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A Review of the Valuation of Environmental Costs and Benefits in World Bank Projects

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THE WORLD BANK ENVIRONMENT DEPARTMENT

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Abbreviations

AET	Actual evapotranspiration
APL	Adaptable program loan
CBA	Cost benefit analysis
CEA	Cost effectiveness analysis
CO_2	Carbon dioxide
CV	Contingent valuation
DFID	Department for International Development, UK
EA	Environmental assessment
ESW	Economic and sector work
EU	European Union
GEF	Global Environment Facility
HEP	Hydroelectric power
IBRD	International Bank for Reconstruction and Development
IDA	International Development Agency
IDB	Inter-American Development Bank
IRR	Internal rate of return
LIL	Learning and innovation loan
NO_x	Nitrogen Oxide
NPV	Net present value
NRM	Natural resource management
O&M	Operations and maintenance
OED	Operation Evaluation Department
PAD	Project appraisal document
PCF	Prototype Carbon Fund
PM_{10}	Fine particulate matter (less than 10 microns in diameter)
SIL	Specific investment loan
SIM	Sector investment and maintenance loan
SO_2	Sulfur dioxide
TAL	Technical assistance loan
TCM	Travel cost method
TOR	Terms of reference
TSP	Total suspended particles
WTA	Willingness to accept
WTP	Willingness to pay

World Bank Regions

AFR Sub-Saharan Africa

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Republic of Congo, Cote d'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

EAP East Asia and Pacific

Cambodia, China, Fiji, Indonesia, Kiribati, Democratic People's Republic of Korea, Republic of Korea, Lao Peoples' Democratic Republic, Malaysia, Marshall Islands, Federated States of Micronesia, Mongolia, Myanmar, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Thailand, Timor-Leste, Tonga, Vanuatu, and Vietnam.

ECA Europe and Central Asia

Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia and Montenegro, Slovak Republic, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

LCR Latin America and Caribbean

Antigua and Barbuda, Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, Uruguay, and Venezuela.

MNA Middle East and North Africa

Algeria, Bahrain, Djibouti, Arab Republic of Egypt, Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Saudi Arabia, Arab Republic of Syria, Tunisia, United Arab Emirates, West Bank and Gaza, Republic of Yemen.

SAR South Asia

Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka.

Executive Summary

The World Bank's Operational Policy on Economic Evaluation of Investment Operations (OP 10.04) requires that project evaluations include all the costs and benefits generated by the project, including environmental costs and benefits. A well done economic analysis would include any positive or negative external impacts generated by the project, regardless of whether these impacts are directly linked to financial transactions or flows. In practice, however, valuing environmental impacts is a challenging exercise as they are often difficult to quantify in physical terms and to value in monetary terms.

The review examines the use of environmental valuation in 101 projects in the World Bank's environmental portfolio approved in fiscal years 2000, 2001, and 2002. It has three broad objectives. First, it examines the extent to which environmental costs and benefits have been incorporated in the economic analysis of projects. Second, it examines how well valuation was used. Third, it seeks to identify areas of weakness so as to feed into plans for capacity building.

The results show that the use of environmental valuation has increased substantially in the last decade. Ten years ago, one project in 162 used environmental valuation. In recent years, as many as one third of the projects in the environmental portfolio did so. While this represents a substantial improvement, there remains considerable scope for growth.

Many projects that did not use environmental valuation pleaded the difficulty of doing so. This review, however, included several examples of projects that valued the same environmental benefits that other projects in the same sector claimed were too difficult to value or "un-quantifiable." Given the substantial methodological progress that has been made in this field in the last decades, "un-quantifiable" can no longer be considered an acceptable excuse in most cases. Lack of data can be more difficult to overcome, but is also not insoluble in most cases.

Among those projects that value environmental impacts, only one values environmental costs and all the others focus solely on valuing benefits. This asymmetry can be partly explained by the fact that most projects seek to avoid or mitigate potential negative impacts through project design or the implementation of environmental management plans, although it strains credibility that there would be no remaining damages.

The degree to which environmental benefits are valued differs from sector to sector. In the energy and transportation sectors, the valuation of changes in air quality benefits from a large body of literature that has developed and applied the existing valuation techniques. Quantifying the impacts of project measures on outdoor air pollution does not appear to be a significant obstacle, at least not in the energy

sector. However, not all projects which quantify emissions reductions take it to the next stage and value these environmental benefits. In the agriculture and water supply and sanitation sectors, on the other hand, quantifying the physical impacts of project measures are generally the major obstacle to valuation of environmental impacts.

To ease the task of project teams, a series of toolkits is being assembled for some of the more commonly-occurring valuation problems. These toolkits will describe the available valuation methodologies from a problem-centric perspective and provide detailed examples of how to use these methodologies in a project context.

1 Introduction

The economic analysis carried out to ascertain the desirability of a project should take into account all the costs and benefits generated by the project. In principle, that should include environmental costs and benefits as well (Box 1). In practice, however, including environmental impacts is a challenging exercise because they are difficult to quantify in physical terms and to value in monetary terms. The *Environmental Assessment Sourcebook* states that "in spite of these difficulties, a greater effort needs to be made now to 'internalize' environmental costs and benefits by measuring them in money terms and integrating these values in economic appraisal" (World Bank 1991). A well done economic analysis is more than just a process for adjusting prices from the financial analysis to correct for market inefficiencies. It should be a process that includes social costs and benefits regardless of whether the impacts are directly linked to financial transactions or flows. In particular, it should include in the evaluation any positive or negative external impacts which are generated.

This review examines the use of environmental valuation in World Bank projects. It has three broad objectives. First, it examines the extent to which environmental costs and benefits, whether direct or in the form of externalities, have been incorporated in the economic analysis of World Bank projects. Second, it examines how well valuation was used. Third, it seeks to identify areas of weakness so as to feed into plans for capacity building.

An earlier review of the quality of economic analysis in Staff Appraisal Reports (SARs)[1] carried out by the Operations Evaluation Department (OED) found that only one of the 162 projects examined quantified environmental costs and benefits and considered those in the cost-benefit calculation (OED, 1995).[2] The purpose of the current review is much narrower and does not focus on the overall quality of the economic analysis, but solely on how environmental values are incorporated into that analysis. We therefore adopt a different sampling strategy. The main finding of this

Box 1.
What Is Required?

The requirements for the economic evaluation of projects are given in the Bank's Operational Policy (OP) 10.04 on economic evaluation of investment operations, and its companion Bank Procedure (BP) 10.04. OP 10.04 specifies that "economic analysis [must be conducted] to determine whether the project creates more net benefits to the economy than other mutually exclusive options for the use of the resources in question." BP 10.04 further elaborates that "[t]he economic evaluation of projects integrates financial, institutional, technical, sociological, and environmental considerations."

review is that, there has been a substantial increase in the number of projects incorporating environmental values into the analysis since the earlier review. However, many projects that carry out a cost benefit analysis (CBA) still do not quantify or value environmental impacts. The use of environmental valuation in projects, moreover, is often poorly documented, making it difficult to assess both the extent to which it is used and the quality of the work.

The review begins by discussing the potential role of environmental valuation in World Bank projects. The methodology used in the review is presented in Chapter 3. The overall results are presented in Chapter 4. Chapters 5 to 8 then examine in more detail the use of valuation in each broad sector: agriculture, energy, transportation, and water supply and sanitation. Chapter 9 discusses the special case of evaluating global environmental benefits.

2 The Role of Environmental Valuation

For many years, the environmental impacts of projects—whether positive or negative—were either ignored or, at best, placed in a list of 'intangible' costs and benefits that complemented the formal economic analysis. This was due partly to a lack of awareness about the importance of environmental impacts, and partly to a lack of appropriate methodologies to measure them in a way that would allow them to be incorporated into standard cost-benefit analyses. Both problems have been largely overcome in recent years. In particular, a very extensive literature has developed on the valuation of environmental costs and benefits.

Environmental Valuation in the Project Cycle

Environmental valuation can play a role at many points in the preparation of Bank-financed projects. The most obvious, of course, is in *appraisal*—in helping determine whether the benefits of a project justify its cost, or whether a project is a cost-effective way of meeting a given objective. Many of a project's costs and benefits are likely to be environmental in nature, and valuation allows these costs and benefits to be included in the overall analysis. But valuation can also play an important role at many other stages of the project cycle, as shown in Table 1.

Table 1. Environmental assessment, economic analysis, and the project cycle

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

Source: Dixon and Pagiola, 1998.

- At the *identification* stage, or in prior economic and sector work (ESW), it can help diagnose problems and prioritize interventions. For example, by showing that current land use practices lead to severe downstream problems, it can help determine that a watershed management project may be necessary.[3]

- During *preparation*, it can help determine what approach is best suited to addressing the problem. In the case of land use practices that cause downstream problems, for example, it might point to the need for creating a mechanism that internalizes those externalities (as in the *Costa Rica Ecomarkets Project*). Alternatively, if use of damaging land use practices is driven by policy distortions, it may point to the need for a policy reform program. As preparation progresses, valuation of expected environmental costs and benefits can also lead to adjustments in project design—by dropping sub-components that appear less beneficial than originally anticipated, for example, and expanding others that now appear more beneficial.

- During *implementation*, the extent to which expected environmental costs and benefits are being realized—and whether any unexpected impacts occur—should be monitored, just as other project impacts are monitored, so that mid-course corrections may be made if necessary.

- During *evaluation* of completed projects, valuation plays the same role as it does in appraisal, namely it contributes to the overall evaluation of the project's impact, this time on an *ex post* rather than *ex ante* basis.

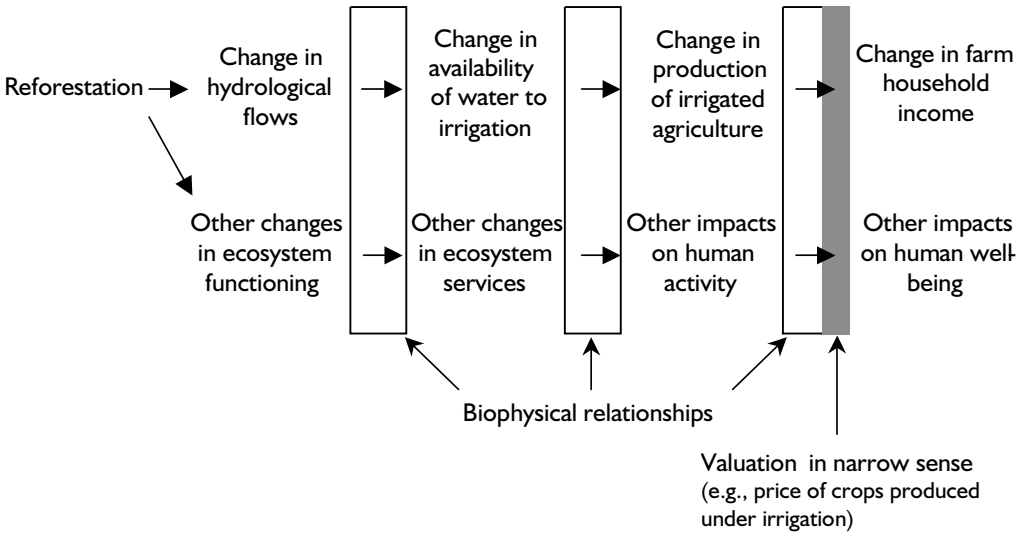
Although valuation of environmental impacts can and should play an important role throughout the project cycle, the analysis in this paper focuses on its role in project appraisal, as this is the step in which the best documentation is available.

Environmental Valuation Methodologies

Many methods for valuing environmental impacts are found in the resource and environmental economics literature (Dixon and others, 1994; Hufschmidt and others, 1983; Braden and Kolstad, 1991; Hanemann, 1992). Some are broadly applicable, some are applicable to specific issues, and some are tailored to particular data sources. As in the case of private market goods, a common feature of all methods of economic valuation of environmental goods and services is that they are founded in the theoretical axioms and principles of welfare economics. These measures of welfare change are reflected in people's willingness to pay (WTP) or willingness to accept (WTA) compensation for changes in their level of use of a particular good or service (Hanemann, 1991; Shogren and Hayes, 1997).

Valuation is a two-step process. The first step in any economic valuation of environmental impacts is to determine what those impacts are. This includes understanding the nature of the impact and its magnitude; who is affected and in what way; and what alternatives they have. As shown in Table 1, this step is often closely tied to the environmental assessment (EA) process. The bulk of the work involved in valuation actually concerns quantifying the biophysical relationships. In many cases, this requires tracing through and quantifying a chain of causality such as that shown in Figure 1

Figure 1. Valuing the impacts of a reforestation project



Source: Adapted from Pagiola, Acharya, and Dixon (forthcoming).

for a hypothetical reforestation project. Valuation in the narrow sense only enters in the second step in the process, in which the value of the impacts is estimated in monetary terms.

Different users and authors often classify the various methods of valuing environmental impacts differently, but the different grouping and naming systems converge to a broad classification that depends on whether measures are based on observed or hypothetical behavior, and whether measures are direct or indirect.

- **Measures of economic value based on observed behavior.** This category includes methods of valuation that use data on actual observed behavior and is further divided into direct and indirect observed behavior methods. These methods, when they can be applied, are generally considered preferable to those based on hypothetical behavior.

- **Direct observed behavior methods.** These methods derive estimates of value from the observed behavior of producers and consumers. They often use market prices and are most often applicable in cases where the environmental impacts are on goods and services traded on markets.

- **Indirect observed behavior methods.** This category of methods also uses actual observed behavior data but not that of the specific environmental good or service in question. In absence of actual market behavior, these methods use observations on actual behavior in a surrogate market, which is hypothesized to have a direct relationship with the good or service of interest. Examples of methods in this category include hedonic pricing methods (which use statistical techniques to break down the price paid for a good and service into the implicit prices for each of its attributes, including environmental attributes such as access to recreation or clean air) and travel cost methods (TCM) (which use observed costs to travel to a destination to derive demand functions for that destination). This group also includes

cost-based methods (such as replacement cost methods, which value services at the cost of replacing them, for example, the cost of building a water treatment plant to replace a water purifications service provided by an ecosystem) that do not exactly reflect (sometimes underestimate and sometimes overestimate) welfare (benefit-based) measures of value.

Measures of economic value based on hypothetical behavior. In this category of methods, valuation is based on hypothetical rather than actual behavior data: people's responses to direct questions describing hypothetical markets or situations are used to infer value. These methods can be divided into direct hypothetical (for example, contingent valuation (CV), in which respondents are asked directly how much they would be willing to pay for specified benefits) and indirect hypothetical (contingent ranking or conjoint valuation, which ask respondents to rank different bundles of goods) measures of WTP or WTA.

Benefits transfer. A final category of approach is known as benefits transfer. This is not a methodology per se, but rather refers to the use of estimates obtained (by whatever method) in one context to estimate values in a different context. For example, an estimate of the benefit obtained by tourists viewing wildlife in one park might be used to estimate the benefit obtained from viewing wildlife in a different park. Benefits transfer has been the subject of considerable controversy in the economics literature, as it has often been used inappropriately. A consensus seems to be emerging that benefit transfer can provide valid and reliable estimates under certain conditions. These include that the commodity or service being valued is identical at the site where the estimates were made and the site where they are applied; and that the populations affected have identical characteristics. Of course, the original estimates being transferred must themselves be reliable for any attempt at transfer to be meaningful.

Each of these approaches has seen extensive use in recent years, and an extensive literature exists on their application. In general, measures based on observed behavior are preferred to measures based on hypothetical behavior, and more direct measures are preferred to indirect measures. However, the choice of valuation technique in any given instance will be dictated by the characteristics of the case and by data availability. Several techniques have been specifically developed to cater to the characteristics of particular problems. The TCM, for example, was specifically developed to measure the utility derived by visitors from sites such as protected areas. The change in productivity approach, on the other hand, is very broadly applicable to a wide range of issues. CV is potentially applicable to any issue, simply by phrasing the questions appropriately, and as such has become very widely used—probably excessively so, as it is easy to misapply and, being based on hypothetical behavior, is inherently less reliable than measures based on observed behavior. Data availability is a very frequent constraint and often restricts the choice of approach. Hedonic price techniques, for example, require vast amounts of data, thus limiting their applicability.

3 Assessing Environmental Valuation in World Bank Projects

This review focuses on the use of environmental valuation in the economic analysis of World Bank projects. It examines the extent to which the economic analysis of World Bank projects incorporates environmental costs and benefits, whether direct or in the form of externalities, and how well valuation was used.

Projects Reviewed

The review examines projects in the World Bank's environmental portfolio, namely projects which are classified as environmental according to the new thematic codes.[4] The selection of themes is based on the objectives of the project's operation. The 'Environment and Natural Resources' thematic group includes the following sub-themes: biodiversity, climate change, environmental policies and institutions, land management, pollution management and environmental health, water resources management, and other environmental and natural resources management. Projects with environmental themes approved in fiscal years 2000, 2001, and 2002 are considered.[5] This portfolio of some 150 projects includes several types of lending instruments. The review focuses primarily on investment lending instruments: specific investment loans (SIL), sector investments and maintenance loans (SIM), and adaptable program loans (APL).[6] Some learning and innovation loans (LIL) and technical assistance loans (TAL) are also included, when they have substantial environmental components and carry out some analysis of project benefits. However, most LIL and TAL projects are excluded, as those types of loans generally do not require a full economic analysis. The review focuses on projects which would usually be required to carry out a full cost-benefit analysis, but also includes some projects that carry out a cost-effectiveness or incremental cost analysis.

The final sample of projects reviewed includes 101 projects. A full list of the projects examined is provided in the Appendix. Table 2 shows the projects included in the review, categorized into four major sectors: agriculture, energy, transportation, and water supply and sanitation. The agriculture sector includes irrigation and drainage projects, as well as forest or other natural resource management (NRM) type of projects. Some projects have components in more than one sector; they are listed under both sectors as appropriate. For example, the *Beijing Second Environmental Project* has a sewerage component (water sector) and a boiler conversion component (energy sector). The total number of project components is 108. Table 2 also shows the total costs of the projects, which includes the amounts financed by International Bank for Reconstruction and Development (IBRD) and International Development Agency (IDA) loans, Global Environment Facility (GEF) and other donors' grants, as well as any public and private sector financing of the project.[7]

Table 2. Number and cost of projects evaluated, by sector and region

	Number of project components								
	Sub-Saharan Africa (AFR)	*East Asia and Pacific (EAP)*	*Europe and Central Asia (ECA)*	*Latin America and Caribbean (LCR)*	*Middle East and North Africa (MNA)*	*South Asia (SAR)*	***Total***	*Total cost (billion US$)*	*Average project cost (million US$)*
Energy	2	6	10	1	0	6	**25**	6.0*	251.2*
Transportation	5	5	0	3	0	3	**16**	5.7	354.0
Agriculture, fishing, and forestry	4	4	7	8	4	5	**32**	2.6	78.5
Water, sanitation, and flood protection	6	8	6	7	5	3	**35**	4.8	136.5
Total/Average	**17**	**23**	**23**	**19**	**9**	**17**	**108**	**19.1**	**174.8**

Notes: Projects with components in multiple sectors are counted separately in each appropriate sector.
*Does not include the Chad/Cameroon Oil Pipeline Project, which alone costs US$3.7 billion.

Agriculture and water supply and sanitation are the two sectors with the most projects. The average cost of projects in the water supply and sanitation sector is about twice that of projects in the agricultural sector. Although there are fewer projects in the energy and transportation sectors, they have the highest average cost per project, reflecting the magnitude of investments in these sectors.

Table 2 also shows the distribution of projects evaluated by sector and region. Most regions have several projects in each sector. The Middle East and North Africa (MNA) region has the fewest number of projects reviewed and also no projects in the energy or transportation sector. There is only one energy projects in the sample from the Latin America and Caribbean (LCR) region, but seven projects in the water supply and sanitation sector. The East Asia and Pacific (EAP) region has the highest number of transportation projects reviewed, while the Europe and Central Asia (ECA) region has the highest number of energy projects reviewed. Projects in the agriculture and water supply and sanitation sectors are found in all regions.

Methodology

The review is based on information contained in the project's appraisal document (PAD), particularly the summary information concerning the EA and the cost benefit analysis (CBA) in Annex 4 of the PAD. It does not take into account any other documents that may have also been presented as a part of the project's approval process. In some cases, additional documentation was sought from task teams to clarify how the analysis was conducted, but time and resource constraints precluded doing so for more than a handful of projects. With some notable exceptions, the response rate to such requests for additional information was very low.

All projects do not necessarily require the use of environmental valuation, and even among those that do, needs are likely to vary substantially, given differences in local circumstances and in project activities. The review initially planned to rely largely on the EA carried out for each project to assess the need for valuation. The EA summary, however, proved to be of limited usefulness in this regard. In particular, there was little discussion of any expected *positive* environmental impacts, even though all the projects included in the review have one or more environmental objectives. Indeed some of the projects with the strongest environmental objectives have sometimes been classified as category C projects.[8] The EA process, or at least the summary of it provided in the PAD[9], seems generally primarily concerned with identifying adverse environmental impacts that would violate the Bank's operational and safeguard policies or the country's own environmental regulations. Where positive environmental impacts are expected, these are often discussed outside the EA summary.[10] In many cases, the PADs contain little if any discussion of specific environmental impacts. In only a few cases is sufficient information provided to indicate that a project is likely to have few significant environmental impacts that would warrant valuation.[11]

Several additional criteria were used, therefore, to assess whether environmental impacts in any given project are likely to be sufficiently important to warrant a valuation effort. Projects that listed one or more environmental themes as their primary objectives were considered likely to have environmental impacts significant enough to be valued. Projects that listed environmental themes as secondary objectives were compared to other projects with similar objectives, similar types of interventions, and comparable scale of investments. This left several projects for which no information was available on likely environmental impacts. In the absence of any other information, these projects were assumed to have either no environmental impacts or only minor impacts that might not require valuation.

Limitations

Several limitations of the analysis should be borne in mind in interpreting results. First, the analysis focuses only on approved projects. By definition, these are all projects for which benefits are deemed to exceed costs. If projects with large environmental benefits were not approved—or perhaps not pursued in the first place—because their environmental benefits were not measured, they would not be in the sample.

By focusing on PADs, the analysis also only looks at the use of environmental valuation in the completed project design. The extent to which valuation may have been used in preceding steps, as discussed in Chapter 2, is largely invisible.

Determining whether projects valued any environmental impacts and included those in the CBA proved much more difficult than expected. In large part, this difficulty stems from the limited amount, and sometimes poor presentation, of the information provided in the PAD. In several instances, the environmental benefits generated by a project are discussed at a great length in qualitative terms, but then only an overall net present value (NPV) of costs and benefits is given. Whether any of the environmental benefits discussed were actually valued, and if so, how they were valued, is often

unclear. Although BP 10.04 stresses that economic evaluations need to be "transparent and replicable", this is often far from the case (Box 2).

Box 2.
Presenting the Results of Environmental Valuation

Presenting the results of the environmental valuation in a clear and transparent way is essential to assessing it. Unfortunately, most projects reviewed performed very poorly in this area. The table below shows an example of good presentation, taken from a project outside the review sample. In this case, all the benefits listed are environmental, but similar tables could easily combine environmental and non-environmental benefits. This table has several desirable properties:

- It shows different benefits separately. This is particularly useful when projects have both environmental and non-environmental benefits, as it allows their relative importance to be compared.
- It includes place-holders for costs and benefits that could not be quantified, with comments to provide whatever qualitative information may be available.
- It clearly shows the uncertainty of some of the estimates by giving results for different scenarios and showing ranges rather than single figures; further limitations of the estimates are noted in the comments.

Estimated costs and benefits of the natural reserve management component of the Haiti Forest and Parks Protection Technical Assistance Project (US$ million)[a]

	Degradation halted [b]	*Degradation reduced* [b]	*Comments*
Costs			
Project expenses	6	6	Includes post-project maintenance costs
Forgone agricultural income	2	2	
Forgone logging income	?	?	Unlikely to be large
Total quantified costs	**8**	**8**	
On-site benefits			
Tourism potential	?	?	Significant, but needs additional investment
Sustainable harvest of			
• *Timber*	?	?	Limited potential in one area
• *Non-timber products*	?	?	Probably important, but no data
Biodiversity/natural habitats	?	?	Global benefit: regionally outstanding ecosystems, many endemic species
Off-site benefits			
Reduced damage to irrigation	4-14	6-24	Does not include maintenance cost savings
Reduced flood damage	2.5-5	3.5-6	Only includes damages to roads and canals
Increased water availability	?	?	
Reduced siltation	?	?	
Total quantified benefits	**6-19**	**9-30**	

Source: Staff Appraisal Report, Haiti Forest and Parks Protection Technical Assistance Project. Report No.T–6948–HA. 1996.
Notes: [a] Quantified benefits shown in present value terms, discounted at 10% over an infinite time horizon.
[b] Alternative scenarios of project outcome.

4 Overall Results

The broad findings of the review are presented in this chapter. It examines the extent to which environmental values are incorporated into the projects' economic analysis. In other words, if environmental impacts are identified, are those impacts valued and incorporated into the analysis? The following sections then examine the use of valuation in projects in each sector.

How often is Environmental Valuation Used?

Table 3 summarizes the use of valuation of environmental impacts in project analysis. Overall, these results show a very notable increase in the use of environmental valuation relative to that found in the 1995 OED Review. Whereas only one project in 162 undertook environmental valuation in that review, about a third of projects in this review undertake some form of valuation, though some do not then include it in the economic analysis.[12] Considering that this review includes only projects with explicitly environmental objectives, however (whereas the OED review was based on a sample of all projects), the use of valuation is still in many ways disappointingly low. The energy and water sector have the largest number of projects valuing environmental impacts explicitly. The agriculture sector stands out for having the largest number of projects valuing environmental benefits implicitly.

Table 3. Valuation of environmental impacts in project analysis

	Energy	*Transportation*	*Agriculture, fishing, and forestry**	*Water, sanitation, and flood protection*	***Total***
Environmental impacts valued					
Explicitly	5	3	3	7	**18**
Implicitly	0	0	6	3	**9**
Valued but not included in analysis	2	0	1	1	**4**
Environmental impacts not valued					
Lack of data	0	1	2	3	**6**
Too difficult/'un-quantifiable'	6	1	4	7	**18**
No reason given	7	5	8	7	**27**
No economic analysis	1	0	1	1	**3**

Note: * Two forestry projects that valued only carbon sequestration benefits were not counted as valuing environmental benefits. See discussion on valuation of global environmental benefits in Chapter 9.

The treatment of negative environmental impacts is quite different from that given to positive environmental impacts. Discussion of a project's potential negative environmental impacts generally focuses on how they are to be resolved or are going to be addressed by implementing environmental management plans. The EA process is specifically designed to identify any significant negative environmental impacts early in project preparation and develop plans to mitigate those impacts. These may include changes in the project design itself and the location of project activities. Environmental management plans may be established and put in place to monitor and evaluate impacts that may be expected. To the extent that an environmental management plan or changes in project design eliminate adverse impacts, there would be no need to value them. Still, despite all best efforts, some negative impacts are unavoidable and may still occur. It is surprising, therefore, to find that only one project in the sample, the *Cameroon/Chad Oil Pipeline Project*, directly values the negative environmental costs associated with the project's activities—presumably because this project's very high visibility required it to cover all its bases. Other projects presumably include the cost of mitigating the negative

Box 3.
Which Costs Should Be Included in the Economic Analysis of a Project?

If a project activity causes environmental damage, that damage needs to be included in the economic analysis of the project together with the activity's benefits and any other damages. To do otherwise would be to make the activity appear artificially more attractive than it is. Likewise, if additional costs are incurred to avoid such damage, those costs need to be included in the project costs considered in the economic analysis. (The decision to avoid or mitigate expected environmental damages can, of course, itself be subjected to cost-benefit analysis or, where such an approach is mandated by Bank safeguard policies or country regulations, a cost-effectiveness analysis.)

However, projects do not necessarily include all of the estimated costs in their economic analysis. For example, most projects tend to omit the cost of institutional strengthening components in the economic analysis, arguing that their benefits are difficult to quantify and extend beyond the project itself. In many instances, the costs of institutional strengthening activities supported by a project are to develop the capacity of the environment ministry to monitor and enforce compliance with existing environmental regulations and the environmental management plans required by the project. These institutional strengthening costs may be only one subset of the overall environmental management costs associated with the project. The question that arises, then, is which of the costs of dealing with potential environmental impacts that are directly or even indirectly related to project activities should be included in the economic analysis of a project?

Several projects explicitly omit the cost of measures to abate environmental damages from the economic analysis. The *Georgia Irrigation and Drainage Community Development Project*, for example, omits the costs of environmental and safety measures because, it argues, the benefits from these measures are not included either. If the need for the measures arose directly from project activities, however, their cost should have been included. Conversely, if the measures were adopted on their own merits, then that decision should have been the subject of its own cost-benefit or cost-effectiveness analysis. In this case, however, omitting the cost of mitigating environmental damage can be justified on more practical grounds: the cost of these measures is only about 1 percent of total project costs, and so it likely has little impact on the analysis. In contrast, the *Yemen Irrigation Improvement Project* excludes more than 50 percent of the total project costs from the economic analysis. Given that the estimated rate of return for the overall project is just below 12 percent, the exclusion of more than half of the project's costs is certainly a reason for concern. In contrast to these two projects, many projects do not indicate very clearly which costs are included in the economic analysis.

environmental impacts of project activities in the overall costs subjected to the CBA. However, these costs are not always explicitly identified in the discussion of project costs, so that their magnitude—or even whether they are included in the CBA at all—is difficult to determine.[13] Box 3 discusses some of the issues related to determining which costs should be included the CBA of a project.

The number of projects valuing environmental impacts in Table 3, therefore, refers almost exclusively to instances where environmental *benefits* were valued. Projects are counted as explicitly valuing environmental benefits if the results are shown, either by indicating the value of environmental benefits in dollar terms or as a percentage of total benefits, or by giving the NPV or rate of return for the project with and without the inclusion of environmental benefits. In some cases, although environmental impacts are not explicitly valued, the analysis clearly rests on the assumption that the project's positive environmental impacts would generate benefits, such as increases in yields, productivity, or conservation of natural resources. In such cases, the valuation of environmental benefits is implicit in the broader analysis. Projects are counted as valuing environmental impacts even if they do not value all impacts, or only value the impacts for some of the project's components. Finally, some projects value some environmental benefits, but decide not to include these estimates in the CBA, either because of the uncertainty regarding how these values were calculated or because of the global nature of the environmental benefits generated (see Chapter 9).

Table 3 also indicates the reasons given, if any, by projects that do not value environmental benefits. Most frequently, no reason is given for not valuing environmental benefits. Some projects argue that environmental benefits are either too difficult to value or that they lack the data necessary to do so. As lack of data may be one reason why some projects thought environmental benefits were too difficult to value, these two categories overlap to some extent.[14] In some cases, such as biodiversity conservation, there are undoubtedly significant methodological difficulties involved in trying to quantify and value environmental impacts. It is interesting to note that the sectors with the largest number of projects valuing environmental impacts—energy and water—are also the sectors with the largest number of projects stating that such impacts are too difficult to value. In both sectors, there are examples of projects that value the same environmental benefits that other projects claim are too difficult to value or "un-quantifiable." In the energy sector, several projects go as far as quantifying emissions reduction, but then do not take the additional step of valuing these environmental benefits. In the water sector, many projects that consider environmental benefits too difficult to value chose to do a cost effectiveness analysis (CEA). Whether this is an appropriate strategy is discussed in Box 4.

In most cases, projects with primary environmental objectives value at least some of the expected environmental benefits, or at least provide a reason for not doing so. Even among projects with primary environmental objectives, however, there are several that do not value any environmental impacts.

Although no PAD explicitly says so, it seems likely that one reason for not attempting to value environmental benefits is that the project may be already justified without them. Why go to the trouble of undertaking valuation when it

Box 4.
Selecting the Appropriate Type of Economic Analysis

Several projects, particularly in the water sector, opt to undertake a CEA rather than a full CBA, citing difficulties in valuing environmental benefits. In some cases, projects actually carry out a CBA, but because the rate of return without environmental and health benefits proves to be too low or with those benefits too uncertain, a CEA is chosen instead. A CEA is appropriate when, for example, the goal is to meet a predetermined target and the relevant question is how to achieve this standard at the lowest possible cost (Dixon and others, 1994). This is the case for the *Hungary Municipal Wastewater Project*, for example. The project aims to reduce water pollution emissions to levels acceptable by the European Union's (EU) environmental standards, as the country progresses to fulfill the requirements for EU membership. The amount of pollution reduction has been decided and for the purposes of the project, valuing these benefits is not necessary.

However, for most of the other water projects carrying out a CEA, the primary justification for wastewater treatment investment are specific outcomes, such as the protection of existing water supply sources, a reduction in the incidence and costs associated with water borne diseases, the protection of downstream water sources, improved agricultural yields, the protection of tourism and amenity values, and so on. Given that multiple objectives are desired and the difficulties in measuring the impact of the project on each of these objectives, the target chosen is often input based (for example, the quantity of wastewater to be treated) rather than outcome based.

While the desired environmental benefits would be generated by setting a fixed target for the quantity of wastewater to be treated, the CEA cannot help in the decision of what the target should be. Also, the environmental impacts of the adopted measures will depend largely on not just the quantity of wastewater treated, but also the level of treatment chosen. A CEA based on the quantity of wastewater to be treated may reject a slightly more expensive treatment option which could generate substantial additional benefits relative to the additional costs. Alternatively, a CBA might have shown that most benefits could have been achieved with a lower-cost option, and that the last increment in benefits is disproportionately expensive.

would not change the conclusion that the project should be approved? From the narrow perspective of getting the project through, it is hard to argue with this logic. Nevertheless, this does represent a significant missed opportunity. First, in terms of the project itself, it means a missed opportunity to adjust the design so as to maximize benefits (Box 5). If environmental benefits are valued, their magnitude relative to other costs and benefits may lead to a re-evaluation of the effort devoted to various components. Components which are found to provide particularly large environmental benefits may be expanded, for example. Conversely, components that are targeted primarily at generating environmental benefits may be reduced in scope or dropped entirely if the value of those benefits proves low. Second, there is also a significant missed opportunity in terms of improving overall understanding of the problem. Given the very significant effort and expense that already needs to go into project preparation and appraisal, the additional effort needed to undertake environmental valuation is often small. This relatively small marginal cost could provide valuable information to future projects. As the number of observations increase, it would also become simpler and less risky to base evaluation on cheaper techniques such as benefits transfer.

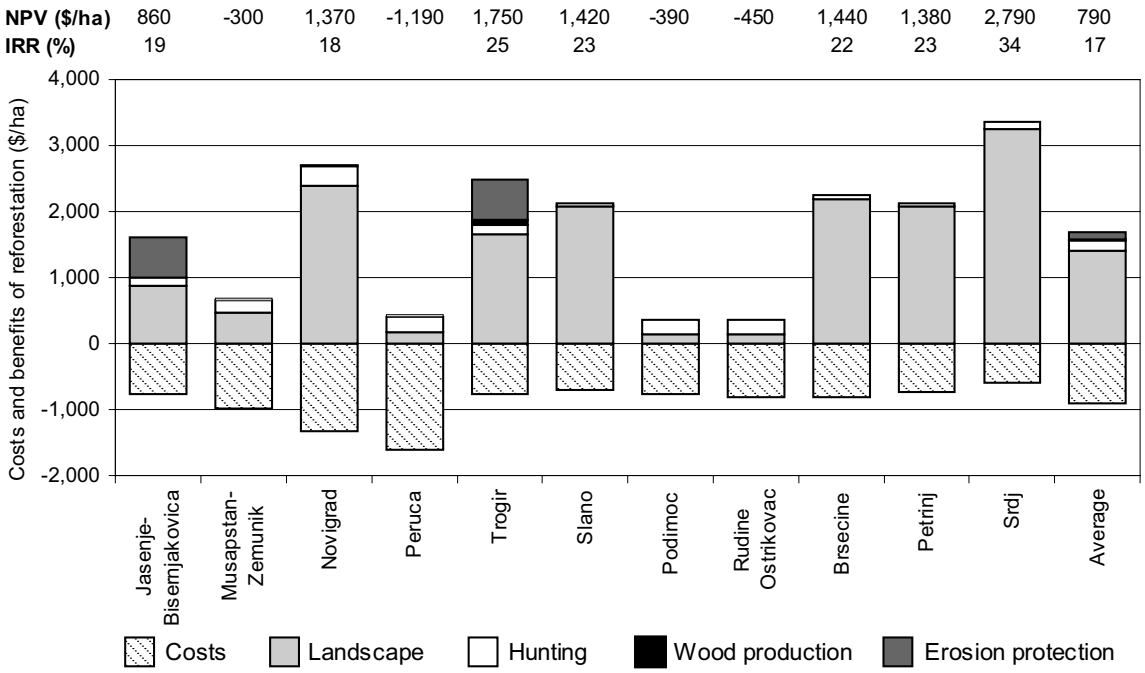
It is interesting—and surprising—that some projects in the sample do not carry out *any* economic analysis of the benefits generated by the project, environmental or otherwise. This is

Box 5.

Using Environmental Benefits Estimates to Revise Project Design

In many instances, economic analysis is used solely to determine whether an already-designed project should be undertaken or not. This misses an important opportunity to use the results of the analysis to improve the project design. This is equally true in the case of environmental benefits.

The figure below shows the estimated costs and benefits of proposed reforestation activities in the *Croatia Coastal Forest Reconstruction and Protection Project* (which was not in the reviewed sample), by site. The overall analysis, shown in the last column, indicates that this component, as designed, is beneficial, with a NPV of $790/ha, and an internal rate of return (IRR) of 17 percent. However, this overall result masks the fact that the costs and benefits of reforestation vary substantially from site to site—even within the same county, benefits can vary by several orders of magnitude. If only the sites with positive net benefits are included, the average benefits almost double to US$1,570/ha, and the overall IRR rises to 24 percent. As a result of this analysis, the component was restructured to drop all the proposed sites that were found to have negative net benefits, and guidelines were developed, based on the characteristics of the high-benefit sites, to select additional sites to meet the original reforestation target.



Source: Based on data in *Croatia Coastal Forest Reconstruction and Protection Project*. Staff Appraisal Report No.15518-HR.

despite the fact that projects in sectors that traditionally do not require an economic analysis were excluded from the review.

Use of valuation techniques

Table 4 shows the valuation techniques used in the projects reviewed, where the specific technique used is stated or can be deduced (in most cases, no information is provided on which teschniques are used).

The change in productivity approach is used mostly in irrigation projects, to estimate the benefits of improved water supplies on

Table 4. Valuation techniques employed in projects reviewed

	Frequency used	*Environmental benefits valued*
Change in productivity	5	Water quality (impact on agricultural output)
Avoided costs	11	Water and air quality improvements
Contingent valuation (CV)	6	Water quality
Benefit transfer	4	CO_2 reduction, 'watershed' benefits
Hedonics	2	Flood protection

Notes: Projects may use multiple valuation techniques.

agricultural yields. Avoided cost methods are used frequently in projects that aim to improve air and water quality. CV is used mostly in the water supply and sanitation sector, although the WTP studies are often aimed primarily at determining the affordability of water tariffs and ensure the financial sustainability of the project. rather than at estimating consumer welfare increases. Hedonic analysis is used in estimating the benefits of flood control, by comparing property values in areas under flood risk to those in safe areas, although the analysis falls short of a full hedonic analysis by not controlling for other factors.

It may appear surprising that benefits transfer—in which estimates obtained elsewhere, by whatever method, are applied to the case of interest—is used to such a limited extent. With its low cost, benefits transfer is often an appealing approach. The appearance is partly misleading, in that some of the other approaches also use benefits transfer to a degree. Thus the CV studies cited in several of the projects that rely on them were actually conducted for other purposes (three of the projects reviewed conduct CV surveys specifically for valuation purposes). Projects that use avoided cost methods also rely on benefit transfer to a certain extent. For example, air pollution valuation studies often take dose response functions from US studies and apply them to the target countries, with adjustments.

The limited use of benefits transfer is good news, as this approach can often provide very misleading results. The data in Box 5 illustrate this well: even within a narrowly defined category of problems (here, reforestation in coastal forests in Croatia), benefits can differ by several orders of magnitude. Taking the net result obtained at a particular site, or even the average result at all sites, and applying it elsewhere would be quite risky. Taking part of the result and applying it, with adjustments, may be a better approach. Thus taking the tourist WTP for forested landscapes used in the Croatia study and using it to estimate the benefits of forest landscape in tourist areas elsewhere may be justified, if tourists in Croatia and the site of interest are drawn from the same pool. As noted, several of the air quality studies rely on transferring dose-response functions estimated in one site to another. This approach may seem a priori plausible, in that it transfers a medical relationship, but it does not allow for the many other factors that can affect that relationship—such as lifestyle factors that affect exposure (for example, time spent outdoors) or vulnerability (for example, through additional risk factors such as malnutrition or smoking). The transferability of dose-response functions has thus been the subject of considerable controversy. For example, Chestnut and others (1997) found that the value of averting illness, as a share of income, is similar in Bangkok and the USA, but in the same issue of the journal,

Alberini and Krupnick (1997) found that illness in Taiwan is poorly predicted by the Los Angeles dose-response function, and call into question the transfer of dose-response functions. Barton and Mourato (2003) compare the transfer of WTP for water quality as estimated with benefits transfer from a CV survey in Portugal to the results of a CV survey in Costa Rica, and find errors of as much as 100 percent, which are not reduced by adjusting for income levels.

It is useful to compare estimates to the results obtained in other studies, as a check. The estimates obtained in a given project area may well fall above or below the range of results obtained elsewhere without necessarily being wrong, but such a check would at least trigger a caution light and justify a close re-examination of data and assumptions.

Additional details on how these valuation techniques were used is provided in the sector-specific sections below.

Impact of Environmental Valuation

How important are these environmental benefits relative to the other benefits generated by these projects? The answer varies considerably from project to project. Table 5 shows the effect of including environmental benefits on the NPV and IRR of projects that provide enough information for this impact to be computed. Other projects provide estimates of environmental benefits in ways that can not be directly compared to total benefits. For example, the health benefits generated by the *Senegal Water Sector Project* are estimated to be about US$10 million in the early years of the project, reaching as high as US$114 million in the project's final years. However, no information on the total health benefits are provided. In the *China Water Conservation Project*, water savings benefits could be as much as US$100 million, but are not included in the CBA. In the *Chongqing Urban Environment Project*, reduced health costs, protection of tourism, and amenity values are estimated to be worth as much as US$482 million. While this project undertakes a CEA, these benefits are not far from the total project costs of US$535 million. As this table shows, environmental benefits can at times be very substantial, and their inclusion in the analysis can raise estimated project returns significantly. The results shown are probably un-representative, however. It seems likely that many projects that provide no explicit information on the magnitude of environmental benefits do not do so because these benefits were found to be small.

The remainder of the review examines the analysis in those projects which carried out any valuation of environmental benefits. The evaluation of how this valuation was done focuses on the appropriateness of the methodologies chosen and how they were applied. The assumptions underlying the calculations and the source of values used are also discussed, where applicable. Evaluating the quality of the analysis proved difficult, however, as PADs often provide only very limited information on how the valuation was done. The discussion is organized according to the broad sector classifications presented in Table 2. A general description of the types of projects financed in the sector is followed by a discussion of the kinds of environmental impacts that arise, and how those impacts have been valued in the existing economic literature. This provides a context to evaluate how the environmental impacts were valued.

Table 5. Effect of including environmental benefits on estimated project returns

Project	*Change in NPV (%)*	*Change in IRR (% points)*	*Comments*
Poland Geothermal		4	Estimated health benefits range from US$20-23 million and represent 95% of total environmental benefits
Krakow Energy Efficiency	60		Not clear whether global benefits are included
China Hubei Hydropower	49	1.9	Additional global environmental benefits of US$13.6 million not included in NPV and IRR
Beijing Environment (Energy Component)	67		Environmental benefits include reduced health costs and land savings (see project discussion in section 5)
Uruguay OSE Modernization	10		Without the environmental benefits, the project's sewage treatment component is not justified
Cartagena Water Supply	41		IRR with environmental benefits is 16%
Tehran Sewerage	153	8	Higher benefits estimates based on WTP for sanitation and avoided costs. Lower estimates based only on avoided costs benefits
Azerbaijan Irrigation		6	Water supply benefits important in sensitivity analysis
Armenia NRM	130	4	Environmental benefits include both local and global environmental benefits
Mumbai Urban Transport	36		

5 Energy

Twenty five projects, relating primarily to provision of energy and reform of the power sector, are reviewed for this analysis. Regional differences in the focus of projects in this sector are fairly pronounced. Fifteen of these projects concern improving the efficiency of transmission and distribution of energy supply and/or conversion of cleaner energy supply sources (that is, switching from coal to gas boilers). These are primarily in the ECA region.[15] All three of the large scale hydroelectric power (HEP) projects reviewed are in China. Four of the energy projects reviewed focus on the development of renewable energy or small scale HEP, primarily in context of expanding access to electricity in rural areas. Three projects concern the development of new energy supply sources in the oil, gas, and mining sector. The total cost of the reviewed projects amounts to US$6 billion—not including the *Chad/Cameroon Oil Pipeline Project*, which by itself amounts to US$3.7 billion.

Environmental impacts can often be substantial in this sector, given the scope and nature of investments. However, there seems to be little connection between the environmental impacts identified and discussed in the EA and the CBA. This is true even when the environmental impacts are positive. For example, while reduced emissions of air pollutants are highlighted in the EA of a majority of the projects, only four projects incorporate these benefits into the analysis. Environmental costs, on the other hand, are evaluated in only one project, the *Chad/Cameroon Oil Pipeline Project*.

Air Quality Impacts of Energy Projects

The burning of fossil fuels is a major cause of air pollution in urban areas. Energy production from coal fired power plants, large boilers, and furnaces are certainly a main contributor to air pollution in urban areas, as are emissions from motor vehicles. Many studies have investigated the impacts of air pollution, particularly on health, and how to value those impacts.[16]

A detailed study of fossil fuel combustion in six developing country cities (Lvovsky and others, 2000) finds that local health impacts account for approximately two thirds of the environmental damages from fuel combustion. Particulate emissions alone contribute to almost three-quarters of the local health costs. Global damages due to the effects of carbon emissions on climate change are the second major source of environmental damage, accounting for a fifth of total environmental damages. Based on these results, Lvovsky and others propose a methodology for the rapid assessment of urban air pollution health costs. The methodology requires information on annual average exposure, demographics of the population exposed, and average annual income (and the

associated relevant income elasticities) to calculate health damages due to air pollution. The study provides a particularly useful reference point for the health costs of particulate matter, which is known to be the major contributor to health damages associated with air pollution.

In rural areas, it is primarily the use of biomass fuels for heating and cooking that is often a significant source of air pollution. It is estimated that as many as 90 percent of rural households still rely on biomass fuels, the use of which can lead to levels of indoor air pollution many times higher than international ambient air quality standards (Bruce and others, 2000). The burning of biomass fuels produces many substances that are damaging to human health, such as particulates, carbon monoxide, nitrous oxides, sulfur oxides (from coal), formaldehyde, and other carcinogenic substances. Women and children, in particular, may be exposed to very high levels of these pollutants for 3-7 hours daily for many years. In mountainous areas and during the winter, exposure is even longer. Consistent evidence suggests exposure to biomass smoke increases the risk of childhood acute lower respiratory infections, chronic obstructive pulmonary disease, and lung cancer. Recent studies have also found associations between biomass smoke exposure and upper respiratory infections, asthma, tuberculosis, low birth weight and prenatal mortality, and eye irritation and cataract (von Schirnding and others, 2002). A smaller number of studies quantifying the impacts of exposure to indoor air pollution exist compared to outdoor air pollution.

The projects examined cover a wide variety of contexts, but have in common the primary objective of providing additional energy. The sources of additional energy include efficiency improvements in the distribution and transmission of energy to reduce losses; the development of renewable energy sources; the construction of HEP facilities; and the exploration and development of oil and gas reserves. Quantifying the emission impacts of alternative energy sources does not appear to be the major obstacle in the valuation of environmental impacts, at least in the context of urban air pollution. In fact, several projects do provide detailed estimates of the expected reduction of emissions of different types of pollutants. Few projects, however, take it one step further and identify the health impacts of these emission reductions. Identifying these impacts is the crucial step in the valuation process, as the methodology to value the benefits of air pollution reduction in monetary terms is reasonably well developed. The discussion below is intended to illustrate how some of the projects in the energy sector identify the health impacts of emissions reductions and use this information in the valuation of the environmental benefits generated by the project.

Valuing Changes in Air Quality

Generally, the benefits of energy projects are estimated by calculating the consumer surplus generated by the consumption of the additional energy produced. The change in consumer surplus is often proxied by the incremental revenues generated by the project. A number of the projects examined entail energy efficiency investments that will reduce the amount of inputs necessary to produce a given amount of energy output. In such cases, project measures also generate benefits due to the resource savings incurred. These resource savings are typically included in the estimates of the project

benefits when applicable. If a more efficient production process, or the switch to an alternative production process (for example, the switch from a coal to a gas boiler), also results in lower emission of pollutants, the avoided health costs can be viewed as just another type of cost savings that should be considered in the evaluation. While the EA of fourteen projects emphasize the air quality improvements that will result from the project's measures, only 4 projects actually value these benefits.[17] These are the *Poland Geothermal District Heating and Environment Project*, the *Krakow Energy Efficiency Project*, the *Beijing Environment Project,* and the *China Hubei Hydropower Project*.

Outdoor air pollution

The *Poland Geothermal District Heating and Environment Project* provides an interesting example where the valuation of air quality benefits proved significant, as the heat cost savings alone would not have yielded a satisfactory rate of return for the project.[18] The valuation of the air quality benefits also seems motivated by the supplemental funding provided by the GEF, which requires that such funds finance only the additional costs incurred to reduce carbon emissions which are not justified by the local benefits incurred. The primary objective of the project is to reduce air pollution in a ski resort area in southern Poland that experiences considerably higher levels of air pollution during the heating season. This is to be achieved by replacing coal-fired space heating boilers with cleaner energy sources such as geothermal heat and natural gas boilers.

The local health benefits resulting from the estimated reduction in the emission of total suspended particles (TSP) and sulfur dioxide (SO_2) are calculated using a dose-response model developed by the World Bank (Hughes and Lvovsky, 1998). To value the expected reductions in mortality and morbidity that result from the project's emission reductions, the analysis uses estimates developed in the United States based on the costs of health care, wage rates, and the WTP to reduce the risk of death. These values are adjusted to reflect the differences in income levels between Poland and the United States. In addition to the health impacts, the benefits from reduced air pollution in improving the attractiveness of the area for both visitors and residents are also included. The estimated health benefits, however, represent over 95 percent of the total environmental benefits, which amount to between US$20-23 million in NPV terms. It would have been of interest to know how these environmental benefits compared to the heat cost savings benefits, but this information is not presented anywhere in the PAD.[19]

Two other projects, similar in spirit to the Poland project discussed above, replace coal-fired boilers with oil and gas boilers. One is the *Krakow Energy Efficiency Project,* also in Poland. While no information is provided on how the environmental benefits were valued, they are said to amount to US$9 million, or about 15 percent of the discounted net benefits generated by the project. The environmental benefits will result from annual energy savings equivalent to 73,000 tons of coal, an amount equivalent to 10 percent of total fuel consumption in 2000. It appears the environmental benefits calculated include both the local benefits of improved air quality and the global benefits of reduced greenhouse emissions.[20] The *Beijing Environment Project* also values the health benefits from reduced air pollution from boiler conversion to natural gas. The air quality model uses predicted emissions reduction for TSP and

SO_2, since no reliable estimates of ultra fine particulate matter (PM_{10}) reduction could be made. The project acknowledges that since PM_{10} are the most damaging to human health, the health damages are underestimated.[21]

The *China Hubei Hydropower Project* entails the construction of four small or medium HEP stations to replace 226 MW of energy being produced from coal fired units and gas turbines units. This would result in an average annual reduction of 4,400 tons of SO_2, 1,000 tons of TSP, 2,200 tons of nitrogen oxide (NO_x), and 704,900 tons of CO_2 emissions. These emissions reductions are estimated to generate US$21.9 million of local environmental benefits and $13.6 million of global environmental benefits, in NPV terms (but no details are given on how these estimates were made).[22] The presentation of the project's rate of return with and without the inclusion of environmental benefits is particularly helpful.

It could be argued that when the project benefits, the additional consumer surplus and resource savings incurred, are enough to justify the project costs, there is no need to estimate the environmental benefits for the analysis. However, different project alternatives under consideration may have different impacts on the amount of pollutants emitted. Nearly all projects reviewed provide evidence of carrying out a least cost analysis to justify the chosen project alternative, as it is standard practice in the energy sector to consider both investment and operating costs of alternatives to meet the same energy requirements. However, there is no evidence to suggest that this comparison takes into account the environmental impact of different alternatives. Examining the pollution emission impacts of alternative energy solutions should clearly receive more emphasis in the evaluation of energy projects. When appropriate, the choice between alternatives may necessitate the consideration of the associated health impacts due to different emission scenarios.

Box 6.
Valuing Environmental Costs in the Chad/Cameroon Oil Pipeline Project

The *Chad/Cameroon Petroleum Development and Oil Pipeline Project* supports the construction of drilling production wells and other infrastructure in Chad and an oil pipeline to transport the oil to the coast of Cameroon to be exported. The financing for the project includes US$92.9 in IBRD and US$400 million IFC loans. Adding the US$2.2 billion from private oil companies and other sources of financing, the total cost of the project stands at US$3.7 billion. The massive scale of activities supported by this project has certainly been one of the factors contributing to concerns regarding its potential negative environmental impact.

The project is expected to generate substantial benefits, in terms of oil revenues, for both countries. The development of the oil exploration capacity in Chad and the pipeline to transport it in Cameroon are expected to generate revenues worth US$463 million for Chad and US$144 million for Cameroon, in present value terms. By comparison, the present value of incremental environmental and social costs are estimated at less than US$10 million for both countries. The implementation of environmental management plans cost an additional US$15 million to each country. However, even with these environmental management plans, additional negative impacts could impose a cost to the countries of Chad and Cameroon. The costs identified and valued in the CBA of the project include: oil spill costs, agriculture production losses, livestock fodder losses, and forest and bush product losses. These costs amount to approximately US$13.5 million and some would be compensated under the agreements with the oil producing consortium (for example, the clean up costs in the event of an oil spill).

Indoor air pollution

Three of the projects reviewed focus on increasing access to electricity in rural areas: the *Vietnam Rural Energy Project*, the *Bangladesh Rural Electrification and Renewable Energy Development Project* and the *Sri Lanka Renewable Energy for Rural Economic Development Project*. All three projects partly support the development of some form of renewable energy source (hydropower and/or solar), in addition to providing access to electricity from the conventional main grid lines. It is expected that these energy sources will replace less efficient and more expensive sources, such as kerosene (for lighting), diesel, and batteries. The potential impact of this switch in energy sources on indoor air pollution is only briefly mentioned. The rate at which households will switch energy sources is a frequent source of uncertainty in such projects. Clearly the environmental benefits generated, if any, will depend on the extent to which households continue to use biomass fuel for cooking and heating. Only if electricity service becomes reliable and affordable enough could it be expected to replace the use of biomass and make significant contributions to reducing indoor air pollution. Therefore, it may be that the impact of these projects on reducing indoor air pollution is very difficult to predict.

6 Transportation

Most of the projects in this sector consist of construction, rehabilitation, and/or maintenance of roads, rails, and ports. When substantial construction is involved, the environmental screening process classifies such projects as requiring a full EA. Of the 16 transportation projects reviewed for this analysis, 13 require a full EA and only 3 are categorized as only requiring a partial EA. The total cost of the 16 transportation projects reviewed amounts to US$5.7 billion, or about US$354 million per project.

Despite the magnitude of the investments involved and the EA status of a majority of the projects, the EA of only 6 of the projects reviewed concludes that there are significant environmental impacts and raise specific concerns. Some of the environmental impacts listed are the possible negative impact of project measures on air pollution and on sensitive ecological areas. Construction related impacts are generally addressed by establishing environmental management plans, if they are temporary, localized, and amenable to mitigation through appropriate measures. The relevant costs incurred are part of the overall budgeted project costs (see Box 2), but may not necessarily be subjected to the CBA carried out by the project. The EA explicitly foresees positive environmental impacts, in the form of reduced air pollution, in only two of the projects.

Environmental Impacts of Transportation Projects

The major environmental impacts of transportation projects are related to land use changes and air pollution. The impact on land use changes will depend to a large extent on whether the project under consideration involves new construction or just rehabilitation and maintenance of existing infrastructure. If a project involves new construction, the potential environmental impacts would ideally be identified during the design phase of the project and some procedure to minimize adverse impacts chosen. Even so, some direct impacts of construction and the choice of site may occur. To the extent that land acquisition and compensation for resettlement takes place, some of these costs are reflected in the project costs incurred. In addition to the direct environmental impacts, new infrastructure, particularly roads, may also cause indirect environmental impacts by providing access to areas previously undeveloped. These indirect impacts may be even more damaging than the direct impacts of the project. Efforts to identify and mitigate such indirect impacts are therefore just as important. But as mitigation of environmental impacts is costly, the costs and benefits of such measures should be assessed as well (Belli and others, 2001).

For transportation projects where the infrastructure already exists, most direct and

indirect environmental impacts are likely to have already occurred. The major environmental impact of rehabilitation and maintenance of existing transportation infrastructure is therefore related to the impact of traffic volumes on air pollution, noise, and vibration. For road improvements, however, the impact of higher traffic volumes on air pollution is difficult to predict a priori. Road improvements may reduce congestion and so reduce emissions per vehicle, as less time is spent idling or at low speeds. However, these same improvements are likely to divert traffic from other modes of transportation and to generate additional traffic. Most models used to value the benefits of transportation investments were developed primarily to estimate vehicle operating costs savings and passenger time savings. However, most models can now provide some estimate of emission impacts based on predictions of vehicle miles traveled by different types of vehicle as a result of specific transportation investments. The information on the emissions impact of project measures can then be used with other data, such as air quality and respiratory illness data, to quantify the environmental impacts of the project. The *Senegal Urban Mobility Improvement Project*, discussed below, provides one example of how this can be done.

The importance of valuing the air pollution impacts of transportation projects is highlighted in a World Bank study of air pollution in six metropolitan developing country cities. In that study, motor vehicles are identified as the second largest source of pollution damages. In cities where the mix of fuel use is predominantly petroleum based, vehicles account for about half of the total environmental costs estimated. Health impacts account for the largest share of these damages across all cities (Lvovsky and others, 2000).

Valuing the Environmental Impacts of Transportation Project

The main benefits valued in transportation projects are resource savings—generally reduced operating costs and passenger time savings, using for the economic analysis standard traffic management models such as the World Bank's Highway Design and Maintenance standards model (HDM III), or similar models.[23] In a few cases, the benefits of increased safety and reduced emissions are also valued. The three projects which value reduced emission benefits are the *Senegal Urban Mobility Improvement Project*, the *Mumbai Urban Transport Project*, and the *São Paulo Metroline 4 Project*.

Air quality impacts

The *Senegal Urban Mobility Improvement Project* is the only project that explains how the benefits of reduced air pollution are estimated. It is also the only project that values air quality benefits of road rehabilitation investments. To estimate the associated health benefits from reduced air pollution, data on Dakar's emissions and air quality are used in conjunction with data on the incidence of respiratory illnesses. Emissions estimates from a transportation model used to evaluate the impact of the project's impacts establish that the public transport sector contributes up to a third of the air pollution in the city. The Dakar area averaged 25,150 yearly respiratory related illnesses. Health benefit calculations are usually based on dose-response functions, which provide estimates of how changes in pollution levels change the risk of specific respiratory diseases. As precise data on the average level of

pollution in Dakar are not available, the benefit calculations are based on the assumption that project measures will lead to a five percent reduction in the prevalence of respiratory illnesses due to transport. Presumably, the average cost of treatment for the reduced number of respiratory illnesses is used to arrive at a NPV of about US$6,240 for the health benefits generated by the road and rehabilitation component of the project. Compared to the other benefits generate, the air quality benefits are small and amount to only one percent of the total benefits estimate for this component of the project.

Both the *Mumbai Urban Transport Project* and the *São Paulo Metroline 4 Project* estimate the benefits of reduced air pollution associated with project investments in railway transportation. The Mumbai project also has a road rehabilitation component, for which estimates of reduced vehicle emission are obtained. However, the benefits of reduced emissions from the road component are not quantified and therefore not included into the CBA of the project. Neither project provides any information regarding how the reduced emission benefits are estimated.[24] For the Mumbai Project, the benefits of reduced air pollution are the second largest source of benefits, amounting to 17 percent of the total benefits from the rail component. The significance of these benefits to the project's overall benefits certainly warrant more information on how they are calculated. In the São Paulo project, the benefits of reduced air pollution are a result of a reduction in total kilometers of bus travel and are considered "minor" benefits. We can only conclude from the available information that those benefits amount to less than 10 percent of the project's total benefits.[25]

Land use impacts

In three of the projects reviewed, the *Goias State Highway Management Project*, the *Grand Trunk Road Improvement Project*, and the *Gujarat State Highway Project*, concerns regarding the direct and indirect environmental costs of project measures are raised in the EA report. Project measures to mitigate these impacts are required for compliance with operational safeguard policies instituted by the Bank. However, even with mitigation measures in place, some adverse impacts may still occur as a result of the project. An attempt to measure the magnitude of the potential environmental damages in question would be informative to assess the appropriate level of measures to mitigate these impacts.

For example, in the Goias project, the EA finds that paving one particular road could facilitate access to an area of rare natural beauty, thus increasing the risks of degradation in the area. To mitigate these impacts, the project establishes a protected area to limit access to the area and, with appropriate installations, protect its natural stone bridges, waterfalls, and interesting geological formations. A CV study to estimate the level of visitors to the area and how much they would be willing to pay to visit the protected areas could help determine how much should be spent in protecting this area. The concerns raised in the other two projects mentioned relate to the proximity of the project roads to existing protected areas. Some of the mitigation measures adopted in these projects include a 10 meter thick band of roadside plantation on either side of the highway (to act as a buffer for noise and air pollution generated), physical barriers to prevent the dumping of wastes alongside the highway, and the establishment of a contingent fund for

further impact studies or further mitigation measures.

It is important to incorporate these indirect environmental impacts in the evaluation of transportation projects. Indeed, an earlier assessment of the impacts of road maintenance on the environment concludes that the "environment is seldom taken into account in the design and implementation of road maintenance" (Lantran, 1994). The assessment argues that the marginal costs of maintenance works that generate significant environmental benefits are often low. Economic analysis can help determine when that is indeed the case and therefore such work should become a part of a project.

7 Agriculture, Fishing, and Forestry

A wide variety of issues are addressed by projects in this sector, such as irrigation and drainage, crop and livestock production, land titling, research and extension, and forest and other natural resources management. The primary objective of most projects in this sector is to increase agricultural production. The value of the additional agricultural output is generally the only benefit valued and often used as a proxy for the overall benefits generated by project measures. The increase in agriculture production may be a result of direct measures, such as rehabilitating or expanding irrigation infrastructure, or indirect conservation measures that may increase productivity or avoid future losses.

Most of the project measures in this sector are likely to produce significant external impacts. The financing of irrigation infrastructure, for example, may lead to increased use of fertilizers and pesticides, thereby polluting water resources for downstream users. If drainage systems are not properly designed or maintained, increased use of irrigated water may lead to salinization and waterlogging. On the other hand, increased productivity can lead to less pressure to convert other land to agricultural cultivation (Shively and Pagiola, forthcoming). Reforestation and other conservation activities may generate downstream benefits, such as reduced siltation and regular water flows, as well as global benefits in the form of carbon sequestration and biodiversity conservation. In irrigation projects, most of the benefits generated accrue to the landowner, while most of the resulting environmental impacts are externalities. In contrast, in forestry and NRM projects, most of the costs are incurred by the landowner, while the benefits generated are externalities.

Sixteen of the agriculture projects reviewed involve irrigation and drainage infrastructure investment. The total cost of these projects amounts to US$1.6 billion. About half of the other 16 projects concern forestry issues, while the rest are relate to general land management issues, such as agriculture research and extension, community or productive partnerships, and land access/titling. These projects amount to US$1 billion.

Irrigation and Drainage

Irrigated agriculture accounts for 60 to 80 percent of total water use (Tiwari and Dinar, 2002). The amount of irrigated land worldwide has tripled over the last five decades, amounting to more than 275 million hectares in 2000. The development of irrigation has contributed to a substantial increase in food production. It has also generated a polarized debate concerning the social and environmental impacts of irrigation developments. As one study concludes, the "inadequate information

on estimates of the full range of costs and benefits and the overall impacts of irrigation has been a major constraint in resolving this controversy"(Hussain and Bhattarai, 2002). The irrigation projects reviewed involve the rehabilitation of existing irrigation and drainage systems rather than the construction of new irrigation infrastructure. Therefore, most of the environmental impacts of the infrastructure itself, such as conversion of land into agriculture and disturbance of natural habitats, have already occurred. The focus here is on water use decisions and the environmental impacts of water used for irrigation.

Water is difficult to value. Water use generates both commodity and environmental values, and these values tend to be site-specific. Market prices for water as a commodity, for private consumption or as an intermediary good, are often non-existent or subject to pricing distortions. Water's environmental values and external impacts are rarely priced (Young, 1996). Estimating these values is becoming increasingly important as demand for water increases. Increasing demand for water has also generated significant debate on the appropriate pricing of water to encourage its efficient allocation (Tiwari and Dinar, 2002).

The concept of water's 'full economic costs' is useful in the discussion of efficient water allocation. These costs include the use, opportunity, and environmental costs of allocating water for a particular purpose.[26] Water should be priced so as to reflect its full economic costs. In the case of irrigation, the use costs are the costs associated with the construction, maintenance, and operation of any infrastructure for storing, treating, and distributing the water (Briscoe, 1996). The recovery of use costs have become a central focus of the design of most pricing schemes for irrigation projects.[27] In general, these are the only costs included in the CBA of irrigation projects.

There is no doubt that estimating the opportunity and the environmental costs of water is a difficult task. However, ignoring these costs is "a matter of huge practical significance when it comes to irrigation" (Briscoe, 1996:17). The opportunity cost of water used for irrigation is generally high because the sector uses large volumes of water. In contrast, water for domestic consumption is a high-value, low-volume use. The opportunity costs of water in supporting natural ecosystem's functioning will depend on the specific set of circumstances, but can be potentially large—as in the case of the decline of the Aral Sea, for example. The exclusion of the opportunity and environmental costs of water in the CBA of irrigation and drainage projects could lead to a significant overestimation of the benefits of such projects where water scarcity is an issue.

Irrigation and drainage investments may affect soil and water quality, both positively and negatively. Some of these impacts, such as salinization and waterlogging, can have a direct impact on agricultural productivity. Other impacts may affect other water users, for example, when groundwater levels and the inflow of water to surface water bodies decrease, and water quality deteriorates due to increased use of agrochemicals. In many cases, projects in this sector are addressing environmental problems caused by the existing irrigation systems, such as salinization or waterlogging, due to improper design or lack of maintenance of drainage infrastructure. If implemented judiciously, these projects are generally expected to have a positive impact on

the environment. That is not to say that there are no environmental risks associated with these projects. Quite often the EA conclusion is that the environmental benefits expected outweigh any negative impacts that may result from the project.

Most projects value irrigation benefits based on the estimated net value of agricultural output with and without irrigation water. The availability of irrigation water may allow increased use of fertilizer and improved seed varieties, leading to higher yields on a given parcel of land; cultivation of additional land; and a switch to higher value crops. The difference in revenues between the two scenarios, after all input costs other than water are taken into account, is the value of irrigation water. Most models employ a crop budget approach, although more advanced mathematical programming techniques are sometimes used. The crop budget approach, sometimes also called the "residual imputation" approach (Southgate, 2000), is used in nearly all projects reviewed.

The residual imputation approach provides an estimate of the benefits of irrigation to society as long as the full economic costs of water are taken into account. In practice, however, most projects only consider the direct costs (investment and operation and maintenance) of providing the water (that is, the user costs). The potential impact of a project on the availability of water for other uses is sometimes discussed, but not quantified and incorporated into the analysis.[28] One exception is the *Azerbaijan Rehabilitation and Completion of Irrigation and Drainage Infrastructure Project*, which values the water supplied by the project to the city of Baku. The project's rehabilitation of the irrigation canals will ensure that water continues to be delivered to the city's main reservoir, which serves 40 percent of the population. Without the benefits of the water supply, the rate of return for the specific project component falls by 6 percentage points to 17.3 percent. In some instances, however, the impacts of irrigation projects would be to reduce the amount of water available for other uses. Several projects, for example, raise concerns about the possible negative impact of irrigation on groundwater level. Since such impacts are generally difficult to quantify, projects generally just require that these impacts be monitored during implementation.

Project measures that enhance the efficiency with which water is delivered to an irrigation distribution system and distributed in the field reduce the amount of water that is not used productively, thus increasing the supply of water available for irrigation without reducing the supply of water for other purposes. This is the primary objective of several of the irrigation projects reviewed. For example, the *Yemen Irrigation Improvement Project* estimates that the amount of water saved due to project measures would allow the area irrigated to increase by 10 to 35 percent. The project analysis argues the net value of the additional agricultural output produced in those areas reflects the value of the saved water. If this is the highest value use of the water, then it is correct to say that the opportunity cost of the water used has been taken into account. In the *China Water Conservation Project* the value of the water saved is estimated from the avoided costs to obtain the same amount of water from an alternative source. However, because of the uncertainty in the prediction of the amount of annual water savings due to project measures, these benefits are not included in the CBA of the project.

The impact of pricing mechanisms in increasing the efficiency with which irrigation water is used is discussed in only one project, the *Tajikistan Rural Infrastructure Rehabilitation Project.* The project incorporates into the analysis the impact of fees and management practices in reducing the per hectare water requirements of different crops.[29] Whether the gradual increase in irrigation fees generates the expected reduction in water consumption will of course depend on reforms being fully implemented and on collection of these fees taking place.[30] While a few other projects also incorporate gradual increases in irrigation water charges, it is not clear whether these are volumetric based charges which would lead to anticipate reductions in water use. The establishment or increase of fees to cover the operation and maintenance costs of irrigation and drainage infrastructure are important to ensure the financial sustainability of a project's investments. The potential of pricing mechanisms in mitigating some of the negative environmental impacts due to water overuse is also important to consider in the analysis of irrigation and drainage investments. Box 7 discusses the importance of fees in the amount of water used and as a source of revenue to maintain irrigation systems.

A reduction in water use can have significant environmental implications—particularly in areas that are prone to salinization and waterlogging due to poorly drained soils. Maintenance of appropriate drainage infrastructure is also an important element to mitigate the problems associated with salinization and waterlogging caused or exacerbated by excessive irrigation. Since both of these problems directly affect crop yields, project benefits are estimated by the difference in the value of the agricultural output produced with and without drainage improvements. The *Egypt National Drainage Project*, for example, assumes that the benefits of subsurface drainage improvements would immediately reduce waterlogging (and therefore increase crop yield within 2 or 3 months), while the effects of the reduction of salinity would begin to take effect on crop yields two years after the installation of subsurface drainage. The estimated increase in crop yields varies from 5

Box 7.
Irrigation in Central Asia

Substantial investments in irrigation during the Soviet era have led to a massive dependence on irrigated agriculture in the Central Asian republics in the Aral Sea Basin. Agriculture, almost all of which is irrigated, provides 20–40 percent of GDP and employs some 28 million people. None of these irrigation systems charged more than nominal water fees, resulting in extremely high levels of water use, with water applications per hectare 50 percent higher than comparable countries such as Pakistan. The environmental consequences of this system have been well documented. They include, most spectacularly, the drying up of the Aral Sea, but also substantial salinization problems that affect downstream agriculture and the health of riparian populations. Over the last decade, lack of funding has resulted in plummeting investment in irrigation and drainage systems, and near-collapse of maintenance. As a result, as much as 70 percent of water abstracted for irrigation is wasted before it reaches the fields, and many drainage systems are almost inoperable. Unreliable or scarce water supply have reduced the area irrigated substantially, usually affecting poorer households disproportionately.

Source: Pagiola and others 2002.

to 20 percent, depending on the type of crop and the location where it is planted. Most projects, however, are not explicit on the specific causes of the expected increases in crop yields. The impact of better drainage in reducing salinization and waterlogging, as well as other factors influencing crop yields, such as the total area irrigated, cropping intensity, and types of crops grown, are jointly evaluated.

Forestry

The loss of forest cover over the last few decades has been a cause of concern (FAO, 2001). Forests provide many valuable environmental services at the watershed level (reduced sedimentation, stream flow regulation), at the national level (ecotourism, scenic values), and at the global level (carbon sequestration, biodiversity conservation). Valuing these benefits is difficult because most of these services have not been traded in a market and because of the limited understanding of the biophysical relationships involved (Chomitz and others, 1998; Bishop, 1999). Forests and other natural ecosystems also provide benefits by supporting the growing nature-based tourism industry. These benefits can be valued using the travel cost or CV methods—but again the benefits generated are very site specific. Forests also provide many global benefits, as discussed in chapter 9.

Some of the environmental benefits of natural resources management and watershed protection measures are site specific and depend not just on physical characteristics, such as rainfall pattern and soil types, but also on the number of downstream users affected and how they are affected. Several studies have tried to estimate these values and emphasize that the values derived are highly dependent on the specific conditions of the site under question (Chomitz and Kumari, 1998; Pattanayak and Kramer, 2001).

Generating these environmental benefits are among the objectives of most of the forestry and NRM projects reviewed. Measures supported by projects to achieve these goals vary and include, for example, providing secure land access to poor farmers, developing/demonstrating sustainable farming activities, restricting activities in protective buffer zones, and improving environmental regulations and management practices to reduce forest fires. Still, it is possible that some of the activities pursued by the projects will create environmental risks. The EAs of about half of the projects reviewed acknowledge and list such risks.

Natural Resources Conservation

Like the irrigation projects discussed above, most forestry and NRM projects use farm models to value the benefits of project measures by the changes in income with and without the project. Several factors contribute to the predicted changes in productivity. The analysis does not usually separate these effects. For example, in the *Karnataka Watershed Development Project*, the impact of conservation activities are expected to increase moisture retention in soils, reduce soil erosion and the loss of nutrients, and increase groundwater tables. Along with measures to encourage improved cropping systems, including appropriate tillage, the use of improved seed varieties, and balanced use of fertilizers and pesticides, yields are expected to increase by 10 percent for rainfed crops and 15 percent for irrigated crops. Thus the effect of improved NRM is embedded in the estimated impact of a broader package of interventions.

Two of the 16 projects reviewed, however, do value the environmental benefits associated with reduced soil erosion and increased water flow due to project activities directly. These are the *Armenia Natural Resource Management and Poverty Reduction Project* and the *Papua New Guinea Forestry and Conservation Project*.[31] Valuing these benefits involves some judgment as far as what values to use because impacts are site specific and depend on the types of downstream uses affected. In the *Armenia NRM Project* the watersheds where project activities take place play an important role in providing water for agricultural production and HEP generation in downstream areas. The project uses a value of US$10 per hectare for the watershed benefits of newly established forests and US$5 per hectare for the benefits of new tree plantations and the rehabilitation and improved management of pasture land. These values are based on a review of the literature that showed hydrological and ecosystem services provided by forests ranging in value from US$7 to $20 per hectare.[32] This is an example of the use of Benefits Transfer. The estimated environmental benefits, including carbon sequestration benefits, amounts to US$0.9 million, or about 10 percent of total project benefits.

The Papua New Guinea project, on the other hand, involves moving from large scale logging to sustainable forest management by small landowners. The value of improved soil and water management under sustainable forest management is assumed to be US$2 per hectare of forest area logged for a period of 8 years. After the 8 years, the benefits are assumed to fall to zero. There is no discussion on the basis for the assumptions used. It is not possible to judge how significant the environmental benefits are relative to other benefits generated by the project.

8 Water, Sanitation, and Flood Protection

The analysis of the environmental impacts of projects in the water, sanitation, and flood protection sector differs somewhat from that in most other sectors, where environmental costs and benefits are often externalities caused by project activities. The expected benefits of most projects in this sector are often direct improvements in environmental quality—improvements in water quality, or reduced pollution from wastewater discharge, for example. Although valuing these benefits can be complicated, it is essential to justify project investments as they are the primary objective of these projects.

Of the 35 projects reviewed, 30 carry out a CBA and 5 a cost-effectiveness analysis. Twenty three projects have both a water supply and a sanitation component, 6 have only a sanitation or sewerage component, and 6 deal primarily with flood protection and waste disposal and management. The total cost of these projects amounts to US$4.8 billion, with about 95 percent of that amount going to projects in the urban sector. More than in any other sector, a variety of valuation techniques are employed to value environmental impacts.

Water Supply and Sanitation

The valuation of water for domestic consumption tends to focus on the benefits of increasing the availability, reliability, and quality of drinking water, even though the irrigation and industrial sectors can also benefit. Increasing water scarcity has also highlighted the importance of water's environmental values—its role in maintaining ecosystem functions and providing recreational benefits. The impact of water supply projects on water availability are generally not very significant, particularly when compared to irrigation projects. Water supply investments are often accompanied by sanitation and/or sewerage treatment investments, and the impacts of such projects on water quality can be very significant. While the disposal of household waste is only one of the sources of pollution affecting water quality, sanitation and sewage treatment projects are often a key component to achieve reductions in the pollution levels affecting surface water bodies and groundwater sources.

The relative merits of different methodologies to value improvements in environmental quality have been the topic of considerable debate in the environmental economics literature. This debate has led to substantial development in the non-market based valuation techniques, such as CV, over the last twenty years (Griffin and others, 1995). Several of the water supply and sanitation projects carry out WTP studies, often as a part of the social assessment to evaluate the distributional impact of proposed tariff changes or to assess the project's financial feasibility. In some cases, the WTP estimates are used to value the benefits of

improved water quality. The reliability of WTP estimates depends on the survey accurately describing the exact nature of the service to be provided. WTP values also depend on the specific context, such as the availability of alternatives and relative ranking of priorities.

For example, a CV study for the Philippines finds that households in Davao have a low WTP for wastewater treatment to improve the water quality of rivers and sea. The improvements in water quality are aimed primarily at making a popular beach near the community safe for swimming and other recreational activities. The low WTP values may in part reflect the fact that households take private measures to avoid suffering damages from polluted water and the population's greater concern for other environmental problems, such as solid waste disposal (Choe and others, 1996). The value of improved water quality at the popular local beach in the Philippines study is also estimated using the TCM. Both methods produced similar results, which is reassuring. However, that need not always be the case. A study of the environmental costs of water pollution in Chongqing, China, for example, finds that the methodology employed in valuation can sometimes produce very different results. Using the human capital approach (which calculates the discounted value of production lost when a person dies prematurely) to estimate the cost of premature deaths, health damages are estimated to account for 18 percent of the total damage costs from water pollution. Damages to agriculture and fisheries account for a majority of the costs. However, when the implied WTP to reduce the risk of death from wage differential studies is used, health damages become 76 percent of the total damages, and agricultural damages fall to 18 percent of total damages (Yongguan and others, 2001). While projects should always provide clear information on what methodologies underlie their calculation of benefits, this is particularly important in cases where alternative methodologies can produce dramatically different results. This can often happen with the valuation of health benefits.

The choice of valuation methodology applied often depends on the specific context of projects. Of the 23 water supply and sanitation projects, 7 are in rural areas. The projects in rural areas value the benefits of water supply using the avoided costs of obtaining water from alternative sources. The time savings from collecting water are often the main source of the quantified benefits. The benefits of additional consumption are also calculated, but are generally of secondary importance. The benefits of increased water quality, often one of the main motivations for most rural water supply and sanitation projects, are rarely assessed. Only one of the 7 rural projects reviewed, the *Karnataka Rural Water Supply and Sanitation Project*, values the benefits of improved water quality by estimating the reduced health costs incurred.[33] How these benefits are estimated is explained in more detail in Box 8.

In urban settings, the valuation of water supply and sanitation benefits tends to focus primarily on estimating the incremental revenues generated by the project. The calculation of incremental revenues is mostly based on the estimated expansion of water supply and sanitation coverage with and without the project.[34] Improvements in water quality are likely not captured if the analysis focuses solely on incremental revenues,[35] particularly when current water and sanitation tariffs are used to calculate incremental revenues. The *Colombia Water Sector Reform Assistance Project*, however, uses data from a household survey conducted by the government's statistics department to

Box 8.
Valuing the Health Benefits of Rural Water Supply and Sanitation

The *Karnataka Rural Water Supply and Sanitation Project* describes the typical benefits expected for rural water supply and sanitation projects: the time savings in collecting water, the increased availability and convenience of water to be supplied, and the health benefits from access to cleaner water. Most rural water supply projects only value the time savings and increases in availability of water. This project stands out not just because it values the associated health benefits of cleaner water, but because it presents very clearly how each type of benefit was calculated.

The health benefits estimates are based on information collected from a survey of 970 households. The survey data is used to determine the time and treatment costs incurred due to diarrhea and gastroenteritis and the proportion of the population affected by these illnesses. The incidence of those diseases from the survey data is compared with information from other sources, such as health surveys, for validation. The information collected is then used to calculate of the morbidity and mortality costs incurred. The calculations of morbidity costs are based on an incidence rate of 68 per 1000 population for both diseases, treatment costs between Rs 50 (US$1.1) and Rs 350 (US$7.6) per episode, direct person days lost of between two and seven days, and indirect person day losses between one and three days. The lower end of the estimated monetary and time costs are for diarrhea, while the higher end of these estimated costs are for gastroenteritis. Based on experience from a previous project, it is assumed the project would lead to a 25 percent reduction in the incidence of diarrhea and a 40 percent reduction of gastroenteritis. The valuation of mortality risk reduction is based on information from a Health and Family Welfare study conducted by the Government of Karnataka during 1996-1998, which estimated a 1.6 ratio of number of deaths to the number of cases of gastroenteritis. The value of a statistical life (VSL) approach is used to value the reduction of mortality risks for different sex-age groups.

The health benefits generated from improved water quality are likely known to users and their WTP for water from improved sources may capture at least some portion of these benefits. However, since the Karnataka project values the incremental water consumed at the cost of provision, rather than household's WTP, it is unlikely that adding the avoided health costs could lead to double counting. The health benefits are also generated in part by the sanitation component of the project, which will expand access to individual household latrines to 25 percent of the population. The estimated health benefits are therefore attributed to both the water supply and sanitation components of the project.

estimate a demand function for water supply. The estimated demand curve is then used to predict household consumption with the proposed tariffs. Although the project is expected to improve water quality, the analysis assumes water quality would remain unchanged.

Because water supply and sanitation services are often bundled, particularly in urban areas, separately estimating the benefits of each component may not always be possible. Evaluating the project as a whole, as in case of the Colombia project, may be the only alternative. However, in instances where these are distinct components, the analysis should try to assess the economic feasibility of each component separately.[36] Valuing the benefits of water supply generally does not present a problem. However, the benefits of sanitation, particularly sewage treatment, are often regarded as being "too difficult" to value. The projects discussed below provide some examples of how these environmental benefits have been valued.

The *Uruguay Modernization and Systems Rehabilitation Project* provides perhaps the clearest example of how important a full economic analysis can be. A 'short-cut'

economic analysis, which amounted to simply adjusting financial prices to reflect taxes and subsidies, was carried out, and led to the conclusion that the benefits of the sewage treatment plants were not justified. The full economic analysis, however, establishes that the sewage treatment facilities generate significant social benefits by reducing the level of pollution affecting water quality in the rivers and nearby beaches.

To value improvements in water quality, the Uruguay project conducts a detailed analysis of water and sewage tariffs and a household survey. The tariff analysis establishes that the current water tariffs being charged are appropriate to cover the costs of supplying water to households, but that the sewage tariffs cover the cost of sewage collection but not of treatment. To assess the benefits of sewage collection and treatment, a sample of 900 households are surveyed about their WTP for these services. Households without sewage collection services are asked, through a referendum method, about their WTP for sewage collection. Households with sewage collection services are asked about their WTP for sewage treatment. Econometric analysis of the survey results is used to derive the demand for sewage collection and treatment. In each case, the mean WTP for these services is between 50 to 160 percent more than the average tariffs charged. The WTP values obtained for sewage collection are between 3.5 to 4.5 percent of household income, and considered "quite acceptable" costs for these services. The WTP values for sewage treatment are lower, between 1.0 and 1.8 percent of income, as might be expected since some of the benefits generated from sewage treatment are externalities. The value of these environmental benefits are likely still underestimated, as they will also benefit other people, such as those not connected to the sewage system or living downstream of the rivers. However, the valuation of some of the environmental benefits generated is enough to justify the inclusion of the sewage treatment component in the project.

The *Cartagena Water Supply, Sewerage, and Environmental Management Project* also conducts a similarly detailed WTP survey for sewage collection and treatment. Approximately 500 households are surveyed about their WTP for sewage collection and another 500 households are surveyed about their WTP for sewage treatment. The results of the survey are very similar to the Uruguay project, with most households willing to pay about 5 percent of their income for sewage collection and 1 percent for sewage treatment. The environmental impacts of the sewage treatment would contribute to the recovery of beaches and enhance tourism activities. A separate study is also conducted to evaluate the benefits of improved water quality, using the TCM. The results of this study are not available, however, the analysis provides additional support for the inclusion of the sewage treatment component in the project.

Several other projects reviewed also conduct WTP assessments, but depending on how the information is collected, it may or may not be useful for the economic analysis. The *Vietnam Environmental Sanitation Project*, for example, surveys 1,000 households about their WTP for wastewater collection and treatment.[37] However, the WTP values derived from the survey are not used in valuing the project's benefits, as the information elicited in the survey is thought likely to only be capturing the private benefits of improving the water quality in the canal, and not the broader public benefits.[38] An alternative approach to valuing the project's benefits is conducted, based on the

Box 9.
Willing to Pay but Unwilling to Charge — Do WTP Studies Make a Difference?

The water and sanitation program in South Asia recently conducted an evaluation of WTP studies in India and the impact of such studies on the levels of tariffs charged. The study identified eight WTP studies conducted in the water supply and sanitation sector. Field visits to the locations where four of the studies took place followed to evaluate the impact of these studies on policy reforms.

Besides generating additional government revenues, the study identifies two reasons why policy makers may want to assess WTP for water and sanitation and increase those fees accordingly. First, knowledge of consumers' WTP can guide future investments to provide the services that consumers want. Second, it can assist the move towards financial sustainability and independence for the agencies providing these services.

Despite such incentives, the results of the evaluation show a mixed outcome regarding the impact of WTP surveys. In one instance where tariffs were increased, the increases cannot be attributed to the survey that took place, as the results of the survey were not presented to authorities setting water tariffs. Rather, the increase in water charges was a condition for the city to receive a loan from the housing and urban development government agency. In the other three cases, tariffs were not increased for political reasons. The study also identifies instances where policy reform has taken place in the absence of WTP studies to support tariff increases. By estimating the costs of alternative supply sources and health damages from existing water supply sources, a convincing case for policy reform can also be made.

Source: DFID 1999.

avoided cost of using septic tanks.[39] However, this approach also provides only a partial assessment of the benefits generated, since it only values the private savings from the avoided construction and maintenance of septic tanks. These benefits, as the project states, "are likely of only secondary importance in relation to improved public health benefits and general environmental improvements."

In order to separate private and public environmental benefits, a WTP study must be carefully structured to elicit the information of interest. In the *Uruguay Modernization and Systems Rehabilitation* and the *Cartagena Environmental Management* projects discussed above, the studies are careful to distinguish the valuation of the private benefits accruing to the households from sewage collection from the more public environmental benefit generated by the sewage treatment component. Knowing what benefits a WTP study elicits values for is also important to avoid double counting when different methodologies are used to value project benefits. For example, the WTP for water and sanitation services can in part reflect the expected reduced health costs that result from the provision of safer drinking water and proper sanitation. Therefore, estimating the benefits of project measures by WTP for water and sanitation services and the avoided health costs as a result of provision of these services could lead to double counting. The *Senegal Long Term Water Sector Project* may have run into this problem, although this is difficult to determine without specific information on the exact questions consumers were asked in the WTP survey.

Whereas in the above examples there was a choice between different methodologies to value the same benefits, oftentimes project measures generate multiple benefits or benefits to multiple users. In such cases, different methodologies may be used together to value these benefits. The *Second Beijing Environment*

Project, for example, uses CV to estimate the benefits of improved water quality for drinking purposes, and avoided costs to estimate the benefits of improved water quality for agricultural and industrial uses.[40] The benefits to agriculture are based on the expected increases in yield from using cleaner water. Yields are assumed to increase by 10 percent in the areas immediately downstream from the wastewater treatment facility.[41] The benefits of improved water quality for industry are based on the avoided cost of treating polluted water to acceptable levels for different types of industrial uses. The costs of water treatment are expected to increase without the project. [42]

The *Lebanon Water and Wastewater Project* also values the benefits of sanitation services in multiple ways. First, it estimates the benefits accruing to households that will connect to the centralized system. These consist of the avoided expenditures of maintaining on-site sanitation systems and the higher quality of services households will enjoy by being connected to the centralized system. Wastewater will be treated, thus improving the quality of water used for irrigation. The net value of the additional agricultural output produced with treated wastewater is the second source of benefits estimated in the analysis of the sanitation component.[43] A similar approach is also adopted in the *Tehran Sewerage Project*. While these projects do not value all the environmental benefits associated with project measures, the valuation of some the benefits generated is at least better than no valuation at all.

A variety of environmental valuation techniques can be applied to value the benefits of improved water quality. The discussion above highlighted some of the issues in choosing among alternative methodologies and integrating different methodologies when valuing multiple benefits. These issues are important, particularly when CV methods are applied. CV methods can potentially be very useful to value some of the perceived 'unquantifiable' environmental benefits generated by projects in this sector. Conducting the surveys and analyzing the data, however, can be quite costly and time consuming. Table 6 summarizes the findings of the projects that value these benefits and other results from the available literature. The *Uruguay Modernization Project* and the *Cartagena Environmental Management Project's* findings are very similar, which is not surprising given that both projects are estimating essentially the same type of benefits in a very similar context. These two projects' results are also in line with estimates of WTP from project analysis carried out by the Inter-American Development Bank (IDB) for similar sewage projects (Russell and others, 2001). However, country and project specific variation in the IDB project sample is so significant that the report warns against using these simple WTP averages for benefit transfers. The WTP values reported for various EAP countries in Table 6 further illustrate the potential pitfalls of simple WTP value transfer. The WTP values are much lower, even when adjusted for income. Comparison is also difficult because each project or study addresses different situations. Great care must therefore be taken when transferring WTP values from one study or project to another. However, as the number of CV studies carried out increases, useful benchmarks may begin to be established.

Flood Protection

The projects with flood protection components reviewed consist primarily of drainage improvements to prevent the loss of life and reduce the damages incurred in the event of a

Table 6. Willingness to pay for water and sanitation

Benefits valued	*Mean WTP per household (US$/month)*	*Mean WTP per household (% income)*
World Bank projects		
Uruguay Modernization Project		
• *Sewage collection*	15 to 22	3.7 to 4.5[a]
• *Sewage treatment*	5 to 7	1 to 1.8[a]
Cartagena Environmental Management Project		
• *Sewage collection*	8 to 12	4.8 to 5.7
• *Sewage treatment*	5.5	1
Vietnam Environmental Sanitation Project		
• *Sewage collection and treatment*	0.85	..[b]
• *Improved water quality and canal appearance*	0.76	..[b]
Other sources		
IDB's average for similar sewage projects (Russell and others 2001)	20.5	3.3[c]
EEPSEA Bangkok Study (Tapvong and Kruavan 1999)		
• *Improving water quality in the Chao Phraya River and its canals from 'boatable' to 'fishable'*	2.3	<1
• *Further improving water quality from 'fishable' to 'swimmable'*	2.7	<1
Beijing Study (Swanson and others, 1999)		
• *Maintain water quality at 3 major rivers*	1.8	1.3
Philippines Study (Choe and others 1996)		
• *Improved surface water quality aimed at making surface water bodies safe for swimming and other recreational uses*	1.4 to 2.3	<1

Notes: a. A similar project, the *Colombia Water Sector Reform Project*, uses household expenditure data to estimate that water and sanitation tariffs average 4 to 8% of household income.
b. Average income information for households surveyed is not reported, but from the available income data it appears the mean WTP for both benefits amounts to 1 to 2 % of income for the lower income half of the sample, and less than 0.5% for higher income half of the sample.
c. Sample standard deviation of $10.7 and 4.2 for the mean WTP values.

Sources: PADs of cited projects; other sources as cited.

flood. In addition to damages to physical structures and from the loss of livestock and agricultural output, all projects recognize that floods create significant environmental and health risk. These environmental and health risks are most severe when sewage networks receive both wastewater and storm water overflow. The still waters after a flood can also cause the spread of waterborne diseases by providing a breeding ground for snails and mosquitoes.

Three flood protection projects value the benefits of project measures by estimating the avoided costs incurred. Using loss-probability curves for the baseline and project scenario, the

expected annual flood losses are estimated from the difference in the probability and the severity of floods occurring under the two scenarios. Generally the avoided costs of damage to property or due to lost output are the main source of benefits. The avoided costs of flood mitigation measures are the second most important benefits. These include the avoided cost of private flood protection, as in the *Vietnam Ho Chi Minh Environmental Sanitation Project*, and of public health measures instituted in the event of a flood to control the spread of vector diseases, as in the *Yangtze Dike Strengthening Project*. Both projects cite surveys conducted to assess the damage of previous floods as the basis of the cost estimates adopted in the analysis.[44]

The *Belize Roads and Municipal Drainage Project*, on the other hand, values the benefits of drainage improvements by estimating the increased property values resulting from the project's investments. The discussion of the analysis notes that property values in well drained areas are 20 to 100 percent higher than in poorly drained areas. It determines that an 18 percent increase in property values would be sufficient to justify the project's investment in the drainage component. The break-even analysis assumes that property values would increase "modestly" in the initial years following project completion, until households realize the benefits of flood protection are taking place and they no longer need to invest in raising their plot level to avoid flooding.

Solid Waste Management

Solid waste disposal and management projects are also primarily concerned with environmental health hazards created by the lack of waste collection services in poor areas or the inappropriate handling of solid waste at landfill sites. Only one of the three solid waste projects reviewed, the *Liepaja Region Solid Waste Management Project* in Latvia, conducts a CBA and is therefore the focus of the discussion here.[45] Grants from international donors account for 55 percent of project investments. This includes US$2 million from the Prototype Carbon Fund (PCF) to extract methane gas from the existing landfill and use it in electricity generation. The alternatives examined by the project include several options for expanding the existing landfill or establishing a new landfill at another location. The existing landfill facility is located in an area with a number of endangered species and leachate from the site polluted a nearby lake. The CBA without consideration of environmental impacts identifies expansion of the existing facility to meet sanitary standards as the best alternative. Including the benefits of carbon sequestration, to be financed by the PCF grant, improves the rate of return of all alternatives. The inclusion of carbon benefits, therefore, is not sufficient to make the relocation options examined preferable to expanding the existing landfill site. When the grants from other donors are included in the analysis, the relocation of the landfill site becomes feasible. These grants can be thought as payments for the internalization of the environmental benefits relating to the reduction of pollution affecting regional surface water bodies. While the expansion of the existing landfill remains the option with highest rate of return, the feasibility of the relocation alternative and the recognition that there are some environmental impacts not included in the CBA are enough to justify the selection of relocating the landfill site. The incorporation of environmental values thus has a significant impact on the choice to establish a new landfill rather than to expand the capacity of the existing landfill.

9 Global Costs and Benefits

Global costs and benefits are a special case of environmental benefits, as they accrue to the global community rather than to the country undertaking the project. Because of this, OP 10.04 specifies that these benefits, although they should be "identified in the Bank's sector work or in the EA process" should only be "considered in the economic analysis when (a) payments related to the project are made under an international agreement, or (b) projects or project components are financed by the Global Environment Facility."

The most valued type of global environmental benefit are carbon sequestration benefits. Some projects value these benefits and include them in the CBA. Other projects may value such benefits but do not include them in the analysis, as per OP 10.04.

Two approaches are generally used to value carbon sequestration benefits. The first estimates the benefits of carbon sequestration by using the estimates of climate change damages in the environmental economics literature. While there are several uncertainties involved in trying to estimate climate change impacts and the resulting damages (see Watson and others, 1996), estimates in the literature have converged in the range of US$5 and $40 per ton of CO_2 equivalent (tCO_2e). This approach has been used primarily in forestry projects, such as the *Armenia NRM* and the *Tanzania Forest Conservation and Management* projects, by applying the estimates of climate change damages to the amount of carbon sequestered per hectare of forest land. These projects use values for damages in the range of US$5 to $20 per tCO_2e

A second approach takes the GEF or other donor's WTP as a lower bound measure of value for the environmental benefits generated.[46] Actual payments made under embryonic carbon emissions markets have tended to be at the low end of the range of damage estimates, however. The PCF, for example, pays US$3-4 tCO_2e equivalent (PCF, 2002). This approach, which would seem preferable in light of OP 10.04, is used in the *Poland Geothermal*, the *Liepaja Solid Waste Management,* and the *Papua Guinea Forestry Conservation* projects, for example.

In contrast to carbon sequestration benefits, the benefits of biodiversity conservation are seldom valued. This is despite the fact that some of the benefits of biodiversity conservation can potentially be captured by the host country, for example, in the form of higher revenues from nature based tourism or bioprospecting contractual arrangements. The tourism benefits can be estimated using the TCM or CV. The development of the tourism industry is indeed one of the main motivations for the *Mozambique Coastal and Marine Biodiversity Management Project*.[47] The project does not, however, estimate the potential benefits from tourism

development of the coast. Instead, it just notes that the potential development could equal the US$500 million a year generated by tourism revenues in Kenya. Whether this is a reasonable assumption upon which to base the assessment of the tourism benefits from the project could have been investigated.

Attempts to value the benefits of biodiversity for bioprospecting purposes have been the focus of a number of biodiversity valuation studies (Simpson and others, 1996; Ruitenbeek and Cartier, 1999; Rausser and Small, 2000). Costa Rica has been the leading developing country trying to capture the pharmaceutical potential of biodiversity conservation. However, even with adequate compensation for the collection of biotic samples and generation of taxonomic information bioprospecting revenues alone may not be sufficient for the conservation of these resources (Barbier and Aylward, 1996). The conservation of critically important biodiversity habitats will likely need other sources of funding. Two of the projects reviewed, the *Armenia NRM* and the *China Sustainable Forestry Development* projects, receive GEF support for forest conservation activities in biodiversity rich areas. Whatever the actual benefit to the global community, from the perspective of an individual country what matters is what it will be paid for the environmental benefits it provides.

10 Conclusion

Ten years ago, one project in 162 used environmental valuation. The use of environmental valuation has increased substantially, so that in recent years as many as one third of the projects in the environmental portfolio did so. Over the last 3 fiscal years, an average of 6 to 9 projects per year used environmental valuation. While this represents a substantial improvement, there remains considerable scope for growth.[48]

Many projects that did not use environmental valuation pleaded the difficulty of doing so. This review, however, included several examples of projects that valued the same environmental benefits that other projects in the same sector claimed were too difficult to value or "un-quantifiable." Given the substantial methodological progress that has been made in this field in the last decades, "un-quantifiable" can no longer be considered an acceptable excuse in most cases. Lack of data can be more difficult to overcome, but is also not insoluble in most cases.

Among those projects that value environmental impacts, only one values environmental costs and all the others focus solely on valuing benefits. This asymmetry can be partly explained by the fact that most projects seek to avoid or mitigate potential negative impacts through project design or the implementation of environmental management plans, although it strains credibility that there would be no remaining damages.

The degree to which environmental benefits are valued differs from sector to sector. In the energy and transportation sectors, the valuation of changes in air quality benefits from a large body of literature that has developed and applied the existing valuation techniques. Quantifying the impacts of project measures on outdoor air pollution does not appear to be a significant obstacle, at least not in the energy sector. However, not all projects which quantify emissions reductions take it to the next stage and value these environmental benefits. In the agriculture and water supply and sanitation sectors, on the other hand, quantifying the physical impacts of project measures are generally the major obstacle to valuation of environmental impacts.

To ease the task of project teams, a series of toolkits is being assembled for some of the more commonly-occurring valuation problems. These toolkits will describe the available valuation methodologies from a problem-centric perspective and provide detailed examples of how to use these methodologies in a project context.

Appendix — Projects Reviewed

Project ID	*Region*	*Country*	*Project Name*	*Total Cost (US$ millions)*
P051059	AFR	Cameroon	Chad/Cameroon Pipeline Project	70.00
P044305	AFR	Chad	Petroleum Development and Pipeline Project	85.00
P050623	AFR	Ghana	Road Sector Development Project	1191.00
P050616	AFR	Ghana	Community Water and Sanitation Project (02)	28.00
P052208	AFR	Madagascar	Transport Sector Reform and Rehabilitation Project	66.00
P041723	AFR	Mali	National Rural Infrastructure Project	139.27
P044711	AFR	Mauritania	Integrated Development Project for Irrigated Agriculture	46.03
P069095	AFR	Mauritania	Urban Development Project	99.06
P070305	AFR	Mozambique	Coastal and Marine Biodiversity Management Project	10.60
P072996	AFR	Niger	Private Irrigation Promotion Project	48.39
P045182	AFR	Rwanda	Rural Water and Sanitation Project	21.42
P055472	AFR	Senegal	Urban Mobility Improvement Project	103.00
P041528	AFR	Senegal	Long Term Water Sector Project	248.43
P058706	AFR	Tanzania	Forest Conservation and Management Project	32.80
P002797	AFR	Tanzania	Songo Songo Gas Development and Power Generation Project	296.00
P064064	AFR	Zambia	Mine Township Services Project	38.00
P056516	EAP	China	Water Conservation Project	185.67
P064729	EAP	China	Sustainable Forestry Development Project	214.58
P068049	EAP	China	Hubei Hydropower Development in Poor Areas Project	222.41
P056424	EAP	China	Tongbai Pumped Storage Project	904.10
P056199	EAP	China	Inland Waterways Project (03)	220.22
P056596	EAP	China	Shijiazhuang Urban Transport Project	286.20
P045915	EAP	China	Urumqi Urban Transport Improvement Project	270.00
P064730	EAP	China	Yangtze Dike Strengthening Project	545.51
P042109	EAP	China	Beijing Environment Project (02)	1255.00
P049436	EAP	China	Chongqing Urban Environment Project (CUEP)	535.90
P047345	EAP	China	Huai River Pollution Control Project	226.89
P051859	EAP	China	Liao River Basin Project	203.60
P045910	EAP	China	Hebei Urban Environmental Project	293.00
P040528	EAP	Indonesia	Western Java Environmental Management Project	20.13
P056200	EAP	Mongolia	Transport Development Project	49.54
P004398	EAP	Papua New Guinea	Forestry and Conservation Project	22.29

Project ID	*Region*	*Country*	*Project Name*	*Total Cost (US$ millions)*
P039019	EAP	Philippines	First National Roads Improvement and Management Project	305.42
P042568	EAP	Vietnam	Coastal Wetlands Protection and Development Project	65.60
P066396	EAP	Vietnam	System Efficiency Improvement, Equitization, and Renewables Project	347.90
P056452	EAP	Vietnam	Rural Energy Project	204.80
P052037	EAP	Vietnam	Ho Chi Minh City Environmental Sanitation Project (Nhieu Loc- Thi Nghe Basin)	199.96
P069479	ECA	Albania	Pilot Fishery Development Project	6.66
P074905	ECA	Albania	Power Sector Rehabilitation and Restructuring Project	35.06
P057847	ECA	Armenia	Natural Resources Management and Poverty Reduction Project	10.87
P008284	ECA	Azerbaijan	Rehabilitation and Completion of Irrigation and Drainage Infrastructure	46.86
P044748	ECA	Belarus	Social Infrastructure Retrofitting Project	40.43
P057950	ECA	Bosnia-Herzegovina	Solid Waste Management Project	21.00
P055068	ECA	Georgia	Irrigation and Drainage Community Development Project	32.80
P008497	ECA	Hungary	Municipal Wastewater Project	88.90
P046045	ECA	Kazakhstan	Syr Darya Control and Northern Aral Sea Phase 1	85.79
P058476	ECA	Latvia	Liepaja Region Solid Waste Management Project	16.97
P070112	ECA	Lithuania	Education Improvement Project	45.41
P063656	ECA	Lithuania	Vilnius District Heating Project	54.52
P038395	ECA	Macedonia	Water Supply and Sewerage Project	42.37
P037339	ECA	Poland	Podhale Geothermal District Heating and Environment Project	91.30
P065059	ECA	Poland	Krakow Energy Efficiency Project	78.04
P056337	ECA	Romania	Mine Closure and Social Mitigation Project	59.50
P053830	ECA	Russian Federation	Sustainable Forestry Pilot Project	74.50
P038551	ECA	Russian Federation	Municipal Heating Project	127.88
P008832	ECA	Russian Federation	Municipal Water and Wastewater Project	168.90
P058898	ECA	Tajikistan	Rural Infrastructure Rehabilitation Project	24.00
P055738	ECA	Ukraine	Sevastopol Heat Supply Improvement Project	35.70
P055739	ECA	Ukraine	Kiev Public Buildings Energy Efficient Project	30.20
P035786	ECA	Ukraine	Lviv Water and Wastewater Project	40.80
P040150	LCR	Belize	Roads and Municipal Drainage Project	18.40
P043869	LCR	Brazil	Natural Resources Management and Rural Poverty Reduction Project	107.50
P039200	LCR	Brazil	Energy Efficiency Project	125.50
P051696	LCR	Brazil	Sao Paulo Metro Line 4 Project	933.90
P055954	LCR	Brazil	Goias State Highway Management Project	130.00
P006449	LCR	Brazil	CEARA Integrated Water Resources Management Project	247.20
P041642	LCR	Colombia	Productive Partnerships Support Project	52.32

Project ID	Region	Country	Project Name	Total Cost (US$ millions)
P044140	LCR	Colombia	Cartagena Water Supply, Sewage and Environmental Management Project	85.00
P065937	LCR	Colombia	Water Sector Reform Assistance Project	70.00
P052009	LCR	Costa Rica	Ecomarkets Project	49.20
P039437	LCR	Ecuador	Poverty Reduction and Local Rural Development Project	41.96
P049924	LCR	Ecuador	Rural and Small Towns Water Supply and Sanitation Project	50.25
P073035	LCR	Honduras	Access to Land Pilot Project	17.00
P057530	LCR	Mexico	Rural Development in Marginal Areas Project (02)	73.00
P056018	LCR	Nicaragua	Land Administration Project	38.50
P050595	LCR	Panama	Land Administration Project - APL	72.36
P070244	LCR	St. Lucia	Technical Assistance Water Sector Reform Project	8.36
P063383	LCR	Uruguay	OSE Modernization and Systems Rehabilitation Program	48.09
P045499	MNA	Egypt	National Drainage Project (02)	278.40
P069946	MNA	Iran	Tehran Sewerage Project Loan	340.00
P074042	MNA	Lebanon	Ba'albeck Water and Wastewater Project	49.63
P056978	MNA	Morocco	Irrigation-Based Community Development Project	42.40
P035707	MNA	Tunisia	Water Sector Investment Loan Project	258.00
P062714	MNA	Yemen	Irrigation Improvement Project	25.60
P070092	MNA	Yemen	Taiz Municipal Development and Flood Protection Project	50.00
P005906	MNA	Yemen	Rural Water Supply and Sanitation Project	29.40
P071794	SAR	Bangladesh	Rural Electrification and Renewable Energy Development Project	290.10
P057570	SAR	Bhutan	Urban Development Project	12.23
P071033	SAR	India	Karnataka Community Based Tank Management Project	124.97
P040610	SAR	India	Rajasthan Water Sector Restructuring Project	180.20
P050647	SAR	India	Uttar Pradesh Water Sector Restructuring Project	173.70
P067216	SAR	India	Karnataka Watershed Development Project	127.60
P035172	SAR	India	Uttar Pradesh Water Sector Restructuring Project	236.00
P035173	SAR	India	Powergrid System Development Project (02)	1314.00
P038334	SAR	India	Rajasthan Power Sector Restructuring Project	266.80
P049770	SAR	India	Renewable Energy (02) Project	300.00
P010566	SAR	India	Gujarat State Highway Project	533.00
P071244	SAR	India	Grand Trunk Road Improvement	756.00
P050668	SAR	India	Mumbai Urban Transport Project	945.00
P050653	SAR	India	Karnataka Rural Water Supply and Sanitation Project (02)	193.44
P055454	SAR	India	Kerala Rural Water Supply and Environmental Sanitation Project	89.80
P071092	SAR	Pakistan	NWFP On-Farm Water Management Project	32.05
P076702	SAR	Sri Lanka	Renewable Energy for Rural Economic Development Project	125.70

Notes

1. SARs have been replaced by Project Appraisal Documents (PADs).
2. The review examined all projects approved during the 1993 calendar year and included 162 projects in a wide variety of sectors. Of those 162 projects, 112 were in sectors which traditionally require a cost benefit analysis, namely agriculture, energy, financial, power, telecommunications, transportation, urban, and water supply and sanitation.
3. The negative of this can also be important: by showing that an externality is much smaller than had been supposed, valuation might lead to the conclusion that a project is not warranted in a specific instance, and that efforts would be better applied elsewhere.
4. Under the new classification system, each project can have up to five sectoral assignments and five thematic objectives. The sectoral and thematic assignments represent different dimensions of the same operation. The sectoral classification is based on the sectors of the economy affected by the project, while the thematic classification relates to the stated objectives of the project.
5. The project list for 2002 was based on preliminary data at the end of FY2002.
6. Adjustment lending instruments and other non-project lending instruments are excluded from our review.
7. The project costs reported in Table 1 reflect the new sector code classification, which allocates the share of project costs to components in different sectors.
8. Category A projects are "likely to have significant adverse impacts that are sensitive, diverse, or unprecedented, or that affect an area broader than the sites or facilities subject to physical works." They require a full environmental assessment. Category B projects have impacts that are "site-specific in nature and do not significantly affect human populations or alter environmentally important areas, including wetlands, native forests, grasslands, and other major natural habitats. Few if any of the impacts are irreversible, and in most cases mitigation measures can be designed more readily than category A projects." They also require an environmental assessment, but of a more limited scope. Category C projects are those "likely have no adverse impacts at all, or the impacts would be negligible."
9. We did not examine the full environmental assessment report, but rather relied on the summary information presented in the PAD.
10. The impression that the identification of environmental benefits is considered to lie outside the mandate of the EA process is reinforced by several instances where environmental benefits were valued despite there being no mention of such benefits in the EA summary.
11. For example, while the *Mauritania Integrated Development Project for Irrigated Agriculture* is a category A project with both primary and secondary environmental objectives, the first phase of the projects has only a few rehabilitation components and consists primarily of feasibility studies for future investments. The project's classification reflects mostly its future rather than its current impacts.
12. Twenty-six percent of all projects reviewed value environmental impacts and include those values in the economic analysis. If projects with no or only minor environmental impacts are excluded, 32 percent of the projects value and include environmental impacts in the analysis.
13. It would be interesting if these costs could be made explicit, as several valuation techniques are based on such cost estimates.
14. "Lack of data" and "too difficult" are treated as mutually exclusive categories in Table 3—that

is, projects which list both reasons as obstacles for valuing environmental impacts are listed under one category only.

15. Nine of the 15 such projects are in ECA. Three others are in India, two in China and one in Vietnam.
16. For a brief review of these studies, particularly in the context of developing countries, see Hegde (2001).
17. None of the projects reviewed explicitly acknowledge situations where increased air pollution may result and therefore the environmental costs of energy production are not valued.
18. This is the case when all investments costs (including those already incurred) are evaluated. However, if the investments which already took place are treated as sunk costs, as they should, the heat cost savings are enough to justify the incremental investments. The full evaluation is carried out to establish the replicability of such investments.
19. The value of CO_2 emissions reductions is taken to be the GEF's willingness to pay for the alternative that produces additional emissions reduction than the base case scenario (see chapter 9).
20. This is taken from the information discussed in an associated GEF project, also called the *Krakow Energy Efficiency Project* The GEF project is technically a separate project, but its main objective is to finance risk guarantees that will enable the private sector to invest in the energy efficiency measures supported by the IBRD financed project—in other words, the GEF financing is essential to remove the market barriers preventing these financially sound investments.
21. In addition to the health benefits estimated, the Beijing project also estimates the value of land that has been used as ash yards for the coal boilers. About 2,000m2 of land are needed for a typical boiler house consisting of three or four medium size boilers. Given that these boilers are located in the center of urban districts, where land values are high, these land savings turn out to be a significant source of benefits generated by the project. Although these benefits are estimated on the basis of real estate values, they may well have an additional environmental component, in terms of reducing environmental disamenities to neighboring properties.
22. However, the alternative of hydropower generation also entails possible environmental costs. Indeed, the environmental assessment (six volumes) of the project is primarily devoted to the potential environmental impacts of the construction of the dams. The EA argues that since these rivers have existing dams, most of the environmental damage to the aquatic environment of the rivers in question has already taken place. The new dams constructed for the project will thus only have an small additional impact on the river's aquatic environment. They will also affect water flow during the dry season and to downstream irrigation infrastructure in some locations. Relatively little inundation of valuable land is expected, as the reservoirs will be long and narrow due to the geographical characteristics of the area. These environmental impacts have not been valued. Measures are included in the project's environmental management plan to mitigate these impacts.
23. A simpler model, the roads economic decision model (RED), has been devised to evaluate road investments in rural areas where low traffic volumes and uncertainty in the assessment of traffic and road conditions are likely to be common. RED also includes the additional benefits to local economic development and to non-motorized road users (Archondo-Callao, 1999). For more on those issues, see OED (1996) which examines the education and health benefits of road projects in rural areas in Morocco.
24. The Mumbai project classifies the environmental benefits into direct and indirect benefits from reduced air pollution, but provides no information on what these direct and indirect benefits might be. The indirect benefits account for 97 percent of the environmental benefits.
25. Vehicle operating cost savings and time savings amount to 92 percent of benefits, other minor benefits include the environmental benefits, safety benefits from reduced accidents, and operations and maintenance (O&M) savings due to reduce number of kilometers traveled by buses.
26. The environmental costs and opportunity costs are not necessarily mutually exclusive. The highest valued alternative for water used for irrigation may be the loss of its use to maintain ecosystem functions, in which case, the opportunity cost would be the environmental

costs or damages incurred. The environmental cost of water used for irrigation can also be those associated with the external impacts of water on soil quality, for example, salinization and waterlogging. Such environmental costs would be independent of the water's opportunity cost.

27. A comprehensive review of World Bank financed irrigation projects carried out by the OED concludes that irrigation charges in most developing countries do not cover operation and maintenance costs (Briscoe, 1996).
28. For example, the *Northern Aral Sea Project* does not quantify the benefits of a dam in providing water supply to downstream consumers and (strangely) of maintaining irrigated area—the only benefits valued from the dam construction are the power supply generated. Also the benefits of a flood protection dike, which according to the project would save an average of 800 million m^3 of water annually, are not valued.
29. The amount of water to be supplied is actually expected to decrease with the project. The water savings, however, are not quantified or valued.
30. The irrigation service fees would be reviewed and adjusted annually by the project, taking into account the willingness and ability of farmers to pay, and the collection rate in project areas monitored.
31. These projects and two other projects also value the environmental benefits of carbon emission reduction. However, since these are global environmental benefits we discuss their valuation separately, in Chapter 9.
32. One could potentially argue whether the lower value for the benefits from pasture lands is appropriate, particularly if the primary interest is to increase water flows rather than regulate the timing of flows. A study of a watershed in Lake Arenal, Costa Rica, suggests that if the total flow of water is of primary interest, pastures generate higher positive externalities than forest cover (Aylward and others, 1998).
33. A survey carried out for the *Ecuador Rural and Small Towns Water Supply and Sanitation Project* finds that expenditures related to water borne diseases are not significant. Therefore, health benefits are omitted from the analysis of that project. However, the survey does not assess direct and indirect income losses due to illnesses, and so may underestimate health impacts. Such costs may represent a significant share of the health costs from water pollution than direct treatment costs, as in the case of the *Karnataka Rural Water Supply and Sanitation Project*.
34. In some cases, incremental revenues are higher due to increased efficiency or reduced O&M costs, such as in the *Ukraine Water and Wastewater Project*. The project's benefits are almost entirely justified by reduced energy costs.
35. The *Lebanon Water and Wastewater Project*, discussed below, does factor in improvements in the quality of the services provided, by assuming the demand curve for sanitation shifts out to reflect the difference between an on-site sanitation system and being connection to the public system.
36. The *Russia Federation Municipal Water and Wastewater Project*, for example, has stand alone water supply and sanitation components in different cities. Even though the project says that 54 percent of rehabilitation investments have been identified, very few are subjected to an economic analysis. The project only values two water supply components (amounting to $3 million of the $169 million cost of the project). It discusses a water quality improvement and a wastewater treatment component, but the benefits of these components are not valued. Both are expected to produce significant health and environmental benefits.
37. The survey asks households to volunteer how much they would be willing to pay for certain improvements in water quality. Open ended questions are usually not the recommended to elicit WTP values.
38. While the WTP values from the household survey are not used to value the project's benefits, the information from the survey is useful in designing the project by establishing that biological treatment of sewage is not affordable to area residents. The project is designed therefore to discharge screened wastewater in the Saigon River instead of directly into the canal., which is prone to flooding.
39. The project finances the construction of a sewage interceptor which will make septic tanks no longer necessary.
40. The benefits of improved water quality to households amount to 55 percent of the total

benefits from the wastewater treatment component, those to agriculture amount to 38 percent, and those to industry 7 percent.

41. The information presented in the PAD suggests that a 10 percent increase may be an optimistic assumption. The PAD cites a study finding that agricultural production could increase by at least 5 percent if the water quality level in the Hai River basin was raised to the government mandated water quality level. The project estimates that the amount of water treated in the wastewater plant will contribute to only about 10 percent of the planned reduction in pollution levels in the whole Hai River basin.

42. Three other projects in China, the *Huai River Pollution Control Project*, the *Liao River Basin Project* and the *Chongqin Urban Environment Project*, are wastewater treatment projects similar to the Beijing project discussed above. These projects appear to have estimated some of the benefits generated by the project, but do not present their analysis, citing the uncertainties involved in these estimations as a reason. Instead these three projects opt for a cost effectiveness analysis.

43. The estimated IRR for the component based on these two benefits is low, but other—unquantified—benefits are thought likely to be sufficiently important to justify this component. These benefits include the conservation of scarce water resources, the reduced health risks from the use of untreated sewage water in agriculture, and overall environmental quality improvements that benefit households not connected to the sewage system. While efforts to value environmental benefits are important, data limitations or other problems may prevent a full assessment from being made. In such cases, it is important to exercise good judgment in assessing whether the remaining unquantified benefits are likely to result in a different conclusion, as was thought to be the case here.

44. The *Taiz Municipal Development and Flood Protection Project* in Yemen does not provide very many details of cost benefit analysis carried out. The project states that annually avoided damage per structure is approximately US$600. It does not mention other key factors or assumptions, such as the average flood/storm return period, the flood depth, or the conceptual model used, as the China and Vietnam project do.

45. The *Western Java Environmental Management Project* presents some results of the analysis of a previous project. *The Solid Waste Management Project* in Bosnia-Herzegovina says it carried out a cost-effectiveness analysis, but only presents a table of per capita investment costs (which ranged from $12 to $30) in the three cities where the project is to be implemented.

46. Formally, the GEF is not paying for the benefits, but reimbursing for the incremental cost of receiving them. From the perspective of the country implementing the project, however, it does not matter whether the GEF grant is considered to be a reimbursement for cost or a payment for benefits, as the effect on the project's NPV is the same.

47. The conservation of coastal resources will also benefit the local population. Approximately 43 percent of Mozambique's population live on the coast, and most of these 7 million people depend on the coast's natural resources for their livelihoods.

48. To some degree, the limited extent to which environmental valuation is used in the economic analysis of projects reflects the declining emphasis that is being placed on economic analysis in general in Bank project preparation. Whereas a decade ago the NPV and IRR were the be-all and end-all of project preparation, today it is not unusual for neither to be even mentioned in a PAD review meeting. It was not the objective of this review to assess the quality of the economic analysis as a whole, but it seemed to be very uneven.

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