Environmental Assessment Sourcebook
UPDATE

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Economic Analysis and Environmental Assessment

Successful economic development depends on the rational use of natural resources and on reducing as far as possible the adverse environmental impacts of development projects. Environmental assessment (EA) is a primary tool for achieving this objective, by inserting critical environmental information into the process of project identification, preparation, and implementation. Economic analysis, by comparison, is employed to determine if the overall economic benefits of a proposed project exceed its costs, and to help design the project in a way that produces a solid economic rate of return. Adverse environmental impacts are part of the costs of a project, and positive environmental impacts are part of its benefits. Consideration of environmental impacts, therefore, should be integrated with the other aspects of the project in the economic analysis to the extent possible. This EA Sourcebook Update *discusses the relationship of EA and economic analysis and gives guidance on how economic analysis might incorporate environmental costs and benefits. This Update replaces guidance provided in Chapter 4 of the* EA Sourcebook.

Bank requirements

The World Bank's Operational Policy on EA (OP 4.01) states that "environmental costs and benefits should be quantified to the extent possible, and economic values should be attached where feasible." This should be done for both alternative project designs and alternative mitigation options. Moreover, the Operational Policy on Economic Evaluation of Investment Operations (OP 10.04) states that EA findings and recommendations should be taken into account in project appraisal and supporting benefit-cost analysis.

EA, economic analysis, and the project cycle

EA is an information-gathering and analytical process that helps avoid environmentally unsound development. It focuses on environmental externalities: unintended adverse effects of development projects on the environment. For example, land clearing for an aquaculture project could convert wetland areas, resulting in reduced bird habitat and water quality. EA seeks to identify and evaluate these environmental effects in qualitative terms, and to quantify them when feasible (for example, air pollution in parts-per-million, or tons of topsoil lost to erosion). The impacts identified in the EA process have not often been converted into monetary terms, however. A major reason behind the generally weak link between EA and economic analysis has been the lack of useful guidance on converting physical impacts into monetary terms. Recently, however, the science of environmental economics has moved to a point where it can be more readily applied in the project context. This Update seeks to explain how this might be done.

The role of EA and environmental economic analysis in the Bank's project cycle is illustrated in simplified terms in table 1. Environmental economic analysis can play an important role at three main stages: (i) in the assessment of the impacts of a proposed project and its various alternatives; (ii) in the analysis of preventive or mitigative options; and (iii) in project appraisal, once a specific alternative has been selected. In the case of both economic analysis and environmental assessment, the important distinction is between what would happen with the project and without the project, not other changes that may be happening over time. This point is sometimes lost as there may be important long term trends that occur irrespective of the project itself.

In the first stage, the economic analysis will normally consist of estimating monetary costs and benefits (valuation) of the various environmental impacts identified in the EA, using a range of

Table 1. EA, economic analysis, and the project cycle

Project stage	*EA activity*	*Associated economic analysis activity*
Preparation	Environmental screening	Potential environmental costs and benefits are considered on a preliminary basis
	Preparation of EA TORs	Requirement to quantify environmental impacts and assign monetary values spelled out
	EA team selection	EA team includes resource or health economist, as appropriate
	EA preparation	EA team analyses the impact of project alternatives and compares them, using monetary values on their costs and benefits, where feasible
	Review of EA	The Bank reviews the EA report, including the economic analysis
Appraisal	Incorporation of EA into project design and documentation	EA findings, including the environmental costs and benefits, are incorporated into the project economic analysis and the estimation of the economic rate of return
Negotiations	Agreements reached on actions to be taken, based on the findings of the EA	
Implementation	Environmental supervision	Supervision includes monitoring the project's actual environmental costs and benefits

valuation techniques. In the second stage, the analysis is extended to consider the costs and benefits of preventive and mitigative measures, so that comparisons can be made with the original project impacts. At the third stage, the monetary values for the selected alternative are integrated into the overall economic *evaluation* of the proposed project. These evaluation techniques, which are generic, are discussed briefly towards the end of this *Update*.

For the integration of EA and economic analysis to be successful, both need to be designed and undertaken with the needs of the other in mind. All indices of environmental damage are not equally helpful for economic analysis. For example, a measure of soil loss in areas affected by erosion will be less useful than a measure of the resulting change in agricultural productivity. Similarly, consideration of the economic benefits at stake can help target EA resources to the areas of greatest interest. These possible inter-relationships should be incorporated from the beginning in the development of TORs, the selection of the EA team, and other stages of the EA and project preparation process (see table 1). Needless to say, the services of a trained economist will be required.

Valuing environmental impacts

For a project's environmental impacts to be valued, they must first be identified and measured. This is generally far from straightforward. Environmental impacts are often dislocated in time and space, making cause and effect difficult to establish. The severity of environmental impacts often depends on the accumulation of problems (over time, over space, or both). Many environmental goods and services do not enter markets, or do so only imperfectly. The difficulties this causes for valuation are compounded by the empirical limitation that available data are often scarce or of poor quality.

Total economic value. Economic valuation is still an evolving science. For some goods and services (for example, a kilo of rice or fish, or a cubic meter of timber), the market provides prices that are good reflections of the values society places on that good or service. For other goods and services, market prices either do not exist or only capture a small part of the total value. Examples of such goods and services include endangered species and scenic vistas. To ease in the task of analysis, therefore, it is often useful to disaggregate any environmental impact into individual components of value. One approach to doing this is called the *Total Economic Value* (TEV) approach, whereby an impact is decomposed into a number of categories of value (figure 1). The idea behind the TEV approach is that any good or service is composed of various attributes, some of which are concrete and easily measured, while others may be more difficult to quantify. The total value, however, is the sum of *all* of these components, not just those that can be easily measured. The breakdown and terminology for the components of TEV vary slightly from analyst to analyst, but generally include (i) direct use value; (ii) indirect use value; and (iii) non-use value. The former two are generally referred to together as “use value”. Each is often further subdivided into additional categories.

Direct use value. Direct use value, also known as extractive, consumptive, or structural use value, derives from goods which can be extracted, consumed, or directly enjoyed. In the context of a forest, for example, extractive use value would be derived from timber, from harvest of minor forest products such as fruit, herbs, or mushrooms, and from hunting and fishing. In addition to these directly consumed goods, direct use values can also be non-consumptive. For example, people who enjoy hiking or camping in the same forest receive a direct use value, but do not actually “consume” any of the forest resource. Similarly, in a coral reef direct use values can include the harvesting of shells and catching of fish, or the non-consumptive use of the reef by scuba divers.

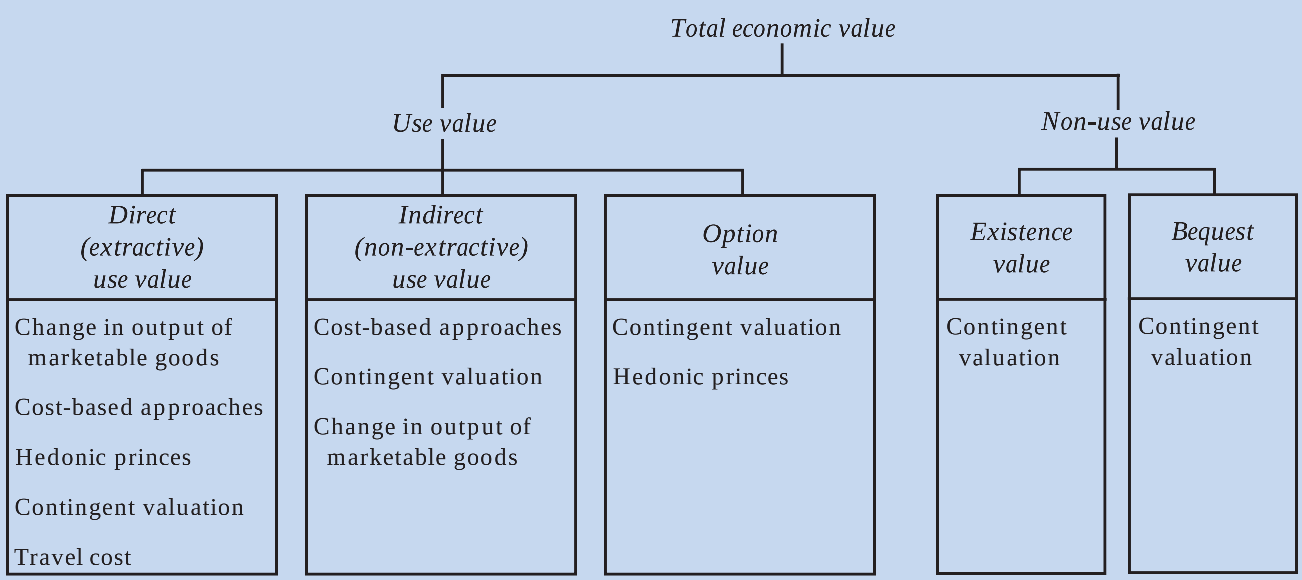
All of these benefits are real, can be measured, and have values, even if the consumption by one individual does not reduce the consumption by another (economists call this non-rival consumption, and these goods are classified as public goods). Consumptive use is generally the easiest to value, since it usually involves observable quantities of products whose prices can usually also be observed. Non-consumptive use is often more difficult to value since both quantities and prices may not be observed.

Indirect use value. Indirect use value, also known as non-extractive use value or functional value, derives from the *services* the environment provides. For example, wetlands often filter water, improving water quality for downstream users, and national parks provide opportunities for recreation. These services have value but do not require any good to be harvested, although they may require someone’s physical presence. Measuring indirect use value is often considerably more difficult than measuring direct use value. The “quantities” of the service being provided are often hard to measure. Moreover, many of these services often do not enter markets at all, so that their “price” is also extremely difficult to establish. The visual aesthetic benefits provided by a landscape, for example, are non-rival in consumption, meaning that they can be enjoyed by many people without detracting from the enjoyment of others.

Option value. Option value is the value obtained from maintaining the option of taking advantage of something’s use value (whether extractive or non-extractive) at a later date. It is, therefore, a special case of use value, akin to an insurance policy. (**Quasi-option value**, which derives from the possibility that even though something appears unimportant now, information received later might lead us to re-evaluate it, is a related concept.)

Existence and bequest value. In contrast to use value, non-use value derives from the benefits the environment may provide which do not involve using it in any way, whether directly or indirectly. In many cases, the most important such benefit is **existence value**: the value that people derive from the knowledge that something exists, even if they never plan to use it. Thus, people place a value on the

Figure 1. Total economic value and selected valuation techniques



existence of blue whales, or of the panda, even if they have never seen one and probably never will; if blue whales became extinct, many people would feel a definite sense of loss. **Bequest value** is the value derived from the desire to pass on values to future generations. Non-use value is the most difficult type of value to estimate, since in most cases it is not, by definition, reflected in people's behavior and is thus wholly unobservable.

Benefit-cost vs cost-effectiveness. Two approaches are possible to the economic analysis of environmental impacts. The first is to use standard benefit-cost criteria, in which the benefits of an action are compared to its costs to determine whether the action is worth undertaking. This approach is commonly used to compare alternative options and requires that the environmental impacts be identified and that monetary values be placed on the outcomes. An example is the analysis of different air pollution control measures and the expected health benefits associated with each alternative.

In some cases, however, a traditional benefit-cost analysis may not be feasible or desirable. It may not be possible to make monetary estimates of benefits. For example, some natural areas may be so unique that it might be felt they should be conserved at all costs. In other cases, there might be substantial uncertainty about the benefits provided by environmental goods and services, either now or in the future, or great problems in determining appropriate values in monetary terms. When loss of these goods and services would be irreversible, it may be desirable to choose the strategy that minimizes maximum possible losses due to environmental damage, unless the social cost to do so is unacceptably large; this is known as the *safe minimum standard* approach. In such cases, the appropriate approach to the analysis is one of *cost-effectiveness* rather than cost-benefit; that is, the issue becomes one of finding the cheapest and most effective way of achieving the conservation objective or some other goal. Note that the cost-effectiveness approach does identify the most *efficient* way of reaching a goal, but does not tell you if the expected benefits justify the costs. Answers to the latter question must rely on informed judgment and common sense.

Valuation techniques

Incorporating environmental impacts identified in the EA into the project analysis is a two-step process. First, one has to understand *what* are the impacts. This information is provided by a traditional EA. Second, one has to estimate the value of the impacts (where feasible and appropriate) in monetary terms to determine their relative economic importance, and assess the benefits and costs of various alternatives. This section focuses on *valuation techniques*, and their use in project analysis.[1] In most cases, the techniques have two parts: measuring the physical impact, and then assigning a value to that impact.

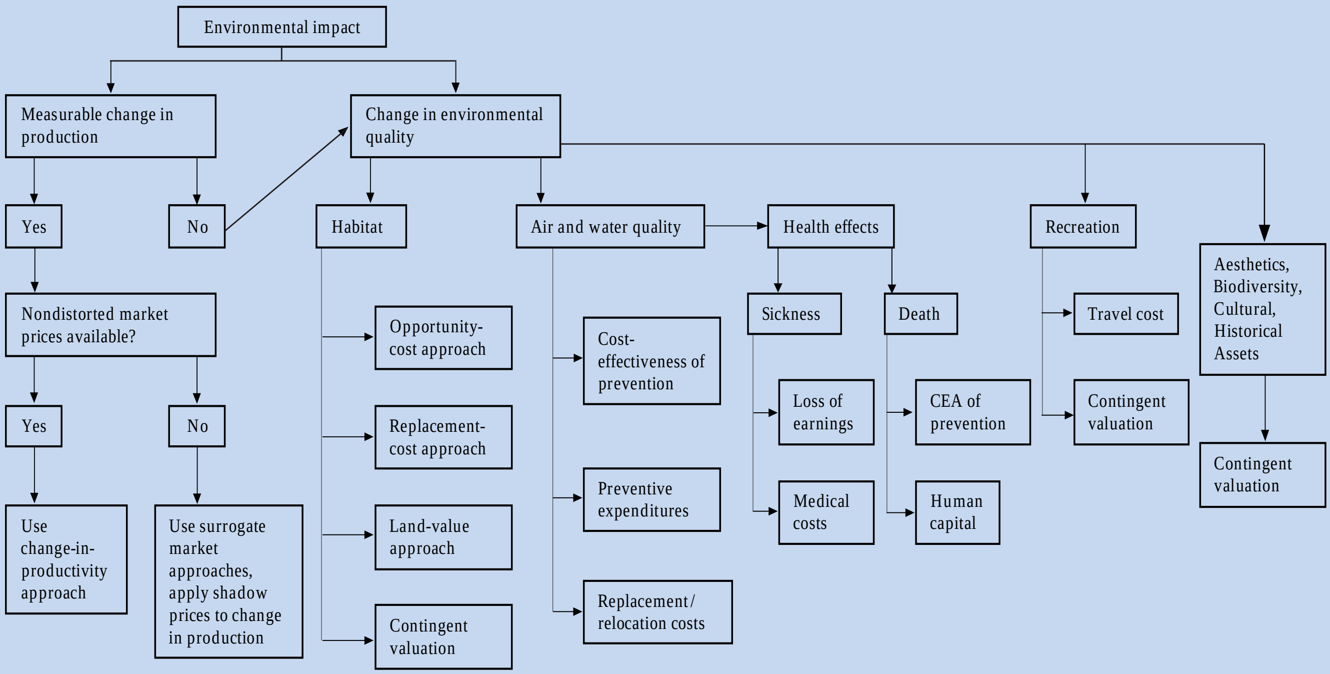
As can be seen in figure 1, a number of valuation techniques are potentially applicable to each category of value. Figure 2 provides a simplified guide to choosing an appropriate technique for a given situation. The flow chart begins with an environmental impact and asks if there is a measurable change in production, or a change in environmental quality. Depending on the answer, it traces out different possible scenarios and their possible impacts. It shows the most commonly-used techniques used to estimate monetary values for each kind of impact. As an example, consider the case of an aquaculture development project which will reduce the area of mangrove forest. The EA might identify reduced water quality due to loss of the mangrove forests' water-filtering services and loss of habitat as adverse impacts. Unless the mangrove forests are directly harvested, techniques such as change-in-productivity will clearly not be very useful. Several techniques might be used to value the reduction in water quality; some are based on the cost of obtaining clean water by other means (for example, replacement or relocation cost), while some are based on the consequences of reduced water quality (increased sickness or death). The specific choice of technique will depend on the situation and on data availability. Likewise, the loss of habitat could be valued in a number of ways, depending on the specific nature of the situation. Figure 2 is only intended as an indicative guide; depending on the specific conditions encountered and on the data available, other techniques may be preferable in a given situation.

I. Valuing Changes in Outputs and Direct Costs

Change in output of marketable goods

In many cases, the environmental effects of projects manifest themselves (at least in part) in changes in output of marketable goods: loss of forest, for example, results in the loss of timber products, of fuelwood, of fodder (whether collected or eaten on site by livestock grazed in the forest), and a variety of non-timber products such as fruit, herbs, and mushrooms. In cases such as these, the value of the unintended benefits and costs can be estimated by using the simple technique of valuing the change in output caused by the project. This approach is often referred to as the *change-in-productivity* approach. In **Croatia**, for example, reforestation activities under the Coastal Forest Reconstruction and Protection Project were estimated to result in increased wood production, which would be harvested at various intervals in the future. Using the increased wood

Figure 2. Choice of valuation technique



Source: Dixon and Bojö in Dixon et al., 1994.

output (in terms of both quantity and quality), the expected prices at time of harvest, and a discount rate of 10%, the present value of increased wood production was estimated at between 2.5US$/ha and 82US$/ha, depending on the site. Box 1 below provides an additional example of the use of this technique, to value the damage to agriculture resulting from flooding and damage to irrigation caused by watershed degradation in **Haiti**. Even when prices cannot be observed (for example, products harvested for home consumption), there are generally-accepted and reliable ways to estimate the value of the products (for example, by using the value of close substitutes or the cost of collection).

The biggest difficulty in valuing such impacts generally arise from measuring the amounts of goods being produced and in predicting how these amounts will change with and without the project. The EA can be very helpful in arriving at estimates of these changes. Once these estimates are in hand, valuing the changes is usually relatively simple.

Cost of illness and human capital

Many environmental impacts, such as air and water pollution, have repercussions for human health. Valuing the cost of pollution-related morbidity (sickness) requires information on the underlying damage function (usually some form of a dose-response relationship) which relates the level of pollution (exposure) to the degree of health effect as well as information on how the project will affect the level of pollution. The costs of an increase in morbidity due to increased pollution levels can then be estimated using information on various costs associated with the increase in morbidity: any loss of earnings resulting from illness, medical costs such as for doctors, hospital visits or stays, medication, and any other related out-of-pocket expenses. This approach is symmetric: the benefits of actions that reduce the level of pollution and hence of morbidity are estimated in the same way.

This approach was applied in Santiago, **Chile**, where a package of air pollution control investments was evaluated in terms of the health benefits from reduced levels of particulates, volatile organic

Table 2. Annualized benefits and costs of air pollution control strategy in Santiago, Chile

(US$ millions)

Program component	*Benefits*	*Costs*	*Net benefits*
Fixed sources	27	11	16
Gasoline vehicles	33	14	19
Buses	37	30	7
Trucks	8	4	7
Control strategy	**108**	**60**	**48**

Source: World Bank, 1994.

compounds (VOC), and nitrous oxides (NOx) in the city. As shown in table 2, the analysis estimated that the benefits of the overall strategy exceeded costs by about 70 percent, with the benefits of individual components of the strategy exceeding their costs by between 20 percent and 140 percent (World Bank, 1994; Ostro and others, 1996). The costs of doing this type of study, both in money and time, can be considerable. In the case of Santiago, however, since data were available for many variables, it was possible to produce good results in a timely manner. The details of the analysis are presented in the papers cited earlier.

The estimates obtained in this manner are interpreted as lower-bound estimates of the presumed costs or benefits of actions which result in changes in the level of morbidity, since this method disregards the affected individuals' preference for health versus illness, for which they may be willing to pay. Also, the method assumes individuals treat health as exogenous and does not recognize that individuals may undertake defensive actions (such as using special air or water filtration systems to reduce exposure to pollution) and incur costs to reduce health risks. In addition, the method excludes non-market losses associated with sickness, such as the pain and suffering to the individual and to others concerned, and restrictions on non-work activities. Also, the approach ignores other, non-health benefits from reducing pollution levels such as amenity values (better views), productivity losses, and ecosystem impacts.

When this approach is extended to estimate the costs associated with pollution-related mortality (death), it is referred to as the *human-capital approach*. It is similar to the change-in-productivity approach in that it is based on a damage function relating pollution to productivity, except that in this case the loss in productivity of human beings is measured. The human-capital approach is an extension of the more standard human capital theory which relates the demand for education to its potential payoff in terms of expected life-time earnings. Because it reduces the value of life to the present value of an individual's future income stream, the human-capital approach is extremely controversial when applied to mortality. We recommend, therefore, that this approach *not* be used. In many cases, the costs and benefits of activities that affect mortality can be expressed in terms of changes in the number of deaths (without monetary values) and a cost-effectiveness approach used. Alternatively, the US / OECD type estimates of the value of a statistical life based on willingness to pay estimates (which includes much more that just lost productivity and is often 5 to 10 or more times larger than the straight human-capital estimates) might be used, adjusted using relative per capita GNP (see World Bank, 1996c, for more on these estimates). In general, estimating monetary values for mortality is a complicated, quite subjective process that has to be used with great caution and transparency.

Cost-based approaches

When the benefits of a given environmental impact cannot be estimated directly, information on costs can be used to produce valuable information. For example, an order of magnitude estimate of the potential costs (or savings) to society from a change in an environmental problem, can be obtained by using the cost of reducing or avoiding the impact, or the cost of replacing the services provided by the environmental resource. The major underlying assumptions of these approaches are (i) that the nature and extent of physical damage expected is predictable (there is an accurate damage function available), and (ii) that the costs to replace or restore damaged assets can be estimated with a reasonable degree of accuracy. It is further assumed that these costs can be used as a valid proxy for the cost of environmental damage. That is, the replacement or restoration costs are assumed not to exceed the economic value of the asset. These are strong assumptions and may not be valid in all cases. It simply may cost more to replace or restore an asset than it was worth in the first place. For example, cultivated hillsides may be eroding and there may be methods available (terracing, changes in cropping patterns) to reduce or prevent the erosion. Each of these preventive measures has a cost, however, and it is the responsibility of the analyst to determine if the total costs of prevention are greater or less than the benefits of preventing erosion. In some case, the costs of erosion control may be so high (and / or the benefits from controlling erosion may be so low) that erosion control measures would be an inappropriate use of scarce resources.

In some cases, there may also be more cost-effective ways to compensate for environmental damage than to replace the original asset or restore it to its original condition, and these substitution possibilities are ignored with the use of this technique. If substitutes are available, the method will likely overestimate the value of the damaged or destroyed asset. Because of this, these methods are generally thought to provide an *upper-bound* estimate of the benefits of measures taken to prevent the damage from occurring.

Replacement cost. The replacement cost approach is often used as an estimate of the cost of pollution. This approach focuses on potential damage costs as measured by *ex ante* engineering or accounting estimates of the costs of replacement or restoration if damage from pollution were to occur. For example, the costs of air pollution-related acid deposition in urban areas could be approximated by the restoration and replacement costs from damaged infrastructure. Similarly, the cost of restoring a river or a wetland could be used as an estimate of the costs of environmental damage to these natural assets. Note that this approach provides only a partial measure of damages caused by pollution.

For example, the replacement cost technique can be used to estimate the costs of pollution of potable water supplies. Pollution of water resources by agrochemicals is common in many countries, resulting in drinking water below acceptable health standards. Quantifying the aggregate health impacts, or estimating a damage function for this type of water pollution, is often difficult because of the complex relationship between ambient quality, exposure, and illness. However, order of magnitude estimates of the cost of providing alternative safe water supplies often are possible. The incremental investment cost of alternative water supply usually can be derived from proposed water supply investment projects containing data on total investment cost and the quantity of incremental water supply. Using the replacement cost technique, an estimate of the annual cost of pollution of potable water can be made. For instance, assuming an estimated investment cost for alternative water supply on the order of US$0.5–1.0 per cubic meter, and current level of total potable water use at about 100 million cubic meters per year, the cost of pollution of potable water would be approximately US$50–100 million per year at current levels of water use. Box 1 provides an example of the use of replacement cost to value the benefits obtained from reduced flooding thanks to watershed protection in **Haiti**.

The replacement cost technique is particularly useful to assess the costs associated with damage to tangible assets, the repair and replacement costs of which are easily measurable. This information can then be used to decide if it is more efficient to allow the damage to occur and pay the replacement costs or to invest in preventing the pollution in the first place. The technique is less useful, however, for very unique assets, such as historical or cultural sites and unique natural areas, which cannot be replaced and cannot easily be restored, and about which restoration costs are uncertain.

Box 1. Costs and Benefits of the Pic Macaya National Park in Haiti

The economic analysis of the Natural Reserve Management component of the Forest and Parks Protection Technical Assistance Project in the Republic of Haiti provides an example of the use of several valuation techniques in a data-scarce environment (World Bank 1996d). The main objective of the project is to protect critical remnants of Haiti's forest ecosystems, including the Pic Macaya National Park. By protecting this area, important benefits are expected in terms of (i) protecting some of the last remnants of the Hispaniolan moist forest ecosystem, which is considered regionally outstanding and as having the highest priority for conservation at the regional scale; (ii) preserving the potential for ecotourism development; (iii) protecting downstream areas, which include one of the country's main irrigated areas, from damage from flooding and sedimentation; and (iv) helping to regulate downstream water flows.

- **Change in productivity.** Protecting the Pic Macaya watershed will help reduce damage to irrigation systems downstream, both from siltation and from reduced dry-season flow, which is forcing a reversion to rainfed cultivation and a switch to lower-value crops. Returns from rainfed production are about 200-800US$ / ha / year lower than for irrigated production, depending on the crops being planted. Combined with estimates of the effects of damage to irrigation infrastructure on the area irrigated, the present value of the benefits of avoided reduction in productivity, relative to the no-project case, were estimated to be about US$2–7 million (the wide range reflecting the weakness of the underlying data).

- **Replacement cost.** The costs of damage to irrigation and other infrastructure were estimated using their replacement costs (2,500 to 5,000 US$ / km for irrigation canals and 3,500 to 7,000 US$ / km for roads). This resulted in an estimated benefit from avoided damage, relative to the no-project case, of about US$2.5–5 million.

- **Opportunity Cost.** Protecting the Pic Macaya area also means forgoing its use as agricultural land and the benefits of harvesting standing timber. By using crop production budgets developed for the surrounding area, the potential value of the Pic Macaya area for agriculture can be estimated. Assuming that half of the area still under forest at Pic Macaya (about 3,500ha) is suitable for agricultural use (the rest being too steep or inaccessible), the present value of forgone agricultural production is about US$175 thousand. This relatively low estimate is due to the unsustainability of agriculture under conditions such as those at Pic Macaya. The foregone wood harvesting benefits could not be estimated for lack of data on standing timber, but were expected to be relatively low due to the high transport costs of extracting timber from the area.

Table 2 summarizes the results of the economic analysis of Forest and Parks Protection Technical Assistance Project, which covered Pic Macaya and two other National Parks.

Relocation cost. Similar to the replacement cost approach, the *relocation cost approach* uses estimated costs of a forced relocation of a natural or physical asset due to environmental damage. For example, the construction of brackish water ponds in a coastal area of **Thailand** resulted in the discharge of salt water into nearby freshwater streams traditionally used for irrigation and domestic water supply. Part of the environmental costs associated with this discharge is the need to relocate the intakes for both irrigation facilities and domestic water supply. The costs of relocating these intakes can then be compared to the alternative costs of redesigning and constructing drainage canals from the brackish water ponds directly to the ocean, to obviate the need for discharge into the nearby freshwater streams.

Another recent example of the relocation cost approach can be found in **China**, where the government decided to relocate Shanghai's water intake. Shanghai, a city of 14 million, was facing increasing difficulties in ensuring a safe potable water supply. The lower Huangpu River was heavily polluted by wastes from industries and ships, and by municipal sewage. The cost of moving the municipal water intake up river to take advantage of cleaner water supplies, reduced pre-use treatment costs, and lower risk of major pollution incidents was estimated. This was then compared to subjective estimates of the cost to clean up the industries and plants discharging wastes into the river — that is, to clean up the existing pollution. The analysis did not consider the benefits of a clean, safe water supply, however. The costs of relocation were judged less than the costs of cleanup, so the relocation option was chosen.

Opportunity cost. In some cases it is decided to protect a particular resource and forego other development options. The term *opportunity cost* refers to the value of these lost economic opportunities due to environmental protection. It is, therefore, a measure of the cost of environmental protection in terms of development benefits foregone. Box 1 provides an example of the use of this approach in **Haiti**. Since this approach gives no information on the expected benefits from protection, society must still decide if the opportunity cost of conservation is acceptable or not. This is a very powerful technique, however, since it clearly identifies the expected economic cost of protection to society. In many cases, this amount is actually very small; in other cases, this information can be used to mobilize other sources of funds to compensate individuals or society for the opportunity cost of protection. The Global Environment Facility (GEF) and other donors may be willing to provide grant funds to cover these types of costs, especially when the benefits produced are important at the global level.

II. Valuing Environmental Amenities: Recreation, Nature, and Biodiversity

Often, the environmental good or service being valued is not traded per se in the market place. Examples of these amenity-type services include recreational sites and the preservation of biodiversity. A number of valuation techniques exist that can be used to place monetary values on these resources and this information, in turn, can be incorporated into a more conventional benefit-cost analysis.

Hedonic analysis

We know that environmental quality affects the price people are willing to pay for certain goods or services. Ocean front hotels, for example, charge different rates depending on the view (rooms with ocean views cost more than the same size room with a "garden" view —usually a nice way of saying the parking lot!). Hedonic models have been widely used to examine the contribution of different attributes to prices for housing and to wage levels, including the contribution of environmental quality.[2] Many observed prices for goods are prices for bundles of attributes. For example, property values depend on physical attributes of the dwelling (such as number and size of rooms, amenities such as plumbing, condition); on the convenience of access to employment, shopping, and education; and on a number of less tangible factors such as environmental quality. Since each house will differ slightly from others, the influence of the various factors on its price can be broken down statistically, provided sufficient observations are available.

This approach is of interest because many environmental dimensions are likely to be embodied in property values. A home in a neighborhood with low air pollution, for example, should sell for more than a similar home in a neighborhood with high ambient air pollution. Hedonic techniques allow this effect to be measured, holding other factors such as size and amenities constant. In essence, the technique estimates the implicit prices for various attributes, which together make up the sale price.

When applied to housing data, this approach is often referred to as the *property value* approach; when applied to wage data, it is generally referred to as the *wage differential* approach. In **Croatia**, for example, a hedonic analysis was used during preparation of the Coastal Forest Reconstruction and Protection Project to help estimate the landscape benefits of reforestation. Analysis of hotel room prices showed that rooms with views of forested landscapes cost, on average, about 3–6US$ / day more than rooms in hotels in areas without such views. The challenge of both of these techniques is to correctly specify the relevant variables and the functional forms.

Hedonic methods require observations of the prices of goods and of the attributes of these goods. To enable the effect of the many different factors to be distinguished, large data sets are usually needed. Because of their data intensity and the need for open reporting of prices, the application of these techniques has had limited (but often successful) application in developing countries.

Travel cost

The travel cost (TC) method is an example of a technique that attempts to deduce value from observed behavior.[3] It uses information on visitors' total expenditure to visit a site to derive their demand curve for the site's services. The technique assumes that changes in total travel costs are equivalent to changes in admission fees. From this demand curve, the total benefit visitors obtain can be calculated.[4]

The TC method was designed for and has been used extensively to value the benefits of recreation. The TC method depends on numerous assumptions, many of which are problematic in the context of international tourism. The basic technique generally assumes that travel cost is proportional to distance from the site and that people living at the same distance from the site have identical preferences. While these assumptions are often valid in the case of national tourism (tourism within a country), neither assumption may be valid in the case of international tourism. The technique also assumes a single-purpose trip and encounters difficulties when trips have multiple purposes. It should also be borne in mind that the resulting estimates are site-specific. The main application of TC methods in developing countries is to valuing tourists' willingness to pay for national parks. In **Zimbabwe**, a TC analysis of tourists found that they derived about US$610 per person of benefit (consumer's surplus) from their trip, of which about US$275 was obtained from visiting national parks (Brown, Ward, and Jansen, 1995). In **Costa Rica**, the benefit obtained by tourists visiting the parks and reserves was about US$1,150 per person (Mekhaus and Lober, 1996).

Contingent valuation

Unlike techniques which use observed data, the Contingent Valuation (CV) technique relies on direct questioning of consumers (actual or potential) to determine their willingness-to-pay (WTP) to obtain an environmental good.[5] A detailed description of the good involved is provided, along with details about how it will be provided. The actual valuation can be obtained in a number of ways, such as asking respondents to name a figure, having them chose from a number of options, or asking them whether they would pay a specific amount (in which case, follow-up questions with higher or lower amounts are often used).

CV can, in principle, be used to value *any* environmental benefit. Moreover, since it is not limited to deducing preferences from available data, it can be targeted quite accurately to ask about the specific changes in benefits that the proposed project would result in. This also means that, with appropriately-worded questions, CV can provide an all-encompassing estimate of the perceived costs and benefits of environmental changes, in contrast to other techniques which, as noted above, often only provide a partial estimate of environmental costs and benefits. Because of the need to describe in detail the good being valued, interviews in CV surveys are often quite time-consuming. It is also very important that the questionnaire be extensively pretested to avoid various sources of bias. CV methods have been the subject of severe criticism by some analysts (see, for example, Hausman, 1993). A "blue-ribbon" panel was organized by the US Department of Interior following controversy over the use of CV to value damages from the 1989 *Exxon Valdez* oil spill. The report of this panel (NOAA, 1993) concluded that CV can provide useful and reliable information when used carefully, and the panel provided guidance on doing so. This report is generally regarded as authoritative on appropriate use of the technique.

In some cases it is possible to do both a CV and a Travel Cost analysis for the same valuation question. This allows the analyst to "cross check" the two estimates and get an idea of the robustness of the results. This approach has been used a number of times in determining the consumer's surplus of safari visitors to game parks in East Africa, with surprisingly consistent results. It is particularly useful since one measure is based on observed behavior (the travel cost approach) while the other is based on hypothetical survey information (the CV approach). Box 2 provides some examples of the application of CV methods in the context of Bank operations.

Benefits transfer

Benefits transfer is not a methodology *per se,* but rather refers to the use of estimates obtained (by whatever method) in one context to estimate values in a different context.[6] For example, an estimate of the benefit obtained by tourists viewing wildlife in one park might be used to estimate the benefit obtained from viewing wildlife in a different park. This has, in fact, been done in East Africa where estimates of the consumer's surplus for safari visitors in one country have been used to estimate the benefits to new safari destinations in nearby countries. The main attraction of benefit transfer is that it provides a low-cost way of estimating values when time or resources do not allow fuller valuation studies, or when the good or

Box 2. Applications of contingent valuation in Bank operations

In recent years, there has been increasing use of contingent valuation (CV) techniques to value environmental goods and services, in both developed and developing countries. Recent examples carried out in the context of World Bank operations include:

- In **Madagascar**, CV was use to value the cost to local communities of refraining from using the area of the Mantadia National Park, established under the Bank-financed Forest Management and Protection Project, to gather a variety of products (Kramer and others, 1995). Local residents were asked whether they would be willing to accept specified levels of compensation (denominated in units of rice, the local staple food) to forgo access to the forests in the Park. Their responses were used to estimate a mean value per household of about $108—very similar to the value obtained by other means. A separate CV survey of international tourists showed they would be willing to pay about $65 more per tourist for access to the new Park.

- In **Croatia**, CV was used to estimate tourists' willingness to pay for restoration of forested landscapes in coastal areas that were destroyed during the war, as part of the economic analysis for the Coastal Forest Reconstruction and Protection Project (World Bank, 1996b). Two parallel surveys were carried out, one among tourists in Croatia itself and one among foreign tourists at similar destinations in Italy. Both showed a willingness to pay for forested landscapes of about US$3 / person / day.

- In **Morocco**, CV was used to estimate tourists' willingness to pay for conservation and rehabilitation of the historic Medina at Fès, a UNESCO World Heritage site that is rapidly deteriorating. The survey distinguished the willingness to pay for improvements of visitors of the site itself (who derive *use value* from visiting the site) from those of other visitors to Morocco (who only derive *existence value* and *option value*). Visitors to the site itself were found to be willing to pay as much as US$70 each in the form of increased tourist taxes or admission fees for improvements aimed at preserving and improving conditions in the Medina, while non-visitors would be willing to pay about US$30 each.

service to be valued has not yet been created (for example, a new safari-tourism destination national park) so that there are no users to survey. This approach also has considerable risks, however. For many reasons, estimates derived in one situation can be inappropriate in another. As a result, benefits transfer has been the subject of considerable controversy in the economics literature. A consensus seems to be emerging that benefit transfer can provide valid and reliable order-of-magnitude estimates under certain conditions:

- The commodity or service being valued have to be very similar at the site where the estimates were made and at the site where they are applied; and
- The populations affected must be very similar.

Of course, the original estimates being transferred must themselves be reliable for any attempt at transfer to be meaningful. The estimates of the value of timber products produced by reforestation in **Croatia** cited previously indicate the limitations of benefits transfer techniques: even in a seemingly homogeneous area, environmental benefits can vary by an order of magnitude. The likelihood that benefits transferred from another area will be appropriate is, therefore, extremely low. Conversely, the use of CV to value tourists' willingness to pay for forested landscapes in Croatia (see Box 2) provides an example of a situation in which benefits transfer can be used with considerable confidence. Since tourists visiting Croatia are drawn from the same pool as those visiting other Mediterranean resort areas, and since forested landscapes are relatively similar, estimates of tourist willingness to pay obtained in one location can be used in another. The benefits transfer technique should be used with caution, therefore, and only when no site-specific measures are possible.

Incorporating environmental costs and benefits into economic analysis

The choice of technique depends on the specific problem being studied. Except in very simple situations, however, it is likely that a variety of techniques will be necessary to estimate the full range of benefits. Moreover, where substantial investments are contemplated, it might be desirable to cross-check estimates by deriving them from multiple sources.

Once the various environmental impacts have been identified and the benefits and costs of various alternatives assessed, this information can be incorporated into the broader economic analysis of the project. This is usually done in a benefit-cost framework, whereby the streams of benefits and costs of a proposed project (including both direct project inputs and outputs, as well as environmental impacts to the extent that they can be identified and monetized) are compared over some period of time. The three main decision criteria used in benefit-cost analysis are: *net present value* (NPV), *internal rate of return* (IRR) and *benefit-cost ratio* (BCR). All of these criteria rely on the concept of discounting a stream of benefits and costs which occur at different times over the duration of the project being evaluated. Discounting puts all of these costs and benefits into a common time frame to allow for more accurate comparison. Adding environmental costs and benefits does not change the method of analysis and guidance is available in various Bank publications, such as the *Handbook on Economic Analysis of Investment Operations* (World Bank, 1996a). However, several aspects of project analysis need particular attention when environmental problems are present. The impacts of many environmental changes, whether positive or negative, are often only felt in the future, long after the activity which caused the change has ceased. Similarly, effects are often felt far beyond the boundaries of the project itself. Special attention must be given, therefore, to the *temporal* and *spatial boundaries* of the analysis.

Temporal Boundaries. Since environmental impacts extend long beyond the normal life of the project, it is important to extend the time horizon of the analysis so as to include all the benefits and costs associated with environmental impacts, even if they go further into the future than the normal life of a project. The effective length of the time horizon of an analysis is determined by both the number of actual years included in the analysis and the discount rate used. Using too short a time horizon effectively ignores many environmental impacts, both positive and negative. For example, an activity that results in the permanent loss of a fishery should include in the analysis the present value of the entire future loss of that resource, even if the activity itself only lasts for a few years.

The choice of the appropriate *discount rate* is also an important decision, since a high discount rate effectively reduces to zero the present value of benefits and costs that occur many years in the future. This *does not* imply that a different discount rate should be use when environmental impacts are important; in fact, it is always wrong to mix discount rates within one analysis. Given the importance of the discount rate, however, it is important to do sensitivity analysis using different discount rates. This can yield useful information to the decision maker when comparing alternatives that have very different time profiles of benefits and costs (including environmental ones).

Two approaches are possible to incorporating long-term environmental effects. One approach is to extend the time horizon of the entire analysis to cover a period long enough to include all environmental effects (at least to the point where, given the discount rate, any additional environmental impact has no further effect on the analysis, typically after 50-100 years). Alternatively, the present value of the entire future stream of environmental impacts (benefits and costs) can be computed, and then incorporated in the normal project analysis framework in the same way that a residual value estimate for a long-lasting capital good would be.

Spatial Boundaries. When environmental effects are present, careful thought must also be given to the appropriate *spatial boundary* of the analysis. The analyst often has to look far beyond the geographical boundaries of the project itself, especially when water or air pollution is involved. In other cases, global aspects may be important and require a further expansion of the "accounting stance" of the analysis.

With both spatial and temporal externalities, the important rule is to be transparent in the assumptions being made, and explicitly state the adjustments that have been used in defining the analytical boundaries for the project—both in space and over time.

Whatever the actual techniques used to estimate the value of environmental benefits or damages, an important point that should be borne in mind is the likelihood of **underestimation**. Inevitably, some types of value will prove impossible to estimate using any of the available techniques, either because of lack of data or because of the difficulty of extracting the desired information from them. To this extent, any estimates of value will underestimate the total value; the estimates of project benefits will, therefore, be conservative, while estimates of costs will be optimistic. That some environmental benefits cannot be quantified, however, does not mean that they should be ignored. Rather, any unquantified benefits should be described qualitatively to the extent possible. Table 3 illustrates how a mix of quantifiable and unquantifiable benefits might be presented in a table. Several of the benefits that were not quantified in this instance are in fact potentially quantifiable, using the techniques indicated, but data and budget constraints prevented this. Since the quantifiable benefits were large enough to justify the proposed investments by themselves, devoting additional resources to quantifying the remaining benefits was judged to be unnecessary.

Another potential problem which must always be considered is the risk of **double-counting**. The likelihood that total benefits will be underestimated because some benefits cannot be measured is well-recognized. Less well recognized is the opposite danger: that benefits (even if accurately measured) might be overestimated because some benefits are counted twice. An example will illustrate the problem. Suppose that the project aims to reduce air pollution at the site by relocating or shutting down polluting activities. The benefit of this reduction could be estimated by predicting the reduction in the prevalence of respiratory illnesses and valued using

Table 3. Quantified and unquantified benefits of protecting national parks in Haiti

Benefits	*Amount (US$ million)*	*Comments*	*Valuation technique*
Costs			
Project expenses	6		From PAD
Forgone agricultural income	2		Opportunity cost
Forgone logging income	?	Unlikely to be large due to high transport costs	Opportunity cost
Total	**8**		
On-Site benefits			
Biodiversity conservation	?	Regionally outstanding ecosystem with many endemic species	CV
Tourism potential	?	Considerable potential, but will require additional investment	CV, TC
Sustainable harvest of timber products	?	Limited potential due to high transport costs	Change in productivity
Non-timber products	?	Considerable potential, but no data exist to estimate incremental benefits	Change in productivity
Sub-total			
Off-site benefits			
Reduced damage to irrigation	6–24	Siltation and reduced dry-season flow reduce yields and area irrigated	Change in productivity
Reduced damage from flooding	4–6	Flooding damages standing crops and infrastructure	Replacement cost
Increased water availability	?	Reduced dry season flow endangers the population's water supply	Replacement cost
Sub-total	**10-30**		
Total quantifiable benefits	**10-30**		

Notes: All amounts are expressed in present value terms, discounted at 10%.
Source: Adapted from World Bank, 1996d.

the reduction in treatment costs. At the same time, suppose that a hedonic technique is used to estimate the value of overall environmental quality. Since air pollution is part of environmental quality, treating these two estimates as though they described separate problems and adding the corresponding benefits together would be inaccurate.

A final point. One should not lose sight of the beneficiaries and stakeholders involved in any project. Because of the existence of externalities, the costs and benefits of various activities to individual actors can vary substantially. The socially desirable outcome or action may well not be privately beneficial. Therefore it often is important to carry out an appropriate analysis of private returns ("financial analysis") in order to understand the individual perspective. Only if this is done will it be possible to identify the policies or measures necessary to reconcile the individually and socially desirable actions.

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Endnotes

1. For a general survey of techniques used in valuing environmental benefits, see Dixon and others (1995). For a more detailed exposition of the use of many of these techniques, see Hufschmidt and others (1983). For a technical discussion of the economic theory behind many of these technique, see Braden and Kolstad (1991). Hanemann (1992) provides a historical account of the development of the principal environmental valuation techniques.

2. Palmquist (1987) reviews the theory that forms the basis of hedonic estimation.

3. The theory and application of TC methods are described fully in Hufschmidt and others (1983). For numerous examples of the application of TC methods to value recreational benefits in Europe, see Navrud (1992).

4. These benefits take the form of *consumer's surplus*, the benefit they enjoy above the costs involved in taking part in the recreational activity. A basic assumption is that the consumer's surplus of the most distant visitor is zero, and that anyone more distant does not come to this site since the costs (travel costs) exceed the value of the benefits of the visit (It is important to note that the value of the site is *not* given by the total travel cost; this information is only used to derive the demand curve and thereby estimate the consumer's surplus of visitors.)

5. A vast literature has developed on contingent valuation techniques. The standard text is Mitchell and Carson (1989); for a more theoretical exposition, see Carson (1991).

6. A special issue of the *Water Resources Research* was devoted to benefits transfer, and provides the best available overview of the conceptual and empirical issues involved; see Brookshire and Nell (1992) and the following papers in that issue. A recently completed report by the Asian Development Bank relies heavily on the use of benefit-transfer (ADB, 1996), and contains many examples of the application of benefit transfer.

EA Sourcebook Updates

Number and Title	Date
1 The World Bank and Environmental Assessment: An Overview	Apr. 93
2 Environmental Screening	Apr. 93
3 Geographic Information Systems for Environmental Assessment and Review	Apr. 93
4 Sectoral Environmental Assessment	Oct. 93
5 Public Involvement in Environmental Assessment: Requirements, Opportunities and Issues	Oct. 93
6 Privatization and Environmental Assessment: Issues and Approaches	Mar. 94
7 Coastal Zone Management and Environmental Assessment (also in Arabic)	Mar. 94
8 Cultural Heritage in Environmental Assessment (also in Arabic)	Sep. 94
9 Implementing Geographic Information Systems in Environmental Assessment	Jan. 95
10 International Agreements on Environment and Natural Resources: Relevance and Application in Environmental Assessment (*second edition*)	Mar. 96
11 Environmental Auditing	Aug. 95
12 Elimination of Ozone Depleting Substances	Mar. 96
13 Guidelines for Marine Outfalls and Alternative Disposal and Reuse Options	Mar. 96
14 Environmental Performance Monitoring and Supervision	Jun. 96
15 Regional Environmental Assessment	Jun. 96
16 Challenges of Managing the EA Process	Dec. 96
17 Analysis of Alternatives in Environmental Assessment	Dec. 96
18 Health Aspects of Environmental Assessment	Jul. 97
19 Assessing the Environmental Impact of Urban Development	Oct. 97
20 Biodiversity and Environmental Assessment	Oct. 97
21 Environmental Hazard and Risk Assessment	Dec. 97
22 Environmental Assessment of Mining Projects	Mar. 98
23 Economic Analysis and Environmental Assessment	Apr. 98

This *Update* was prepared by John Dixon and Stefano Pagiola of the Environmental Economics and Indicators Unit. The *EA Sourcebook Updates* provide guidance for conducting environmental assessments (EAs) of proposed projects and should be used as a supplement to the *Environmental Assessment Sourcebook.* The Bank is thankful to the Government of Norway for financing the production of the *Updates.* Please address comments and inquiries to Colin Rees and Aidan Davy, Managing Editors, EA Sourcebook Updates, Environment Department, The World Bank, 1818 H St. NW, Washington, D.C., 20433, Room No. MC-5-105, (202) 458-2715.