremental carbon sequestration of 3 tC/ha/yr and of 3.4 tC/ha/yr as a result of the adoption of agroforestry and reforestation practices, respectively. The sequestration figure for reforestation was adjusted to 2.7 tC/ha/yr reflecting the assumption that only 80 percent of the harvested wood would be used for poles or timber.

Nepal
Estimates of the capacity of forests to fix carbon were based on the incremental production of poles and timber in actively-managed natural forests. Yield figures from the "managed scenario" applied also to the "protected scenario" because while less timber is harvested from protected forest, the carbon is fixed in the unharvested trees. It was assumed in this analysis that 0.2 tons of carbon was fixed per ton of poles and timber produced (which is equivalent to 0.73 ton of carbon dioxide). This analysis applied a value estimate of US$ 20 per tonne.

Andhra Pradesh
It was assumed that the carbon sequestration effect would be built up in eight years: starting from year eight the forestry treated would sequester carbon at an annual rate of 4 tonnes per hectare, and the value placed on sequestered carbon was estimated at US$ 10 per tonne.

The amount of estimated carbon sequestered was linked to type of forests and their utilisation. The estimated economic value ranges from US$ 10–24 per tonne; but in order to make the values comparable in the following calculation of the ERR, a value of US$ 10 was applied, showing a significant difference in the determination of the ERR:

	Maharastra	**Gujarat, Orissa and Rajasthan**	**Philippines**	**Nepal**	**Andhra Pradesh**
ERR with only on-site private benefits	7%	13.5%	Reforestation 43% Agroforestry 48%	14%	22%
ERR including On-site public benefits	Not available	14%	Reforestation 43% Agroforestry 48%	17%	Not available
ERR with GEB valued at US$ 10 per tonne	10%	Not applicable	Reforestation 53% Agroforestry 52%	18%	29%

Biodiversity conservation
Despite the fact that biodiversity conservation was described as one of the main objectives in more than one of the projects analysed, its evaluation was not taken into account in any of them. This was probably due to difficulties estimating this type of benefit, as highlighted in the previous section of this paper. It could also be that given that it is the national government that undertakes the investment (e.g. takes the loan) for this type of project, it is only the costs and benefits accruing at a national level that are of interest to them. The considerations conveyed in the reports are:

Maharastra
By its nature, this project had multiple positive impacts on the environment, including improved biodiversity. However, most of the benefits were either already reflected in other forms of benefits, such as increased production, or were not possible to quantify.

Gujarat, Orissa and Rajasthan
Global environmental benefits such as carbon sequestration or increased biodiversity conservation were not taken into account.

Philippines
The assumption was that because most reforestation activities promote exotic species, biodiversity benefits should not be considered significant to the project.

Nepal
Biodiversity conservation was not addressed at all.

Andhra Pradesh
The estimates considered only potential gains from incremental carbon sequestration, although conservation of biodiversity was an achieved objective.

Not surprisingly, on-site private benefits resulted the most substantial in determining the ERR of the projects. Although all the projects had environmental objectives as main goals, only in a few of them were the forests' ecological functions considered in the analysis, mainly by gathering data from the literature or from previous studies (considered "conservative", as in the case of Nepal). Agricultural benefits were not sufficiently considered in the analysis, whether direct (i.e. the projects involved agricultural activities), or indirect (as in the case of Maharastra and Gujarat, Orissa and Rajasthan). While the on-site public benefits did not make a considerable difference in the determination of the ERR, the way they were calculated does not allow for reaching a conclusion about the worthiness of their inclusion.

With regard to the impacts of global environmental goods, carbon sequestration has been demonstrated to significantly influence the ERR of the projects, while the measurement of biodiversity conservation turned out not to be cost effective. In cases where it was considered to be one of the main objectives of the project, a more detailed justification of its exclusion would have been required. In these cases an *ex-ante* CBA describing the values to be included or excluded in the analysis, along with a justification for excluding certain ones, would have been helpful in reaching a more objective conclusion. A final point worth mentioning here is that lack of data in the Philippines case meant that the ERR was calculated on the basis of assumptions and other information, leading to a suspiciously high result. This would suggest that whenever possible it is advisable to gather actual data and avoid insofar as possible guesstimates or speculative assumptions.

CONCLUSIONS

This paper has attempted to describe and scrutinise procedures and techniques applied in the economic analysis of forestry and agro-forestry investment projects with the aim of investigating how a wide range of forest values have been, or could be, included in the analysis of investment projects. This was done bearing in mind that there may be no absolute right set of values for the goods and services forests provide, particularly when dealing with non-market transactions. The well-off environmentalist in the city, the shifting cultivator whose survival depends upon the forest and the commercial logger may each have a different set of values (Gregersen, 1996; Shabman and Stephenson, 1997). The most challenging issue in estimating the value of forest projects is that most of the outcomes have at least a partially public nature not subject to market transactions which would assign them value. Forest management produces many externalities and market failures. Attempts to assess the full value of various management options usually requires non-market valuation techniques.

In order to understand the evaluation process, a description of the purpose and methods used in economic analysis was presented, followed by a detailed categorization of forest products distinguished on the basis of the nature of the good or service produced and the recipient of this value. Goods are categorized into direct, indirect, option and non-use values, which can be distributed as on-site private, on-site public and global values. On-site private values are quite straightforward to identify and to include in the evaluation process, as they are comprised of mostly direct values for which direct or indirect market estimates are applicable. However the inclusion of on-site public and global benefits is more complicated and requires the adoption of one or more valuation techniques, described in the text.

To complement the analysis, the paper reported a summary of *ex post* evaluation of five projects implemented by FAO Investment Centre in collaboration with the World Bank in order to show how analysis is carried out in practice, to identify gaps in the procedure and to extract important lessons on how environmental values are, or are not, actually integrated in the analysis.

The analysis revealed that the main determinants of economic viability of forestry projects are on-site private benefits deriving from the increased production of timber, fuelwood, fodder and non-timber forest products, despite the fact that the latter were not always assessed or disentangled from the estimate, while traditional environmental services such as impact on flood regimes, soil fertility etc., tend to be negligible. Whether this is due to the benefits being small or rather to the difficulty or high cost of their assessment is difficult to attain. In the projects reviewed, they did not make a major difference in the determination of the ERR, but the data collected and estimates done were not sufficient for a full accounting of the values of on-site public benefits. These values were included in only three out of five projects reviewed, one of which used a "conservative" estimate gathered from previous studies.

Benefits associated with the enhancement of agricultural production can be either direct on-site private, when the project involves agro-forestry activities or other on-farm activities, or on-site public when the enhancement is obtained through soil protection, maintenance of nutrients, watershed protection, etc. However, in the analyses considered here, they were always considered as on-site private benefits and assessed through the market value attributed to increased production involved. No effort was made to assess the value of externality impacts associated with on-site public benefits. In contrast, global environmental benefits arising from carbon sequestration resulted in large benefits and had a substantial impact on the economic rates of return. Biodiversity benefits accruing from the project were not included in the analyses, despite the fact that its conservation was claimed to be a primary objective of many of the projects. Biodiversity and its conservation is actually the most difficult good to assess in the economic valuation of forestry. It involves not only direct benefits connected to species of plants and other organisms actually used, but also to the option values associated with maintaining the possibility of discovering other "useful commercial" species in the future and to the existence value of the mere preservation of the forest.

Calculating the impacts of forest management options on the generation of global environmental goods is useful in order to form an idea of the level of transfer payments that would be required to induce their provision. Where markets are already evolving, as is the case with carbon sequestration, then the potential values can be included even in the financial analysis. For goods for which no markets currently exist and which are difficult to value, such as biodiversity, the inclusion of valuation into the economic analysis will be less likely, and where included, the impacts on the economic analysis may be controversial. It is important to consider these values despite the difficulty of doing so, particularly where a project may lead to their irreversible loss. It is also important to keep in mind that it is those local populations who rely upon forests as a livelihood source that will bear the costs of generating global goods and services if this involves limiting access and constraining use rights. Under such conditions, valuation could have the function of supplying a rational basis for estimating the amount of international transfer payments needed to compensate those communities that are conserving forests beyond their own needs for the benefit of the global community (Kengen, 1997(a)).

In many cases the analysis presented here showed that some values were neglected because of scarcity of data. Certainly the data to be collected must depend on the priority of each value and the type, objectives and impacts of each project. The information needed by the policy-maker or decision-maker must be clearly defined at an early stage as some complex valuation techniques can produce more information that can be usefully applied to the decision at hand. It is important that of all the methodologies and techniques that can be applied, the ones selected produce the kind of information needed to achieve the valuation objectives, within the budget and time available. When time and money restraints impede data collection, attempts should be made to provide at least a detailed qualitative descriptive assessment of all relevant values. The price of neglecting significant forest values and their impact is higher still – for everyone from local communities to the global population.

REFERENCES

Abelson, P. 1979. *Cost–benefit analysis and environmental problems*. South Wales, Saxon House.

Adams, J. 1993. The emperor's old clothes: The curious comeback of cost benefit analysis. *Environmental Values*, 2(3): 247–260.

Adger, W.N., Brown, K., Cervigni, R. & Moran, D. 1995. Total economic value of forests in Mexico. *Ambio,* 24(5): 286–296 (August).

Andersen, L.E. 1997. *A cost–benefit analysis of deforestation in the Brazilian Amazon.* Discussion Paper 455. Rio de Janeiro, IPEA/DIPES (available at http://www.ipea.gov.br/pub/ td/td0455.pdf).

Anderson, A., May, P. & Balick, M. 1991. *The subsidy from nature: Palm forests, peasantry, and development on an Amazon frontier.* New York: Columbia University Press.

Angelsen, A. & Wunder, S. 2003. *Exploring the forest–poverty link: Key concepts, issues and research implications.* CIFOR Occasional Paper No. 40. Bogor, Indonesia, Centre for International Forestry Research (CIFOR).

Arnold, J.E.M. 2001. *Forestry, poverty and aid.* CIFOR occasional paper No. 33. Bogor, Indonesia, CIFOR.

Ayres, W.S. & Dixon, J.A. 1995. *Economic and ecological benefits of reducing emissions of sulphur oxides in the Sostanj Region of Slovenia.* Environment Department Paper No. 009. Washington, DC, World Bank.

Azar, A. & Sterner, T. 1996. Discounting and distributional considerations in the context of global warming. *Ecological Economics,* 19(2): 169–184.

Bann, C. 1997. *The economic valuation of tropical forest land use options: A manual for researchers.* Ottawa, Canada, International Development Research Centre.

Barbier, E., Burgess, J. & Folke, C. 1994. *Paradise lost: The ecological economics of biodivesity.* London, Earthscan.

Barbier, E. 1989. *The economic value of ecosystems: 1 – Tropical wetlands.* Gatekeeper Series No. LEEC 89–02. London, IIED.

Bass, S., Dubois, O., Ford, J., Moura–Costa, P., Pinard, M., Tipper, R. & Wilson, C. 1999. *Rural livelihoods and carbon management. An issue paper*. Report from the workshop on the implication of carbon offset policies for the rural poor and landless. Edinburgh, UK, 20–21 September 1999 (available at www.ecosecurities.com or www.ecce.uk.com).

Baum, W.C. & Tolbert, S.M. 1985. *Investing in development.* New York, Oxford University Press.

Baumol, W.J. & Oates, W.S. 1988. *The theory of environmental policy.* New York, Cambridge University Press (Second Edition).

Belli, P., Anderson, J., Barnum, H., Dixon, J. & Tan, J.P. 1997. *Handbook of economic analysis of investments operations.* Operation Policy Department Learning and Leadership Center. Washington DC, World Bank.

Bettencourt, S.U. 1992. *Economic valuation of forest and woodlands in sub–Saharan Africa*. (mimeo)

Black–Arbelaez. 2002. *Applying CDM to biological restoration projects in developing nations: Key issues for policy-makers and project managers.* A discussion paper prepared for the GEF (by the Andean Center for Economics in the Environment) for the Forestry Roundtable to be held in conjunction with the UNFF, New York, USA. 24 pp. (available at http://www.gefweb.org/documents.pdf).

Brealey, R.A. & Myers, S.C. 1988. *Principles of corporate finance.* New York, McGraw-Hill.

Broome, J. 1992. *Counting the cost of global warming.* Cambridge, UK, Cambridge University Press.

Brown, K. & Pearce, D.W., eds. 1994. *The causes of deforestation.* London, UCL Press.

Bruijnzeel, L.A. 1990. *Hydrology of moist tropical forests and effects of conversion: A state of the knowledge review.* Amsterdam, Netherlands Committee for International Hydrological Programme of Unesco.

Byron, R.N. & Arnold, J.E.M. 1999. What future for the people of the tropical forests? *World Development,* 27(5): 789–805.

Calder, I. R. 1999. *The blue revolution: Land use and water resources management.* London, Earthscan.

Campbell, B.M., Jeffrey, S., Luckert, M., Mutamba, M. & Zindi, C. 2002. *Household livelihoods in semi–arid regions: Options and constraints.* Bogor, Indonesia, CIFOR.

Carlson, G.E., Zilberman, D. & Miranowski, J. 1993. *Agricultural and environmental resource economics.* New York and Oxford, Oxford University Press.

Cartwright, J. 1985. The politics of preserving natural areas in Third World states. *The Environmentalist,* 5(3): 179–186.

Casoni, G. 1994. *Analisi della domanda ambientale.* Bologna, Italy, Società Editrice Esculapio Progetto Leonardo.

Cavendish, W. 2000. Empirical regularities in the poverty–environment relationship of rural households: Evidence from Zimbabwe. *World Development,* 28(11): 1979–2000.

Cavendish, W. 2002. Quantitative methods for estimating the economic value of resource use to rural households. *In*: B.M. Campbell & M. Luckert, eds. *Uncovering the hidden harvest: valuation methods for woodland and forest resources*, pp. 17–65. London, Earthscan.

Chopra, K. 1993. The value of non–timber forest products: An estimation for tropical deciduous forests in India. *Economic Botany,* 47(3): 251–257.

Cielsa, W.M. 1995. *Climate change, forests and forest management.* FAO Forestry paper 126. Rome, FAO.

Cline, W.R. 1992. *The economics of global warming*. Washington, DC, Institute for International Economics.

CSERGE (Centre for Social and Economic Research on the Global Environment). 1993. *Mexico forestry and conservation sector review: Sub-study of economic valuation of forests*. Report to the World Bank, Latin America and the Caribbean Country Department II (LA2). London, CSERGE.

Dixon, J.A., Scura, L.F., Carpenter, R.A. & Sherman, P.B. 1994. *Economic analysis of environmental impacts*. London, Earthscan.

Dumansky, J., Von Grebmer, K. & Pieri, C.J. 1998. *Opportunities in agriculture and forestry to mitigate greenhouse gases.* Working paper on a scientific consultation, St. Michaels, Maryland, December 3–5, 1998 (available at http://lnweb18.worldbank.org /essd/essd.nsf/0/6b54ff941e90cc4b852567f5005ab8bc/$FILE/carbon1.pdf).

Ekins, P. 2000. Costs, benefits and sustainability in decision–making, with special reference to global warming. *International Journal of Sustainable Development*, 3(4): 315–333.

Fankhauser, S. 1995. *Valuing climate change: The economics of the greenhouse*. London, Earthscan.

FAO (Food and Agriculture Organization of the United Nations). 1997. *State of the world's forests.* Rome.

FAO. 2003. *State of the world's forests.* Rome.

Fearnside, P. 1997. Environmental services as a strategy for sustainable development in rural Amazonia. *Ecological Economics*, 20(1): 53.

Fearnside, P.M. 1995. Potential impacts of climatic change on natural forests and forestry in Brazilian Amazonia. *Forest Ecology and Management***,** 78(1): 51.

Fisher, M. 2002. Household welfare in rural Malawi. Draft submitted to *Environment and Development Economics*, University of York, UK.

Gentry, A.H. & Blaney, C.L. 1990. Alternative to destruction: Using the biodiversity of tropical forests. *Western Midlands*, 16(Spring): 2–7.

Gittinger, J.P. 1982. *Economic analysis of agricultural projects.* Economic Development Institute (EDI) of the World Bank Series in Economic Development. Baltimore, Johns Hopkins University Press.

Godoy, R.A. & Feaw, T.C. 1989. The profitability of smallholder rattan cultivation in southern Borneo, Indonesia. *Human Ecology,* 17(3): 347–363.

Gregersen, H.M. 1996. *Economics for environmental and natural resources management.* Lecture notes for NRES 5–260. St. Paul, College of Natural Resources, University of Minnesota.

Gregersen, H.M., Arnold, J.E.M., Lundgren, A.L. & Contreras-Hermosilla, A. 1995. *Valuing forests: Context, issues and guidelines*. FAO Forestry Paper No. 127. Rome.

Gunatilleke, H.M, Senaratane, D.M.A.H. & Abeygunawardena, P. 1993. Role of non–timber forest products in the economy of peripheral communities of Knuckles National Wilderness Area of Sri Lanka: A farming systems approach. *Econ. Botany,* 47(3): 275–281.

Gupta, R., Banerji, P. & Guleria, A. 1982. *Tribal unrest and forestry management in Bihar.* CMA Monograph No. 98. Ahmedabad, India, Indian Institute of Management.

Hanley, N. & Spash, C. 1992. *Cost–benefit analysis and the environment.* Aldershot, UK, Edward Elgar.

Hearne, R.R. 1996. *A review of economic appraisal of environmental goods and services with a focus on developing countries*. The World Bank Environmental Economics Programme Discussion Paper No. DP96–03. Washington, DC, World Bank.

Heath, J. & Binswanger, H.P. 1998. Policy-induced effects of natural resource degradation: The case of Colombia. *In* E. Lutz, ed. *Agriculture and the environment: Perspectives on sustainable rural development*. Washington, DC, World Bank.

Hecht, S. & Cockburn, A. 1989. *Fate of the forest: Developers, destroyers and defenders of the Amazon*. London, Verso Editions.

IIED. 1994. *Economic evaluation of tropical forest land use options: A review of methodology and applications.* London, International Institute for Environment and Development, Environmental Economics Programme.

Instituto Brasileiro de Geografia e Estatística.1994. *Anuário estatístico do Brasil*. Rio de Janeiro, IBGE.

Jacobs, M. 1991. *The green economy: Environment, sustainable development and the politics of the future.* London, Pluto Press.

Johanssen, P. 1990.Valuing environmental damage. *Oxford Review on Econ. Policy,* 6(1): 34–50.

Kaimovitz, D. 2002. *Not by bread alone. Forest and rural livelihoods in sub–Saharan Africa*. Bogor, Indonesia, CIFOR.

Kaimowitz, D., Byron, N. & Sunderlin, W. 1998. Public policies to reduce inappropriate deforestation. *In* E. Lutz, ed. *Agriculture and the environment: Perspectives on sustainable rural development*. Washington, DC, World Bank.

Kelman, S. 1982. Cost–benefit analysis and environmental, safety, and health regulation: Ethical and philosophical considerations. *In* D. Swartzman, R.A. Liroff & K.G. Croke, eds. *Cost–benefit analysis and environmental regulations: Politics, ethics, and methods*, pp. 53–85. Washington, DC, The Conservation Foundation.

Kengen, S. 1997(a). *Forest valuation for decision–making: Lessons of experience and proposals for improvement.* Rome, FAO.

Kengen, S. 1997(b). Funding sustainable forestry: Linking forest valuation and financing. *Unasylva*, 48(1), Issue no. 188. Rome, FAO (available at http://www.fao.org/docrep /w3247e/w3247e00.htm).

Knowler, D. & Canby, K. 1998. *Land management in Nepal: Economics and ecology.* Draft Working Paper No. 2. Washington, DC, World Bank

Kumari, K. 1995. *An environmental and economic assessment of forest management options: A case study in Malaysia*. Environment Department Paper No. 026. Washington, DC, World Bank.

Lipper, L. & Cavatassi, R. 2002. Harvesting carbon sequestration through land–use change: A way out of rural poverty. *In* FAO, *The state of food and agriculture.* Rome, FAO.

Mallick, R.M. 2000. Sustainable management of non-timber forest products in Orissa: Some issues and options. *Indian Journal of Agri. Econ.*, 553: 384–398.

Markandya, A. & Pearce, D. 1991. Development, the environment, and the social rate of discount. *World Bank Research Observer*, 6(2): 197–152.

Markandya, A., Harou, P., Bellù, L.G. & Cistulli,V. 2002. *Environmental economics for sustainable growth. A handbook for practitioners.* Cheltenham, UK, Edward Elgar Publishing, Ltd.

McGinnis, M.V. 1995. On the verge of collapse: the Columbia river system, wild salmon and the Northwest Power Planning Council. *Natural Resources Journal,* 35(1): 520–552.

Michael, S.G. 1995. *Economic valuation of the multiple use of forests: The case of Bwindi Impenetrable National Park (BINP), Uganda.* University of Edinburgh, Scotland. (MSc dissertation)

Mukherjee, A.K. 1994. *India's forests: A status report. Concepts, definitions, trends, controversies*. Paper presented at the International Workshop on India's Forests Management and Ecological Revival. New Delhi, 10–12 February.

Munasinghe, M. & Lutz, E. 1993. Environmental economics and valuation in development decision-making. *In* M. Munasinghe, M., ed. *Environmental economics and natural resource management in developing countries,* pp. 17–45. Washington, DC, World Bank

Nasi, R., Wunder, S. & Campos, J.J. 2002. *Forest ecosystem services: Can they pay our way out of deforestation?* Discussion paper prepared for GEF for the Forestry Roundtable, New York, 11 March 2002 (available at www.gefweb.org/documents.pdf).

National Park Service. 2002. *What is bioprospecting?* US National Park Service (available at http://www.nature.nps.gov/benefitssharing/whatis.htm).

Neumann, R.P. & Hirsch, E. 2000. *Commercialisation of non-timber forest products: Review and analysis of research.* Bogor, Indonesia, CIFOR and Rome, FAO.

Neumayer, E. 1999. Global warming: Discounting is not the issue, but substitutability is. *Energy Policy,* 27(1): 33–43.

Nordhaus, D.W. 1992. An optimal transition path for controlling greenhouse gases. *Science*, 258: 1315–1319 (20 November).

Olsson, L. & Ardö, J. 2001. Soil carbon sequestration in degraded semiarid agro–ecosystems: Perils and potentials. *Ambio,* 31(1):1315-1319.

Pearce, D.W. 1991. Deforesting the Amazon: Toward an economic solution. *Ecodecision,* 1: 40–49.

Pearce, D.W. 1993. *Economic values and the natural world.* Cambridge, MA, MIT Press.

Pearce, D.W. 1995. *Blueprint 4: Capturing global value.* London, Earthscan.

Pearce, D.W. 1998. Cost–benefit analysis and environmental policy. *Oxford Review of Econ. Policy,* 14(4): 84–100.

Pearce, D.W. & Turner, R.K. 1990. *Economics of natural resources and the environment.* Hertfordshire, UK, Harvester Wheatsheaf.

Peters, C.M. 1994. *Sustainable harvest of non-timber plant resources in tropical moist forest: An ecological primer.* Biodiversity Support Program of World Wildlife Fund, The Nature Conservancy and the World Resources Institute. Washington, DC, World Wildlife Fund.

Picciotto, R. & Weaving, R. 1994. A new project cycle for the World Bank? *Finance and Development,* 31(4): 42–44.

Pigou, A.C. 1932. *The economics of welfare*. London, Macmillan.

Principe, P. 1991. *Monetizing the pharmacological benefits of plants.* Washington, DC, United States Environmental Protection Agency.

Ramsey, F.P. 1928. A mathematical theory of saving. *Econ. Journal*, 38(152): 543–559.

Randall, A. 1991. The value of bioversity. *Ambio,* 20(2): 64–68.

Rausser G.C. & Small, A.A. 2000. Valuing research leads: Bioprospecting and the conservation of genetic resources. *Journal of Political Econ.*, 108(1): 173–206 (available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=201051).

Rawls, J. 1972. *A theory of justice.* Oxford, Oxford University Press.

Repetto, R. 1990. Deforestation in the tropics. *Scientific American*, 262(4): 36–42.

Roche, L. 1989. Forestry and famine: Arguments against growth without development. *The Ecologist,* 19(1): 16–21.

Ruiz–Pérez, M., Belcher, B. & others. 2003. *Global patterns and trends in non-timber forest product use.* Bogor, Indonesia, CIFOR. (manuscript, quoted in Angelsen & Wunder, 2003).

Sandler, T. 1992. *Tropical deforestation: Markets and market failures.* Washington, DC, Institute for Policy Reform.

Shabman, L. & Stephenson, K. 1997. Searching for the correct benefits estimate: Empirical evidence for alternative perspectives. *Land Economics,* 72(4):433–449.

Simpson, R.D. 1997. Biodiversity prospecting: Shopping the wilds is not the key to conservation. *Resources for the Future,* 126 (Winter): 12–15.

Simpson, R.D., Sedjio, R.A. & Reid, J.W. 1996. Valuing biodiversity for use in pharmaceutical research. *Journal of Political Econ.,* 104(1): 163–185.

Swartzman, D. 1982. Cost-benefit analysis in environmental regulation: Sources of the controversy. *In* D. Swartzman, R.A. Liroff & K.G. Croke, eds. *Cost-benefit analysis and environmental regulations: Politics, ethics and methods*, pp. 53–85. Washington, DC, The Conservation Foundation.

Tipper, R. 1996. *Mitigation of greenhouse gas emissions by forestry: A review of technical, economic and policy concepts.* Working Paper. University of Edinburgh, Scotland, Institute of Ecology and Resource Management.

Uhl, C., Bezerra, O. & Martini, A. 1993. An ecosystem perspective on threats to biodiversity in the eastern Amazonia, Pará state. *In* C.S. Potter, J.I. Cohen & D. Janczewski, eds. *Perspectives on biodiversity: Case studies of genetic resource conservation and development*, pp. 213–231**.** Waldorf (USA), AAAS Press (also available at http://www.imazon.org.br/english/publicacoes.htm).

United Nations. 1993. *Agenda 21: Programme of action for sustainable development and Rio Declaration*. New York, United Nations.

Vaughan, W.J. & Ardila, S. 1993. *Economic analysis of the environmental aspects of investment projects.* Working Paper ENP100. Washington, DC, Inter-American Development Bank.

Vosti, S., Witcover, J. & Carpentier, C. 1998. *Arresting deforestation and resource degradation in the forest margins of the humid tropics: Policy, technology, and institutional options for western Brazil*. Washington, DC, IFPRI.

Winpenny, J.T. 1992. The economic valuation of tropical forests: Its scope and limits. *In* F.R. Miller & K.L. Adam, eds. *Wise management of tropical forests.* Proceedings of the Oxford Conference on Tropical Forests, Oxford, UK, 30 March–1 April. Oxford Forestry Institute, University of Oxford.

ANNEX

Below full details are provided on the projects summarised and discussed in the paper.

MAHARASTRA

Objectives and components
The project, while focusing on biodiversity conservation and productivity of forests and wastelands, contributed to the overall objective of slowing environmental degradation through the rehabilitation of degraded forests and the establishment of significant areas of plantations and of vegetative cover on waste and community lands.

The project design was innovative in attempting to address the forest sector in an integrated manner, based on policy and institutional reforms, changes in technology and increase of community participation in forest management, aimed at improving rural incomes and equity.

It embodied the following major components, each including many sub-components:

a) land treatment (plantation development, village eco-development and tribal development, biodiversity conservation and protected area management);
b) technology improvement, addressing deficiencies in the production of plantation materials; and
c) project implementation support providing infrastructure, staff, specialised support services and restructured forest administration.

Costs
Actual project costs were US$ 117.7 million (Rs.4 162 million): US$ 88.77 million spent for land treatment and US$ 18.94 for technology and project implementation support.

Implementation experience
Although in the pre-MTR (Mid-Term Review) period project performance was unsatisfactory, performance improved significantly following the MTR. This improvement was due to programme management enhancement as well as to greater commitment on the part of the implementing agencies.

Sustainability
Suitable sectoral policy changes were introduced along with specialised technical skills. Since the sustainability of project activities is dependent on the policy environment, human resources and government commitment to continued funding, the project was rated as likely sustainable. It was also considered likely that people's participation in management of forest resources would be sustained. The project brought significant environmental benefits. The emphasis on people's participation in the management of resources increased the likelihood of the sustainability of those benefits.

Benefits
On-site private benefits: The project has developed and/or rehabilitated about 330 000 ha over the project period, increasing the production of timber, poles, fuelwood and fodder. This increased production was estimated by using 16 forest plantation models. Models included all physical input and output over the period of 30 years (the rotation period of plantation). Each model was thereafter aggregated with the corresponded area planted over the project period.

Regarding the increased availability and collection of NTFPs, such as fruits, medicinal plants and mushrooms, it was conservatively assumed in the analysis that an incremental benefit of US$ 2 per hectare per year was produced. This was based on reports of some villages in the project area, since there was little data available on the quantity of NTFPs collected.

Lack of data prevented systematic quantification of agricultural benefits, although positive impacts on agricultural and livestock production – such as increases in crop yields and in cropping intensities and changes in cropping patterns towards higher-value crops – were evident in some areas. The introduction of improved technology, particularly for seeds and nurseries, was another important benefit, but was not taken into account in the analysis.

On-site public benefits: Not considered in the analysis.

Other benefits: In comparison to the "without project" situation assumed a saving in women's labour was assumed, owing to the greater availability of water and firewood near villages. Data on this type of social impact is extremely scarce, but the analysis assumed that two hours per household per day would be saved.

Joint Forest Management (JFM) brought a significant transfer of responsibility for the management of forest assets, and a number of institutional benefits such as the development of the Forest Protection Committees, the change in Government of Maharashtra (GOM) management and other changes in approach and management processes.

Global environmental benefits: By its nature, this project had multiple positive impacts on the environment, including improved biodiversity. However, most of the benefits were either reflected already in other forms of benefits such as increased production, or were not possible to quantify owing to lack of data.

Carbon sequestration through development of forests provides global environmental benefits; the capacity of forests to fix carbon was assumed at 4 tonnes of carbon per hectare per year (4ton/ha/yr), based on incremental production of poles and timber. The valuation of carbon is a controversial issue, and various values have been quoted and estimated. For this analysis, a figure of US$ 10 per tonne was adopted. Carbon sequestration would have positive regional impacts.

ERR

The ERRs of the project were undertaken at the aggregate level, summing up all the incremental benefits and costs (using Farmod programme).

Key assumption under ERR: Without the project it was assumed that the forest assets would disappear at the rate of 2 percent per annum due to lack of protection, poor management and over-exploitation.

All project financial costs were included in the stream for calculation of ERRs. Project costs were adjusted to reflect economic costs for the analysis. A standard conversion factor of 0.9 was applied to non-tradable items. The average economic wage of labour was assumed at Rs.38 per person-day, the opportunity costs of labour. The financial wage rate paid by the project was Rs. 49.8, the rate determined by the Government. At full development, annual incremental forest production was estimated at 106 million bamboo poles, 5.5 million teak and various poles, 209 000 tonnes fuelwood, and 100 000 m^3 of teak and various timbers.

In the estimation of the ERRs, two scenarios were assumed:

Without environmental benefits: Including all quantifiable benefits, excepts the benefits from carbon sequestration, the ERR was estimated at 6.9 percent.

With environmental benefits: Benefits were as in the first scenario, plus those from carbon sequestration. With an assumption of the value of carbon at US$ 10/tonne, the ERR is 10 percent, which was considered realistic.

An ERR of 10 percent is acceptable in the forest sector because of the following factors:

- the nature of forestry, in which benefits are realised only after investments have been made;
- significant benefits that accrue to poor rural communities;
- substantial unquantified environmental and other agricultural benefits;
- significant anticipated future benefits from rapid expansion of the JFM programme to 6 000 forest fringe villages throughout Maharashtra.

GUJARAT, ORISSA AND RAJASTHAN

Objectives and components

The project covered the states of Gujarat, Orissa and Rajasthan. Its main aim was to slow down and possibly reverse ecological degradation in a variety of agro-ecological zones in the selected states by promoting a sustainable and replicable use of natural resources and agricultural production systems. It was implemented through a menu of land treatments, emphasising soil and moisture conservation and by introducing more sustainable land management systems, including seeking long-term, community-based management solutions for public non-arable lands.

The project included multiple components, such as the establishment of vegetative contour barriers and associated production systems like agro-forestry, alley cropping and dryland horticulture on arable, private land; land treatments such as vegetative soil and moisture conservation measures, afforestation, silvipasture development on non-arable public lands; structural and vegetative treatments for stabilisation of natural drainage lines both on arable and non-arable land; and establishment of plant nurseries.

Costs

Actual project costs were Rs. 2 492 million (US$ 71.64 million).

Implementation experience

The project was implemented over a three-year pilot phase and a five-year expansion phase. While all three states encountered implementation problems in the pilot phase that caused delays in execution, disbursement and in establishing sustainable management systems on non-arable areas, these problems were resolved during the expansion phase.

Key factors in the success of the project were the substantial participation of beneficiaries in providing labour and materials and in sharing costs; as well as the regular, constructive and flexible approach of Bank supervision.

Sustainability

In order to achieve physical sustainability of the assets created under the project, Memoranda of Understanding (MOUs) between the community user groups and the Government was completed. The MOUs' objective was to ensure sustainability of drainage line works, afforestation, silvi-pasture and multi-tier tree developments and to hand over the assets to the user groups. The communities showed great enthusiasm and involvement, which allowed for rating sustainability as likely achievable.

Benefits

On-site private benefits: Off-farm benefits resulted from three main activities: a) establishing areas of new pasture; b) silvi-pasture; and c) mixed forest plantations (multi-tier canopy). Products generated from these activities included timber, fuelwood and NTFPs such as gum and fodder. They contributed to the overall benefits by 11 percent to 27 percent according to crop models formulated to capture the benefits and costs of these activities.

Increased fodder availability combined with project intervention in animal husbandry had a beneficial impact on livestock production, most importantly on milk production. To represent the benefit to the animal husbandry component, the value of fodder production was used, since systematic data on increased milk production were not available.

Agricultural benefits included a positive impact on rainfed crop yields estimated on the order of 10 percent over the without-project situation. The contribution from rainfed crops to the overall project benefits was estimated at 2 percent to11 percent. Irrigation components were the major contributors to the overall benefits representing 21 percent to 33 percent of the total benefits, although not all crops grown under irrigation were included in the analyses.

Horticulture benefits represented 36 percent to 63 percent of the total benefits, even though only representative fruit trees were included in the analysis over a wide range of tree species used in the project. The total area that benefited from farm forestry was 64 105 hectares over the project period.

On-site public benefits: The aim of the project – to slow down and reverse the degradation of the natural environment – was achieved in all three states. Average soil loss per hectare was reduced along with water runoff. Furthermore, the level of water tables increased from 0.85 to 3.5 metres in selected locations in the three states, and natural vegetation recovered as a result of the increased availability of soil moisture and the reduction in soil loss and fertility.

Due to the difficulty in assessing these environmental benefits, in the analyses undertaken only a portion of them has been picked up and translated into economic benefits (as represented by increased agricultural production), while other benefits were not included.

A rough measure of on-site public benefits was obtained assuming that 0.5 percent of production would be saved through project interventions compared to the non-project situation. On-site public benefits were limited to 2 percent to11 percent of the overall project benefits.

Other benefits: Other benefits vital to the rural communities – such as employment generation in poor communities,[37] benefits generated to minorities and poor people in tribal areas, availability of water to rural women, reduction in migration to large cities and reduction in public expenditure on Operation and Maintenance of rural infrastructure such as roads, drains and dams as a result of reduction in flooding – are very difficult to translate into economic terms. Consequently they were not included in the calculation of the ERRs.

[37] In addition to employment directly related to the project it has been estimated that by the year 2010 an annual employment of 16 million person-days would be created in project areas.

Global environmental benefits: Global environmental benefits such as carbon sequestration or increased biodiversity conservation were not taken into account.

ERR

The economic analysis of the project was undertaken at the aggregate level, summing up all the benefits and costs of the project in the three participating states. Relevant representative crop models were formulated for use in the aggregation to the project level.

Key assumptions under ERR: The total economic costs of the project were derived from project management level and farm level. All costs incurred in the past were converted into 1999 costs. For non-tradable items a standard conversion factor of 0.9 was applied to adjust financial prices to economic prices. For major tradable goods, such as maize, wheat, paddy and fertiliser, parity prices were calculated on the basis of price projections made by the World Bank.

Estimation of increased production was carried out using representative crop models and was then applied to the corresponding areas in each state. Estimations were done by state and then aggregated to the project level. The analysis was carried out over 30 years, assuming 1999 constant prices and economic cost of labour at Rs. 40 per person-day.

Without environmental benefit*s*: The findings of the analysis indicated that the project is economically viable. The ERR for the whole project was estimated at 14 percent.

With environmental benefits: The ERRs captured only quantifiable benefits and the estimation of the benefits was based on rather conservative assumptions. Actual ERRs would be expected to be significantly higher if all the environmental and social benefits were included in the analysis. Due to the incorporation of only those benefits and costs that were quantifiable, the use of ERRs to make judgements on relative performance of the project in each state should be treated with great care.

PHILIPPINES

Objectives and components

The project consisted of: a) a sector adjustment component aimed at implementing major reforms governing the management of the country's natural resources; and b) an investment component to reinforce the local public institutions charged with monitoring and managing those resources.

Detailed objectives (included in the project) were: preserving the biological diversity of the Philippines; re-establishing natural resources that had been degraded or destroyed; introducing sustainable land use practices; developing an effective protected areas system; improving enforcement of logging regulation; providing secure tenure rights to upland dwellers; and developing mechanisms to support small-scale community-based resource management and livelihood projects in impoverished upland areas.

Costs

Actual project costs were US$ 329.7 million.

Implementation experience

The outcome of the project as a whole, both in relation to its development objectives and to its physical implementation as set up at project design, was rated as satisfactory. The overall rating reflects the fact that the implementation of the quick-disbursing Sector Adjustment

Programme (SAP) and the Monitoring and Enforcement Component (MEC) were satisfactorily completed. The Regional Resource Management Projects (RRMPs) component achieved an overall accomplishment rate of over 100 percent and demonstrated that positive economic and environmental effects could be obtained. All major legal covenants of the Loan/Credit component were complied with satisfactorily.

Sustainability
Sustainability of the project was rated as likely, owing to successful accomplishment of sectoral adjustment objectives and most objectives in physical terms. However, while some project activities, such as the reforestation/plantation programme, were considered sustainable and replicable on the basis of their financial and economic viability as well as their acceptance by local communities, the continued availability of the necessary financial resources was a point of concern. Moreover, the replication of some livelihood projects failed because of lack of financial management skills and financial mismanagement. Adequate technical assistance would be necessary to assure the continuation of important income-generating activities.

Benefits
Although financial and economic evaluation analysis was not considered applicable to the project, it was considered useful to provide an indication of the financial viability of both on- and off-farm activities supported by the project as a key determinant of sustainability and replicability.

Based on data provided by the Project Management Office and information collected in the field and in interviews with farmers, one-hectare models of a typical reforestation site (off-farm) and an agroforestry model farm (on-farm) were carried out. Environmental benefits (such as carbon sequestration), which are conventionally not quantified, were also evaluated.

On-site private benefits: The elaborated models indicated that both on-farm and off-farm activities would be viable and attractive for farmers even in the absence of subsidy payments. Reforestation activities based on Gemelina arborea carried out an ERR of 43 percent, assuming a wood volume of 56 m^3/ha harvested after 10 years and sold at a farmgate price of 2 200 pesos/m^3. In order to assess returns to typical on-farm activities a one-hectare model farm planting eucalyptus, fruit trees and cash crops was analysed. This operation would generate a rate of return of 48 percent.

On-site public benefits: On-site public benefits included the reduction in soil run-off upstream leading to reduced sedimentation and siltation problems in downstream infrastructure, a reduction in damages to downstream fishery resources and improved moisture balance reducing incidences of flooding and drought.

Estimates of soil erosion from different land use types were: open grassland – 79.6 t/ha/yr; agroforestry (trees, shrubs, grasses) – 12.5 t/ha/yr; Gemelina plantations – 1 t/ha/yr; and unsustainable upland agriculture – 191.6 t/ha/yr. Estimates for fisheries considered the benefits of a regeneration of fishery yields resulting from reduced upstream soil erosion, based on data collected by the mission on fishermen offering fish at discounted prices to upstream farmers in compensation for their application of agroforestry practices.[38] This estimate reflects a lower bound of the willingness to pay to avoid soil erosion upstream in order to protect downstream fishery resources, and was considered likely to be lower than the full benefits of the value added of additional fish caught.

[38] A contingent Valuation Analysis was carried out.

Estimates referring to the irrigation system were based on the loss of value of production, from a reduction in irrigable area owing to soil erosion/sedimentation. Estimates for dams were based on the total cost of damages from sedimentation owing to the decrease in service life based on amortized capital cost of the four reservoirs most affected by sedimentation problems (57.7 million pesos/year in 1988 prices).

Other benefits: There were also other benefits, such as reduced illness and mortality owing to a reduction in pollution and improvement in air quality and recreation benefits from enhanced natural amenities. They were not considered in the analysis.

Global environmental benefits: In terms of global benefits the estimates only considered potential gains from incremental carbon sequestration. As most reforestation activities promote exotic species, biodiversity benefits should not be significant. Health and recreation benefits were not included in the analysis.

Estimates for carbon sequestration benefits assumed an estimate of US$24/tC (using an exchange rate of 40 pesos/$) and incremental carbon sequestration of 3 tC/ha/yr and of 3.4 tC/ha/yr as a result of adoption of agroforestry and reforestation practices, respectively. The sequestration figure for reforestation was adjusted to 2.7 tC/ha/yr, reflecting the assumption that only 80 percent of the harvested wood would be used for poles or timber.

ERR

Key assumptions under ERR: Values were based on incremental benefits from switching land use to forestry or agroforestry. The assumptions were that reforestation activities should replace grassland (90 percent) and cultivated land (10 percent) while agroforestry should replace grassland (25 percent), cultivated land (70 percent) and plantations (5 percent).

Without environmental benefits: The internal rate of return without considering environmental benefits resulted in 43 percent for reforestation and 47.6 percent for agroforestry.

With environmental benefits: An inclusion of total domestic benefits in the ha models did not change the IRRs for reforestation (43 percent) and agroforestry (48 percent) significantly. Total domestic benefits considered, i.e. the reduction in production losses attributable to sedimentation of irrigation systems, the reduced life-span of dams owing to siltation and the damage to fisheries from soil run off, resulted in very low amounts indeed.

The consideration of benefits from carbon sequestration, however, did have a large impact: it increased the IRR from 43 percent to 69 percent for reforestation and from 48 percent to 59 percent for agroforestry.

Table 2. Effect of Inclusion of Environmental Benefits on the IRR on Reforestation and Agroforestry

Internal Rate of Return (IRR)	Impact	Reforestation	Agroforestry
	without environmental benefits	43.0%	47.6%
	including off-site benefits	43.4%	47.8%
	including global benefits	68.8%	59.4%

NEPAL

Objectives and components

In order to establish a forest management system which would conserve and stabilise a fragile ecosystem, regenerate and expand hill forest resources and increase the production of fodder, fuelwood and timber needed by local communities, management responsibility for forest resources was transferred to the local communities that used them.

The project comprised multiple components, including:

a) building the capacity of the Department of Forestry (DOF) to implement community forestry with Forest User Groups (FUGs);
b) establishing and training FUGs; and
c) investing in improved forest management, including plantation development.

Under the project, 12 557 ha of plantation were established, almost 75 million seedlings had been produced by the end of 1998, more dynamic management activities to improve the condition and productivity of forest were introduced by FUGs; approximately 4 400 FUGs were established in 38 districts, and 320 000 hectares of National Forest were transferred to user groups.

Costs

Actual project costs were US$ 9.27 million, equivalent to 30 percent of the original credit amount.

Implementation experience

The project was extended twice from its initial closing date of 30 June 1996. Project costs were far lower than initially estimated because: a) seedling production and plantation establishment targets were thereafter reduced; b) user group formation and hand-over of forest land required few resources other than those provided by the communities themselves; and c) the depreciation of the Nepalese rupee produced significant savings on domestic costs.

There is little information on the interventions' impact on forest conditions and people's livelihoods, and no synthesis of implementation experience. However, the indicators developed and monitored over the life of the project, field observations, institutional changes and anecdotal evidence suggest that the project had major and significant impact on the condition of forests in the Hills, on the capacity of DOF and on the lives of local people.

Sustainability

The project was rated as likely sustainable despite the fact that some amendments to the Forest Act gave rise to concern. The Community Forestry Programme provided a strong policy and legal foundation from which several thousand FUGs were created. Elements considered important for achieving sustainability included democratic functioning of the FUGs to avoid disaffection among community members, sufficient professional capacity for supporting increasing post-formation demand, and free harvesting and marketing of forest products.

Benefits

On-site private benefits: Direct benefits were quantified in terms of per-hectare off-take of poles and timber, fuelwood, leaf, grass fodder and leaf litter, and incremental production was derived on the basis of those parameters. The annual value of NTFPs in Nepal was estimated at roughly US$ 2/ha (Knowler and Canby, 1998). This estimate was based on the value of annual exports of NTFPs divided by Nepal's forest area. The project's analysis assumed that the annual incremental value of NTFPs is US$ 1 (NRs60) in Years 1–10, and US$ 2 thereafter. The without-project continuation of open access would significantly reduce opportunities for harvesting NTFPs.

On-site public benefits: Reduction in downstream sedimentation, a reduction in flooding and landslides and the regulation of water flow were considered in the analysis undertaken. While much anecdotal evidence exists, there is little quantitative data on these environmental services provided by forests in Nepal. Knowler and Canby (1998) have reviewed the literature for Nepal, which provides estimates of their present value ranging from US$ 8–200/ha. The analysis here reviewed adopted a conservative estimate of US $2/ha/year (equivalent to a net present value of US$ 11 over 30 years using a 12 percent discount rate).

Other benefits: Social and other benefits were not taken into account in the analysis.

Global environmental benefits: Estimates of forests' capacity to fix carbon were based on the incremental production of poles and timber in actively-managed natural forests. Yield figures from the "managed scenario" applied also to the "protected scenario" because while less timber is harvested from protected forest, the carbon is fixed in the unharvested trees. It was assumed in this analysis that 0.2 tonnes of carbon was fixed per tonne of poles and timber produced (which is equivalent to 0.73 tonnes of carbon dioxide). This analysis applied a value estimate of US $20 per tonne.

ERR

Economic rates of return were calculated for the project as a whole, and separately for the plantation component. An attempt was made to quantify benefits from the harvesting of non-timber forest products and environmental benefits, including carbon sequestration, and reduced erosion/flooding resulting from improved forest quality.

Key assumptions under ERR: The output of the project was not traded internationally and border prices were not calculated. The economic price for fuelwood was estimated using the indirect opportunity cost of labour method. Fodder was valued on the basis of the increased productivity of livestock attributable to incremental production of fodder. The value of poles was derived from the ratio of the value of poles relative to fuelwood, which is based on the relative price ratios estimated in Knowler and Canby (1998).

An improvement from "degraded" forest to "good" forest was assumed. Data showed that 70 percent of forests were in good condition at the time of handover; it was assumed that after ten years, 90 percent of community forests were in good condition, and that by Year 20 all forestland classified as degraded at handover would have become good.

For the economic analysis, actual project costs were adjusted to 1998/99 values using GDP inflators for Nepal. All project costs incurred in local currency were adjusted with a Standard Conversion Factor of 0.9. All project costs were included in the economic analysis given the importance of training, extension and institutional support to the success of local level management of forests. The economic analysis for the plantation component was based on actual expenditure under the Forest Resource Management Component and benefits accruing from plantation establishment only.

Without environmental benefits: The ERR without environmental benefits for the whole projects was calculated at 14 percent.

With environmental benefits: The re-estimation of the project's returns as a whole resulted in an ERR of 24 percent including both off-site environmental benefits and carbon sequestration, while without carbon sequestration it was 17 percent.

ANDHRA PRADESH

Objectives and components

The objectives of the projects were to increase forest productivity and quality, protect the environment, alleviate rural poverty and strengthen sector policies to be harmonious with these targets.

The project comprised many components, including:

a) regeneration and rehabilitation by Joint Forest Management;
b) increased forest productivity on forest land;
c) increased forest production on private and communal lands;
d) improved planting material quality and performing of research;
e) conserved biodiversity;
f) strengthened institutional and forest sector management.

Costs

Actual project costs were US$ 91 million.

Implementation experience

The quality at entry was rated as satisfactory. The accomplishment of objectives was based on generally well-thought-out operations. Particular importance was given to the participatory approach and to including women in the development activities in order to improve both their social and economic status. The project performed satisfactorily in terms of producing expected outputs.

A key element in the accomplishment of the objectives was the involvement of fringe dwellers in the participatory protection and management of forests and protected areas, as well as assistance for other private sector involvement in tree growing.

Sustainability

Sustainability was rated as likely achievable. Maintaining expected benefits to the communities involved was considered critical, as was the equitable sharing of benefits as part of a participatory approach. The project connected institutional transformation (and the willingness and ability to further adopt a participatory approach to forest management and protection) with support from an established training cell which reinforced the perspective of maintenance and enhancement. Sustaining the project achievements was considered also a key element for ensuring environmental sustainability.

Benefits

On-site private benefits: On-site private benefits included incremental production of timber, poles, fuelwood, fodder, forest fruits, bamboo, a variety of horticultural products for household consumption and several NTFPs. The aggregate production arising from treatment practices was measured for the first 20 years for bamboo, eucalyptus and other fast growing species and 30 years for hardwood species, based on 17 forestry treatment practices models. In six JFM sample districts, dense forest cover increased since 1996 by an average of 19 percent and open forest by as much as 26 percent. Overall, natural regeneration in JFM areas increased by as much as 60 percent, the number of trees species has increased significantly, forest fire instances have been reduced by about 50 percent and encroachment by 80 percent.

On-site public benefits: The On-site public benefits (which were very difficult to quantify and therefore did not enter into the analysis undertaken) included increases in production outside the project areas, derived from the dissemination of significantly improved production technologies; and increases in agricultural production due to better water management, soil protection and decreased erosion. Soil and water conservation measures provided a significant increase in groundwater supplies as well as decreased erosion.

Other benefits: The project led to the achievement of other benefits related in particular to social or political aspects. It strengthened rural institutions by providing experience with joint management schemes; enhanced efficiency in forestry administration operation through institutional reform; and improved local self-reliance, food security and equity benefits by increasing poor residents' income.

The project also had a beneficial impact on tribal peoples by providing additional income and employment from production and processing of NTFPs; promoting thrift groups and improving food through better agricultural practices, horticulture, soil and moisture conservation works and afforestation. In addition, the participatory process and village-level organisation and training had substantial positive effects on the economic and social status of women. Finally, due to the elimination of policy distortions, the project was expected to lead to a more efficient allocation of resources in the forestry sector. Estimates of poverty reduction and benefits related to sharing costs between people and government were also provided.

Global environmental benefits: Estimates considered only potential gains from incremental carbon sequestration, although conservation of biodiversity was an achieved objective. It was assumed that the carbon sequestration effect would be built up in eight years; starting from year eight the forestry treated would sequester carbon at an annual rate of 4 tonnes/ha, and the value placed on sequestered carbon was estimated at US$ 10/tonne.

ERR

The ERR was undertaken at the project level, summing up all incremental benefits and costs in aggregated economic cash flow, which was built up in line with the physical target achievements of different treatment practices. Financial models were converted into economic models for use in aggregation at the project level.

Key assumptions under ERR: The analysis used market prices for inputs and outputs. All past and future financial flows were valued at constant November 2000 prices. One of the main costs was labour: a rate of Rs 55 per workday was used, which reflected standard wage rates in the rural areas. On the benefit side, all timber, bamboo and pole prices were stumpage prices. All project costs were included for the ERR calculation. All inputs and outputs of the project, except for timber, were considered as non-tradable and therefore a SCF of 0.9 was applied. Timber was valued at market price. All price estimates associated with the project were conservative and were assumed to remain constant in real terms during the life of the project.

A total of 251 600 households were included in the analysis, of which approximately 124 000 families were from scheduled tribes and other weaker sections of the rural communities adjacent to forests. To estimate the poverty reduction impact of the JFM component, cash flow analysis for a typical farm-family with one ha forest was formulated. The analysis shows that the average annual incremental income for one family is Rs.5400 (US$ 120). The JFM component included sharing of costs and benefits between Government and the beneficiaries.

Without environmental benefits: ERR related to the overall project was 22 percent.

With environmental benefits: The inclusion of benefits from carbon sequestration brought the ERR to 29 percent.

ESA Working Papers

WORKING PAPERS

The ESA Working Papers are produced by the Agriculture and Economic Development Analysis Division (ESA) of the Economic and Social Department of the United Nations Food and Agriculture Organization (FAO). The series presents ESA's ongoing research. Working papers are circulated to stimulate discussion and comments. They are made available to the public through the Division's website. The analysis and conclusions are those of the authors and do not indicate concurrence by FAO.

ESA

The Agriculture and Economic Development Analysis Division (ESA) is FAO's focal point for economic research and policy analysis on issues relating to world food security and sustainable development. ESA contributes to the generation of knowledge and evolution of scientific thought on hunger and poverty alleviation through its economic studies publications which include this working paper series as well as periodic and occasional publications.

Agricultural and Development Economics Division
The Food and Agriculture Organization
Viale delle Terme di Caracalla
00100 Rome
Italy

Contact:
Office of the Director
Telephone: +39 06 57054358
Facsimile: + 39 06 57055522
Website: www.fao.org/es/esa
e-mail: ESA@fao.org