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Environmental Safeguards Unit

TECHNICAL NOTE

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Economic Cost - Benefit Analysis (CBA) of Project Environmental Impacts and Mitigation Measures:

Implementation Guideline

John A. Dixon

July 2012

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This Technical Note was prepared by the Environmental and Social Safeguards Unit (VPS/ESG) of the Inter-American Development Bank (IDB). This paper provides guidance to Bank staff on how to conduct an expanded, comprehensive economic cost-benefit analysis (CBA) in order to measure net benefits from a project taking both project and environmental factors into account, as required under Directives B.5 and B.9 in the Bank's operational policy OP-703.

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Acronyms

CBA	Cost-Benefit Analysis
IDB	Inter-American Development Bank
EIA	Environmental Impact Assessment
ESG	Environmental Safeguards Unit
NPV	Net Present Value
B/CR	Benefit/Cost Ratio
CV	Contingent Valuation
EA	Environmental Assessment
TEV	Total Economic Value
PV	Present Value
EIRR	Economic Internal Rate of Return
CVM	Contingent Valuation Methods
BCA	Benefit-Cost Analysis
IRR	Internal Rate of Return
GEF	Global Environment Facility
TC	Travel Cost

Contents

Introduction and Policy Requirements

The expansion of project analysis to incorporate environmental effects is the direct result of an evolution over time in the evaluation of development projects. Traditional project Cost-Benefit Analysis (CBA) was developed in the 1930s to analyze large public investments in the water sector in the United States. The goal was a simple one: projects should produce positive net benefits over time; that is, the present value of benefits should exceed the present value of costs. As experience was gained in project CBA, it was noted that important environmental and social impacts were being ignored. This led to actions to explicitly expand the analysis of projects.

The first step was the inclusion of environmental (and social) aspects in a qualitative manner. It was soon realized, however, that a further step was needed. Since projects were developed and implemented to increase social welfare (usually measured in monetary terms) it became clear that it would be easier to analyze alternative projects, mitigation measures, and remaining impacts if all of the benefits and costs—direct and indirect, financial and environmental—could be measured using a common *numeraire*: money. Hence the focus on monetary valuation of environmental impacts so that they can be included in the more comprehensive analysis of alternatives (and the overall net benefits generated by a project).

Over the past 30 years the international development banks and various international agencies have led the way in this expanded CBA. Great advances have been made in the qualitative, and quantitative, analysis of environmental and social impacts. These changes are reflected in the requirements by major international development banks to take these factors into account in project analysis.

Operational Policy 703 of the Inter-American Development Bank (IDB) contains two policy Directives that explicitly call for economic analysis of environmental impacts and project alternatives. Directive B.5 states that "**The EIA should be supported by economic analysis of project alternatives and, as applicable, by economic cost-benefit assessments of the project's environmental impacts and/or the associated protection measures.**" Directive B.9 states that the Bank will not support projects that degrade or convert critical natural habitats or that damage critical cultural sites unless "**comprehensive analysis demonstrates that overall benefits from the operation substantially outweigh the environmental costs, and … (that) mitigation and compensation measures acceptable to the Bank—including as appropriate, minimizing habitat loss and establishing and maintaining an ecologically similar protected area that is adequately funded, implemented and monitored.**"

B.5 is more focused on environmental impacts identified as part of the environmental impact assessment (EIA), and B.9 is more focused on the special case of impacts on natural habitats and cultural sites. The explicit wording in B.9 is worth repeating: "comprehensive analysis demonstrates that overall benefits from the operation substantially outweigh the environmental costs." This objective has a simple economic goal: the maximization of net benefits from a project taking both project and environmental factors into account.

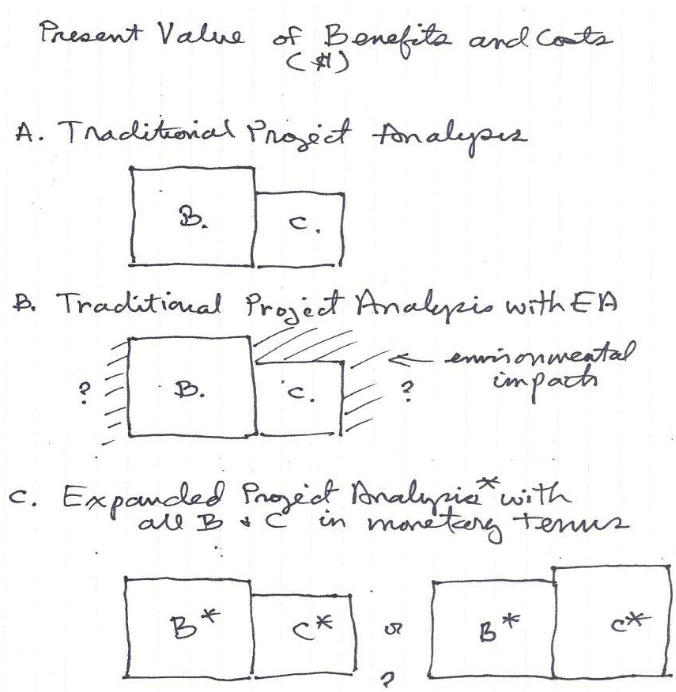
When the Expanded Analysis is Necessary—and when it is not

Experience with previous projects and the initial EIA will indicate when an expanded, comprehensive cost-benefit analysis (CBA) is needed. The Guidelines for Environmental Screening and Classification (ESG Note No. 2) explains the selection of the appropriate Category—A, B, or C. For most projects common sense provides useful guidance. Major infrastructure type investments (e.g. ports, roads, irrigation systems, dams) will normally have major long-term impacts on the environment and significant conversion of natural habitat. These Category A projects will require an EIA and will benefit from the expanded, comprehensive CBA. In contrast, a schoolbook program or a family planning project may require neither an EIA nor an expanded CBA. These are usually Category C projects. For many other projects the correct Category depends on specifics on the ground. The project may be a Category A or may be a Category B—depending on an initial assessment. This note addresses some of the issues that arise when an expanded, more comprehensive, economic CBA is needed.

Adding the environmental dimension does not requiring changing any of the fundamentals of the project analysis methods that have been developed over many years. All three project evaluation criteria commonly used to assess the attractiveness of projects—NPV, B/CR, and IRR (see the Definitions in Annex 2 for details on these terms)—are **based on the same data**. Each criterion can be used to make decisions on individual projects or among competing projects. Explicitly adding the environmental impacts in the monetary analysis is an extension that expands the definition of what benefits and costs are included, both in space and over time.

The expansion of project analysis can be shown graphically (see Figure 1). The figure shows the transformation from **traditional project analysis** (A), to the **qualitative** analysis including of environmental impacts (B), to the monetary valuation of those impacts (C). At present all projects should, at a minimum, have a traditional CBA (Figure 1, alternative A). In addition, many projects also meet the second test and include qualitative (and sometime quantitative) discussion of environmental impacts (Figure 1, alternative B). Fewer projects meet the third criteria of a fully comprehensive monetary analysis of both project and environmental benefits and costs (Figure 1, alternative C). This is both the “intellectual frontier,” and the “best practice frontier” of project analysis.

Figure 1. Different Levels of Project Analysis (Present Value in $)



Practical First Steps/ Guidance for Carrying Out Economic Valuation

The following suggestions are offered for implementing the mandate found in OP-703 to carry out more comprehensive BCAs of projects.

First, at the initial project identification and scoping stage, incorporate the economic analysis of environmental impacts as part of the process (not as something to be "added-on" later). Thereby the necessary staff time and data collection will be included in the project preparation work plan and budget. This is particularly important for Category A projects.

Second, environmental impacts affect social welfare and the generation of net benefits to society, and these impacts should be included in the cash flow tables of benefits and costs over the life of the project. The CBA results can be presented in three ways: first, a standard project CBA can be calculated as seen from the perspective of the borrower (and ignoring all externalities). This is the same as alternative A in Figure 1. Second, the same basic CBA is done but in addition the costs of any negative externalities and the benefits from any positive externalities are included (e.g., externalities are calculated and added in as benefits or costs as appropriate but no mitigation are taken or included in the analysis). This is the same as alternative B in Figure 1 (except that all impacts are now expressed in monetary terms). Third, an analysis is done from the perspective of the country or society and incorporates all benefits and costs, including both direct project variables as well as any environmental and/or social variables. This analysis includes any mitigation costs and any remaining environmental damage costs. The third analysis is referred to as the "comprehensive analysis" and is the same as alternative C in Figure 1.

The three analyses will usually produce different results; the only exception is when there are **no** environmental or social externalities of the project. It is not possible to say *a priori* in what direction the results will diverge. Although people usually assume that the comprehensive analysis will show greater costs and lower net benefits than the project-only CBA, this is not always the case. For example, the project may generate positive economic externalities and these will add to the net benefits estimated in the comprehensive analysis. If the project generates negative externalities, on the other hand, the impact on the results of the comprehensive analysis will depend on the size of the negative externalities and to what extent they are mitigated, and at what cost.

Using the Net Present Value (NPV) criterion, one would normally expect the first analysis to have the largest NPV (since it ignores all externalities). The second analysis will produce a reduced NPV (since the costs of negative environmental externalities are now included). The third analysis should produce a NPV between the first two results—there will be increased costs for environmental protection but reduced costs from environmental damage. The third analysis also indicates the net benefits generated by a project **from the perspective of society.** It is, therefore, the correct measure to estimate the net benefits produced by any project.

The actual mechanical calculation of the three results is not difficult **once the required data have been collected and environmental benefits and costs calculated**.

Annex 1 presents a "synthetic" case study illustrating this approach. The project is a port development in a mangrove coast. This case study gives an example of the three levels of analysis using "synthetic but realistic" data. Result 1 is the traditional, narrow project CBA. Result 2 takes a social-welfare perspective but does not take any mitigation measures or compensation into account. The difference between Result 1 and Result 2 is that the second result gives a more accurate picture of the actual change in social welfare as a result of the original project. Result 3 is the expanded/comprehensive analysis called for in Directives B.5 and B.9, and includes all benefits and costs, after appropriate environmental mitigation or compensation measures are taken into account.

In order to expand the analysis from Result 1 to Result 3 it is necessary to calculate the monetary values of the environmental benefits and costs associated with the project and the needed mitigation measures. Many economic valuation techniques exist that can be used in project preparation. Annex 3 briefly presents some of the techniques that a trained environmental economist has in his/her toolkit. Choosing the correct valuation technique depends on both the type of externality being evaluated, the time, data and resources available for the analysis, and the skill of the analyst. (See Dixon [1994, 2011] and Dixon and Pagiola [1998] for a fuller discussion of these techniques.)

In this case the port development will destroy an area of coral reef and mangrove and these values can be measured using various techniques: *change in production approaches* to value loss of reef ecosystem and associated fish catch and the loss of mangrove forest products, and the *defensive expenditure approach* to look at on-shore costs due to loss of coral reef protection functions and mangrove ecosystem services. Changes to coastal communities and their loss of traditional, non-marketed values from the coral reefs and the mangrove will probably be best valued using some form of *contingent-valuation method*.

The port and its development may also produce some positive externalities, principally through improved access to the coastal area and improved infrastructure including water and electricity. Reduced costs of goods and services to local communities can be valued using *changes in prices*. Medical benefits from improved road access and improved water and sanitation can also be valued using various *cost-side approaches to value changed health outcomes.*

In this example, the analysis uses a 20-year time horizon and builds on the traditional project cash flows of benefits and costs (Costs A and Benefits A). The analysis is expanded by adding various additional benefits and costs (see Annex 1). Costs B are the project costs plus the value of unmitigated environmental externalities due to the original project. Costs C are the costs of investments to mitigate environmental impacts. Costs D are any remaining environmental costs after project re-design. Benefits A are the normal benefits expected from the project. Benefits B are those same benefits plus any positive environmental externalities generated by the original project. In this example, the positive environmental externalities are small and positive; in other cases they may be zero. Benefits C are any additional environmental benefits after mitigation measures are taken. Again, in this case they are small and positive, but in other cases they may be zero.

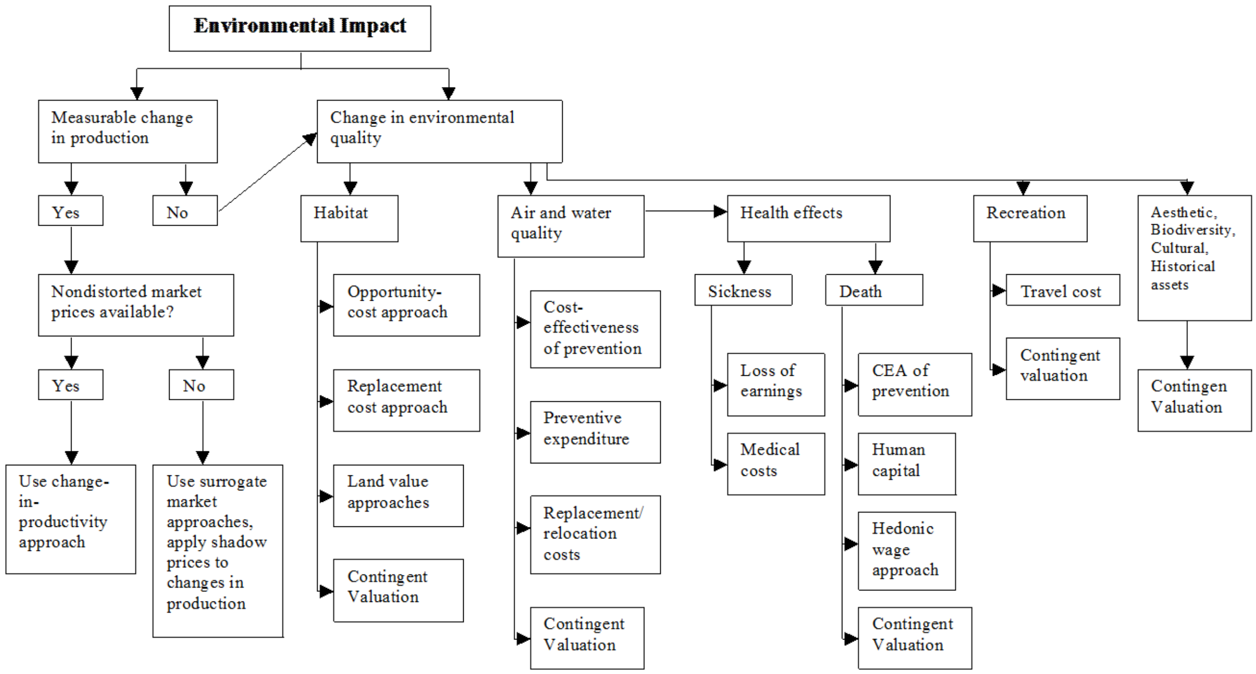
All three results are compared from a social welfare perspective—the generation of net increases in social welfare. Result 1 (Costs A plus Benefits A) has the largest NPV—$262 million; this analysis ignores environmental externalities. Result 2 (Costs B plus Benefits B) has the lowest NPV—$117 million; this result includes the net costs of all environmental externalities associated with the original project. Result 3 (Costs A and Costs C and Costs D plus Benefits B and Benefits C) has a NPV between the other two—$202 million. Result 3 reflects both the benefits and costs of appropriate mitigation and compensation measures as well as direct project net benefits. Result 3 is the comprehensive BCA called for in Directive B.9 and is the most accurate measure of actual welfare changes due to the project. Although the NPV of the comprehensive analysis (Result 3) is lower than the traditional project analysis result (Result 1), it is almost 50% larger than the NPV of the project when environmental externalities are unmitigated but included in the economic analysis of the project (Result 2).

Matching the valuation technique to the environmental externality

In order to complete the comprehensive analysis suggested here it is necessary to decide which valuation technique to use for any given environmental impact. Although each project is unique, there is general agreement among environmental economists that certain valuation approaches are more likely to be suitable for valuing specific environmental goods or services. Figure 2 presents a “valuation flow chart” with suggestions of which valuation approach is most suitable for different environmental impacts. The matrix starts with the simple question: Is there a measurable change in production? If the answer is “yes” then the Change in Productivity approach is usually suitable. If the answer is “no” then one asks if there is a change in Environmental Quality. Four possible changes are listed under this heading: changes in habitat; air or water quality; recreation; and aesthetic, biodiversity, cultural, and historical attributes. Under each heading there is a suggested “first best” valuation technique, followed by other economic valuation techniques.

As seen in Figure 2, those impacts that result in a change of production are among the most robust and frequently used valuation techniques. In most columns the last technique suggested is Contingent Valuation (CV). Although CV is a powerful technique it should not generally be applied if other techniques are possible. However, for some environmental impacts—especially those in the far right-hand column (aesthetic, biodiversity, cultural, historical) CV is usually the only valuation technique possible.

Figure 2. Economic Valuation Flow Chart



In summary, economic valuation is easier when an environmental externality results in a change in production for a good or service for which we can measure market prices. The more tangible and more direct the impacts are, the easier they are to value in economic terms. Examples of the "easier to value" environmental externalities include the following:

Changes in production of crops, forestry, fisheries, ecosystem services;

Air and water pollution and their impacts on health and production;

Costs of alternative measures or mitigation actions (cost-side approaches); and

Recreational use of natural habitats and environmental resources.

Other types of environmental externalities are more difficult to value. The "more difficult to value" externalities include the following:

Biodiversity and/or pristine habitats;

Cultural or historical values; and

Human life (although much can be done to value morbidity and mortality).

Unfortunately, many of the types of environmental impacts addressed by Directive B.9 fall into the "more difficult to value" group. This does not mean that economic valuation is impossible—just that it is often more challenging. Economic valuation techniques exist that can be used to place values on these "more difficult to value" resources, and there are many examples in the literature of such valuations. In addition, it is always possible to do an opportunity-costs analysis to see what development benefits are lost by re-designing the project to avoid the environmental impact. If there are important recreational and/or tourism uses of the resources, the travel cost approach and CVM can both be used to assess economic values. Ecosystem-service values can be measured by using combinations of change in production and various cost-side approaches.

Genetic values and potential loss of species (e.g. extinction) are two areas not handled easily by economic valuation. These environmental impacts are usually valued using CVM approaches, but these may be only partial estimates of their true (total) economic value.

Potential Next Steps for the IDB: Guidance for the Environmental Safeguards Unit (ESG)

Given the fairly daunting task of implementing this new form of comprehensive CBA analysis, project managers will correctly ask "where do we start?" and "what can be reasonably expected?" The following suggestions are offered:

The expansion of a traditional CBA to include the environmental dimension is a **specialized task**. As with any specialized task the person doing the work must have the proper training and experience. In this case an environmental economist—or an economist with experience in addressing environmental issues—is needed. Experience is very important because a major responsibility is to decide what impacts to include and which to exclude, which techniques to employ, and when results are reasonable and when they are not. Conducting an expanded CBA is not a mechanical exercise.

The person responsible for the environmental economic analysis should be **part of the project preparation team from the start** (particularly for Category A projects.) This will facilitate data collection—and working together as a team to better understand the full range of potential impacts, and analyzing alternatives and options as part of project preparation, not merely as an added chapter after all the work on design has been completed. This is not an unreasonable demand. Just as any project that will lead to re-settlement (e.g. dam or port construction) should have sociological expertise in the project team, any project that has a potentially important impact on the environment should have an environmental economist as part of the team.

Taking into account the previous statement, we can say that the “optimal” approach does not necessarily require huge resources and a long time to implement. A trained and experienced economist, working with the project development team, can often produce useful results with a minimum investment of effort if they are efficient in using their time and resources. A “quick and dirty” study may yield a result with an 85% to 90% confidence level, whereas a much larger investment in time and effort may be needed to add an additional 10% to the level of confidence. As with many things in life the optimal tradeoff between time/effort and results will be determined by a lot of “it depends” type questions.

One key element to making this approach successful is to have an experienced, and available, **review team of environmental economists** (with at least one person, but two or three are better) who can give guidance and intervene if needed but are not responsible for the day to day work of analysis. The review panel can do their work from remote sites (e.g. on-line) and use their experience in other projects and training to identify when the analysis is going off-track. A good, and small, review panel can be a very cost-effective way to improve the overall quality of the analysis. They can also add a measure of legitimacy to the final results.

With the previous points in mind, the final messages to ESG include the following:

First, **do not let the perfect be the enemy of the good**. Although a full, expanded comprehensive CBA that includes both project as well as environmental and social impacts is the ultimate goal, a more modest approach may be an acceptable first step. By combining the insights from Environmental Assessment (EA) and the Total Economic Value (TEV) approach (see Annex 3), the project analyst can identify and begin to incorporate the most important externalities into an expanded project analysis. Having the environmental economist as part of the project team facilitates this.

Second, **apply what is already known**. By beginning with the broader conceptual insights gained from the EA process, one can begin to identify major environmental externalities that might be valued and included in the analysis. Good examples exist of valuing many different natural and environmental resources. These include such diverse values as the benefits from recreation and tourism, the health costs of air and water pollution, or the affects of infrastructure investment on natural systems like mangroves or coastal areas.

Third, **start to develop “best practice” examples, one project at a time**. Even partial economic valuation and inclusion of environmental externalities into project analysis will begin the process of developing region- and resources-specific examples. This in turn helps make future project analysis both easier and more robust. It also has the benefit of "embedding" the learning in IDB staff so that the knowledge of how to conduct the expanded analysis becomes part of the institutional memory. Although this process of "learning by doing" can be slow and indirect, the long-term benefit can be major, both for the projects themselves, as well as for the institution.

Annex 1

Synthetic Project Case Study: Port Development in a Mangrove Coast

The project: Country G is developing a new container port to promote expansion of exports and reduce the costs of trade. The port will be developed in an undeveloped area of mangrove coast, and will be linked to the country's existing infrastructure by rail and highway. Initial construction is expected to take four years and the costs of developing the port and later operations, repair and maintenance will be met by port charges, and reduced costs to exporters and importers.

Project costs and benefits: The financial analysis of cash flow of the project is shown in Annex 1 Table 1 in Columns 2 to 8. A 20-year time horizon is included in the analysis and a 6% discount rate is used. The estimated construction costs of $170 million take place in years 1 to 4; Operation and maintenance costs are not estimated here but would be included in Column 2. Major replacement costs are noted in years 9, 14, and 19 (see Column 2). Revenues start in year 5 and grow as shown in the spreadsheet (Annex 1 Table 1, Column 6).

Environmental impacts: The major environmental impacts are the dredging of a channel through the coral reef to reach the new port site, and the loss of 1,000 ha of mangrove for port construction and related infrastructure. There are also impacts on nearby artisanal fishermen who may lose some of their traditional fishing grounds and see a reduction in fish catch per unit effort. The loss of coral to construct a ship channel also results in some shore-line erosion and flooding damages. There are some environmental benefits to the local community from improved access to larger cities, better health care and education, and improved water and electricity infrastructure.

The numbers used in the spreadsheet are "synthetic but realistic" and are designed to show how such a table would look if all the different benefits and costs were identified and entered into the cash flow table. Actually measuring different environmental impacts will depend on time and data available once the different externalities—both positive as well as negative—are identified.

Measuring the environmental impacts

The estimated costs of environmental damage (if unmitigated) are $15 million per year. These are added to project costs to produce Annual Costs B (project costs plus unmitigated environmental costs). These are found in Column 3 of the spreadsheet. Annual Costs C are the costs of environmental intervention after project re-design. These are found in Column 4. In Column 5 are any remaining environmental costs after project redesign—referred to as Costs D. Project related benefits are found in Columns 6, 7, and 8. The first, Column 6, are the project benefits (ignoring all externalities)—Annual Benefits A. Column 7 lists project benefits plus any (potential) positive environmental benefits from the project. Column 8 lists any additional environmental benefits after mitigation measures are taken.

As discussed in the text three scenarios are calculated:

Scenario 1: business as usual (standard project financial analysis). This is CBA Result 1 found in Column 9. The column presents the PV of benefits and costs year by year and the last figure in the column is the NPV over 20 years at a 6% discount rate. One can see the negative PV figures in the early years and then the turn to positive PV figures after major construction is done.

Scenario 2: social welfare NPV with all environmental externalities included. This is CBA Result 2 found in Column 10. Because environmental externalities (both positive and negative) are included, the NPV is considerably smaller than in Analysis 1.

Scenario 3: social welfare analysis with appropriate mitigation measures taken. The comprehensive CBA that includes all costs and benefits produces Result 3 seen in Column 11. The NPV is substantially larger that CBA Result 2 but smaller than Result 1. Result 3 meets the requirement of Directives B.5 and B.9 for a more comprehensive analysis and best reflects changes in overall social welfare due to the project.

The above analyses were done using a discount rate of 6%. Using the same input data on benefits and costs, it is also possible to find the EIRR—the economic internal rate of return of each scenario. The EIRR result is the discount rate at which the NPV is equal to "0"—the PV of benefits is exactly equal to the PV of costs. The same EIRR result also means that the B/CR—the benefit/cost ratio—is exactly equal to 1.0. In this case study the EIRR varies for each scenario, and is just over 17% for Result 1, 10% for Result 2, and 13% for Result 3.

Valuing the environmental externalities: the inputs into the Benefits and Costs estimates

The following lists some of the major impacts (environmental and social externalities) and the techniques that can be used to value them. These values are included in Results 2 and 3:

Lost coral area and associated fish production and ecosystem services: change in production approach (fisheries); defensive expenditures (shoreline protection); replacement costs approach (coral habitat; fish nursery functions); contingent valuation methods— CVM (lost cultural/ social values; loss of endangered species; losses to others who are not direct users of the resources); and other techniques as appropriate.

Loss of mangrove area and associated goods and services: change in productivity (mangrove forest products); CVM (for non-marketed goods and services); replacement cost approach (water filtration services); replacement cost approach, defensive expenditures (shoreline protection); and other techniques as appropriate.

Improved water and sanitation to nearby villages: health care costs avoided (improved water supply, improved sanitation); human capital approach; value of statistical life (deaths avoided); and other techniques as appropriate including use of CVM.

Loss of coastal habitat: replacement coast approach (to restore/ replace habitat); CVM (loss of non-use values to others); and other techniques as appropriate.

Table 1: Net Present Value of Three Analyses for Port Development in a Mangrove Coast

ASSUMPTIONS:	
Discount Rate:	6%
Annual Costs A:	normal project costs
Annual Costs B:	project costs with environmental costs, unmitigated
Annual Costs C:	costs of environmental intervention after project re-design
Annual Costs D:	remaining environmental costs after re-design
Annual Benefits A:	normal project benefits
Annual Benefits B:	project benefits plus any positive environmental externalities
Annual Benefits C:	additional benefits after mitigation, if any
CBA Result 1:	Costs A + Benefits A
CBA Result 2:	Costs B + Benefits B
CBA Result 3:	Costs A + Costs C + Costs D + Benefits B + Benefits C

1	2	3	4	5	6	7	8	9	10	11
Year (time=*t*)	Costs A	Costs B	Costs C	Costs D	Benefits A	Benefits B	Benefits C	CBA Result 1 at *t* =0	CBA Result 2 at *t* =0	CBA Result 3 at *t* =0
1	($60.00)	($75.00)	($10.00)	($5.00)	$0.00	$0.00	$0.00	($56.60)	($70.75)	($70.75)
2	($40.00)	($55.00)	($10.00)	($5.00)	$0.00	$0.00	$1.00	($35.60)	($48.95)	($48.06)
3	($40.00)	($55.00)	($10.00)	($5.00)	$0.00	$1.00	$2.00	($33.58)	($45.34)	($43.66)
4	($30.00)	($45.00)	($10.00)	($5.00)	$0.00	$2.00	$3.00	($23.76)	($34.06)	($31.68)
5	$0.00	($15.00)	($3.00)	($5.00)	$10.00	$13.00	$3.00	$7.47	($1.49)	$5.98
6	$0.00	($15.00)	($3.00)	($5.00)	$15.00	$18.00	$3.00	$10.57	$2.11	$9.16
7	$0.00	($15.00)	($3.00)	($5.00)	$30.00	$33.00	$3.00	$19.95	$11.97	$18.62
8	$0.00	($15.00)	($3.00)	($5.00)	$45.00	$48.00	$3.00	$28.23	$20.70	$26.98
9	($15.00)	($30.00)	($3.00)	($5.00)	$60.00	$63.00	$3.00	$26.64	$19.53	$25.45
10	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$39.09	$32.39	$37.97
11	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$36.88	$30.55	$35.82
12	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$34.79	$28.82	$33.79
13	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$32.82	$27.19	$31.88
14	($10.00)	($25.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$26.54	$21.23	$25.65
15	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$29.21	$24.20	$28.37
16	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$27.56	$22.83	$26.77
17	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$26.00	$21.54	$25.25
18	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$24.52	$20.32	$23.82
19	($10.00)	($25.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$19.83	$15.86	$19.17
20	$0.00	($15.00)	($3.00)	($5.00)	$70.00	$73.00	$3.00	$21.83	$18.08	$21.20
Net Present Value (NPV) of the project over 20 years								**$262.36**	**$116.75**	**$201.75**

Annex 2

Definitions

Cost-benefit analysis (or cost-benefit assessment) **CBA**: cost-benefit analysis is an **economic evaluation technique** that analyzes the generation of economic benefits and costs from a project or policy by comparing the discounted flows of benefits and costs over a prescribed time horizon. The following data are required to complete a CBA: the number of years to include in the analysis (the project life, or time horizon); the values of project benefits and costs (all expressed in monetary terms) for each year included in the analysis; and the discount rate. Benefit-Cost Analysis (BCA) is the same as CBA. All benefits and costs are discounted back to the base year.

The flows of benefits and costs are usually compared using one of three evaluation measures: Net Present Value (NPV), Benefit-Cost Ratio (B/CR), or the Internal Rate of Return (IRR). The third measure is also referred to as the Economic Internal Rate of return (EIRR) when the analysis is done using "economic" prices that remove any policy distortions (such as government interventions in the markets for inputs [e.g. labor/ fuel/ energy] or outputs [e.g. when price boards affect commodity prices]).

The formulas for these three measures are as follows:

Net Present Value (NPV) Equation → NPV = $\sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t}$

Benefit-Cost Ratio (B/CR) → B/C ratio = $\frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$

Economic Internal Rate of Return (EIRR) Equation → $\sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} = 0$

Note that all three measures—NPV, B/CR, and EIRR—use the same input information on benefits and costs (Bs, and Cs), and the same project time horizon, usually measured in years (*t*). To carry out a NPV and B/CR analysis the discount rate (*r*) is pre-determined. For an EIRR analysis the discount rate (*r*) is the answer calculated by the analysis; it is the discount rate when the present value of project costs is just equal to the present value of project benefits.

The three economic evaluation measures provide different pieces of information: a NPV analysis results in a monetary estimate (in $) of the generation of *net* benefits over the life of a project. The B/CR analysis produces a result that is a ratio of net benefits divided by net costs. A

BC/R of 1.0 means that the project produces net benefits of "0"—and the present value (PV) of benefits and costs are exactly equal. A B/CR of more than 1.0 means that a project produces positive net benefits. A B/CR of less than 1.0 indicates a project where the net benefits are negative (the PV of costs is larger than the PV of benefits). When the B/CR is equal to 1.0, the discount rate calculated in the IRR will be exactly equal to the discount rate used in the NPV and B/CR calculation.

Economic externalities: An externality occurs when a project or an activity has an impact on someone who is not part of the decision making process. The important determinant of what are externalities (and what are not) is the involvement (or not) of those affected by an externality in the decision-making process. For example, if a factory produces smoke emissions (or water effluent discharges) that affect someone outside of the project boundaries, then we say that an externality exists. Externalities can be both positive and negative—although we usually think of them as negative. Once an externality is identified and those who are affected are consulted, one of three things can happen: First, the producer of the externality can eliminate it by (in this example) stopping the pollution. Second, those affected can be compensated by money or other actions that make them feel equally well off with the compensation and the pollution. Third, the creator of the externality can ignore the impacts and go on as "business as usual."

Note that if compensation is paid, or appropriate consultation is practiced, the externality is said to be "internalized" and goes away. The pollution may still take place but the act of consultation and/or compensation eliminates the externality. Since many of these externalities occur off-site or later in time, issues of properly estimating the economic size of the damage created and designing appropriate compensation become important. Much of environmental economics is concerned with the identification of externalities and their economic valuation.

Monetary valuation (economic valuation): Monetary valuation (as opposed to economic evaluation—the CBA discussed above) is the placing of monetary values on benefits and costs. The economic or monetary valuation of resources, especially when markets do not exist, is an expanding area for economic research. Different **valuation techniques** exist whereby most goods and services can be valued in monetary terms. Dixon (2011) presents an overview of many of these techniques.

Social welfare: Social welfare, or well-being, is a measure of an individual's or society's sense of how well they are doing. The goal of most individuals, societies and governments is to increase social well-being/social welfare. Social welfare includes both monetary and non-monetary dimensions. Accordingly, environmental externalities that impose "costs" on others lead to a decrease in social welfare, even if those "costs" are not formally priced or even measured. Since the goal of development projects is to lead to a net increase in social welfare (all benefits minus all costs, measured or not) it is entirely appropriate to include costs and benefits associated with externalities—environmental, cultural social—into the analysis of the project.

Total Economic Value (TEV): The TEV concept states that the economic "value" (or "price" for marketed goods and services) is composed of a series of attributes, some of which are more tangible than others. As seen in the standard TEV chart (see Annex 2 Figure 2) the TEV is composed of **Use Values** and **Non-use Values**.

Use Values are those economic values that come from the direct or indirect use of a resource. Use values are usually divided into **direct use values** and **indirect use values**.

- **Direct Use Values**: Direct use values, also known as extractive, consumptive, or structural use values derive from goods which can be extracted, consumed, or directly enjoyed. In the context of a forest, for example, direct use values include the harvesting of timber, the collection 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 enjoyment of the reef by scuba divers. All of these benefits are tangible, can be measured, and have economic 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).
- **Indirect Use Values**: Indirect use values, also known as non-extractive use values or functional values, derive from the *services* the environment provides. Many ecosystem services are examples of indirect use values. 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.

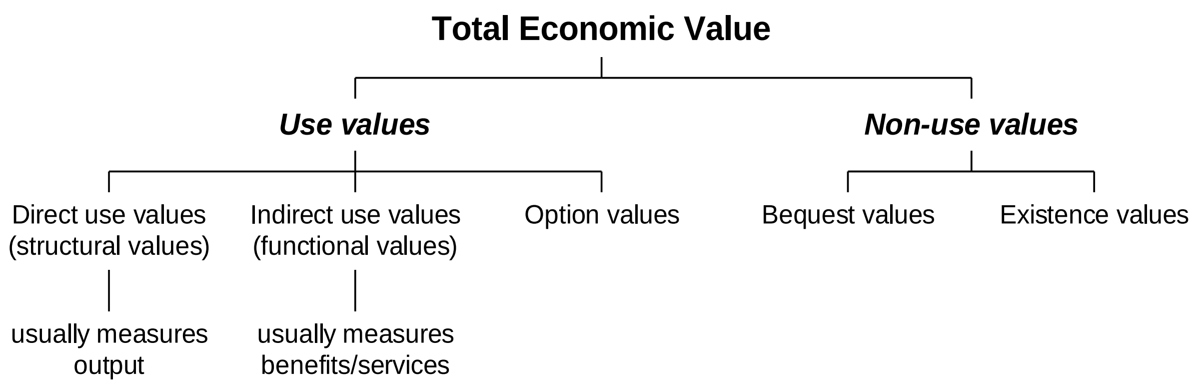
Measuring indirect use value is often considerably more difficult than measuring direct use value. The "quantities" of the services being provided are often hard to measure. Moreover, many of these services often do not enter markets at all, so that their "price" is also extremely difficult to establish. The visual aesthetic benefits provided by a landscape, for example, are non-rival in consumption, meaning that many people can enjoy them without detracting from the enjoyment of others.

Non-Use Values are those economic values where no direct interaction with the resource occurs. For example, in a coral reef one finds direct use values (fishing/ coral collecting) and indirect use values (shoreline protection/ serving as a nursery area for juvenile fish); there may also be important non-use values whereby people who do not visit or use the coral reef still value knowing "that it is there" or seeing photos and films about the reef. The main Non-Use Values include the following:

- **Option Value**: Option value is a deferred use value. This value occurs when people are willing to pay something to have the "option" of using the resource themselves in the future.
- **Bequest Value**: When the option value is for the next generation (e.g. I want my children to be able to see the coral reefs, or the pandas) this is called a Bequest Value. It is the potential use of a resource by the next or future generations.
- **Existence Value**: Individuals also derive a benefit from knowing that a resource is there —whether or not they plan to visit it themselves (a use value) or think that they may want to visit it in the future (an option value), or want to ensure its survival for future generations (a bequest value). An existence value is a benefit that comes from just knowing that the resource in question (e.g. blue whales, pandas, orangutans) exists—hence, the term "existence value."

Note that both Bequest Values and Existence Value imply no use—either direct or indirect—by the present generation. The size of these values may be small per person (in monetary terms) but may be large in the aggregate since many people in a country may have these values.

Annex 2 Figure 2. Total Economic Value



Annex 3

Economic Valuation Techniques

The following survey of major valuation techniques starts with the most direct, robust economic valuation techniques and proceeds to techniques that are more hypothetical or subjective. (See Dixon *et al.* [1994], Dixon and Pagiuola [1998] and Dixon [2011] for an expanded discussion of these techniques.)

Valuing changes in production

Change in output of marketable good. In many cases, the environmental effects of projects are reflected (at least in part) in changes in output of marketable goods and/or services. The biggest difficulty in valuing such impacts comes from being able to measure 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 in monetary terms is usually relatively simple since this approach relies on market prices and measured physical changes in outputs.

Cost of illness and human capital. Good health can also be thought of as a type of "productivity." Many environmental impacts, such as air and water pollution, have impacts on human health, both through illness and death. 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. 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 a form of 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 being measured.

Other 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 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.

However, note that even the most effective "preventive" expenditure may not be justified if we do not have any information on the expected benefits produced (or costs avoided). In some cases it may cost more to replace or restore an asset than it was worth in the first place. 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, these methods will likely over-estimate the value of the damaged or destroyed asset. Because of this, cost-based approaches 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 to estimate 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. The replacement cost technique is particularly useful to assess the costs associated with damage to tangible assets, the repair and replacement costs of which can be estimated. 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.

*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. These costs can be compared to the alternative of changing or redesigning the project to avoid this expense.

*Opportunity cost***.** In some cases it may be decided to protect a particular resource (e.g. a wetland or a protected area—see IDB Policy Directive B.9) and redesign or relocate the project to avoid the environmental impact. (Note that the desired project outputs are still produced, but presumably at higher costs due to the changes made to protect the environment.) The term *opportunity cost* refers to the size of this increased project cost due to changes to protect the environment. The additional costs of realigning a road, for example, to avoid a sensitive ecosystem is said to be the "opportunity cost" of protecting the ecosystem.

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, if the opportunity costs are large, this information can be used to mobilize other sources of funds to compensate individuals or society to compensate for the reduced project benefits. 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.

Valuing environmental amenities: recreation, nature, and biodiversity

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

Property value and wage differential approaches (hedonic analysis)

We know that environmental quality affects the price people are willing to pay for certain goods or services (or demand as compensation to do certain jobs or work in certain places). Ocean front hotels, for example, charge different rates depending on the view. Workers in riskier occupations demand a "wage premium." 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. When applied to housing or land value 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.

Travel cost approach

The travel cost (TC) method estimates values for un-priced goods and services from observed behavior. As commonly applied, 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 information a demand curve can be constructed, and the total benefit to visitors can be calculated. (Note that the costs of travel are used to derive a demand curve from which consumers' surplus can be estimated. The travel costs, per se, do **not** represent the value of the resource being visited. A fuller explanation of this approach would take more space than is available in this note.)

The Travel Cost Method is an example of a "revealed preference" technique since information on actual expenditures (in time and money) is used to estimate demand curves and consumers surplus. It should also be noted that the resulting estimates are site-specific. Travel costs analysis has been widely applied in both developed and developing countries, and an extensive literature exists on the travel cost method.

Contingent valuation methods

Contingent Valuation Methods (CV) are examples of "stated preferences" techniques—consumers answer a survey designed to elicit their "willingness-to-pay" for an environmental good or service. CV is not based on observing actual behavior (as in the case of travel cost studies). 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 environmental quality that the proposed project would produce. 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 most other valuation techniques that only provide a partial estimate of environmental costs and benefits. CV is also the technique used most often to estimate certain non-use values—especially bequest values and existence values.

In the case of recreational use of natural or cultural resources it may be possible to do both a CV and a Travel Cost analysis for the resource being valued. This allows the analyst to "cross check" the two estimates and gives an idea of the robustness of the results. For example, 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).

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. 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. Also, benefit transfer can be appropriate when the good or service to be valued has not yet been created (for example, a proposal to create a new nature-tourism destination national park) and there are no actual users to survey.

This approach has considerable risks. However, 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 has to be very similar at the site where the original estimates were made and at the site where they are being applied; and
- The populations affected must be very similar (e.g. for recreational users the people involved in recreation in the initial study site and in the destination “transfer” site must share many socio-economic characteristics).

Of course, the original estimates being transferred must themselves be reliable for any attempt at transfers to be meaningful. The benefits transfer technique should be used with caution, therefore, and only when no site-specific measures are possible.

Cost-effectiveness versus cost-benefit analysis: when is each approach appropriate?

Cost-benefit vs. cost-effectiveness analysis. Most projects are analyzed in a cost-benefit framework. CBA is commonly used to compare alternative options and requires that the environmental impacts be identified and that monetary values be placed on the outcomes. In some cases, however, a traditional cost-benefit analysis may not be feasible or desirable and it may not be possible to make monetary estimates of benefits. For example, some natural areas may be so unique that it might be determined that 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 difficulties 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 potential losses due to environmental damage (unless the social cost to do so is unacceptably large); this is known as the *safe minimum standard* approach.

When benefits cannot be estimated the appropriate approach is *cost-effectiveness analysis* rather than cost-benefit analysis; that is, the project is designed to find the cheapest and most effective way of achieving the conservation objective or some other goal. Many safeguard policies are analyzed using a cost-effectiveness approach. Note that the cost-effectiveness approach identifies 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.

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