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C O N T E N T S

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Introduction

Cost-benefit analysis of investments for environmental and natural resources protection has become a highly visible and publicly debated topic. In 1992, *The New York Times* (Sept. 8) ran an article entitled "Economists Strive to Find Environment's Bottom Line" that, among other things, reviewed the balance between costs and benefits of U. S. environmental regulation, and interviewed several experts on the difficulties of measuring environmental benefits.

Certainly it is hard, but not impossible, to estimate the benefits of many environmental amenities. But the real issue is how precise our benefit (and cost) estimates are, in the sense that over repeated trials they produce unbiased measures of the true but unknown value, and have reasonably low variance. Professor Myrick Freeman was quoted in the *New York Times* article as saying that the benefits of environmental improvement can be measured within an order of magnitude (a factor of 2), and in some cases, plus or minus 25 percent.

While this degree of variation may not be of great concern in some circles, it does present serious problems for institutions like the Inter-American Development Bank (IDB) that must make a decision to finance an environmental improvement project based on a fixed cutoff rate of return of 12 percent in real terms. Clearly, the smaller the spread in benefits estimates arising from differences among benefit estimation methods, the surer we can be about the feasibility of the project.

This paper develops two main points. First, economic analysis has a definite role to play in informing decision makers about the desirability of going ahead with an investment project designed to improve environmental quality. It is also important to use economic analysis to decide how far to go in preventing environmental damages caused by investment projects whose purpose is not purely environmental. But, second, the precision issue is not trivial. Therefore it is desirable to explore the consequences on our decision of the likely range of benefit estimates introduced by differences among alternative methods available to address the problem, as well as differences introduced by alternative interpretations within any given method. The latter refers to econometric specification issues (like functional form) and model evaluation issues (like integration of estimated demands to get consumer surplus).[1]

The paper begins with a brief discussion of why economic analysis is important, general ways it can be used, and some limitations. Then, the dangers of misapplication of several techniques are illustrated with some real examples drawn from the IDB's experience, to emphasize why it is important to get wholly familiar and comfortable with using the methods before the results they produce can be believed. There are lots of pitfalls for the unwary. It concludes with a section on the use of economic analysis in the environmental assessment process at the IDB.

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[1] This problem is common to most cost-benefit analyses, but often seems to be ignored. Perhaps as environmental economists we are too self-conscious about the imprecision of our benefit estimates in environmental or natural resource valuation problems.

Our attention will be mainly on the costs and benefits of projects directly aimed at natural resource or environmental quality improvement, and the costs implied by the mandatory environmental assessment of investment projects whose primary purpose is not environmental. The discussion is oriented mainly toward problems of environmental pollution caused by the disposal of unwanted byproducts of economic activity, rather than problems of natural resource conservation, although the two are clearly interconnected.[2]

The Cost Of Environmental Quality Improvement and the Desirability of Economic Analysis

Costs

Experience indicates that aggregate pollution control costs are not trivial. For example, in the United States, total pollution control expenditures per year (including annualized capital and operating cost) are two percent of gross national product, and may rise to nearly three percent by the year 2000. Similar proportions of GNP are being spent in western European countries (US EPA 1990).

U. S. environmental regulations in many instances are based on discharge standards that the regulatory agencies define in terms of specific production and pollution control technologies. As a consequence of this misplaced emphasis on technology, ambient environmental quality goals and the discharge limitations needed to meet them have been neglected.

In the United States, the private sector has not been encouraged to innovate or produce a least cost solution to satisfying ambient standards because the regulations discourage investment in new technology and do not have economic efficiency as a primary objective. The way pollution control regulations have been formulated and implemented has led to compliance costs being higher than they have to be to achieve the desired result. For instance, a recent tabulation of case studies (Teitenberg 1990) found that the excess costs of compliance implied by the structure of U. S. regulations are quite large (between 0.7 to 22 times higher than the efficient solution).

A recent review of the record of achievement of federal water pollution control policy in the United States (Freeman 1990) contains a rather sobering assessment. The annual estimated national cost of the policy is between $25 billion and $30 billion dollars (in 1984 prices). The likely range of annual national benefits, the majority of which are from recreation, is between $6 billion and $28 billion. On balance it would appear that the costs of implementing the Clean Water Act probably exceed the benefits. Freeman concludes that present U. S. policies either have to be modified to adjust the ambient water standards in a way that balances marginal control costs and marginal improvement benefits or, more practical perhaps, implement the standards in a more cost-effective way.

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[2] The distinction between pollution control and natural resources management is artificial. Side effects can result from the generation and disposal of waste products in the environment, which directly affect natural resources and ecosystems (e.g. industrial discharges or agricultural runoff can damage fisheries habitat productivity). These effects can, however, be directly tied to project investments without going through waste product pathways. For example, reservoir projects directly remove land from several uses, can indirectly induce erosion in the upper watershed, and interfere with fish migration.

Clearly some U. S. environmental regulations are not cost-effective.[3] These disquieting results suggest that the U. S. pollution control model may not be exportable to developing countries (Halter 1991). It may simply cost too much to implement stringent air and water quality standards through the detailed, control-technology based, discharge permitting process embodied in the U. S. model of command and control.[4]

Of course improved environmental quality need not be unnecessarily expensive, if we add the qualifier that environmental planning must be cost effective in its design and should be implemented in a way that gives business firms some latitude of choice in the methods they can employ to meet environmental goals. Regulatory mechanisms that reduce the generation of residuals in production and consumption and encourage materials and energy recovery often can be more cost effective than an exclusive regulatory focus on end-of-pipe treatment technologies.

How Much is Too Much? The Desirability of Benefit Estimation

The costs of pollution control and natural resource management policies and investments cannot be viewed in isolation from what they bring us in terms of damages avoided. In other words, to determine whether they are worth doing, it is usually necessary to set up the counter factual case of what would happen if such policies or investments were not undertaken. As economists would say, a benefit foregone is a cost, and a cost avoided is a benefit. So, determining if costs are too high is a matter of asking a big question and then two somewhat more manageable and restricted versions.

Environmental policy design can be viewed as a two step process. First standards or targets are set, and then a regulatory structure is established to achieve them (see Cropper and Oates 1992 for a summary).

Referring to the first step, the big question economists like to ask, but have as yet failed to answer in a very precise and operationally useful way (at least in the aggregate) is "What is the overall level of ambient environmental quality that produces a social welfare maximum?" The political process itself is the arena where this question is sorted out through successive iteration. Therefore we will not discuss it here.

However, there are two more practical questions that economists can help answer:

1) Do the benefits of specific environmental regulations or projects outweigh their costs?[5]

and

2) Given a specified set of ambient quality standards in a locality or region, how can they be (or are they being) achieved in the most cost effective way?

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[3] Environmental economists have been saying this for a good while, and recently the U. S. Environmental Protection Agency (EPA) has made progress in introducing economic incentives (the bubble concept, tradeable emissions permits) into the compliance process in order to get the same environmental outcomes at lower cost.

[4] See Mackenthun and Bregman 1992 for a comprehensive review of U.S. environmental legislation and regulation.

[5] This criterion for assessing proposed regulations was introduced in the United States in Executive Order 12291 of 1981 and required U. S. federal agencies to prepare regulatory impact analyses (RIAs) for most major regulations.

Getting an answer to the first of these requires cost-benefit analysis (CBA). The second question is often more tractable, because it takes the goal, or target, (ambient standards) as given, or already established (exogenous, in economist's jargon). When benefits cannot be accurately measured, cost effectiveness analysis (CEA) compares costs of different ways of reaching the target, to identify the alternative (or set of alternatives) that costs the least.

The CEA approach (in variants that can be quite sophisticated) is respectable among environmental economists. Yet economists who are more familiar with conventional CBA analysis for evaluating standard investment projects producing marketable outputs with measurable prices, tend to be skeptical. They prefer CBA with all of its baggage (rates of return, benefit/cost ratios, and the like) for the justification of investments whose primary purpose is environmental.

In cases involving planning for regional pollution control this orientation may require more information than we can reasonably produce — particularly environmental damage functions. If, instead, we take desired environmental targets as given, we can use an approach that Baumol and Oates (1989) call obtaining "efficiency without optimality." This means the design of policies to control environmental externalities that abandons any attempt to obtain extensive information about benefits. Instead it tries to use "the pricing system where it is at its best, in the allocation of damage-reducing tasks in a manner that approximates minimization of costs...." to reach the environmental quality targets.

Steps in Environmental Project Analysis

The plausibility of the result of either CBA or CEA depends on several things, but paramount is the reliability of the noneconomic information which logically precedes economic valuation. First, the potential effects of the intervention (a policy, regulation, or concrete investment project) must be properly <u>identified and quantified</u> in physical and technical terms. Then the outcomes must be <u>valued</u>.

Suppose we want to determine the net benefits of an air or water pollution control regulation, or of a specific pollution control project (e.g. a solid waste disposal scheme), or even the environmental side effects of a project that is not primarily environmental in purpose. Then, the following linkages must be identified and quantified:

<u>Impact Assessment</u>

1. Identify the spatial dimensions of the problem (e.g. a region, an urban area, a watershed).

2. Identify the choice set, which can be either:

   a. A set of alternative environmental regulations (regulatory impact assessment).

   b. A set of alternative environmental improvement investments or a set of alternative productive investments with potentially deleterious environmental side effects (economic project analysis and environmental impact assessment).

3. Determine how alternative regulations, environmental improvement projects, or productive investments will change discharges of residual liquid, atmospheric, and solid wastes (Models of Business and Household Behavior).

4. Determine how changes in discharges will bring about changes in ambient air or water quality conditions (Natural Systems Models of Pollutant Transport, Decay, and Diffusion).

5. Relate changes in ambient quality to changes in exposure of humans, materials, plants, and animals to substances in the environment, and estimate the effect of these contacts in terms of health (morbidity/mortality) effects, materials damage, workplace labor productivity, or decreased leisure opportunities.

Economic Assessment

6. Go from changes in exposure/use to monetary benefits and costs. Choose the best alternative (least cost to meet a specified target or, more generally, the net benefit maximizing package).

Steps 1 and 2, along with steps 4 and 5 that identify and quantify major environmental effects, form the core of the environmental assessment (EA) process. The environmental assessment is largely the province of the physical and natural sciences and other professions that are needed to develop the linkages between development projects, natural systems, and physical damages.

Ideally the analysis process sketched above should not be undertaken in a linear, sequential manner, leaving economics to the end to justify decisions that have already been made. Instead economics should be used to help make them (Moore and Abbasi 1987). Clearly economic analysis enters the picture way before the valuation in step 6 because it has a role to play in steps 1, 2, 3, and 5. Ideally, the project evaluation process should be multidisciplinary and interactive. Yet in practice the EA process is often treated as independent of and prior to economic analysis, and therefore does not build in the degree of multidisciplinary cooperation between economics and the other professions that is needed.

Nevertheless, the principal area where the EA and economics coincide is the common agreement that a set of alternative actions must be postulated and choices must be made among them, using a decision criterion that recognizes tradeoffs. However, traditional EA does not rely on monetary measures of welfare change to choose the best course of action — it invokes other ways of weighing the relative importance of the outcomes from alternative actions (Canter 1986).

Economics comes into play most obviously in the behavioral prediction steps (3 and 5) and the valuation step (6 above). In valuation, an attempt can be made to monetize all benefits and costs for full CBA, or the outcomes in exposure/use per dollar spent, measured in terms of annualized capital cost plus operating cost, can be compared for CEA. Economic approaches become more useful for decision making when they are introduced early in the project design process and when the environmental benefits of mitigating, controlling, or improving actions can be fully and accurately monetized and weighed against their opportunity costs in terms of additional investments, operating costs, or foregone revenues.

Before discussing the assessment of the environmental side-effects of an investment whose primary purpose is not environmental, we first take a brief look at how economic analysis techniques can be used to identify desirable actions to undertake for environmental quality improvement.

An Illustration of CEA and CBA in Environmental Quality Planning

Take an island economy heavily dependent on tourism for foreign exchange. Suppose water quality monitoring results show that pollution loads in nearshore waters are above public health standards and have to be reduced to ensure swimmable water. Then, the authorities must weigh the implications of inaction, particularly the probability of lost revenues from tourism if water quality standards for contact uses like swimming are violated consistently, and the island becomes a less attractive tourist destination. The value added from tourism that would be lost due to inaction is a damage which can be avoided by water pollution control investments, and therefore a benefit that accrues from doing them.

As noted above, there are two approaches to evaluating the situation. The first is a cost effectiveness analysis approach that has been perfected and generalized to a regional context in environmental applications, where it is known as REQM (Regional Environmental Quality Management). REQM is the applied version of the "efficiency without optimality" policy prescription of Baumol and Oates.

REQM essentially is a quantitative way to produce information on the costs and consequences of alternative strategies for improving environmental quality across the environmental media (air, land, and water). It identifies an effective and efficient multisectoral management strategy, that is, the decision concerning what resources to allocate where, how, and when, in order to produce desired levels of environmental quality which can be expressed in terms of a set of measurable indicators like dissolved oxygen concentration, toxic chemical concentrations, and the like (Basta and Bower 1982).

In our example, REQM would take nearshore water quality standards as a target, perhaps simultaneous with ambient air targets in a grid over the region. It would find the least cost combination of activities needed to achieve the targets. These could include control of land based point and non-point sources of pollution (stormwater collection and treatment, sewer and wastewater treatment systems to cover hotels, residences, and industrial establishments, regulation of cleaning and discharge of storage tanks on vessels, reducing fertilizer and pesticide runoff from farms, etc.).

Executing an empirical REQM analysis is not simple, since the pathways of wastewater flow must be determined, and ambient environmental quality levels must be predicted with and without the project. This prediction of natural world outcomes, for instance fecal coliform levels in coastal waters, is done using empirical natural systems models (Basta and Bower 1982). These models, in combination with quantitative activity analysis models of residual wastewater generation by households and business establishments, along with alternatives for wastewater collection, treatment and disposal, allow the system to be solved for an approximation of the least cost set of responses needed to meet the specified target.

The nature of the project itself is defined by initially identifying a large set of alternative actions and their associated costs that can be undertaken in response to the ambient environmental quality (AEQ) constraints, and then finding the cost minimizing subset among them that meets the AEQ target. These activities can (and generally should) go beyond mere public investment in municipal wastewater collection and treatment, to include other options in the regional system for reducing waste loads (including, say, industrial wastewater treatment or process change, intake water pricing options, etc.). Alternatively tightening and relaxing the stringency of the AEQ target(s) in the REQM framework gives decision makers an idea of how total costs for the region react to several different ambient quality levels.

Instead of just showing decision makers the relationship between compliance cost and environmental quality, the most ambitious version of the CBA approach would try to define the best or optimal quality level, including the possibility of no action at all. The more watered down version of CBA we usually meet in practice generally does not claim that the solution is optimal, but only that the discounted net benefits of the chosen activities is positive (activity costs include the "hardware" costs of physical investments and other "software" costs). Here, the new wrinkle is the introduction of benefit (or damage avoided) estimates into the decision process.

In our island example, CBA would try to establish the social rate of return to a pollution control package by actually predicting the reaction of tourist visits, and hence lost revenues, to different nearshore water contamination levels. This is not straightforward, because data may not be available to estimate a statistical model for predicting tourist behavior. Moreover, the "justification" of an arbitrarily specified set of investment activities by CBA is no substitute for the logically prior and perhaps more important elucidation of the least cost set of activities needed for achieving an environmental target embodied in REQM.

CBA or CEA?

The jury is still out on how useful cost-benefit analysis is in the environmental area, despite all the books and articles written by economists extolling its virtues. Not only is CBA time consuming and expensive, in environmental applications there are methodological difficulties in valuing nonmarketed environmental assets and services as well (Barde and Pearce 1991). Because it is harder to quantify all the benefits of environmental regulation or environmental investment projects than it is the costs, the answers CBA provides are often partial and not very precise.[6] That is, environmental quality improvement activities that appear to have a positive social rate of return on investment under one approach to benefit estimation may not be as attractive under another. In this situation, sensitivity analysis is absolutely necessary to find out what changes in methodology or initial conditions lead to decision reversals.

A robust outcome in CBA is a decision that is not influenced overmuch by changes in assumptions or benefit estimation methods because the estimate of benefits is resistant to them and has very narrow upper and lower bounds. In our experience, environmental benefit estimates are not robust, and single point estimates of benefits based on a single estimation method in environmental applications introduce a false sense of security. Limitations in our data and economists' applied methods make imprecision the rule rather than the exception.

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[6] This statement would not be accepted by all, or even most, economists. First, Hazilla and Kopp (1985) demonstrate that engineering costs are not the same as the social costs of regulation. The latter are based on a utility-theoretic definition, i.e. the money equivalent of the utility loss that mandated regulations impose on individuals. To get this measure, a computable general equilibrium model of the economy is needed, which is not easy at all. Second, a host of economists have embraced the extension of cost-benefit analysis to environmental problems (e.g. Dixon et. al.1986, Hufschmidt et.al. 1983, Markandya 1991, Pearce and Markandya 1989 to name but a few).

Winpenny (1991) presents a balanced view of the usefulness of economic evaluation methods in environmental assessment, while Hanley (1992) and Barde and Pearce (1991) give a short review of some of its major shortcomings. In our view cost-benefit analysis can assist in making specific environmental decisions and analyzing specific projects or impacts. But at the national or even regional environmental policy level it is not very precise, given the state of the art. US EPA (1990, p.viii) observes "An ideal comparison of the costs and benefits of pollution control would require that these benefits be identified, quantified, and monetized. This is an extremely difficult and data intensive task ..."

Both specific and more global environmental benefit studies have admitted to the existence of such imprecision, and emphasized the need to exercise professional judgement in interpreting the numbers. For example, with a specific travel cost data set, Creel and Loomis (1990) applied seven alternative statistical methods to produce recreational trip values ranging from $37 to $173. In a contingent valuation application to value the preservation of an endangered species, Bowker and Stoll (1988) found that although their preferred estimate was $130 per person per year, willingness to pay could fall between $5 to $149 depending on which estimation approach was chosen. In work done for the U. S. EPA by Russell and Vaughan (1982), the benefits of water pollution control in the recreational fishing category varied by a factor of ten depending on method and assumptions. These are but a few of the many comparisons of benefit variability that can be found in the environmental economics literature. Later in this paper, some examples from the IDB's experience will show the same thing.

If economic benefit estimates can be enormously sensitive to the method used to produce them, then decision makers should be aware of that and not take any economic analysis as absolute truth. Most impartial analysts regard CBA as an aid to making decisions, but do not suggest that CBA should dictate decisions.[7] Unfortunately, there is always a temptation in bureaucracies to mechanically apply the method, and impart a spurious verisimilitude to cost-benefit exercises by ignoring uncertainties and risks in order to make the results sound convincing. The U. S. Government Accounting Office, for example, criticized US EPA for this tendency in a 1984 review of the agency's application of cost benefit methods, and recommended that decision makers be made aware of the deficiencies and uncertainties in each analysis by the presentation of a range of values (US EPA 1987).

When all is said and done, whether the lack of precision in benefit estimates confounds making a clear-cut decision will depend on the specifics of each case. But it is reasonable to admit that some CBA analyses and outcomes are more reliable than others and that, in principle, honest and scrupulous CBA can be enormously useful.[8] Yet Winpenny's caution is well taken:

> If all environmental assets and effects were able to be captured in economic values we could have much more confidence in CBA... The fact that in the present and foreseeable state of the art large areas of the environment cannot be valued ...means that expedients and safety nets will continue to be necessary in CBA, unsatisfactory as they may seem to the theorists. (p.72)

Alternate Routes to Benefits Estimation: Some Cautionary Tales

Approaches

In their recent excellent survey of the state of the art in environmental economics, Cropper and Oates (1992) remarked on the enormous advances that have been made in valuing environmental improvements.

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[7] See the several case studies in Barde and Pearce (1991) that review the application of CBA in environmental decision making in the United States and Europe.

[8] US EPA (1987) analyzed twelve CBA efforts at regulatory impact assessment. The average cost of each study was $675,000, which is small relative to the $100 million per year or more that the major regulations cost the economy. In three of the cases, the use of CBA helped increase the net benefits of the regulations by $10 billion.

Examples of the methods they discuss include:

1. Direct Damage Function Methods
2. Indirect Market Methods which exploit one of the following:

   Averting Behavior that involves estimation of pollution damage by the value of purchased inputs that can be used to mitigate pollution effects. An example is the cost of purchasing bottled water when a public drinking water supply becomes contaminated. Empirical models of household production of health, are used to quantify this sort of effect.

   Weak Complementarity between changes in environmental quality and changes in the demand for a purchased good. A familiar example is the shift in the demand schedule for recreational visits to a lake brought about by water quality improvements. Both empirical travel cost and discrete choice models can be used to estimate the magnitude of this effect.

   Hedonic Market Methods that use regression analysis of the relation between property values (rental or sales price) and the attributes of the property, the local environment, and the neighborhood to calculate the marginal value of a change in these attributes.

3. The Direct Questioning Contingent Valuation Method that directly asks people their willingness to pay for a change in the environment that a public investment project like, say, wastewater treatment, might bring about.

IDB Experience

In the 1980s the Inter-American Development Bank had a general environmental policy, but very few investment projects aimed directly at natural resource management and environmental quality improvement, with the notable exceptions of urban sanitation and urban habitation via self-help construction on serviced lots. In terms of benefit valuation, the method of choice at that time was hedonic. The staff was unfamiliar with contingent valuation, and rarely used travel cost except to construct demand functions for potable water in rural areas where people often walk long distances to get water in the absence of a public supply system.

The situation has changed dramatically in the past few years, as the number of projects of an environmental nature in the Bank's portfolio has increased, and as the new methods like contingent valuation have been used to complement or replace more familiar hedonic method. In fact, the Bank has directly undertaken or contracted at least 18 contingent valuation studies since 1987, five of which were for ex-post evaluation of completed projects, and the balance for appraisal of new investment projects in sanitation, urban development, and environment.

Part of the reason for this shift may have been an increasing discomfort with the inherent tendency toward benefit overstatement in the hedonic approach as applied in the IDB. Bank analysts have never tried to estimate the marginal value functions for attributes. Instead, the hedonic price function alone has been used to produce an upper bound to the benefits of an attribute change, which makes projects with internal social rates of return below our 12 percent cutoff certain losers, but does not make projects slightly above 12 percent certain winners.

Some Words of Warning

Cost-benefit analyses done in our institution have to be subjected to careful review and quality control. The Bank has made strenuous efforts to do an increasing amount of that over the years. But it also means that the admonition of Fisher and Peterson in 1976 to take benefit estimates of pollution control with a grain of salt is still very relevant today in our institutional context. Perhaps the following examples of benefits estimation oversights, omissions, or misunderstandings, many of which were caught in the review process, are part of the reason.

Below we first discuss the use of the damage function approach in agricultural projects in fairly general terms. Some observations about the IDB's hedonic, travel cost, and contingent valuation benefits applications follow, with some recommendations.

Damage-Avoided Estimates Depend on Behavioral and Technical Relationships

Since its formation two years ago, the Environment Protection Division of the Project Analysis Department of the Bank has developed several watershed management projects. These projects attempt to encourage cultivation and soil conservation practices that do not lead to land degradation (erosion). The benefits of these projects principally depend on the avoidance of the crop yield declines that would occur without them. Benefits therefore come from changing the farm production function, and presumably improving the future flow of net farm returns. While it is still too early to tell how reasonable our benefits estimates are for these sorts of projects, they have some elements in common with agricultural research and extension (R&E) projects, where we do have some idea about cost-benefit analysis pitfalls.[9]

The critical variables on the production side are the expected increases in output per acre, technology dissemination, and the technology adoption rates. In general, cost-benefit results are highly sensitive to small changes in these variables. Excessive optimism regarding their magnitude may lead to overestimation of the benefits to be derived from R&E operations. On the demand side, consumer tastes and response to prices should also be carefully taken into account to determine the benefits of the operation.

Increases in per acre production: Per acre yield increases are the most common benefit ascribed to agricultural R&E programs. Although R&E projects do lead to production increases, the Bank's experience suggests that the ex-ante project evaluation often has overestimated the effect.

First, in many cases, the technological gap between agricultural experiment stations and farms yields was assumed to be the expected per acre benefit from the program. While this gap may reflect in some sense maximum potential for improvement in yields at the farm level, it is not realistic to use the full magnitude of the gap in estimating project benefits. Yields from agricultural experiment stations need to be transferred to the farm's soil and weather conditions, and in the process there exists a large probability that the transferred technology may loose a substantial portion of its potential benefits.

Second, for the most part, R&E results are obtained in the medium to long term. It takes some time to gestate a technology, to test it, and to diffuse it after it is found to be appropriate. Therefore, benefits

[9] The authors are indebted to Luis Zavaleta of the IDB's Operations Evaluation Office for the points developed in this section.

from R&E projects should not be expected to accrue in the short term. To assume otherwise should be based on a careful analysis and justification of why the project expects such prompt returns.

In summary, output increases seem to have been overestimated and, consequently, estimated benefits were too large. Two other variables that have contributed to inflating the results of the ex-ante analysis are the assumed adoption rates and the capability of the extension services considered.

Adoption Rates: In several instances, projects have been prepared without an appropriate knowledge of farmers' production incentives and limitations. This later shows up in rates of technology adoption that are below expectations (a case in point: a beans program in a Central American country could not achieve its objective of improved seed adoption because the variety developed did not have much acceptance by farmers). Adoption rates also appear to be low for new technologies requiring substantial increases in agricultural inputs. Poor farmers are reluctant to commit to investments that increase their risk exposure.

Outreach of Extension Services: Another element that has influenced the speed with which new technologies are adopted and, therefore, the benefits to be expected from R&E programs, is the outreach of the extension services. Extension services communicate with only a small percentage of the farmers. In much of the region, extension agencies are inadequately equipped and staffed to meet the requirements of the tasks at hand. In addition, there often were inconsistencies between the time period within which the donor's assistance was provided and the time required for the extension programs to achieve the objectives set for them. Our case studies suggest that extension activity often has not been able to increase farm productivity significantly in the short run.

In conclusion, the ex-ante economic analyses performed in R&E projects have had shortcomings. By placing an exaggerated emphasis in determining the value of the possible increases in output, project analysts have been compelled to use estimates that may have not closely resemble reality) since reliable data were either unavailable or scarce) therefore, overvaluing the benefits to be derived from R&E activities.

Indirect Market and Direct Questioning Methods

Benefit estimates in environmental applications are often not very precise. Alternative general approaches can give widely different estimates of benefit. In real world applications there is no known measurable true value to compare them against because we are outside of an experimental setting, so they all could suffer from systematic upward or downward bias. Moreover, alternative interpretations within a given broad class of model introduce additional noise.

We all know that our choice of method, and of technique once a method has been chosen, can substantially influence the magnitude of our benefit estimates. This has direct implications for the project accept/reject decision. Some examples may give an idea of how benefit estimates from indirect market and direct questioning methods can be sensitive to the approach taken to sample design, econometric specifications, and model evaluation.

There are Differences Across Methods: There have been several experiments in the literature comparing the answers one gets from alternative approaches. One of the most well-known was the attempt by Bishop and Heberlein (1979) to compare the travel cost and contingent valuation methods.

In one of its ex-post valuation exercises, the Bank compared hedonic and contingent valuation (CVM) estimates of the benefits of supplying alternative housing solutions to people currently living in very substandard conditions. The results were consistent with the a-priori expectation that the hedonic method provides an upper bound.

Comparison of Hedonic and Contingent Valuation Estimates of Housing Benefits			
		Hedonic	**CVM**
Basic 2 story home $90m^2$ living space	Net Present Value Benefit (pesos)	2,129,037	1,769,500
Minimum 1 story home $30m^2$ living space	Net Present Value Benefit (pesos)	909,255	1,039,780
Self constructed cement home $72m^2$ living space	Net Present Value Benefit (pesos)	1,505,844	1,205,150
Overall Project Rate of Return	Percent	5.2	-5.2

There are Within-Method Differences: Example I. Statistical Estimation of a Travel Cost Model. To value the services of two urban parks Bank financing was going to help create, a survey was conducted that asked how often families would visit the new parks per month at various levels of a hypothetical entry fee. This experiment was sort of a blend between the travel cost model and a contingent valuation survey.

The relationship between visit frequency and the cost of access, including time cost, travel cost, and fee was statistically estimated. Four popular model specifications were fit. The semilog specification has been one of the most popular in the travel cost literature, but it ignores the problem of truncation in the distribution of the dependent variable introduced by the fact that visits are constrained to be non-negative. The Tobit, Poisson, and Negative Binomial models handle visit levels that are greater than or equal to zero.

These models produced a wide range in average consumer surplus per visit, and hence the rate of return on the urban park investments.

Comparison of Travel Cost Models		
Model	**Average Consumer Surplus**	**Rate of Return**
Tobit	US$1.77	40% Park 1; 20% Park 2
Poisson	$2.55	N/A
Negative Binomial	$2.73	59% Park 1; 34% Park 2
Semilog	$3.63	N/A

Fortunately, for both parks all the rates of return are above 12 percent. Since there was no straddling of the critical 12 percent cutoff rate, the decision to go ahead and finance the project was clear.

Example II. Functional Form and Travel Cost Model Evaluation. In another application of the travel cost model, the demand for rural telephone service in one of our member countries was estimated from the relationship between calls per month made at public telephone offices, and the total value of travel time required to make them, valued at the rural shadow wage. Linear, semilog, and double log models with travel cost and income as explanatory variables were fit to the data. A direct contingent valuation on willingness to pay was also asked.

The project expanded telephone service to isolated rural areas, and thus decreased the cost of making a call by 70 percent. The consumer surplus integral of the estimated demand function taken between the pre and post project sample averages for calls (the dependent variable)[10] gave an expected value of consumer surplus per call of 680 pesos for a semilog specification (see OER-62/90). A double log specification yielded 732 pesos and a linear specification 800 pesos per call in benefits.

Bockstael and Strand (1987) have demonstrated that there is a difference between expected consumer surpluses obtained at the mean of the dependent variable and expected surplus calculated at the value of the dependent variable predicted from the estimated equation. In other words, using a fixed change in calls, the dependent variable, across alternative functional form specifications (linear, semilog, double log) implies an unequal price change across fitted models. But, using the same change in the exogenous variable (cost of a call) across models yields different predicted values for the dependent variable (number of calls).

[10]The uncompensated Marshallian demand specifications and welfare measures are:

Linear Demand: $Q = " + ß_1 \text{ Travel Cost} + ß_2 \text{ Income}$
Total Consumer Surplus: $CS = 1/2ß_1 * [Q_{post}^2 - Q_{pre}^2]$

Semilog Demand: $Q = \exp(" + ß_1 \text{ Travel Cost} + ß_2 \text{ Income})$
Total Consumer Surplus: $CS = 1/ß_1 * [Q_{post} - Q_{pre}]$

In our example, using predicted values instead of dependent variable means in the definite integral surplus formulas reduced the consumer surplus per call in half! For the preferred semilog specification the change in Marshallian consumer surplus fell from 680 pesos to 395 pesos per call. The reduction, due wholly to the way the travel cost model was evaluated, brought the answers in line with the contingent valuation responses as shown in the table below.

Evaluation of Travel Cost Models				
	Travel Cost Models			Contingent Valuation
Consumer Surplus Per Call	**Linear**	**Semilog**	**Log-Linear**	
Using Mean Y	800	680	732	362
Using Predicted Y	412	395	360	

Fortunately the project was extremely attractive in all cases, so the internal rate of return fell from a spectacular 92 percent using the semilog value of 680 pesos per call to a level that were still unusually high (66 percent or greater) using the predicted Y travel cost values or the directly revealed willingness to pay from contingent valuation. The fact that all rates of return were above the 12 percent cutoff meant again that no difficult choices had to be made.

Example III. Both Functional Form and Model Evaluation in Hedonics. To estimate the benefits of an urban sites and services program in one of the Bank's member countries, a hedonic analysis was performed to predict sales value of alternative types of housing. While the semilog is a commonly used functional form, Box-Cox estimation was also performed to see if some other transform of the dependent variable might be better, and found that a cube root transformation was superior to taking the logarithm of the dependent variable.

With either model, the statistical prediction of the dependent variable must be retransformed into original units from the logarithm or the cube root, and simply taking the antilog or third power as a retransformation yields the median, not the expected value of the rental value. To get the expected value, a bias correction factor must be applied (Duan 1983, Miller 1984).

As the following comparison shows, the preferred benefit estimation method (Box-Cox, with bias correction for prediction of value) produces a project acceptance decision, but the benefits from the naive method (semilog, no bias correction) are not sufficient to justify the project, since the rate of return is below 12 percent.

Comparison of Benefit Estimation and Evaluation Methods and Hedonic Analysis		
Model	**Predicted Sales Value (000 1980 pesos)**	**Project Rate of Return (percent)**
Semilog, No Correction	253	6
Semilog, Bias Correction	839	
Box-Cox, No Correction	505	18
Box-Cox, Bias Correction	557	

Understanding Different Methods

Sometimes a method is tried without a sound understanding of either its welfare-theoretic foundations or of how to apply it properly.

In one of our projects, a series of wastewater treatment plants was to be built in several cities along a major river. Downstream at a major city the quality of recreation at a park along the river was supposed to improve, particularly because bad odors would disappear. The benefits of this improvement were calculated supposedly according to a travel cost model. But, the site demand curve was not really built up based on number of visits distinguished by distance. Instead, the total out of pocket cost of travel per visit was erroneously used to value an arbitrarily assumed increment in total visits resulting from the water quality improvement.

What's wrong here? First, it is a measure of consumer's surplus, not actual cost per visit, that is needed to get benefits. Second, there was no way, with the data at hand, to statistically estimate the magnitude of the shift in demand encouraged by the change in water quality. Water quality data showing variation over time or across space should have been combined with visitation data over time or space to properly estimate the model.

Collecting Information

Sometimes projects are proposed to the Bank that are not firmly anchored in fact, and do not reflect a very complete technical understanding of environmental linkages. Information should be collected to verify the magnitude of the environmental problem an investment project is expected to solve and how it will solve it.

In projects addressing air pollution, water pollution, and solid waste disposal, sources of waste discharge should be inventoried. Reliable measurements of ambient conditions should be made to determine how often air and water quality standards are being exceeded. Then, the effects of the proposed investment (e.g. a treatment plant, a landfill, or a motor vehicle inspection program), on ambient conditions should be established. That means determining the changes in ambient quality indicators (like dissolved oxygen for water, sulphur dioxide and particulates for air) across time and space that the project will bring about. Natural systems models of pollutant transport, decay, and diffusion can help. If possible, the changes the project will introduce in exposure to pollutants by human, plant, and animal receptors should be estimated, and changes in important indicators like human morbidity, fish biomass, and beach recreation opportunities should be quantified. The expedient of using outdated survey data, or rapid assessments of inadequate sample size instead of a sample chosen on the basis of sound statistical principles should be avoided.

For example, the Bank was recently presented with a financing request for a sewage treatment plant costing about $60 million. The benefits of the plant were supposed to come from a reduction in pollution levels at recreational beaches whose attractiveness generated significant foreign exchange earnings from tourism. It was feared that these earnings would be lost if there were disease outbreaks resulting from swimming in polluted water.

To establish the validity of this fear a total of 40 samples of coliform counts were taken on 10 beaches to justify going ahead with the project. The Bank suspected that this sample was too small to establish with any reasonable degree of confidence that water quality standards were being consistently violated. Therefore, it commissioned a formal study. The pilot phase of the study required 1536 observations just to decide on the final sample size needed to determine, at the 95 percent level of confidence, that ambient standards have been violated, considering factors such as tide, time of day, and season of the year. The final recommended sample size was 3536, or almost 100 times larger than the original sample.

Use Prior Experience with Care

In valuing changes in environmental amenities, we often can chose among different ways to monetize the impacts, with no a-priori knowledge about which method might be best. Moreover, in a given project with many components (e.g. watershed management) we often may have many classes of benefit, and we would like to know which of them are the most important (i.e. the largest) and which of them may be trivial. Prior knowledge built up from similar analyses done in the past may be helpful, if used carefully.

For instance, in the past it was a matter of faith that watershed management projects introducing erosion control measures upstream of a reservoir would have appreciable benefits through the reduction of reservoir sedimentation because they would prolong the period of reliable service of the facility for irrigation and power production. As it turns out, however, in the Bank's recent experience most of the benefits of these projects accrue on the farm through better yields, and the external benefits are much less important.[11] In analyzing such projects, it has turned out that funds for project appraisal may be best spent in quantifying the agricultural effects of these projects on on-farm productivity, and not on the external, basin wide costs avoided from reduced sedimentation accumulated downstream in an impoundment.

This poses serious problems for developing a work plan for economic analysis, since most of the techniques rely on survey data, unless we are lucky enough to be able to use a relatively recent existing database that suits our needs. For example, in the watershed management project example, it would be better to try to collect information on the relationship between soil loss and crop yield, and on farmers' rates of adoption of soil conserving technologies (terracing, contour plowing, etc.) than it would be to commission expensive bathymetric studies of reservoir sediment accumulation, and models of sediment transport in the basin, because only minor benefits accrue in the latter area.

[11] In U. S. experience the opposite appears to be true (Browne et.al. 1992). It is claimed that off-farm damages from soil erosion (due to siltation of water bodies, increased flood damage, increased waterway maintenance, and reduced storage capacity) are three times greater than on-farm damage in terms of reduced productivity.

Match the States of the World being Valued to the Actual Outcomes

The Bank is currently analyzing the social profitability of several proposed municipal sewage treatment plant investments. Many might argue that it is not realistic to approach a regional water pollution control problem in this way, and that some sort of cost minimizing optimization exercise like the one illustrated before would be more practical, taking environmental quality targets as givens.

In any case, capturing the benefits of wastewater treatment has proven extremely difficult to do. Some of the reasons are explained in Annex A, but one of the main reasons has been trying to establish a close relationship between the actual improvements in water quality the projects would bring about based on technical measures (biochemical oxygen demand (BOD), etc.) and the change described in less technical terms for the contingent valuation (CV) surveys. In some recent CV studies attempting to measure the benefits of water quality improvement, it turned out that the degree of improvement in the CV studies was much greater than what the project, as designed, could achieve, and that to reach the quality improvement of the CV question, several subsequent stages of project investment would be required. This has meant that some creative calculations will have to be invoked to scale back the CV benefits to match the reality of the projects' effects on ambient quality.

Economic Aspects of Environmental Assessment

Environmentally related investments can either be subcomponents of specific projects, where their purpose is to mitigate the project's negative environmental side-effects, or they can be designed to obtain environmental quality improvement in conjunction with or independent of specific projects.

The economic feasibility of the class of environmental investments represented by environmental quality improvement programs like our previous example should be analyzed in project preparation. In addition, an economic analysis of environmental damages is also desirable for proposed nonenvironmental investment projects.

Types of Responses

In the Environmental Assessment of projects whose primary purpose is not environmental, there are several kinds of measures that can be taken to make the project more environmentally sound. Avoiding the problem altogether by reconfiguring or relocating the project is one alternative. It leaves no visible cost record. Pure mitigation and control/improvement are two other kinds of responses that, although they have known costs, are quite different in terms of whether they represent a net benefit or cost to the overall investment project. The difference depends on whether the environmental consequences of the project would leave us environmentally worse off than we would have been without the project (e.g. pure mitigation).

Environmental safeguards fall into the following categories:

1. Avoidance: If a component of a project poses severe environmental risks that outweigh the net value of its output contribution, that component may be eliminated from the project entirely. Similarly, if the location of the project is the prime reason why its negative impacts are severe, an alternative site could be selected. Avoidance could also be an environmentally beneficial side-effect of an investment program that improves the operating efficiency of existing infrastructure.

Here, the costs and benefits of avoidance will usually not be reflected in the final project design information provided to the Bank. An example of pure avoidance would be eliminating proposed irrigation acreage from a project in those areas where the risks of agrochemical contamination of groundwater supplies are extremely high.

2. Pure Mitigation: Definable measures with known costs that reduce the negative environmental impacts, either direct or induced, introduced by the project relative to a better environmental status quo without the project. We can distinguish between investment and operating costs of control mechanisms and devices used to reduce the amount of contaminants disposed, and higher project costs due to changes or adjustments in the production technology or project design. Installing fish ladders at a hydroelectric dam or installing atmospheric pollution control equipment at a new thermal power plant are examples of mitigating environmental investments. Pure mitigating expenditures represent net costs for the project.

3. Improvement: Definable measures with known costs that eliminate negative environmental impacts that existed in the pre-project situation. Examples are: installation of water and air pollution control equipment at an existing thermal electric generating facility being modernized, or better waste disposal practices at a hospital undergoing modernization and expansion. In fact, these kinds of expenses bring about environmental quality improvements relative to the without-project status quo, and represent net benefits for the project.

Finally, there are expenses that masquerade as environmental protection measures but really aren't:

4. Infrastructure Protection or Optimization: Measures that would (or should) be undertaken anyway without an environmental assessment because they contribute to net profits by improving the functioning of the investment, prolonging its service life, or reducing maintenance costs. Examples include the reuse of cooling water, materials recovery and recycling in an industrial plant, or expenditures to improve the stability of slopes in road projects.

The boundaries between these kinds of outcomes of the EA process are not clear-cut, and depend critically on how the without-project case is defined. But, net costs are most clearly imposed on investment projects by the EA process in the case of pure mitigation. Avoidance is hard to evaluate and improvement brings about net benefits compared to the alternative of not executing the environmental component of the project. Infrastructure protection or optimization involves net benefits, not net costs, and is part of proper project design. Below we concentrate on the economics of pure mitigation.[12]

The Economics of Pure Mitigation

Many projects can generate environmental impacts that cause a deterioration in ambient conditions from the without-project status quo (e.g. erosion along new road beds, downstream fisheries productivity

[12] Damage mitigation as a result of EA should not be confused with infrastructure protection that is an integral part of good project design. For instance, in a reservoir project, installation of a hydrometeorological network is necessary for efficient operation and is not strictly mitigatory, even though having it may reduce flood losses in extreme weather events. The same is true for seismic activity and sediment accumulation monitoring. In contrast, wildlife rescue programs, habitat reserves, fish ladders, and human resettlement are mitigatory costs.

declines from new reservoirs, ambient air quality deterioration from new industrial plants, etc.). Taking the without-project status quo as a given, we must decide whether all, some, or none of the negative environmental impacts should be prevented. So, when an investment project is expected to generate environmental damages which can be directly and uniquely assigned to it, two questions arise.

The first issue is whether environmental damage mitigation should be undertaken and, if so, to what extent. Should environmental damage control measures be implemented irrespective of their cost in an attempt to prevent all negative environmental side-effects, or is it reasonable to only partially control these effects?

Second, whatever the route taken to decide on the appropriate degree of mitigation, once the decision is made, how should environmental mitigation costs and benefits (i.e. damages avoided) be handled in the overall cost-benefit analysis of the project? Should damage control costs be ignored and the project analyzed as if environmental effects did not exist; should the costs of damage mitigation be included in the cost flows of the economic project analysis, or are both of these options incorrect?

Both of these questions have simple answers in theory, but they can often be difficult to solve in practice. Take a situation where environmental protection, not improvement or enhancement beyond pre-project levels, is contemplated. If damages could be monetized and expressed as a continuous function of an index of environmental deterioration (or of an environmental quality index) it is not hard to show that:

1. <u>The Optimal Extent of Mitigation</u>: Environmental damage mitigation measures should be carried out up to the point where the value of marginal damage prevented (the marginal benefit of mitigation) equals the marginal cost of damage control. This rule leads to minimization of the total environmental cost of the project, which includes both the total cost of any mitigation measures plus the total value of any residual damages remaining after mitigation. Unless the rule leads to 100 percent mitigation where residual damages are zero, which is most unlikely, residual damages will usually be positive under optimal mitigation.

2. <u>Total Environmental Costs in Cost-Benefit Analysis</u>: The cost-benefit analysis of the project should ideally incorporate environmental effects by including the sum total of environmental costs, as defined above, in the project cost stream (i.e. out-of-pocket mitigation expenses plus the value of residual damages). Ignoring them is incorrect, as is the inclusion of only the out-of-pocket expenses.

A simple demonstration of the above statements appears in the stylized numerical example provided in the second annex. A mathematical proof justifying them is given in the table notes. The example in the annex is theoretical, and assumes the damage and cost functions are continuous, well behaved, and fully known by the analyst performing the EA. However, in real applications these conditions are not always going to be satisfied, so some difficult choices have to be made.

The cost of a full CBA study of environmental mitigation alternatives is not likely to be warranted for projects with small environmental effects or low mitigation costs. Moreover, it is often very difficult to quantify in physical terms, all of the environmental damages that might occur as a result of an investment project let alone monetize them so that an optimization exercise can be carried out to determine the best level of protection. Instead, the informed judgement of experts is often used to design mitigation measures which are in some sense either acceptable, reasonable or in conformity with promulgated standards.

Optimality considerations are often set aside in EA because optimality cannot be determined given the limited information available, particularly on the side of environmental benefits.

In this usual situation, the environmental damage function is unknown and economists who must analyze a project's economic feasibility only have the cost flows associated with environmental protection to work with. In this case we believe that these environmental mitigation costs should be included along with the direct investment and operating costs of the project in any cost-benefit analysis.

The rationale for this conclusion is the obvious one that if some mitigation is worth doing, the total cost of the effort will presumably be less than the full environmental cost of the project, including residual damages. Therefore, while the level of protection chosen on the advice of experts may well not be optimal, the costs of implementing the prescribed measures will be an understatement of the true environmental costs of the project at that specified level of protection.

In sum, project costs for economic analysis should always, as a crude approximation, minimally include the costs of pure environmental mitigation and, ideally, an estimate of residual uncontrolled damages as well. Even without including the latter, a clear signal to re-analyze the environmental aspects of the project is provided if the project acceptance decision hinges on the inclusion or exclusion of pure mitigation costs. In this case, either the direct service flow benefits of the investment are insufficient to offset its negative environmental externalities, or the level of mitigation selected is excessive and suboptimal. To carefully determine which is the case, an economic evaluation of environmental costs and benefits should be made. If that is impossible, there is no obvious economic reason to believe that going ahead with the project at a low or even minimal level of damage prevention would be preferable to project postponement.

On the other hand, if the environmental intervention or safeguard produces net environmental benefits relative to the no project case because it involves improvement or infrastructure protection/optimization instead of pure mitigation, there are two options. The less desirable is to ignore the environmentally related costs altogether in the full project cost-benefit analysis if the environmental benefits can't be fully quantified, because environmental benefits are <u>believed</u> to exceed environmental costs. This will understate the overall net benefits of the project. The preferable alternative, because it involves benefit quantification rather than belief, is to include all benefits and costs, both environmental and nonenvironmental, in the project analysis.

Bank Procedures for Environmental Mitigation and their Cost Implications

IDB Environmental Procedures

In the latter part of the 1980s the IDB took significant steps toward strengthening its commitment to environmental protection and sound natural resource management, by implementing an environmental assessment classification and review process and establishing an Environmental Protection Division in its Project Analysis Department.

The environmental review of a proposed operation (IDB, 1990) begins when the Bank's country or project team, supported by the Environmental Protection Division, classifies the environmental status of a proposed lending operation into one of four categories. Projects that are environmentally beneficial or neutral (Categories I and II) do not require an EA. Projects that are expected to have moderate or severe environmental effects require an EA whose complexity depends on the specifics of the case. The point of the EA is to reduce environmental risks by introducing environmental safeguards into the project's design.

Overall, the IDB environmental classification system has played an important role in screening projects according to their potential environmental impacts. In particular, it streamlines and targets environmental processing of projects by eliminating cases where mitigation is not relevant (Categories I and II), and emphasizing cases where it is known a-priori to be critically important (Category IV). However, a large number of projects fall in the grey area of Category III. In 1991, the Bank's Environmental Committee (CMA) classified 186 operations, 97 of which were loans.[13] Of the loans, 58% fell in Category III. The full breakdown of operations classified in 1991 appears in the table below.

IDB Operations Classified in 1991

Type of Operation	Category				Total
	I	II	III	IV	
Loans	6	31	56	4	97
Small Projects	0	44	2	0	46
Technical Cooperations	7	32	4	0	43
Total	13	107	62	4	186

Source: IDB. 1991. *Annual Report on the Environment and Natural Resources*. p. 12.

A Review of Economics in the IDB's Environmental Assessment Practices

At the request of the IDB, Professor Anil Markandya of University College in London reviewed the environmental dimension of over 50 IDB projects in 1991. Of his several observations, two have a direct and important bearing on the way EA findings and recommendations should be incorporated into the economic analysis of the Bank's development projects. Dr. Markandya noted (1991 pp.71-72. Italics added):

> *There is a clear asymmetry in the valuation of environmental impacts between positive and negative ones.* Considerable effort has been expended to value the positive effects, but there are virtually no cases where environmental damage is valued. The *tendency is to argue that the mitigation program takes care of all negative environmental effects and that there are none left. But this is clearly untrue in general* and it would be desirable to recognize and to accept that, in some cases a negative impact does occur, and may even be acceptable if the benefits of the project outweigh the costs.

[13] Data for 1992 became available after this presentation was given. In that year, the CMA classified 144 operations, 64 of which were loans. Of the loans, 28% fell in Categories I and II, 64% fell in Category III, and 8% fell in Category IV. (See: Inter-American Development Bank. 1992. *Annual Report on the Environment and Natural Resources*.

> *Where mitigation programs are put together, it helps if this is done prior to the full project appraisal*, so that they can influence the design of the project and the costs of the plan can be fully factored into the socio-economic analysis. This has not always been the case. In general, the costs of the mitigation programs have not been large relative to the costs of the project, so they have not impeded the viability of the project. It is not possible, however, to confirm this as *the costs are not always reported separately and clearly. Doing so would be helpful. Also, there are projects where the mitigation costs could be so high as to result in it not being accepted. In those cases some attempt at monetary valuation of the damage is important*.

Therefore the EA process requires that decisions be made about the level and cost of environmental protection, and, more importantly, the kind of environmental intervention that we are talking about: mitigation or improvement.

The Bank's Experience with Mitigating Measures and their Costs in the Early 1990s

From a cursory review of project documents prepared in 1991 and 1992 (environmental summaries and project reports), it appears that the different categories of environmental expense defined above are rarely distinguished. Rather, they all have been grouped under the rubric of environmental costs. Most project cost-benefit analyses do not clearly report on the way these environmental costs were handled in the overall economic appraisal, or the magnitude of capital versus operating costs. Therefore, from the available documentation it is hard to determine what proportion of total project cost is attributable, on average, to pure environmental mitigation.

The tables that follow present some basic information on ten projects from the Caricom area and ten projects from non-Caricom countries approved by the Bank during the last couple of years.[14] The sample of non-Caricom projects was not drawn to be statistically representative. Rather, we chose projects that had some clearly identified environmental cost information in the project report.

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[14] The Caribbean Development Bank (CDB) plays a key role in promoting economic development and integration throughout the Commonwealth Caribbean. Direct IDB financing of development operations is confined to the five member nations of the Caribbean Community that are IDB members (The Bahamas, Barbados, Guyana, Jamaica, and Trinidad and Tobago). The seven OECS states (Antigua and Barbuda, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines), along with Belize only have indirect access to IDB financing through the CDB.

PROJECTS IN CARICOM COUNTRIES

Project	**Country and Year**	**Cost (US$ mill)**	**Type**	**Environ-mental Classification**	**Mitigation Cost (US$ mill)**	**Associated Env. Cost (US$ 000)**
Secondary Oil Recovery	Trinidad/Tobago 91	403.00	Investment	IV	10.0	95 (TC)
Rural Township Development	Jamaica-91	45.00	Investment	III	Minor impacts	--
Family Island Electrification	Bahamas-91	45.47	Investment	III	Positive impacts	50 (TC)
Environtmental Protection and Rehabilitation	Trinidad/Tobago 91	5.07	Investment	I	Positive impacts	n/a
Rehabilitation-Guyana Electric Corporation	Guyana-90	15.50	Investment	II	n/a	n/a
Electricity System Rehabilitation	Jamaica-90	117.00	Investment	III	Transition Phase	117 (TC)
Agricultural Sector-Hybrid Loan	Guyana-91	52.00 (20 Inv.)	Sector-Investment	III	n/a	Studies
Trade Finance & Investment	Jamaica-91	130.00	Sector	II	n/a	n/a
Economic & Social Assistance	Haiti-91	12.40	Sector	III	n/a	0.72 for Env. Projects
Agricultural Rehabilitation	Guyana-90	30.10	Sector	n/c	Transition Phase	n/a
Agricultural Rehabilitation	Jamaica-90	50.00	Sector	II	n/a	n/a

Note: "Transition Phase" means that the project report preceded the date of inception of the IDB environmental classification system, so the EA was required after, not before loan approval. Therefore, no costs are reported. N/A: not applicable; n/c: not classified; T.C.: technical cooperation.

PROJECTS OUTSIDE THE CARICOM AREA						
Project	Country and Year	Cost (US$ mill)	Type	Environmental Classification	Mitigation Cost (US$ mill)	Associated Env.Cost (US$ mill)
Forestry Development of the East	Venezuela-91	125.0	Investment	III	26.0 (?)	n/a
Irrigation, Drainage Investment	Mexico-91	1245.0	Investment (Time Slice)	III	34.0	n/a
Urban Water Supply/Rehab Sanitary Infrastructure (Limon Province)	Costa Rica-91	70.0	Investment	III	Minor negative impacts	5,600.0 (TC)
Water Supply & Sewerage	Argentina-91	250.0	Investment	III	Positive impacts	500.0
Rehab/Expansion/Maintenance Highway	Honduras-91	202.0	Investment	III	n/a	200.0
Concepcion-Cuero Fresco Highway	Paraguay-91	77.5	Investment	III	Transition phase	n/a
Electrical Transmission & District	Paraguay-91	127.0	Investment	III	Minor negative impacts	22.6 (Relocation)
Export Sector Loan	Mexico-91	250.0	Sector	II	n/a	n/a
Global Credit Program	Argentina-91	60.0	Sector	III	Not easily predictable	90.0
Trade Sector Loan	Peru-91	425.0	Sector	II	n/a	n/a

Note: "Transition phase" means that the project report preceded the date of inception of the IDB environmental classification system, so the EA was required after, not before, loan approval. Therefore no costs are reported. N/A: not applicable; TC: technical cooperation.

The tables include investment projects as well as sector loans, showing in all cases the IDB environmental classification, the mitigation costs included in the loans, and associated environmental expenses that, in most cases, refer to technical cooperation assistance. These latter funds are provided for monitoring, institutional strengthening, and other elements whose benefits go beyond the narrow boundaries of controlling or mitigating the environmental impacts of the specific project they are associated with. So, again, they are not uniquely assignable as pure, project-specific mitigation.

In reviewing this experience, it is necessary to distinguish clearly between specific investment loans and global credit or sector loans. The environmental effects of specific investment projects are more readily discernable during project preparation than the effects of either credit operations or sector loans that provide balance of payments support for countries engaged in structural adjustment and reform of public enterprises, agriculture sector policies, trade policies and the like.

In global credit operations, the Bank lends to a financial intermediary who places the funds in private investment projects in a number of sectors. Because the nature and sector composition of these projects is not known beforehand, the mitigation costs associated with global credit loans are primarily for establishing systems for environmental review within financial or other responsible institutions in the borrowing country. The mitigation costs of the eventual projects are not included.

In sector loans, the direct and indirect impacts of macroeconomic policy changes on the environment and natural resources are difficult, if not impossible, to anticipate. Often, the Bank will provide financial support for institutional strengthening, environmental studies, and regulatory and legislative reforms alongside a sector loan, but the magnitude of these expenditures bears no particular relationship to the environmental and natural resource implications of the sector loan itself. Even if the effects were suspected to be mainly positive, associated environmental funding would not necessarily be precluded.

With these clarifications in mind, our brief review of the environmental cost information brings us to two rather unsatisfactory, but unsurprising, general conclusions that support Professor Markandya's observations.

First, a review of the EAs prepared for some of these projects suggests that these studies normally don't use economic criteria to weigh positive and negative environmental impacts, although the nature of these impacts is identified. Most recommendations are made to achieve "acceptable" standards.

Second, the mitigation cost information is spotty and incomplete, and does not readily permit generalizations about the share of true environmental mitigation costs in overall project capital and operating costs across the several sectors of Bank operations. Although informed guesses place the share of mitigation costs in the total cost of nonenvironmental projects at ten percent (IDB, 1992), this is not a statistically reliable estimate. It is not yet possible to establish reliable ranges for how much environmental mitigation costs, properly defined, add to total project cost for the different categories of projects financed by the IDB.

In the case of investment loans, two additional tentative conclusions can be drawn. First, a large number of projects appear to have been classified as Category III whose environmental assessments later concluded that most environmental impacts could be dealt with by means of proper construction and operation techniques, without significant cost increases. This result suggests a certain amount of risk aversion at the preliminary stage of categorization, which is not necessarily bad if environmental reassurance can be purchased at a reasonable cost through the preparation of a semi-detailed EAs. Moreover, some projects in this category needed significant environmental mitigation measures and incurred significant environmental costs, which can only be discovered through the preparation of an environmental analysis.

Second, for those investment projects in our small sample that required environmental control actions, the costs of direct environmental impact mitigation undertaken through end-of-pipe type expenditures, has not exceeded four percent of total project cost. Estimation of the costs of mitigating direct environmental impacts via project design adaptations is much more difficult. It would require a detailed analysis of project designs, and even a review of certain decisions made during preparation of the studies for each project.

In the case of sector loans, the Bank's experience suggests that it is very difficult to identify the impacts, and even come up with an efficient and consistent environmental control procedure. The main difficulties arise in the identification of the agency or body that will control the operation, the availability of personnel with the skills required to do it, and the ability of the controlling body to enforce the existing or new regulations.

Concluding Remarks

Cost-Benefit Analysis Techniques

The notion that there exists a unique point estimate of project benefits that is not influenced by professional judgement is naive. Economists have to be concerned about the quality of the technical information upon which the economic analysis depends, even though that is someone else's job (the agronomist, hydrologist, engineer). The main lessons taught by practical experience with cost-benefit applications to environmental and natural resource problems suggest that it is advisable for economists to:

1. Get the right technical information and understand it. Identify the technical problem that needs to be solved and the alternative means available to solve it.

2. Spend the time to develop statistically representative and reliable surveys in consultation with experts in survey research.

3. Explore alternative benefit estimation methods when time permits (convergent validity comparisons in technical jargon). One method can backstop the other in case something goes wrong, and the use of more than one will help bound the plausible range of benefits. Fall back on cost effectiveness if benefit estimation fails.

4. Explore the implications of alternative model specifications for benefits within each alternative approach.

5. Be skeptical.

Economic Analysis in Environmental Impact Assessment

We have a long way to go before economic analysis can be used effectively to decide on the optimal degree of environmental protection in our nonenvironmental investment projects. Nevertheless, by anticipating undesirable environmental effects of projects and explicitly including measures for their prevention, control and mitigation, the Bank's environmental assessment process provides a measure of protection that heretofore was not present. The process will become mature when the national authorities can confidently apply a uniform set of environmental regulations to private and public investments, irrespective of the source of the financing, and the environmental assessment process becomes an integral component in the appraisal of major projects in our borrowing countries. In the meanwhile, the EA process would be more productive and understandable to economists if it placed more emphasis on the need to find cost-effective solutions.

Annex A.
The Cost-Benefit Analysis of Sewer Network and Sewage Treatment Projects

In many countries cost-benefit analysis is not normally involved in the decision to build sewage treatment plants. However, the IDB has attempted to do so on occasion, and some internal doubt exists about whether such analysis can be consistently and successfully applied. One problem seems to be that constructing a collection system, or a collection system with just primary treatment, may actually lead to a degradation of water quality downstream from the outfall, relative to the no-project situation where each household has its own septic tank. This annex simply outlines the problems that this particular case presents, without proposing any specific solutions.

The Problem

Imagine a project situation which involves extending the sewer network to a previously unserved residential urban area. The project may or may not optionally involve construction/amplification of a sewage treatment plant to process the collected household wastewater. Ignoring, for simplicity, the various sewage treatment options (primary, secondary, tertiary, etc.), the following alternatives exist, where all monetized flows are understood to be in present value terms and subscripts denote alternatives:

BENEFITS and COSTS	No Project Base Case	Project with Sewer But No Treatment (Direct Discharge)	Project with Sewer and Waste Treatment Prior to Discharge
Change in Net Private Household Benefits from No Project Case		NB_1	$NB_2 = NB_1$
Neighborhood/Localized Environmental Damage	D_0	0	0
Downstream/Regional Environmental Damage	R_0	R_1	R_2
Treatment Cost	0	0	C_2

In this setup, the conventional cost-benefit account is represented by the first row in the table. The present value of private, nonenvironmental net benefits is obtained from the increment in total willingness to pay occasioned by a demand curve shift (because the sewer hookup permits increased water consumption at any given price), less the capital and operating costs of the sewer network. The magnitude of this private benefit is independent of whether the wastewaters collected in the sewer system are treated or not ($NB_1 = NB_2$). The environmental side of the account appears in the next three rows. Without the sewer system, there may be neighborhood environmental damages (groundwater contamination, disease vectors, aesthetics) given as D_0, and some damages may spillover into surrounding urban areas and watercourses as well, given as R_0. The sewer project presumably eliminates D_0, and, depending on whether the collected outfall is treated or not, generates downstream damages of R_1 or R_2 instead of R_0.

If the monetary value of the environmental damages (D_0, R_0, R_1 and R_2) cannot be estimated with any degree of precision for such projects (and there is no a-priori reason to believe they can be, particularly the public health effects), what are the implications for cost-benefit analysis?

Choice of the Best Option

A full analysis would compare alternatives 1 and 2 with the no project base case:

(a) Alternative 1 versus Base Case:

Is $(NB_1 + D_0 + R_0 - R_1) > 0$?

where $D_0 + R_0$ are damages avoided due to the project (its environmental benefits) and R_1 is the downstream damage it introduces in their stead (its environmental costs).

(b) Alternative 2 versus Base Case:

Is $(NB_1 + D_0 + R_0 - R_2 - C_2) > 0$?

where $D_0 + R_0$ again are damages avoided due to the project (its environmental benefits) and R_2 is the residual downstream damage it introduces in their stead after treatment at cost C_2 (its net environmental costs). By definition R_2 is less than R_1.

(c) If the results of (a) and (b) are both positive, we would choose the one with the highest net present value. This is tantamount to making the decision to build the treatment plant or not based on a benefit/cost criterion. That is, assuming NB_1 is positive so that under a purely private benefit criterion (the conventional SIMOP analysis) we go ahead with the sewer component, (a) can be subtracted from (b) and, after cancellation:

IF $R_2 + C_2 < R_1$ THEN Build the Treatment Plant
IF $R_2 + C_2 > R_1$ THEN Do Not Build the Treatment Plant

Implications

Taking last things first, (c) illustrates how a firm decision about whether to build sewage treatment plants using cost-benefit analysis rests on our ability to reliably monetize the environmental damages involved. Without accurate information on R_1 and R_2 we cannot reach an informed decision. This is the basis for our suggestion in the main text that physical world environmental effects should be compared to costs of treatment to give some indication of project advisability without necessarily performing cost-benefit analysis. That suggestion is, of course, debatable.

In any event, to avoid ineffective treatment plant investments, a regional river basin water quality planning exercise should be undertaken. It would identify the cost-minimizing locations, sizes, and technologies of the set of treatment installations needed to achieve specified water quality standards by river reach, subject to an overall budget constraint. Because location matters so much in environmental pollution control planning, each proposed municipal wastewater treatment plant project cannot be considered separately, de-coupled from the regional setting or from what industrial dischargers are doing.

A second issue is whether a partial cost-benefit analysis that omits several difficult to measure environmental cost and benefit flows can tell us anything, given a situation where, because of nationally promulgated norms, borrowers insist on attaching a treatment plant to a potable water/sewerage network expansion project. The analysis of measurables would replace (b) above with the question:

Is $(NB_1 - C_2) > 0$?

Unless D_0 and R_0 are negligible, project benefits will be understated. Similarly, unless R_2 is small — i.e. either a high removal efficiency treatment plant or a less efficient plant discharging into a watercourse with high assimilative capacity — the project's environmental costs will be understated. A-priori it is not possible to know how all of this might balance out. Nevertheless, the truncated cost-benefit analysis might serve to detect unnecessarily costly treatment plant proposals. However, it would not seem advisable to reject projects solely on the basis of a partial cost-benefit analysis without sound supporting justification based on the cost of achieving favorable natural world impacts measured in physical terms. Nor would it be legitimate to assume that the environmental damage flows are nil simply because they can't be estimated in money terms.

Annex B.
An Example of Optimal Mitigation

Figure 1 and Table 1 show alternative levels of mitigatory effort. The idea is to choose the optimal level.

Reading Figure 1 from right to left, in the absence of any mitigating measures the damage index with the project equals 20, as opposed to 0 without it. With no mitigation, the total environmental cost of the project (ENVCOST) is $497.17, which is wholly due to the value of environmental damage. At the opposite extreme, if expenses of $600.00 are incurred to fully restore the environmental status-quo, the environmental cost of the project is wholly due to environmental control costs (TC). In between these two extremes, the full environmental cost of the project is the sum of environmental damage control costs (including design or process changes) and the unprevented (residual) damages remaining after partial mitigation. Both of these costs which are positive under a scheme of partial mitigation.[15]

As mitigation measures are progressively instituted to reduce the damage index below 20 in the example, total control cost rises but total residual damage falls. Their sum is minimized by setting the marginal benefits (marginal damage prevented) equal to marginal costs of prevention. In the example, optimal mitigation brings about a 4 point improvement in the damage index (reducing it from 20 to 16), which is only one-fifth of the way to complete damage prevention.

[15] That is, the example does not deal with environmental improvement vis-a-vis the no project case.

TABLE I. EXAMPLE CALCULATION OF THE NET ENVIRONMENTAL COSTS OF A PROJECT

ENVIRON DAMAGE INDEX	ENVIRON IMPROVEMENT INDEX	GROSS DAMAGE AVOIDED	GROSS MARGINAL DAMAGE	TOTAL COST OF AVOIDANCE	MARGINAL COST OF AVOIDANCE	NET BENEFIT OF DAMAGE AVOIDED	RESIDUAL ENVIRON DAMAGE	ENVIRON COST (TC+RD)
EQ	EQ'	TB	MB	TC	MC	NB	RD	ENVCOST
0	20	368.47	5.63	370.00	18.50	-1.53	0.00	370.00
1	19	362.84	5.84	351.50	18.50	11.34	5.63	357.13
2	18	357.00	6.07	333.00	18.50	24.00	11.46	344.46
3	17	350.93	6.32	314.50	18.50	36.43	17.53	332.03
4	16	344.61	6.61	296.00	18.50	48.61	23.86	319.86
5	15	338.00	6.92	277.50	18.50	60.50	30.47	307.97
6	14	331.08	7.28	259.00	18.50	72.08	37.39	296.39
7	13	323.80	7.68	240.50	18.50	83.30	44.67	285.17
8	12	316.12	8.14	222.00	18.50	94.12	52.35	274.35
9	11	307.97	8.68	203.50	18.50	104.47	60.50	264.00
10	10	299.29	9.31	185.00	18.50	114.29	69.18	254.18
11	9	289.98	10.07	166.50	18.50	123.48	78.49	244.99
12	8	279.91	10.99	148.00	18.50	131.91	88.56	236.56
13	7	268.92	12.15	129.50	18.50	139.42	99.55	229.05
14	6	256.77	13.67	111.00	18.50	145.77	111.70	222.70
15	5	243.10	15.74	92.50	18.50	150.60	125.37	217.87
16*	4	227.36	18.80	74.00	18.50	153.36	141.11	215.11
17	3	208.56	23.89	55.50	18.50	153.06	159.91	215.41
18	2	184.67	34.67	37.00	18.50	147.67	183.80	220.80
19	1	150.00	150.00	18.50	18.50	131.50	218.47	236.97
20	0	0.00	0.00	0.00	0.00	0.00	368.47	368.47

* = OPTIMUM LEVEL

NOTES:

DAMAGE FUNCTION IS TB = (EQ'^0.3)*150. COST FUNCTION IS TC = EQ'*18.5.

ENVIRONMENTAL DAMAGE INDEX SETS NO DAMAGE = 0, MAXIMUM DAMAGE WITH PROJECT = 20.

GROSS DAMAGE AVOIDED BY MITIGATION MEASURES = GROSS BENEFITS OF PROTECTION.

NET BENEFIT OF DAMAGE AVOIDANCE = GROSS DAMAGE AVOIDED - TOTAL COST OF PROTECTION.

RESIDUAL DAMAGE = MAXIMUM DAMAGE WITH NO PROTECTION ($368) - DAMAGE AVOIDED.

ENVIRONMENTAL COST OF PROJECT = TOTAL COST OF PROTECTION + RESIDUAL DAMAGE.

OPTIMAL LEVEL OF PROTECTION IS AT MC = MB. THIS MINIMIZES ENVIRONMENTAL COST OF THE PROJECT.

PROOF: THE OBJECTIVE FUNCTION IS MINIMIZE C(EQ) + D(EQ=0) - D(EQ) = EC(EQ)

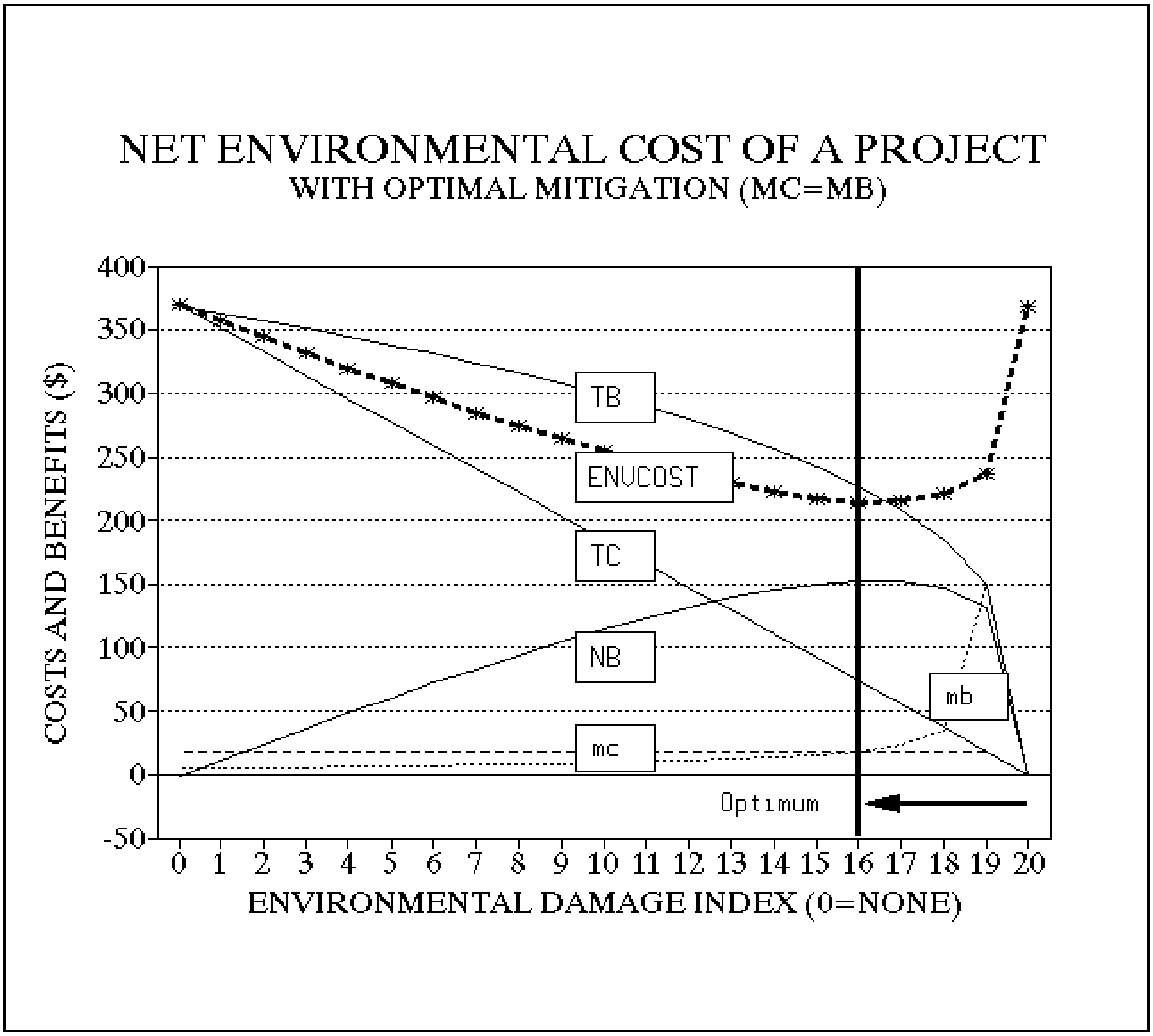
WHERE:
C(EQ) = TOTAL PROTECTION COST
D(EQ=0) = MAXIMUM DAMAGE WITH NO PROTECTION
D(EQ) = GROSS DAMAGE AVOIDED, OR THE TOTAL BENEFIT OF PROTECTION

EQ = DAMAGE INDEX, 0 = NO DAMAGE (EQUAL TO WITHOUT PROJECT DAMAGE LEVEL).

DIFFERENTIATING (lower case represents first partials w.r.t. EQ):

c(EQ) - d(EQ)=0

OR FIND EQ = EQ* THAT SETS c(EQ*) = d(EQ*), WHICH IN THE EXAMPLE IS EQ* = 16


NET ENVIRONMENTAL COST OF A PROJECT
WITH OPTIMAL MITIGATION (MC=MB)
COSTS AND BENEFITS ($)
400
350
300
250
200
150
100
50
0
-50
TB
ENVCOST
TC
NB
mb
mc
Optimum
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
ENVIRONMENTAL DAMAGE INDEX (0=NONE)

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