2

An Introduction to the Application of Economic Valuation Techniques to Environmental Problems and Cost-Benefit Analysis

The previous Chapter highlighted the links between the environment and the economy, which lie at the heart of the principle of environmentally sustainable development. If environmental resources were available in infinite quantities, and if they could be deployed at zero costs, there would be no economic problem. However, choice becomes a necessity once it is recognised that resources are finite in terms of their absolute quantity, or in terms of the costs of extracting or using them.

The purpose of economic valuation is to reveal the true costs of using scarce environmental resources. Choosing whether to use environmental resources is made easier if both costs and benefits of this action are expressed in terms of a common unit, e.g. money. Valuation is relevant at all levels of public choice:

- In *project appraisal* the environmental impacts of any investment need to be estimated and compared to the other costs and benefits.
- In *programme appraisal* the value of environmental impacts similarly needs to be integrated into the evaluation process.
- In *policy appraisal* environmental factors need to be treated on an equal footing with other costs and benefits so that sectoral priorities are not distorted. This is as important in choosing between marginal expenditures on, say, transport as against energy, as it is in choosing between conservation and development projects. Similarly the setting of environmental standards should be informed by valuation analysis. In short, environmental valuation should be an integral part of decision-making on sectoral priorities, the balance between conservation and development, and the choice of environmental standards.

2.1 Environmental Valuation Techniques

The monetary measure of a change in society's well-being due to a change in environmental quality is called the *total economic value* of the change. The total economic value is the sum of use value and non-use value.

Use-values comprise:

- Direct values – where an individual makes direct use of a resource (e.g. harvesting timber from a forest).

Table 4: Total Economic Value in the Context of Tropical Forest

1 **Direct value**	2 **Indirect value**	3 **Option value**	4 **Existence value**
• Timber	• Nutrient cycling	• Future use as per direct and indirect values, e.g. future medicinal values of plant species	• Forests as objects of intrinsic value and as a gift of nature
• Non-timber products	• Watershed protection		• Includes cultural and heritage values
• Recreation	• Air pollution reduction		
• Medicine	• Micro-climate regulation		
• Plant genetics			
• Education			
• Human habitat			

- Indirect values – where an individual benefits from ecosystem functions (e.g. the protection of watersheds by forests).
- Option value – where an individual is willing to pay for the option of using an asset at some future date (e.g. future medical use of forest plant species).

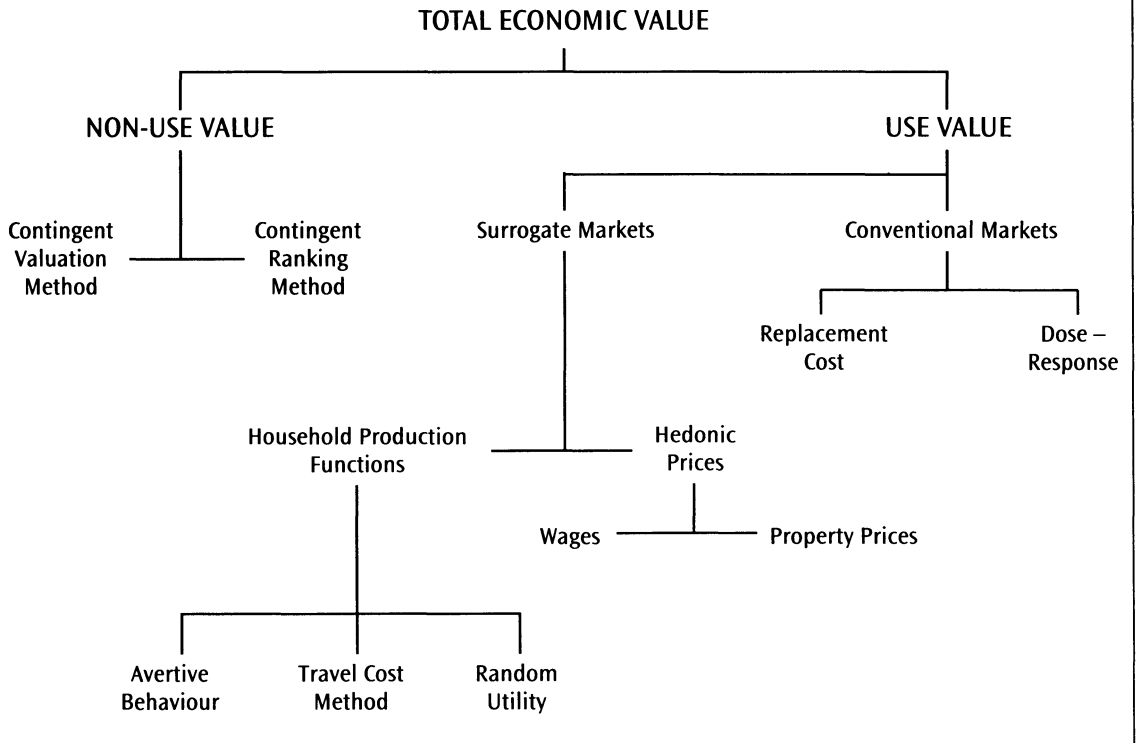
Non-use values can take the form of:

- Existence values – which measure willingness to pay for a resource for some moral, altruistic or other reason that is unrelated to current or future use.
- Bequest values – which measure people's willingness to pay to ensure that their heirs will be able to use a resource in the future.

Table 4 illustrates the components of Total Economic Value in the context of tropical forests.

Suppose a 50 km2 area of tropical primary forest can either be destroyed and subsequently developed or, alternatively, conserved in its present state. The policy-maker can use the techniques described below to estimate the total economic value of the forest as it stands (see Table 4). This total economic value can then be compared with the value of the land in some alternative use, e.g. agriculture. If the total economic value of the conservation of the forest is greater than the value of its development as agricultural land, then society is better off if the forest is conserved. On the other hand, if the forest area had greater value as agricultural land then the reverse would hold. Estimating these values for different land uses is known as *demonstrating economic value*. As we see later, demonstrating value is not enough: it will be necessary to ensure that these values accrue as real financial gains to those whose livelihoods are affected by the different land uses. This is known as *capturing, or appropriating economic value*.

Figure 3: **Economic Valuation Techniques**



There are two broad approaches to valuation, each comprising several different techniques, as Figure 3 illustrates. One approach consists of directly asking people questions designed to elicit their values. These techniques are usually termed *direct techniques* and can be used to value both direct values and indirect values. Alternatively, values can sometimes be elicited from conventional or surrogate markets, where environmental quality is an element of satisfaction people derive from consuming a good or service. This is termed the indirect approach, and is restricted to use values. The rest of this Chapter describes the different valuation techniques highlighting their applicability, procedure, validity and expense in a format which enables them to be compared.

2.2 Indirect Valuation: Dose-Response Function

Applicability:
This approach is extensively used where the dose-response relationship between pollution and impact or response is known and the impact can be measured. Examples include health, crop and forest damage from air pollution, or crop yield losses due to soil erosion. This approach cannot be used to measure non-use values.

Procedure:
Statistical methods are used to estimate the relationship between pollution (dose) and its environmental impacts (response). Some impacts can then be valued at the real price of the loss (net of any taxes and/or subsidies). In other instances, the value of the impacts cannot be readily estimated from a market price and require the application of other valuation techniques (e.g. in valuing the health impacts of air pollution).

Validity:
Despite being a theoretically sound approach, dose-response functions suffer from uncertainties in scientific data. There are also uncertainties in estimating the economic value of some health impacts.

Expense:
This method can be costly if large databases need to be manipulated in order to establish dose-response functions. If these already exist and can be transferred to the current context, the method can be quite inexpensive with low time demands.

Using the *Dose-Response Function* Approach to Value the Costs of Soil Erosion: a Case Study in Mali

Soil erosion reduces the productivity of the land. A dose-response function predicts the 'response', in terms of reduced crop output resulting from a unit 'dose' of erosion. Soil loss is a function of, among other factors, the erodibility of soils, the slope of the land, and conservation practice. Soil loss can then be related to loss in crop yield, based on results of a range of tests examining this relationship. This reduction in crop production can then be valued. By multiplying the loss in yields by the current market price for the crop. Soil erosion also reduces the need (and hence cost) for weeding and harvesting. This study, conducted in Mali, allowed for these effects by looking at the total impact on farm budgets with and without erosion.

Much of the work on estimating the dose-response relationship has been done in the USA, Canada or Australia. In the absence of any Mali-based research, the dose-response functions were estimated on the basis of research results in the US. This dramatically reduced the expense of the study, but also reduced its accuracy since soil and climate conditions in the US are different from those in Mali. The study estimated that the national annual income losses due to soil erosion were as follows:

Annual Loss (1988 prices)	= US$ 4.6 million
As % of GDP	= 0.2 %
As % of agricultural GDP	= 0.6 %

The economic losses from soil erosion in Mali, at least as suggested by this study, appear high enough to warrant conservation investments in some areas of the country. Investing in

additional agricultural output may be less profitable than a simple financial appraisal would suggest. However, the important question of why soil erosion occurs has not really been tackled, and research on the dose-response relationship in Mali's own soil and climate conditions is necessary to make more precise estimates.

Source: Bishop et al, *1989.*

2.3 Indirect Valuation: Replacement Cost Approach

Applicability:
The replacement cost approach is applicable in situations where the cost relates to achieving some agreed environmental standard, or where there is an overall constraint requiring that a certain level of environmental quality is achieved or maintained. The method cannot be used to estimate non-use values.

Procedure:
Ascertain the environmental damage done (in physical units) and then estimate the cost of restoring the environment to its original state.

Validity:
This method is only valid in contexts where agreed standards must be met. It cannot produce measures for the damage caused by pollution or resource use.

Expense:
Usually inexpensive as standard engineering and cost data often exist.

Using the *Replacement Cost Technique* to Value the Loss of Life Support Capacity of Wetlands: A Case Study from the Baltic Sea

The Martebo Mire wetland system on the island of Gotland, Sweden, provides a range of life support services such as cleansing nutrients and pollutants, maintaining the level and quality of drinking water, and sustaining genetic diversity. Extensive draining of the Mire has resulted in the loss of the wetland, consequently creating needs for replacement technology which can be costed on the basis of market data. Note that the cost of replacement is only part of the *total economic value* of wetland.

Replacement technologies include artificial fertilisers, irrigation dams, water transportation, well-drilling, water purification, and sewage treatment plants. The additional purchase of these technologies would correspond to an annual sum of 2.5-7 million SEK (£220,000-614,000). Note that the required environmental standard in this example is the level of service that was provided by the wetland prior to destruction.

Source: Folke, 1990.

2.4 Indirect Valuation: Avertive Behaviour

The approaches examined so far tend to use data from conventional markets. The avertive behaviour technique along with others shown in Figure 3 tend to use data from surrogate markets which typically embody some form of environmental quality within a product or service.

Applicability:
This method is applicable in cases where households spend money to offset environmental impacts. In addition to the case study below, the method can be applied to estimate the economic value of clean water (e.g. cost of household water filters) and noise (e.g. cost of double glazing). The method cannot be used to estimate non-use values.

Procedure:
Measures undertaken by households to mitigate an environmental impact are identified and then their costs are estimated at the market price.

Validity:
Because the method uses actual expenditures, the results should be valid, as long as the only benefit people receive from the expenditure is in terms of greater environmental quality. However, there are very few studies to test the results.

Expense:
A large scale study requires econometric analysis of survey data which may be fairly expensive. However, small-scale local studies, which are cheaper, can also be useful in some contexts.

Using An *Avertive Behaviour Model (ABM)* to Value the Health Benefits of Reduced Ozone Depletion: A Case Study from the USA

Emissions of CFCs damage the ozone layer, which in turn increases the number of cases of skin cancer. What is the value of this damage? The ABM imputes the value people place on reducing the risk of contracting skin cancer by examining sales of sun-protection products. This value can then be compared with the costs of reducing ozone damage in a standard cost-benefit framework. A sample of people were interviewed, and information collected on:

a the amount of time spent in direct sunlight

b the clothes worn in direct sunlight

c the use of sun protection products

d inherent skin sensitivity to direct sunlight

Respondents were also asked how much they were willing to pay for a hypothetical sun-cream that prevented skin cancer. This information, once analysed with a variety of statistical procedures, estimated a mean willingness to pay (WTP) for a one per cent reduction in perceived cancer risk across the sample. If the sample were representative of the entire US population, the total willingness to pay for a one per cent reduction in skin cancer risk would be $500 million. This is a relatively small amount, although most abatement measures would involve reducing risks by much more than one per cent. The following results show that there was no significant difference between the WTP of the young and the elderly.

Age	Mean WTP for 1% reduction in risk, 1990 prices
21 & older	$2.73
21-30	$3.06
31-40	$3.03
41-50	$2.97
51-60	$2.66
61-70	$2.24
71 & older	$2.09

Source: Dickie et al, *1991.*

2.5 Indirect Valuation: Travel Cost Method

Applicability:
The method is generally used to value recreational benefits of environmental resources which is important in analysing public policy responses towards ecotourism. It can also be used for the valuation of time (e.g. for collection of water and fuelwood). It cannot measure non-use values.

Procedure:
A detailed sample survey of travellers, their cost of travel, site characteristics and alternative recreation options is needed. The analysis of the survey requires the use of complicated statistical methods.

Validity:
The method is theoretically correct but complicated especially when alternative recreation sites and multi-purpose trips are involved. Similar studies produce comparable results. The method is widely used by official agencies and conservation groups. It is well suited to estimating the total demand for recreation associated with a site, but is somewhat limited in its ability to measure the value of a change in the site's characteristics.

Expense:
It generally requires large surveys and complicated statistical methodology and hence is expensive.

Using the *Travel Cost Method (TCM)* to Value Ecotourism: A Case Study of A Costa Rican Rain Forest Reserve

Should a rain forest be preserved as a nature reserve or cleared for development? Forests have values other than as a source of timber products, or as agricultural land when they are cleared. It is important to recognise all components of their *Total Economic Value (TEV)*. The TCM technique is used to infer the value tourists place on the recreational experience of visiting a rain forest. Tourists must place some value on the site or they would not incur the expense of travelling there. However, the technique does not include

values of people who do not travel to the site, and it may therefore be an underestimate of its TEV.

The study team collected information on the addresses of domestic visitors to the reserve. Visitors were then zoned according to their addresses into one of the 81 'cantons' in Costa Rica, and the average number of trips from each canton calculated. This was divided by the population of each canton to calculate the average visitation rate from each zone. The estimated total cost of travel from each zone comprised:

a Out of pocket costs to travel; e.g. petrol
+
b A proportion of the fixed costs of travel, e.g. vehicle wear and tear
+
c Value of time spent travelling.

= Total Costs of Travel

The total costs of travel were calculated by multiplying an average cost per kilometre (0.15 US$ per km) by the distance from the centre of each canton to the reserve. This average figure included (a), (b) and (c) above.

With information on both the price and quantity of trips from each zone a demand curve was constructed. This was then added across all zones to derive aggregate demand for recreation in the forest reserve. The study estimated a present value of between US $2.4 and $2.9 million = $35 per Costa Rican person per year. The study then included an estimate of the value to local and foreign tourists as well, yielding a present value of US $2.5 – $10 million. Consequently the total estimated present value per hectare of the reserve was $1250. The current price of forested land cleared for agriculture is $ 30-100 per hectare. Hence, conversion of rain forest to agricultural land represents an economic cost of approximately $ 1150-1220 per hectare. Conversely, the study suggests that the preservation of the reserve represents a well-justified investment from a social and economic perspective. These figures also suggest that social well-being may increase if the conservation site is expanded. However, it should also be considered that as the reserve gets larger, the economic benefits foregone from not developing the site (the opportunity cost of conservation) will increase.

Source: Tobias et al, *1991.*

2.6 Indirect Valuation: Random Utility Models

Applicability:
The model is applicable in the same situations as the travel cost method, i.e. to the valuation of recreational site characteristics, and the valuation of time as in the case study mentioned below. Like the travel cost method, it cannot measure non-use values.

Procedure:
In the case of studies examining the value of time, the choice among sources of the demanded good or service is a function of the characteristics of the available options. The function has a random, unpremeditated, component which is also believed to be determining the choice.

Validity:
The model can explain the choice between different options based on the valuation of time. However, it cannot explain the total demand for a good or service.

Expense:
The collection of data and modelling can be costly.

Using A Random *Utility Model (RUM)* to Value the Time Spent Collecting Water: A Case Study for Kenya

In developing countries, many women spend a significant proportion of their time carrying water from sources to their homes. A benefit from installing yard taps is the reduction in travelling time to and from water sources. Calculation of the benefits of saving time from installing a yard tap, requires information on the value people place on time spent hauling water. This is what

the Random Utility Model (RUM) was used to estimate.

Ukunda is a village of 5,000 people close to Mombasa. Residents can get water from three sources: purchase it from water kiosks, buy it from travelling vendors, or use village handpumps. Data were collected via a survey on demand for water from different sources, distance and travel time to each source, and socio-economic status of respondents. The RUM required the construction of a statistical model, which allowed estimates to be made of the trade-off between the price of water and time spent collecting it. The study suggested that the value of time spent collecting water was US$ 0.31 per hour. Interestingly, this is almost 25% more than the market wage rate for unskilled labour in Ukunda.

Source: Whittington et al, *1990.*

2.7 Indirect Valuation: Hedonic Price Methods

The Property Price Approach

Applicability:

This method is applicable to all environmental attributes likely to affect property prices such as water supply, noise and air quality. It is relevant to cases where the property market is developed and the property owners are aware of the environmental attributes/impacts and act accordingly. The method cannot estimate non-use values.

Procedure:

The method involves the collection of data on house prices over time and in different areas with similar characteristics. An implicit price for the environmental attribute in question is found by applying multiple regression to the data.

Validity:

Despite difficulties with data collection and analysis, various studies using this method have produced similar results.

Expense:

Large data requirements increase the cost.

Using A *Hedonic Pricing Method (HPM)* to Value Willingness to Pay for Water Supply: A Case Study of the Philippines

The HPM is used to calculate how much people value different types of water supply equipment, e.g. a private connection to a house; a tap in a yard; or a communal source. This study illustrates that the amount people are willing to pay for housing in different locations is partly based on the availability of different types of water supply. 1,903 households in a very poor area were surveyed, with the head of the house asked about value of the property, nearest water source, characteristics of the house, e.g. number of bedrooms; and location of the house. A statistical regression technique was used to measure the trade-off people made between attractive characteristics of the dwelling including proximity to water sources, and paying rent. The study revealed that willingness to pay for piped water to the house (1995 prices) was as follows among different income groups:

High income households:	$US 2.62
Middle income households:	$US 3.03
Low income households:	$US 1.90

These amounts were additional to current payment for water services In addition, the willingness to pay for a closer communal source of water was also calculated. Only higher income groups appeared willing to pay for a closer communal source, and only a small amount. This may have been because most of those interviewed lived quite near a communal source. The study shows that the housing market in a poor, rural area of the Philippines does reflect the value people place on different types of water source.

Source: North et al, *1993.*

2.8 Indirect Valuation: Hedonic Price Methods

The Wage Risk Premia Method

Applicability:

This method is limited to the valuation of morbidity and mortality risks in occupations. It aims

to find the wage premium for risky occupations, i.e. the extra amount individuals are paid to accept risk. The 'value of a statistical life' has been widely used and applied elsewhere (e.g. to value the health impacts of air pollution as measured by dose-response functions). The method cannot estimate non-use values.

Procedure:

The method uses multiple regression to relate wages and salaries to the factors which influence them. Included in the determining factors is a measure of the risk of accidents. The resulting wage premium can then be related to risk factors to derive a 'value of a statistical life'.

Validity:

Although theoretically sound, labour markets are often not as well developed as the method demands.

Expense:

Data collection and analysis can be time consuming and hence expensive.

Using the *Hedonic Wage Method (HWM)* to Value Changes in Risk Faced by People: A Case Study in Britain

Many forms of environmental degradation inflict greater risk of illness or death on people e.g. air pollution. To evaluate the benefits of reducing these risks by abating air pollution, we need a measure of how people value a small change in risk. The *HWM* provides this.

Some people accept more dangerous jobs than others. We would expect these people to be paid higher wages than in otherwise comparable jobs. Empirical evidence on how much more they are paid can be used to measure the value people place on changes in risk. This study in Britain used data from 1970-72 on wages and expected risk in a variety of jobs. The risk variable used was the amount by which death rates exceeded the average due to accidents. Other possible factors explaining changes in wage rates were included in the regression: years of schooling, years of experience, presence of trade unions etc.

The results showed that a change in risk of death of 0.001 (1 death in 1000 people) resulted in a change in wage of about £890 (1995 prices). Hence, 1000 people in total would pay £890,000 to reduce the risk of having a fatal accident by 0.001. The total change in risk becomes 1000 * 0.001 which equals 1 statistical life. The Value of a Statistical Life (VOSL) according to this study was, therefore, £890,000.

Careful analysis is needed in order to be confident that the figures suggested are correct. There are many possible sources of bias in the data set, where, for instance, people who are ill change to less dangerous jobs, e.g. in the coal mining industry, ill miners were typically given jobs as office clerks. Despite these limitations, the technique is useful. It does, however, make simplistic assumptions about the workings of the labour market, not least in that people can choose how much risk they expose themselves to at work. It is best evaluated against other techniques used to measure the same value.

Source: Marin et al, *1982.*

2.9 Direct Valuation: Contingent Valuation Method

The contingent valuation technique provides a method of estimating non-use values.

Applicability:

The method can be applied to any environmental impact.

Procedure:

The method involves setting up a carefully worded and structured questionnaire which asks people their willingness to pay to avoid (WTP), and/or accept compensation (WTAC) for changes in environmental resources. Responses to these questions can give a preliminary idea of people's preferences. Moreover, the results can be statistically analysed to estimate a mean willingness to pay/accept figure for society for the given environmental resource.

Validity:

Various forms of bias, i.e. the difference between the true value and the value stated during the interviews, have been identified. Two important

biases are 'hypothetical' and 'strategic' biases. Hypothetical bias arises because respondents are not making real payments but answering hypothetical questions: if the size of the bias can be estimated (e.g. by comparing hypothetical and actual payments) then adjustments can be made to expressed willingness to pay. Strategic bias arises if respondents state values which are less than their true willingness to pay, thinking that somebody else will be making the real payment. In some instances people have no idea of the value of the service they are being asked to value, e.g. biodiversity. In these cases, factual information can be provided to the respondent in advance of the valuation question.

Expense:

A reliable survey requires around 1,000 respondents to be contacted. As a result, it can be fairly expensive. But surveys with smaller samples have also been shown to be valid and useful.

Using the *Contingent Valuation Method (CVM)* to Measure Household Demand for Improved Solid Waste Management: A Case Study of Gujranwala, Pakistan

The study aimed to measure the household demand for solid waste collection and disposal in Gujranwala and tested two strongly held but untested beliefs. First, households consider the provision of these services to be an obligation of the government and resent paying for them; and, second, households consider solid waste disposal services less important than water and sanitation services.

The survey was conducted with a random sample of 1000 households (out of a population of 1,000,000 people). Both survey data and field observations indicated that single-family, owner-occupied dwellings are the norm in the city with an average household size of just under 10. Average monthly household income, as computed from survey data, was Rs2,770 for low-income neighbourhoods; Rs3,350 for middle income neighbourhoods; and Rs4,170 for high income neighbourhoods. The average monthly income for the entire sample was Rs3,330 (around US$180). Although the actual volume of waste to be disposed is low at 0.50 kg per capita per day, high residential densities result in the generation of considerable amounts of total waste in most neighbourhoods. The funding for solid waste management was Rs28 million, about 17% of the municipal budget for 1989-90 (Rs35 or US$1.8 per household per month). This level is in line with what is being spent in Jakarta, Bangkok, Kuala Lumpur and Beijing. Only 20% of the total waste generated is disposed of; the rest is left either on empty plots, streets or garbage heaps, or drainage ditches, ponds and canals.

An iterative bidding procedure was used to elicit a respondent's willingness to pay (WTP). The respondent was first asked whether or not he/she would accept the service offered at a given monthly fee. Depending upon a YES or NO response the monthly fee was raised or lowered and the question repeated. A maximum of two iterations were employed. The procedure ended with an open-ended question enquiring the maximum WTP. Those who were not interested in the service at any price were asked the reason.

The results showed that 82% of the households were interested in the improved solid waste service offered and 71% were willing to pay for it. The mean WTP of the latter was Rs11.20 per month. If a zero willingness to pay is assumed for households not interested in the service, the average WTP over the entire sample was Rs8. The results also showed that the mean WTP bid increased with the years of education, the value of the dwelling and the employment of a servant. The results indicate some prospects for limited cost recovery with households currently willing to pay an average of Rs8 per month for improved solid waste services. It is encouraging to note that, contrary to general belief, only 20% of the households considered free provision of solid waste services to be a responsibility of the government; 80% of the households were willing to pay for the improved service. The absolute WTP for the improved service is low, perhaps because

there is no tradition in the city of paying for either public solid waste or sanitation services, nor is there much confidence in the capacity of the public sector to provide better services.

Source: Altaf et al, *1996.*

Using the *Contingent Valuation Method (CVM)* in Project Planning and Evaluation: A Case Study in Orissa, India

About 100,000 hectares of village woodlots (VWL) were planted in Orissa through the Swedish International Development Agency (SIDA) supported Orissa Social Forestry Project during 1984-1992. Many of the plantations disappeared without giving the communities much more than the salaries they received from the project while planting the trees. Others became well established and now benefit the communities greatly, especially by making fuelwood more accessible.

Two CVM studies were carried out in 1993 and 1995 as part of a larger evaluation process. Household interviews were conducted in villages with and without VWL at different distances from the natural forest. The interviews, 170 in the first round and 743 in the second, included detailed questions regarding the use of VWL and natural forests, willingness to pay, fuel use in different seasons specified by kind and source, as well as additional household characteristics.

Villagers who expressed a zero-WTP were asked their reasons for this. In most cases their answer was that they were "too poor to pay" rather than "the government should pay". In order to account for this cash-constraint, the respondents were given the opportunity to restate their bids in terms of labour days. It turned out that in many cases where there was a zero-WTP in terms of money, because of poverty, there was still a positive WTP in terms of labour. The latter was valued at the average market wage. The average WTP per village per hectare of VWL for the 1995 survey ranged between Rs12,125 and Rs126,096. Based on the full cost of the VWL project and supplementary costs of material and labour, plus the opportunity cost of land and overhead costs for the project, the present cost per hectare was Rs27,400. This comparison meant that 60% of the villages have an aggregate WTP that would cover all project costs and all villages have a WTP higher than the direct costs. This result shows that it is very likely that in some villages, investment in VWL would be a very profitable investment as seen from the point of view of the village community. However, this is not true in all villages, and this is probably an important reason for the failure of some VWL projects.

Given this result, CVM can be more successfully used at the project planning stage rather than for evaluation. Moreover, analysis of the WTP function can shed light on distributional effects of the project.

Source: Köhlin, 1996.

Using the *Contingent Valuation Method (CVM)* to Value A Protected Tropical Forest: A Case Study in Madagascar

Protecting forests gives rise to benefits from conserving biodiversity and the maintenance of environmental services. However, some costs are borne by local people who cannot use forests for firewood, food, and medicines. The CVM can be used to evaluate these costs imposed on local people. Failure to adequately consider the views of local people, or compensate them, has resulted in the poor performance of many projects.

This survey was conducted in only 351 households in 17 villages by a local NGO well versed in rural survey techniques. These villages lay in a 7 km radius around the Mantadia National Park boundary. The CVM values something which is not traded in a market e.g. the value of forest resources to villagers. In this study, since villagers were more familiar with trading rice than money, rice was used as the common unit. Villagers were asked:

> *Suppose you are asked to use only the buffer zone set aside for collecting forest products*

and for growing crops, and are asked not to use the rest of the forest anymore.

Suppose in order to make up for asking you not to use the forests in the national park, you are given _____ vatas of rice every year from now on. Would this make you as content as before when you could use the forest in the national park?

(Note that since no additional information on possible future plant genetic value of the forest was provided to the respondents, their answers reflected only their current state of knowledge about forest benefits.)

The results indicated that, on average, rice equivalent in value to $108 per year per household would compensate them for being denied access to forests in the national park.

The CVM is a useful tool for the economic evaluation of national parks, especially if the results can be compared with other techniques. Great care must be taken in conducting the survey in order to avoid biasing the results.

Source: Kramer et al, *1992.*

2.10 Direct Valuation: Contingent Ranking

Applicability:
The contingent ranking method can be applied to any environmental impact, although its actual application has been more limited than the contingent valuation method. It can measure non-use values.

Procedure:
Respondents are asked to rank several alternatives for environmental quality rather than express a willingness to pay. The list of the alternatives differs according to the topic of the survey but include some from real markets. The real market transactions in the list provide the "anchor" for the willingness to pay estimate for the environmental resources.

Validity:
Although theoretically valid, too few studies have been conducted to test its empirical validity.

Expense:
Similar to the contingent valuation method.

Using A *Contingent Ranking Technique* (CRT) to Value the Benefits of Reducing Pesticide Use for the Production of Bread: A Case Study From the UK

The use of pesticides in agriculture has been a topic of concern for many decades. The more scientific evidence is gathered showing levels of high toxicity of pesticides, the more alternatives to pesticides are designed. Some of these alternatives reduce the risk of negative impacts on human health and the environment without any extra costs, while others may result in an increase in the price of the agricultural output in question.

The design of a contingent ranking survey entails a number of distinct stages: first, the focus product is identified; second, the relevant environmental impact and other attributes are selected; third, the levels of those attributes to be presented to consumers are established; finally, the sets of hypothetical products to be ranked by each consumer are constructed. This study was conducted to measure people's willingness to pay to reduce the amount of pesticides applied to produce wheat in the UK. The focus product whose price changed with different rates of pesticides use was bread. "Number of cases of illness in the general public" and "number of farmland bird species in decline", determined by the existing scientific evidence, were chosen as attributes of different scenarios of wheat production with different levels of pesticide application. The third and final attribute was the price of a loaf of bread.

A sample of 500 adults, randomly chosen from England, Scotland and Wales, was given a set of four pesticide use alternatives with varying levels of these attributes. The resulting mean WTP per household to avoid a case of ill health was £1.87 and WTP per household to avoid serious decline in the numbers of one bird species was £11.56. The fact that WTP for the human health attribute was less than that for birds may seem counter-intuitive. However, this was

because the human health and bird welfare attributes related to risks on very different scales. The former related to individual cases of morbidity (such as nausea and dizziness) while the latter related to almost certain extinction of a species.

These WTP values have been used as weights to develop a scientific toxicity index of different pesticides, e.g. physical level of impact (say 10 cases of ill health) times the WTP to avoid this impact (£1.87) = £18.7/person. The ultimate policy aim is to make pesticide application choices based on the position of a pesticide in this index. Similarly, differentiated taxes can be placed on different pesticides according to their score in the index.

Source: Foster et al, *1997 forthcoming.*

2.11 Crtitcisms Levelled at Techniques of Valuation

By eliciting values for environmental assets, the techniques described in this Chapter can help answer the fundamental question of how much of our scarce resources should be allocated to the conservation of these assets. There are two competing approaches used to answer that question and, to a degree, criticisms of the techniques reflect a division between those accepting the economic approach, but who are worried by the robustness of the estimates, and those who disagree with the entire economic approach and thus see the techniques as futile. The competing approaches can be identified as:

- a 'rights-based' ecology approach; and
- an economic approach.

A rights-based approach argues that non-human biota and maybe even nonsentient things have a right to exist. The implication of this view is that all environmental assets should be conserved, regardless of the cost this imposes on people. An economic approach argues that conservation should be pursued until the point where the costs outweigh the benefits. This recognises the fundamental trade-off that exists when conservation is advocated: e.g. preservation of a rain forest imposes a cost on someone who could otherwise convert the land to agriculture and thereby earn money. Conservation implies an 'opportunity cost'. Criticisms of the economic approach include:

a Over-reliance on human preferences

The costs and the benefits of conservation are measured in terms of human preferences. But people may be very poorly informed about the true impact of conservation loss.

In response to this criticism, it is argued that:

- Economic valuation is not appropriate in all cases of public choice: e.g. paternalism of the State with respect to drugs, alcohol and tobacco. The presumption should be that economic valuation is the relevant approach unless there are good reasons for supposing otherwise.
- Information is often no worse with respect to environmental goods than in other markets where 'ill-informed' preferences are the basis of allocation.
- Where information is sparse, it can be supplied, as is often the case in contingent valuation studies.
- Some techniques explicitly adopt expert opinions anyway: the dose-response technique relies on people to value the effect, without any regard for the effect of the dose of pollution on response. The role of the experts is to convey the requisite information.

b Environmental standards can be set through social agreements

It has been argued that valuation is not needed. Society can simply agree a set of environmental standards. The cost of achieving those standards is then society's valuation of the standard: an implicit valuation occurs. This still begs the question of how the standards are set. There

is no social valuation of the standard. To use the costs of achieving the standard as a measure of the benefits, implies that the cost-benefit ratio of every standard is one, or greater. It follows that all standards are for the best. It is not necessary to revisit any standards and see if they were justified or not. Hence, this argument for implicit valuation does not impair the case for explicit valuation.

c Problem of future generations

Preferences elicited by these techniques, it is sometimes argued, reflect the preferences of one generation only, and thereby exclude those of future generations. However, generations overlap, and therefore the interests of future generations are at least partially included.

d Preference revelation does not capture everything

The techniques advocated above may still only value part of total value. In the context of biodiversity, for example, it is argued that no one really knows what destroying the rain forests will do: the forests are to some extent the lungs of the world and they contain a certain primary value as a sort of glue holding together the life support functions of the biosphere. This primary value is in some sense a pre-condition for the existence of other values.

However, this appears to be an argument about uncertainty. Uncertainty can be incorporated into the decision-making approach, and it need not be the case that because something is uncertain, no action should be taken. Uncertainty is not an argument for rejecting the valuation techniques out of hand. However, to argue that uncertainty implies that there should be no change at all, comes close to saying that all environmental assets have unmeasured values and should therefore be protected, i.e. the rights-based approach. This may be relevant for large changes in the quantity of environmental resources, e.g. no rain forest versus present rain forest, but it is of little relevance in the marginal decision to develop another acre of rain forest. There are numerous concerns about the robustness and accuracy of preference revelation techniques. But these concerns often apply to other techniques as well (e.g. political voting).

In conclusion, it would appear that despite the criticisms levelled at them, economic valuation techniques are indispensable in making policy decisions on environmental conservation. But it is important to continue to refine these techniques through further research and empirical testing.

2.12 The Cost-Benefit Analysis Framework

Individuals and institutions are used to making decisions on the basis of a balance of gains and losses, advantages and disadvantages. The idea behind such a weighing up is that individuals only do those things that yield them net gains, and that where a choice between alternatives has to be made, they choose the one which offers the greatest net gain. Instead of gains and losses, benefits and costs can be used. This is the simple foundation of cost-benefit analysis (CBA) (Turner *et al*, 1994).

The basic CBA rule is that an investment is to be judged potentially worthwhile if its benefits exceed its costs, where benefits and costs are defined to include any welfare gains and losses which occur because of the investment. The CBA should also present a comparison between cases "with" and "without" a given alternative. This implies that comparing the net costs and net benefits of a project with the existing situation or baseline is required:

Net benefits of alternative A (NB) = [Ba – Ca] – [Bb – Cb]

where *a* denotes alternative A and
b denotes the baseline.

The term 'costs'(C) include capital investments, operation and maintenance, and opportunity cost of capital, i.e. the revenues which would have accrued if the capital in ques-

tion was used for the next best alternative. Benefits(B) can be straightforward revenue from an investment or the findings of economic valuation studies when non-marketed environmental goods are concerned. Given the shortfalls of scientific and economic data, CBA is a procedure for:

- measuring the costs and benefits to all individuals, i.e. the society, using money as the measuring rod of those costs and benefits, and
- aggregating the money valuations of the costs and benefits of individuals and expressing them as a net social cost or benefit.

There are five essential steps in undertaking a CBA. These are:

- problem definition;
- identification of costs and benefits of the baseline and alternative A;
- data collection and analysis (shadow pricing);
- Net Present Value (NPV) calculation (discounting); and
- critical presentation and assessment of results.

Two of these steps require special emphasis:

Shadow Pricing

The above discussion on the uses of cost-benefit analysis is familiar in the sense that it is regularly applied by private firms and governments to measure the financial or economic costs and benefits of projects and policies. A less familiar application is cost- benefit analysis of environmental impacts of projects and policies. Extending CBA to account for environmental impacts presents no conceptual problem. The CBA calculates measured benefits and costs and converts them into 'economic' values by correcting for distortions in the market such as taxes and subsidies. Environmental impacts are simply additional costs or benefits. The necessity for shadow pricing them tends to arise more from the fact that they lack associated markets altogether, rather than from the existence of distorted markets.

If the environmental impacts of a project result in damages to goods and services which are marketed, the shadow pricing is straightforward. For example, if scientific data can show that there is a decline in wheat yields due to soil erosion, then the cost of this environmental impact will be lost revenue from reduced wheat sales. In other words, price per tonne of wheat (net of any taxes and subsidies) is multiplied by the reduction in wheat yields measured in tonnes. This assumes that the reduction in wheat yields does not affect the price of wheat.

If the environmental impacts of a project result in damages to goods and services which are not marketed, the shadow prices will have to be estimated using economic valuation methods as discussed earlier. Such estimates depend on individual's willingness to pay to avoid, or willingness to accept compensation to tolerate, the environmental impacts. For example, if scientific data can show that the air pollutants emitted from a paper mill lead to damages to human health, then the cost of this environmental impact will be people's WTP to avoid or WTAC to tolerate these damages.

Discounting

The dynamic nature of economic and environmental costs and benefits is a complex issue within the CBA framework. Conventional cost-benefit approaches would regard £1 of future cost as being of less value than £1 of cost today because of the phenomenon of discounting. There are two basic inter-related reasons to why the discounting phenomenon occurs.

First, treating £1 in year 2 as being the same as £1 received in year 1 implies that society is indifferent as to when it receives the £1. But casual reflection will indicate that this is not so. For, by taking the £1 in year 1 we can put it into a savings account (or some other form of money

investment) and earn £1 plus the rate of interest on £1 by year 2. This means that we shall value £1 in year 1 at more than the £1 in year 2. We would rather have the £1 earlier than later simply because there exists a positive interest rate in the economy. If we argue that interest rates exist because of *the productivity of capital*, then we have one reason for arguing that a given unit of benefit (and cost) is worth less the further and further it occurs in the future. In other words, £1 invested now in real capital assets will be worth £1+r next year, where r is the rate of capital productivity. Hence, £1 now and £1+r next year are to be viewed as equivalent. Put another way, £1 next year is the same as £1/(1+r) now. Estimates of the rate of capital productivity, or more strictly, the rate of return on the marginal project displaced by the expenditure in question, vary.

Second, we could simply observe the behaviour of individuals and conclude that, regardless of interest rates, people do prefer their benefits now rather than later. They could simply be impatient. Or they might think that, as they will be richer later on, the £1 in the future will mean less to them. Hence the earlier the £1 accrues, the more they prefer it. On the basis of either or both these criteria, individuals will have *positive time preference* – they will prefer now to later. We cannot logically exclude their preference about the incidence of costs and benefits through time. In turn, this means that we must 'discount' future benefits and costs.

Since we are measuring the costs and benefits as they accrue to the society as a whole, the time preference of the society is what counts rather than the time preference of an individual. This is logical as the lifetime of an individual is much shorter than the lifetime of a society. Hence, it can be expected that individuals will be more impatient than society as a whole. Estimating the rate of time preference for the society as a whole is not straightforward. Pearce and Ulph (1995) show that a rate applicable to the UK is 2.5-3%. Other research suggests public investments should be evaluated at the risk free rate of return of about 2.5%. (For more information see Pearce, 1993).

Discounting when environmental costs and benefits are concerned is more complex. If the current generations value benefits and costs more strongly now, they would prefer to choose projects and policies which produce benefits now and costs later. This raises the issue of intergenerational equity since most of the environmental costs and benefits of projects and policies are likely to be realised sometime in the future. There are two broad options for accommodating the distant nature of environmental costs and benefits in discounting. The first requires that some intergenerational criterion of sustainability be imposed (such as the requirement for the protection of a minimum number of organisms necessary for the survival of the marine ecosystem), leaving the conventional discount rate unmodified as a means of allocating resources within a generation. The second involves seeking some quantitative adjustment to the conventional discount rate. The problem with the former adjustment is that, as yet, few specific rules for practical operation have emerged. Indeed, it may be that there is no requirement for special rules: each concerned individual simply argues for a 'fairer' allocation of resources to the future. The problem with the second approach is that it takes fairly heroic assumptions to make a quantitative adjustment that is other than arbitrary. The discounting problem is not resolved either way in terms of real-world conclusions. If discount rates above 1-2% are used, an issue such as global warming is very unlikely to be seen as significant. Future generations would simply have to bear the cost.

Net Present Value (NPV) is then the discounted value of the benefits net of costs, i.e.:

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

Where C_t is costs occurring between now and t; B_t is benefits occurring between now

and t; **r** is the discount rate; **t** is year t, and **n** is the time period over which costs and benefits are discounted.

Hence, the requirement for choosing project x is that NPVx > 0 and that NPVx > NPVy, where y is the alternative project. Note that NPVx need not be > 0 if some project has to be chosen. The same relationship can be expressed as a benefit-cost ratio, i.e. the ratio of present value of benefits over the present value of costs (B/C). The requirement for choosing project x is then that (B/C)x > 1 and that (B/C)x > (B/C)y. Another measure of net benefit is called internal rate of return (IIR) and defined as the rate of return or the interest rate prevailing at the point of break-even when present values of costs and benefits are equal or NPV is equal to zero. If IRR is greater than the market interest rate, this is an advantage for the project.

Case Study:
Agroforestry in Malawi

1 Problem Definition

The rapid disappearance of extensive areas of woodlands in Malawi has been the subject of concern, particularly at the policy and planning levels. However, the evaluation of past projects showed that there was little information on how they related to the wider rural agricultural economy and the costs and benefits of alternative agroforestry projects. This study evaluates a Tree Planting Bonus scheme for *faidherbia albida*, an agroforestry species indigenous to Malawi which can return substantial amounts of nitrogen to the soil.

2 Identification of Costs and Benefits

The principal benefits of an agroforestry system which would increase nutrient availability are increased yields; costs per unit of nutrient that are lower than the costs for chemical fertilizers; lower risks of losing benefits from chemical fertilizers in the event of the failure of rains; improved soil structure due to the addition of organic matter; and the increased availability of other outputs such as firewood and fodder. The principle costs relate to the relatively long time period involved before benefits are realised, the sometimes labour-intensive requirements of agroforestry management, problems of establishment, and the importance of the timing of the planting.

3 Data Collection and Analysis

Costs

Farmers need a stand of 25 trees per hectare (ha) in order to gain maximum benefits. This costs a total of MK 3 (at MK 0.12 per tree from the Forest Department). In this analysis, it is assumed that 100 seedlings are bought at MK 0.2 (to account for subsidies) plus two days labour to plant and another day of labour per year to protect. Labour was costed at MK 3.30 per person day. The present value of the establishment costs over the 30 years of project life would then total little more than MK40 per ha. Because of higher yields, additional labour of 12 person days per ton for harvesting, and 5.5 person days for shelling, would be required.

Benefits

The yields of local maize varieties would be increased by 15% and that of hybrid maize by 50%, over initial yields of 850 kg and 1,020 kg per ha, respectively. Added benefits which are not considered here include the production of fodder and firewood.

Time Period

It is assumed that the trees will be fully mature in the 25th year. Yield benefits would accrue slowly during the first five years, accelerate between the fifth and 15th years, and then slow down. It was estimated that half of the yield increases would be achieved by the 12th year.

Baseline

To produce similar maize yields using the best crop management and chemical fertilizers instead of *Faidherbia*, a farmer would have to use at least

20 kg of chemical fertilizer nutrient per ha every year. Under poor crop management, as much as 63 kg per ha would be required. At current prices, this would cost at least MK 67 for the 43 kg of urea which would be required in the former instance, or at most, MK212 for the 134 kg of urea which would be required under poor management. Compared with these very high annual costs for chemical fertilizers, the use of *Faidherbia* for increasing crop yields, at a one-time capital cost of MK40 per ha for tree planting, makes an enormous amount of sense.

4 Net Present Value

Based on all of the above assumptions, and a 15% discount rate, benefit-cost ratios of 2.3 and 5.3 could be expected for local and hybrid maize, respectively, grown under *Faidherbia*, as opposed to the baseline case of chemical fertilizers. Note that a cost-benefit ratio greater than one is sufficient for the agroforestry alternative to be chosen over the baseline. In addition, internal rates of return are 23.8% for local maize and 41.4% for hybrid maize.

5 Sensitivity Analysis

The above analysis is repeated for different assumptions, baseline costs, and time periods for realising the benefits of agroforestry. The results show that the benefit cost ratios are most sensitive to the establishment costs, and to the proportionate increases in yields which could be expected.

Source: Dewees, 1995.