Financial, Economic and Distributional Analysis

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Compiled by the World Commission on Dams (WCD) Secretariat
Including Contributions by:


Secretariat of the World Commission on Dams
P.O. Box 16002, Vlaeborg, Cape Town 8018, South Africa
Phone: 27 21 426 4000   Fax: 27 21 426 0036.
Website: http://www.dams.org   E-mail: info@dams.org
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The WCD Knowledge Base

This report is one component of the World Commission on Dams knowledge base from which the WCD drew to finalize its report “Dams and Development – A New Framework for Decision Making”. The knowledge base consists of seven case studies, two country studies, one briefing paper, seventeen thematic reviews of five sectors, a cross check survey of 125 dams, four regional consultations and nearly 1000 topic-related submissions. All the reports listed below, are available on CD-ROM or can be downloaded from www.dams.org.

Case Studies (Focal Dams)
- Grand Coulee Dam, Columbia River Basin, USA
- Tarbela Dam, Indus River Basin, Pakistan
- Aslantas Dam, Ceyhan River Basin, Turkey
- Kariba Dam, Zambezi River, Zambia/Zimbabwe
- Tucurui Dam, Tocantins River, Brazil
- Pak Mun Dam, Mun-Mekong River Basin, Thailand
- Glomma and Laagen Basin, Norway
- Pilot Study of the Gariep and Van der Kloof dams- Orange River South Africa

Country Studies
- India
- China

Briefing Paper
- Russia and NIS countries

Thematic Reviews
- TR I.1: Social Impact of Large Dams: Equity and Distributional Issues
- TR I.2: Dams, Indigenous People and Vulnerable Ethnic Minorities
- TR I.3: Displacement, Resettlement, Rehabilitation, Reparation and Development
- TR II.1: Dams, Ecosystem Functions and Environmental Restoration
- TR II.2: Dams and Global Change
- TR III.1: Economic, Financial and Distributional Analysis
- TR III.2: International Trends in Project Financing
- TR IV.1: Electricity Supply and Demand Management Options
- TR IV.2: Irrigation Options
- TR IV.3: Water Supply Options
- TR IV.4: Flood Control and Management Options
- TR IV.5: Operation, Monitoring and Decommissioning of Dams
- TR V.1: Planning Approaches
- TR V.2: Environmental and Social Assessment for Large Dams
- TR V.3: River Basins – Institutional Frameworks and Management Options
- TR V.4: Regulation, Compliance and Implementation
- TR V.5: Participation, Negotiation and Conflict Management: Large Dam Projects

Regional Consultations – Hanoi, Colombo, Sao Paulo and Cairo
Cross-check Survey of 125 dams
Financial and in-kind Contributors:

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- ABB
- ADB - Asian Development Bank
- AID - Assistance for India's Development
- Atlas Copco
- Australia - AusAID
- Berne Declaration
- British Dam Society
- Canada - CIDA
- Carnegie Foundation
- Coyne et Bellier
- C.S. Mott Foundation
- Denmark - Ministry of Foreign Affairs
- EDF - Electricité de France
- Engevix
- ENRON International
- Finland - Ministry of Foreign Affairs
- Germany - BMZ: Federal Ministry for Economic Co-operation
- Goldman Environmental Foundation
- GTZ - Deutsche Gesellschaft für Technische Zusammenarbeit
- Halcrow Water
- Harza Engineering
- Hydro Quebec
- Novib
- David and Lucille Packard Foundation
- Paul Rizzo and Associates
- People's Republic of China
- Rockefeller Brothers Foundation
- Skanska
- SNC Lavalin
- South Africa - Ministry of Water Affairs and Forestry
- Statkraft
- Sweden - Sida
- IADB - Inter-American Development Bank
- Ireland - Ministry of Foreign Affairs
- IUCN - The World Conservation Union
- Japan - Ministry of Foreign Affairs
- KfW - Kreditanstalt für Wiederaufbau
- Lahmeyer International
- Lotek Engineering
- Manitoba Hydro
- National Wildlife Federation, USA
- Norplan
- Norway - Ministry of Foreign Affairs
- Switzerland - SDC
- The Netherlands - Ministry of Foreign Affairs
- The World Bank
- Tractebel Engineering
- United Kingdom - DFID
- UNEP - United Nations Environment Programme
- United Nations Foundation
- USA Bureau of Reclamation
- Voith Siemens
- Worley International
- WWF International
Foreword

The World Commission on Dams has a mandate to develop a knowledge base that contributes to three outputs:

- a global review of the development effectiveness of dams;
- a framework for options assessment and decisions making processes for the development and management of water and energy services; and
- a set of criteria, guidelines, and standards where appropriate for the planning, appraisal, design, construction, operation, monitoring, and decommissioning of dams.

The original WCD Scoping Paper for the Thematic Review on Financial, Economic and Distributional Analysis stated that the review was intended to “provide a knowledge base that will assist the WCD in formulating relevant criteria, guidelines and standards in this area. The tools, methods and best practices will contribute directly to the framework for options assessment and decision-making processes.” The full text of the scoping paper is found in Appendix A of this paper.

Two previous versions of this thematic paper have been prepared by different consultant teams.

The first paper was prepared by Industrial Economic, Inc. This paper follows the instructions in the scoping paper and states its objectives in the following manner:

This review paper addresses the gap between current practices for evaluating dam projects and what available economic methods have to offer, including discussion of key limitation of economic methods and the proper role of economic analysis in decision-making. It should not be viewed as an all-inclusive treatment of dam project evaluation issues; the focus is on important controversies surrounding the economic analysis of dam projects, as identified in the paper’s scope of work (McKenney et al. 1999).

The paper highlights the five topical areas identified in the scoping paper: (1) valuation of externalities (2) discounting (3) risk and uncertainty (4) macroeconomic effects and (5) equity and distribution issues and provides initial ideas on improving current practice.

A circulation draft of this paper was sent out for review to the WCD Review Panel for this thematic and to interested WCD Forum members. Comments from these reviewers, as well as the assessment by the WCD Secretariat, led to the suggestion that further work was necessary to better understand: (1) current practices in financial analysis, (2) the relationship (in practice) between economic and financial analysis (3) the role and use of economic analysis in multi-criteria approaches and (4) the unique aspects of the valuation of water-related goods and services provided by dams.

Based on this input the Secretariat commissioned an additional, yet complementary piece of work intended to ensure that the thematic covered not only the “good practice toolchest” but also provided details on

- existing guidelines of multilateral agencies;
- existing practice; and
- the way forward, i.e. suggestions for improving guidelines, practice and the assessment process.

The second paper was prepared by Alec Penman. The objectives of the second paper were as follows:

- to review and synthesise the requirements currently espoused for project appraisal in the operational guidelines of the major multilateral funding agencies;
• to summarise the range of current practice that exists in the assessment of dams and their impacts, and to document how this range of practice is determined by key contextual/causal variables; and
• to provide specific recommendations on how guidelines may be strengthened and how actual practice may be improved, particularly with regard to the structure of the appraisal process.

This paper was also sent out for reviews (to the Review Panel, Forum Members and a set of Peer Reviewers) and an additional series of reviews were received. Many of these comments highlighted the continued lack of specific detail on existing practice and the need for further reflection on the adequacy of methods employed in accurately projecting the costs and benefits of dam projects. Comments from peer reviewers indicated that the paper, while making substantial headway in terms of providing a suitable set of recommendations for the future, still did not accurately portray the potential of current economic methods for improving project assessment (within a multi-criteria framework). Further, the criticism – one voiced by NGO stakeholders from early on in the thematic process – that the paper did not examine the evidence with respect to the economic costs and benefits of large dams was also repeated.

In response to this feedback the Secretariat designed a set of follow-up activities to counter continued gaps and weaknesses in the two existing papers. Principally these consist of drawing in more examples and experiences in actual practice and extending the coverage of the paper to more fully accommodate the issues surrounding valuation of direct project impacts and costs.

While recognising the potential contribution of the WCD case studies in this regard, the Secretariat acknowledges the absence of a thematic activity aimed at documenting the wider experience with the economic costs and benefits of dams. As a response, the Secretariat has undertaken a literature review on this topic. Where germane to the objectives of this Thematic Review – as with the evaluation literature from multilateral agencies – this material is incorporated in this version of the paper. Otherwise the literature review will feed directly into the global review and synthesis of the WCD knowledge base.

Recognising that no single consultant is likely to be able to fully cover the range of topics, experiences and perspectives raised through the process of writing and review to date, the Secretariat has chosen to respond by providing a third version of the thematic paper. This is accomplished by integrating the two previous papers, with the addition of the following inputs as relevant:

• results from the WCD Case Studies (as finalised at the time of writing);
• results from the WCD Survey of Multilateral Development Bank Practice on Financial and Economic Analysis of Large Dams (as reproduced in Technical Annex 2 of this paper);
• submissions and literature received by the Secretariat; and
• a series of contributions from specialists in particular fields (as acknowledged above).

The current paper has now returned to the original structure (from the first paper) of following an issues paper approach, i.e. presenting the topics one-by-one. However, within each topic the approach taken in the second paper is followed in terms of covering the full range of experience (i.e. actual practice, performance of methods, guidelines, good practice toolchest) as relevant to each topic.

While this paper provides a basis for deriving principles, criteria and guidelines in the area of financial, economic and distributional analysis the paper must be regarded as a work in progress. At this time the paper can only provide a partial integration of the WCD Knowledge Base activities that bear on this topic and a number of follow-up activities will continue to add depth to the discussion. The full integration of the WCD Knowledge Base in terms of the application of the derived recommendations to the full set of stages involved in options assessment, project appraisal, project monitoring and re-evaluation will emerge as the knowledge base is synthesised into the Final Report.
and Global Review. Given the multidisciplinary nature of this integration process it must be realised that the recommendations for the operationalisation of the principles and criteria as presented here are only a first cut at this task, based only on the findings from one discipline and one perspective of project assessment. Readers interested in obtaining a holistic view on these matters will want to also read the following WCD Thematics to obtain a more complete picture of the range of findings and recommendations on methodological and process issues emerging from the WCD Knowledge Base:

I.1 Social Impacts of Large Dams: Equity and Distributional Issues  
I.2 Dams, Indigenous Peoples and Vulnerable Ethnic Minorities  
I.3 Displacement, Resettlement, Rehabilitation, Reparation and Development  
II.1 Dams, Ecosystem functions and Environmental Restoration  
II.2 Dams and Global Change  
III.2 International Trends in Project Financing  
IV.5 Operation, Monitoring and Decommissioning of Dams  
V.1 Planning Approaches  
V.2 Environmental and Social Assessment for Large Dams  
V.5 Participation, Negotiation and Conflict Management

All of the Thematic Papers, along with other elements of the WCD knowledge base can be found on the Commission’s website at http://www.dams.org.

As they are finalised the WCD Case Studies and Crosscheck Survey will yield additional observations on the performance of ex ante studies as well as lessons learned across the stages of the project cycle.
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Executive Summary

This thematic review provides an assessment of the effectiveness of actual practice and the identification of good practices among the various approaches, methods and tools for the financial, economic and distributional analysis of dams and their alternatives. Financial and economic analyses are primarily used in the context of dams to determine the profitability of the project to the project owner(s) and to society through cost-benefit analysis (CBA). Distributional analysis considers the broader question of who gains and who loses from a project and can be viewed both in purely financial terms and in terms of the effects of a project on the economic welfare of stakeholders.

The fundamental question addressed in this thematic is whether Cost-Benefit Analysis (CBA) is necessary and/or sufficient as a basis for societal decision-making regarding dams. Woven into this question are ethical and methodological concerns regarding discounting the future, assessing project costs and benefits, placing money values on non-marketed impacts, accounting for risk and uncertainty, assessing regional economic impacts and other contentious issues in economics. The current paper uses a series of contributing papers and emerging results from additional activities to highlight issues related to the economic performance of large dams. The latter activities include preliminary results from the WCD case studies, a survey of actual practice in project appraisal, and review of existing literature. As these activities are ongoing, and the results of the WCD Cross-check are expected in May, further evidence on past practice and the economic performance of dams will be incorporated directly into the WCD outputs.

1. Overview on Economics and Decision-Making

Criticism of dam-building is often synonymous with criticism of Cost-Benefit Analysis (CBA) and, by inference, economics and economists. It is certainly true that since the 1970s CBA has become the World Bank’s dominant decision support system at project appraisal and that the economic internal rate of return (or net present value) is the decision criteria most widely applied by government agencies and official aid donors today. This perspective, however, greatly exaggerates the grip of CBA, economics and economists on decision-making regarding dams. On the technical side it is worth noting that the application of Least-Cost Analysis (LCA) is at least as old as CBA and continues to be a fundamental criterion for screening and selecting projects. The larger point – as demonstrated by the WCD set of case studies – is that the political cost-benefit analysis applied by governments has long been not only the final arbiter, but also drives the planning and decision-making process in many cases.

The first finding that must be acknowledged in reviewing the practice of economic analysis of dams is that not only do political factors often drive the assessment of options and planning process but that ultimately political concerns, or more specifically, politicians take the decision to build or not build the project. It is after all the Executive Board of the World Bank that approves projects and not the team undertaking the economic analysis. Ultimately then the question of on what criteria a project is approved must be discussed simultaneously with the question of who has decision-making authority. Conventional methods for dam project assessments have tended to concentrate on performing financial and economic cost-benefit analyses (CBAs) using a limited set of quantifiable parameters, most of which were internal to the dam owners, and for which values were relatively easy to assign. Meanwhile, decision-making on dams has often been driven either by direct concerns of politicians or by the momentum established by large centralised institutions responsible for water and energy resource planning. Recent revelations made public with regard to one such agency, the US Army Corps of Engineers, highlight the relatively secondary role played by economists in many such institutions.

The picture that emerges from this discussion is that politicians, engineers and economists have all played their role in a planning and assessment framework and process that is not only limited in the concerns that it incorporates, but that is top-down, non-transparent and non-participatory. This
approach has tended to ignore or under-emphasise: the external environmental and social impacts of
dams (positive and negative) and the distribution of gains and losses among affected and interested
groups. It is not the role of this thematic to hypothesise as to the balance of outcomes in this regard
(though see WCD Thematic Papers I.1 and II.1). However observed behaviour in the context of dams
suggests that in quite a number of cases (including a number of WCD Case Studies) the failure to
attend to these issues has led to unsatisfactory social, environmental and financial outcomes. In recent
years these outcomes have led to increased agitation by civil society groups, in turn giving financiers
turn to pause before investing in large dams and, eventually, leading to the impasse that has given
birth to the WCD.

Many of the solutions to this impasse will not be found in this thematic review paper. Issues of
resettlement, equity, environmental restoration, participation, good governance and more are all
covered elsewhere in the WCD Thematic Papers. This paper focuses on the areas where economics
has fallen short in the past and the options that are available for turning this situation around. When it
comes to the investment of large amounts of resources in pursuit of fairly specific objectives; i.e. for
electric power, growing of food, supply of drinking water, etc.; there can be little doubt that
economics has an important role to play. The fundamental question addressed in this paper is,
however, how central should be this role. The subsidiary questions, once this role is defined, is what
other changes in practices and processes are necessary to ensure that economics make a positive
contribution in the changing context of political decision-making. Decision-making with regard to
large dams will always be political and economics, as with any decision support system, must serve
decision-makers. However, as the participation in decision-making processes broadens economics is
provided the opportunity to serve not only the needs of bureaucratic and political elites, but to provide
useful and digestible information to the larger body of civic society. A common, shared information
base that makes the economic consequences of alternative choices explicit would seem one important
element in enabling the future negotiations over dams and their alternatives to proceed in an orderly
and informed manner.

2. Findings on Financial, Economic and Distributional Analysis

2.1 Findings on Actual and Best Practice: Methods

Valuation of Direct Costs of Projects. Discussion of dam costs typically revolves around the
perception that cost overruns are endemic to the industry. The paper not only examines issues in
construction costs but other categories of costs that are, or are increasingly treated as, direct project
costs including a number of formerly external costs that are now incorporated in the financial and
economic project budgets. Findings by cost category include:

- **Construction Costs.** Performance data suggests that dam projects often incur substantial cost
  overruns in construction. While, datasets from the World Bank, Inter-American Development
  Bank and Asian Development Bank reveal average cost overruns in the range of from 20-45% in
  nominal terms there is considerable variability in and amongst the samples.

- **Resettlement Costs** are highly variable depending on site-specific characteristics of the dam and
  the environs within which it is situated. Once overlooked considerable effort now goes into
  estimating these costs for project budget purposes. Still, overruns do occur for various reasons
  including inadequate survey work and “pull” factors that lead to in-migration following the
  announcement of plans to build dams.

- **Environmental Mitigation Costs.** Environmental damages caused by dams are increasingly
  recognised and efforts to internalise these in the form of mitigation projects are growing. Mitigation
  may cost in terms of study costs, capital expenditure on mitigation infrastructure, routine O&M expenditure and/or the opportunity costs of lost production. These measures will also be site-specific and data on the costs of these measures is still unreliable, particularly as the effectiveness of the measures themselves is often questionable.
• **Operations and Maintenance Costs** of dams are low compared to capital costs (1-3%) yet are likely to rise over time as facilities age and efforts to mitigate the negative effects of sedimentation are undertaken.

• **Decommissioning Costs** are real costs that every dam project will face sometime in the future, although experience is yet limited in terms of evaluating their exact magnitude.

The paper stresses that it is useful to recall that the “internalised” social and environmental costs as budgeted are not necessarily reflective of the full economic welfare effects of social or environmental impacts, but instead represent the financial costs associated with policies and regulations in effect. Incorporating such financial costs into an economic analysis must be regarded as a second-best approach where the resulting cost-benefit analysis is intended to represent the net welfare effects on society as a whole.

**Valuation of Direct Benefits of Projects.** While the valuation of social and environmental impacts of large dams is a topic much discussed it needs to be emphasised that the economic valuation of the direct project benefits provided by large dams is not as straightforward as it seems. The regulation of river flows in most countries is guided by the principle that water is the property of the state. From an economics perspective this principle is given expression through the analytical concept that river water, its flows and its quality are public goods. In a related fashion, the large-scale provision of water and energy services has been recognised as a natural monopoly.

A number of consequences for benefit valuation follow from this analytical approach to the public good character of water and the provision of services derived thereof:

• tariffs (i.e. financial prices) for power, municipal and industrial water supply may be used in financial valuation but are not necessarily good indicator of the economic price of these goods;

• increasing private sector participation in power markets will gradually ease the task of economic valuation of power benefits as prices emerging from power pools, etc will represent competitive market prices that serve as economic prices;

• similar developments in water supply markets will also gradually eliminate the need to depend on willingness to pay surveys in the economic valuation of water supply;

• economic valuation of the value of water in irrigation will remain a complicated and difficult affair requiring substantial survey data and/or complex computational techniques;

• flood control benefit valuation will continue to rely on non-market techniques due to its nature as a public good;

• economic valuation of navigation services provided by dams may be based on market prices where tolls are charged, although adjustments may be necessary where substitutes are absent (i.e. road, rail or air transport) or policy distortions exist in transport markets; and

• other direct benefits of dams such as commercial, subsistence and recreational fisheries and general recreation can be valued using market or non-market methods, but will need to account for the loss of such opportunities were the dam not have been built.

Pending the completion of ongoing surveys of the economic impacts of dams and dam evaluation studies a number of preliminary conclusions on the actual and best practice and the performance of benefit valuation may be offered at this point:

• the prediction of the timing and magnitude of water availability will play a very important role in direct benefit evaluation and will depend largely on quality and extent of historical hydrological records

• sophisticated best practice methods for the evaluation of power benefits are often employed in dam appraisal and these methods appear to be relatively reliable in predicting performance, however exceptions do occur, particularly where a simple alternative power plant method is applied;

• valuation of irrigation benefits remains a difficult endeavour due to the complexity of correctly estimating the respective contribution of irrigation water to augmenting productivity given the

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vagaries of accurately projecting hectares that will be brought under irrigation, crop choice and crop yield;
• economic performance in irrigation tends to deliver less than promised due to management reasons, over-optimistic time-tables and the inherent difficulties in valuation;
• water supply projects are typically evaluated using a least cost analysis, thus avoiding the difficulty of actually valuing these benefits; and
• flood control, navigation, fisheries and recreation benefits are rarely valued in dam appraisals where these uses are secondary benefits.

The conclusion that emerges from this discussion is that in many cases the methods are available to undertake more comprehensive, good practice valuation of direct benefits. In developed countries valuation tends to be more comprehensive as access to data, economic expertise, and resources is more pronounced. In addition, the use of willingness-to-pay surveys is easier and more likely to produce reliable results in developed market-oriented economies than in countries where potential respondents (i.e. consumers of services) are only marginally incorporated into the market economy.

Environmental and Social Valuation. In formal appraisals prepared by multilateral agencies it is rare to see a systematic approach to the valuation of environmental and social impacts of large dam projects. In some cases avoided emissions are valued, but outside of the inclusion of the financial costs of resettlement, compensation and mitigation measures in the economic analysis there is little attempt to incorporate these values into the economics of dam appraisal. This is somewhat surprising given the rather tractable nature of the welfare impacts of dam projects which take place primarily in rural settings and involve the evaluation of effects of dams on households and firms production and consumption options. Methods exist for the valuation of changes in subsistence and commercial production, water consumption, health impacts, recreation, and loss of land. Oftentimes the limiting factor may be obtaining the information on how ecosystem function will change when a dam is built.

While valuation of these impacts is increasingly undertaken in a developed country context where the data and technical expertise is available, developing countries are rapidly equipping themselves for this task. The difficulty will be cases where historical data on economic behaviour at the microeconomic level or ecosystem/hydrological function is required. Still, many experts suggest that the use of the more participatory methods of economic valuation hold out bright prospects for future valuation efforts. It is, however, important to stress that although economists can value a range of social and environmental impacts using best practice methods, a number of intangibles such as biodiversity and cultural values are very difficult to monetise. Further, within the context of a given dam project it will be extremely difficult and costly to provide precise valuation data on all, or even close to all the impacts.

Criticism of CBA is often based on its failure to incorporate the social and environmental costs of large dam projects. In the cases where CBA has been extended to incorporate evolving methods for valuing environmental and social impacts, some feel that this approach has tended to result in even more controversy, and to focus criticism on the entire suitability of economic analysis as a meaningful and practical tool for dam project assessment. While this is an important perspective there remain many stakeholders in the dams debate who are asking for these impacts to be valued in economic terms so that they may be compared with the direct project benefits and costs and thus the debate continues, largely it appears in the absence of a dedicated program of experimentation in this area.

Discounting. Actual practice in dam evaluation amongst multilateral donors consists of applying discount rates for economic analysis in the 8-12% range (all rates cited here are in real terms). These may alternatively be based on host country calculations of the economic opportunity cost of public funds or the intent to ration available capital by the donor. In many cases appraisal documents simply take it for granted that the discount rate is the rate as applied and do not bother to cite a sources for this important parameter. Further, many appraisal do not actually use a discount rate to calculate a net
present value but instead calculate an economic internal rate of return which is then compared with the stated discount or “hurdle” rate.

The literature on discounting is rich in alternative perspectives and suggestions. A number of views regarding the correct way to discount in economic analysis are as follows:

- to use a discount rate of zero in order to avoid making assumptions about the discount rates of future generations and to ensure that long-term catastrophic effects are valued at more than the value of a VW bug in current policy choices
- to use a discount rate that reflects the social rate of time preference or the rate at which people discount future consumption (on the order of 1-3% in many cases)
- to use a discount rate that accommodates both the social rate of time preference and the opportunity cost of capital (anywhere from 2-12%)
- to use the private sector rate of return as an indicator of the opportunity cost of public funds (roughly 16-20 percent)

Additional variations on the use of one of the following rates suggest above are:

- to use a discount rate that begins declining in a generation or two as a way of representing empirical research that has demonstrated that people do not discount the future in a linear fashion
- to use different discount rates for environmental good and services on the grounds that they will be scarce in the future

A final suggestion is to avoid incorporating additional concerns into the discount rate besides those it was designed to account for – i.e the economic “rate of exchange” of units of worth accruing in different time periods. Under this view it is better to proceed with the best estimate of the discount rate and then discuss alternative means of incorporating such concerns (such as long-run effects or resource scarcity) into the project appraisal or planning process.

Risk and Uncertainty. Risk is often assessed through sensitivity analysis based on analyst-selected ranges of a number of parameters. In multilateral appraisal, quantitative risk assessment using probability distributions is found only in best practice examples. The treatment of uncertainty is also accommodated through sensitivity analysis. Little effort has been made to date to conduct either quantitative options analysis or scenario analyses of the joint effects of uncertainty and irreversibility on dam decision-making. Where uncertainty over external impacts is extreme, an alternative that is now employed is to develop a compensatory project, but make the project a number of times larger than would seem necessary in order to err on the side of caution.

Regional and Macroeconomic Impacts. Models for examining regional and macroeconomic impacts have a number of functions which include analysis of the distribution of project impacts and the prediction and monitoring of how a project performs relative to sectoral, macroeconomic and international economic objectives. As a result such models may be used for determining the affordability of a very large dam project to a country. Economists (and policy regulations in some countries) generally agree that secondary economic impacts beyond the scope of project direct benefits should not be used in determining the net economic benefits of a project. Assuming full employment of resources in an economy the gain in secondary benefits from investment in one region will simply result in the off-setting loss of such benefits in another region as the change in supply and demand introduced by the market is accommodated and the economy returns to equilibrium. Still, there may be cases, particularly, in developing countries where the assumptions (such as full employment) do not hold and the results of such models will require further interpretation for decision-making purposes.

Models for use in predicting regional and macroeconomic impacts include input-output models, social accounting matrices, and computable general equilibrium models. These models are data intensive
and require substantial investment of resources and technical expertise. As such these models are not often seen in dam appraisals in developing countries. Still, many developing countries do have these models and the expertise to work with them. The unanswered question is how well do these models respond to the outstanding concerns held by many about the economic and distributional impacts of large dam projects.

**Distributional Analysis.** The need for distributional analysis is increasingly recognised as a valuable input to decision-making, particularly given that perceptions regarding the inequitable distribution of costs and benefits of large dam projects is one of the major issues in the dams debate. Unfortunately, distributional analysis is rarely undertaken outside of Social Impact Assessment or the use of macroeconomic models. The use of distributional weights (Social CBA) is not practised. The use of distributional weights (Social CBA), which was widely promoted in the 1970s is not practised. The new Asian Development Bank guidelines currently recommend the use of a distributional analysis which is intended to show which sectors of society receive the economic benefits of the project and which sectors pay the costs. To date this has proven difficult to implement and the one existing application is reviewed in the thematic paper.

The WCD Case Study experience shows that it is technically possible to collate the material in the context of stakeholder processes, but that the complexity of the resulting matrix requires considerable explanation. In sum, there is considerable need for methodological and process innovation in this area if non-quantifiable indicators are to be incorporated alongside quantifiable figures. Participatory, multi-criteria approaches to decision-making have the advantage of incorporating both types of information into a process where there is time for participation and learning to occur so that distributional information coming from economic analysis and other sources can be understood and explicitly considered in the decision-making process.

**Decision-making.** Traditional methods for project selection have consisted of financial and economic analyses using a limited number of parameters, most of which were internal to the dam owner and for which values were relatively easy to assign. Decisions made to build dams solely on the basis of such an analysis are questionable given the failure to undertake options assessment and to include external impacts, particularly social and environmental costs. An alternative approach to a decision support system based on CBA is to use a method that recognises that projects often have multiple objectives and not simply economic welfare maximisation. Experience to date with these multi-criteria approaches suggest that while economic criteria remain important, these decision frameworks have the benefit of allowing disaggregated information on social and environmental impacts to enter directly into the decision analysis. Such decision support systems appear particularly appropriate and useful in the case of large dams when implemented within a participatory, transparent multi-stakeholder approach.

**2.2 Findings on Actual Practice: Process**

As alluded to earlier, there are different perspectives on the role of economics in the decision-making process. One perspective has the results of these analyses being employed by decision-makers to select and approve the project for development, subject to political considerations. An opposing view is that a project is identified for political or institutional reasons and the CBA is simply used as a tool to legitimate the decision. The tendency to underestimate costs and overestimate benefits in dam appraisals only serves to promote the latter view.

Little divergence of opinion surrounds the claim that historically decision-making processes for large infrastructure projects, including dams, were top-down, non-transparent and non-participatory and were driven largely by political interests, engineers and economists. This approach has tended to ignore or under-emphasise the external impacts of dams (both environmental and social); the typically uneven distribution of gains and losses; and the inadequate compensation provided to those negatively affected. As a result the approach has frequently led to unsatisfactory social and economic outcomes.
An important aspect of the changing context that surrounds dams is the opening up of decision-making processes to a wider body of informed participation, and even to negotiation of decisions amongst stakeholders. Review of the gap between actual practice and that reflected in best “academic” practice and guidelines suggest that in a multi-stakeholder, multi-criteria decision-making arena it becomes important to rethink how evolving tools and methods of economic analysis can inform such decision-making processes in a transparent, participatory and accountable manner. In such a context emphasis needs to be placed not only on the financial sustainability of a project and its economic attractiveness but on the analysis of who gains and who loses from a project, i.e. distributional analysis. This information, when developed in an open and participatory manner can promote stakeholder understanding and negotiations surrounding the decision-making process.

3. Policy Principles for Financial, Economic and Distributional Analysis

The following policy-level principles pertaining to the application of Financial, Economic and Distributional Analysis to the assessment of alternatives for water and energy resources development and the evaluation of dam projects:

**Options Assessment.** A full range of dam and non-dam options should be included in the identification and preliminary assessment phase of selecting water and energy projects. An explicit comparison of options is a necessary precondition for ensuring efficient resource allocation. The options should include both supply and demand management options. The specific stages will vary from one context to the next however, the main objectives is that an exhaustive scoping of options be conducted at the outset with subsequent screening out of unattractive options and that at least two viable alternatives be carried forward to the stage of project selection.

**Decision-Making Criteria.** Economic CBA is a necessary but not sufficient element of options assessment and project selection, monitoring and evaluation. Given that not all important impacts can be valued in economic terms, decision-making should not be based solely on the results of economic CBA, but rather the different aspects of financial, economic and distributional analysis of options should feed into multi-objective and multi-stakeholder decision-making approaches.

**Equity Considerations, the Pareto Principle and CBA.** It may not be enough that the economic gains of a dam project (or a dam option) outweigh the economic losses, rather those who gain must actually make those who lose better off. Implicit to CBA is a weaker formulation of the Pareto Principle, namely the notion that winners could compensate losers. The premise of hypothetical betterment of those made worse of by a project due to the extinguishing of their rights and loss of social/environmental entitlements may be judged to be a poor basis for public policy and decision-making in today’s context. (Note: this principle is intended to demonstrate that an argument for equitable outcomes can be found within the context of efforts to attain economic efficiency. The use of a dam project to effect a progressive redistribution of societal benefits would be a separate project objective where applicable – although economics could assist in monitoring and evaluation of such objectives.)

**Distributional Analysis.** A Distributional Analysis should be mandatory for both public and private sector large dam projects and their alternatives, and serve as a vehicle for informing stakeholder negotiations. The analysis should include an assessment of whether (and to what degree) the project affects vulnerable income groups and groups with distinctive cultural features.

**Economic Analysis of Private Sector Large Dams.** Since large dams typically involve many external impacts, an economic analysis (from the perspective of society) should be performed for projects owned by private enterprises, as well as for those owned by public institutions.
Decommissioning Fund. Decommissioning costs are real costs that every dam project will face sometime in the future. For privately sponsored dam project a decommissioning fund should be mandatory and initiated at commissioning.

Sensitivity Analysis. Sensitivity analysis of potential range of discount rates and quantitative analysis of risk factors must be undertaken as part of the economic analysis.

Affordability. Countries must ensure that dam projects are affordable, taking into account relevant project risks. The possibility that revenue flows will not be forthcoming and hence, that loans will go unpaid, with subsequent deleterious affects on the macroeconomic health of a state or country needs to be carefully evaluated prior to project selection.

4. Recommendations for Future Practice: Methods

Environmental and Social Valuation. Placing monetary values on environmental and social impacts of projects is a useful and acceptable practice insofar as it permits explicit examination of project and policy alternatives. Studies of this nature should be located within the framework of a recursive consultative interaction with project stakeholders that allows for the identification, prioritisation, selection and valuation of project impacts. Valuation does not, however, preclude the direct use of social and environmental indicators in multi-objective frameworks. Where possible, values used to quantify these effects in monetary terms should be based on the choices actually made by individuals in relevant markets. Stated preference methods should not be used with cultures unaccustomed to market transactions. Economic analysis is based on the notion of consumer sovereignty, i.e. that the values reflected in the analysis should be those of the people affected by the project not those of politicians, activists, environmentalists, moral philosophers or economists. Projections of the relative changes in the scarcity of goods and services need to be adequately accounted for in the valuation process using appropriate price escalation factors.

As part of a recursive process with stakeholders the direct project benefits and impacts that need to be valued in economic terms should be developed with a view towards concentrating available funds on assessing those impacts that are expected to be significant but for which the level of magnitude is not clear from existing studies or evidence, or where divergent views on the valuation of the impact exist.

Discounting. The discounting of future flows from society’s point of view (i.e. not the private sector discount rate) must accommodate the time preference of society for consumption and the opportunity cost of capital; the discount rate cannot simply be set at zero. It is of great importance to move beyond the ideological and philosophical debates over theory and methods, and foster applied research and development in this field.

Sensitivity and Risk Analyses. In deciding whether or not a project should be implemented, it is essential to measure, through sensitivity analysis, the robustness of the results of the analyses to reasonable expectations of changes in the key input variables. The choice of ranges of values for the key variables should be based on actual experience with other projects of a similar nature. Using previous experience, probability distributions for the key variables should be estimated and combined in an overall probabilistic risk assessment of the project.

Distributional Analysis. Improved distributional analysis is only possible if increased resources are invested in determining the impacts that large dams have not just on the national economy but on interested and affected populations. Macroeconomic models such as social accounting matrices should be considered where the secondary impacts of the project may be considerable. Financial and economic valuation of project impacts, including the social and environmental impacts, should take place as an integral part of the consultative process of social and environmental valuation described above. Placing valuation of impacts and the analysis of the distribution of these impacts within the context of negotiations over the project is recommended.
Harmonisation of methodological approaches and standardisation of key economic assumptions is required. Eliminating uncertainty with regard to key elements of technical approaches to the problem as well as standardising key variables (such as discount rates) at relevant levels (i.e. of the national economy) both promotes comparability of results and efficiency in the undertaking of analyses. A targeted program of applied research – most likely of a collaborative nature between development banks, research institutes and government agencies – would be ideal.

Financial Analysis. Financial analysis should be conducted, for both privately and publicly funded projects to accomplish the following:

- assess the financial viability of the project as a whole – is the present value of total annual revenues greater than the present value of total annual costs, measured at market prices?
- determine the annual profitability of the project enterprise – for each year of the project’s life, will sufficient revenues accrue to the enterprise (from tariffs, government incentives, etc.) to cover all of its financial obligations including operating expenses, principle and interest payments on debt, income tax on profits, and required return to equity investors?
- in the case of a large project relative to the size of the country appropriate methods (including macroeconomic models) should be used to measure the impacts of the project on foreign exchange liabilities, production levels and prices in the various sectors of the economy, and the effects on the overall fiscal performance of the country? and
- ensure that investment in the project will not divert scarce government funds from important social programs and, by so doing, exacerbate the condition of poorer socio-economic groups.

Economic Analysis. Annual cash flow profiles computed in the financial analysis should be modified for use in the economic analysis. Taxes, subsidies and other distortions should be eliminated through shadow-pricing of inputs and outputs at their marginal opportunity cost; costs and benefits that are external to the project (externalities) should be included; and adjustments made to convert to a common price level using the appropriate exchange rate. The valuation of direct project costs and benefits, as well as of external costs, benefits and impacts should be done at three levels: identification, quantification and valuation. When there is general acceptance of the methods, and the data are of sufficient quantity and quality, the monetary costs and benefits should be estimated and included directly in the economic cost-benefit analysis. Those that are not quantifiable in either physical or monetary terms should be presented to decision-makers in qualitative terms. Where different development options are being considered (e.g. high dam versus low dam), any differences in impacts among the options should be emphasised.

For a multi-purpose project, each independent component should be evaluated on its own merit on a marginal basis. Each successive component under consideration must increase the project’s total net benefit in terms of the stated national/project objectives. Any incremental component that has a negative net benefit (i.e. has the effect of reducing the total net benefit of the project as a whole) should be dropped, even if the net benefit of the total project remains positive. In other words, individual project uses (e.g. hydropower, irrigation, water supply, etc.) should be justified incrementally. Those uses that have net beneficial impacts should not be used to cross-subsidise other uses whose net benefits are negative.

For a project to be considered economically attractive, the present value of its economic benefits must not be less than that of its economic costs. Also, the present value of the project’s net benefits must be no less than the present values of mutually exclusive projects.

Multi-Criteria Analysis. Multi-criteria analysis is recommended as a more comprehensive method of decision-making provided that it is conducted in a participatory manner. The available approaches and methods in multi-criteria analysis are fully explored in the WCD Thematic Review on Planning Approaches and readers should consult this paper for more detail on recommendations in this regard.
5. Recommendations for Future Practice: Process

Project Assessment. At the outset of a project assessment, it is necessary for decision-makers, in consultation with stakeholders, to explicitly define and describe what their long-term policy objectives are, and how the project or options in question might contribute to promoting these objectives. Proponents and analysts should not be left, by themselves, to anticipate or decide on these objectives. These objectives must be elaborated on to ensure that there is a common understanding by all affected groups of the national and project objectives on which the project’s performance will be judged.

It is also necessary, at the outset of the planning process, to define the framework within which the decision-making will take place; the scope of the various technical analyses to be undertaken; the options to be considered; and the range of values for important variables that will be used in the evaluation. Again, these tasks should not be left to project proponents and analysts alone but should also involve inputs from decision-makers and stakeholders.

The results of the process will be more credible and generally acceptable if the relevant objectives, decision-making framework, scope of analyses, options, and values for key variables are discussed and decided in advance, and if stakeholders are encouraged to participate. This approach will also contribute to the assessment process becoming more transparent, thus reducing the ability of certain groups to manipulate the results.

The prescribed process must be sufficiently flexible to allow analysts to make reasonable adjustments during the course of the work to reflect the interim findings of their analyses. However, any major changes in approach and assumptions should be made in consultation with decision-makers and stakeholders.

Options Assessment. At the outset funds should be made available to conduct pre-feasibility studies of a series of options to fulfill the defined objectives. While this list should be winnowed down through feasibility, design and appraisal the decision to limit the field of projects to one should be avoided until uncertainty over potentially crucial aspects of the project are resolved. For this reason it is suggested that at least two projects be taken to appraisal. This will help avoid the problem that has arisen in the past where a single project that has been selected for feasibility study is discovered not to be as attractive than originally thought, but continues to be pursued because it is the only project that can be commissioned in time to meet an imminent shortage of power or water. It may be more cost-effective in the long run to advance spending money on additional feasibility studies rather than waste resources developing a sub-optimal project.

An Integrated, Multi-Disciplinary Approach. It is necessary to devise a process that integrates the expected environmental and socio-economic impacts of a project into the assessment process from the early planning stages, before decisions are made on the project’s configuration, and before it is committed (politically) for development. In so doing, it will be possible to modify the scale and design of the project in order to minimise its impacts, including the costs of mitigation and compensation, and make it more acceptable to all parties concerned. Such an approach, both by private- and public-sector developers, represents enlightened self-interest since it reduces the financial and economic risks associated with project delays caused by protests and legal challenges from project-affected groups. This approach requires that specialists from a wide range of disciplines, including environmental and social scientists, as well as engineers and economists be included throughout the project assessment process.

Stakeholder Participation and Transparency. It is essential to a dam project’s general acceptance, financial and economic sustainability, and equitable distribution of net benefits to consult with all those who will be affected, both directly and indirectly. These consultations should be conducted throughout the project planning, preparation, development and operating stages with the purpose of enabling those affected to have a material influence on the project’s scale and mode of operation, as well as on the ultimate decision on whether or not the project should proceed.
This type of process is designed to help all participants to form and reveal their preferences with the objective of establishing a basis for negotiation and ultimate agreement. The process requires that all parties concerned have access to publicly funded analyses that are conducted in connection with the project (i.e. there is freedom of information). Also, it is essential that analysts view themselves not just in the service of project proponents but in the service of all parties affected by the project.

In developing countries, it is necessary that stakeholder consultations be facilitated, not by project proponents but, by impartial groups and individuals who are experienced in this area of endeavour, and who are familiar with the cultural environment in which the consultations are taking place. For the consultation process to be effective, all participants (project proponents, analysts, affected groups and decision-makers) must be objective, informed and flexible. Unless a general spirit of cooperation exists and there is widespread acceptance of, and confidence in, the consultation process, it is unlikely to be credible and successful.

Conflicts of Interest. In order to avoid conflict of interest, it is important that, although the various analyses should be highly coordinated, they should be undertaken by independent firms or individuals. In particular, the environmental and socio-economic impact assessments should not be performed by the same firm or group that is undertaking the engineering work.

Panel of Experts. For all large dam projects, an independent panel of experts should continue to be appointed to review project assessment. Care should be taken to ensure that the panel is multi-disciplinary in nature, composed of a wide range of eminent technical specialists including engineers of various disciplines, environmental scientists, and economists and other social scientists. It is essential that the panel be truly independent (see the WCD Thematic on Regulations and Compliance for more on this theme).

These specialists should not only review the assessment after it has been completed but should be involved from the early stages in helping to guide the process to ensure that the data, methods and subjective assumptions being used are rigorous and comply with accepted (improved) practice. The panel should also participate in the consultation process to ensure that the opinions of all affected groups, on issues specific to the project, are taken into account in the project design and assessment.

Political, Legal and Institutional Issues. The establishment and support of effective, relatively independent regulatory institutions to oversee project assessment, and to ensure that the prescribed rules for project assessment are adhered to is vital. Having such institutions in place will have the potential to improve the transparency and credibility of the process, and to provide more acceptance of the recommendations made by the regulatory institutions to political-level decision-makers.

It is important that the legal/institutional process that is developed be clear, timely and efficient. It should not add unnecessarily to the overall costs borne by the government, project proponents and those who would be negatively affected by the project. Nor should it be so protracted as to discourage development of projects that are fundamentally sound from the point of view of meeting stated national and project objectives.

Resources Available for Project Assessment. In order to achieve and implement the improved project assessment process outlined in the previous sections, it is essential that adequate resources, in terms of both time and money, be allocated by governments, and by lending and development institutions to conducting the various engineering, environmental, financial, economic, social (including distributional) and multi-criteria analyses required. If it is deemed desirable by those involved in the dams debate to significantly improve the assessment process and to design projects in such a way as to make them acceptable to the broad range of stakeholders involved, these agencies must commit more resources to project assessment than they have done in the past.
Basic Research and Information from International Funding Agencies. The international funding agencies should assist practitioners of project assessment by conducting, and regularly updating and publishing evaluations, on a regional and country basis, of the most appropriate values for basic financial, economic and social variables that should be used in the analyses. Also, on the basis of experience, they should provide plausible ranges for these variables to assist practitioners perform sensitivity and risk analyses. In addition, they should continue to publish specific, detailed and practical guidelines for conducting acceptable, comprehensive and high-quality project assessments. A number of areas that require further research and evaluation include:

- a systematic program for the application of methods of social and environmental valuation within the context of options assessment and project valuation of large dams and their alternatives;
- evaluation of global experience with macroeconomic models in the analysis of the economic impacts of large dams;
- the applicability of benefits transfer to dams as a means of lowering the cost of environmental valuation;
- harmonisation of discount rates at the country level and the application of existing methods in this regard;
- exploration of the implications of new approaches to analysing decision-making in the presence of uncertainty and irreversibility.
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This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
1. Introduction

Traditional methods for dam project assessment have focused on conducting financial and economic cost-benefit analyses using a limited set of quantifiable parameters. Indeed, the typical procedure for conducting economic analyses of dam projects has been to weigh expected capital investments and operating and maintenance costs over a specified period of time against the project’s expected benefits (e.g., power, water supply, flood control, river navigation).

As concerns over the social and environmental impacts of dams and their distribution amongst groups in society have become more prominent, the limitations of cost-benefit analysis as a decision-making framework have become increasingly apparent. Rather than estimate the actual social and environmental costs, the aforementioned “limited” cost-benefit analysis has simply been modified to include the cost of regulatory measures to mitigate (reduce), or compensate for, social and environmental impacts. People affected by dam projects and non-governmental organisations have consistently criticised these measures as grossly inadequate and demanded that project evaluation account for all costs and benefits (Bosshard 1999 eco040; Colajacomo 1999 eco039).

In response to criticisms of the ability of economic analyses to accurately capture the full range of costs and benefits associated with projects such as dams, economists have sought over the past three decades to refine economic methods and develop alternative approaches. Specifically, this research has focused on approaches for valuing non-market factors, accounting for regional and macroeconomic impacts, addressing impacts among different affected groups and across generations, and improving how risk and uncertainty is accounted for in project analyses.

Economists have made significant progress in a number of areas, particularly in the development of methods for the valuation of social, environmental and health impacts; models for analysing regional and macroeconomic impacts and, with the increase in computing power, increased capability and ease of modelling project risk. Recently, techniques for the analysis of the distribution of economic costs and benefits of projects – first devised in the 1970s – have reappeared in multilateral agency guidelines and handbooks. Similarly, a renewed interest in actually calculating discount rates – again using long established methods – is noted in these same guidelines and handbooks. However, it is questionable how far these new and resuscitated methods have penetrated actual practice. Only, in the case of valuation of environmental impacts in the USA does a clear trends towards adoption emerge.

The debate over discounting long-term impacts has spawned a large literature but little agreement amongst academic economists on the resolution of the ethical dilemma presented by discounting (Portney and Weyant 1999). Advances in theory and methods have not been transferred to the operational level in funding agencies – such as the World Bank - which continue to employ a single rate across countries. Understanding of the relationship between uncertainty, irreversibility and investment timing in capital budgeting has opened up new avenues and methods of analysis for exploring the option values associated with the timing of project decision-making using methods initially developed for valuing financial options (Pindyck and Dixit 1994). The application of these advances in theory and methods – including complementary approaches from the environmental economics literature on quasi-option value – have seen little to no exposure in the dam decision-making or the dams debate more generally.

Regardless of the progress that has been made, it remains a daunting (and potentially expensive) task to fully account for the large number of complex impacts (such as cultural values, ecosystem function and biodiversity values) associated with a single large dam project. At the same time, many critics of CBA have questioned the commensurability of these values, asking whether it is possible to add values for wildlife and human suffering to mundane consumables such as electricity and crops (Lohmann 1999 eco034).
Meanwhile, suspicion that much cost-benefit analysis is simply used as a tool to justify projects that achieve larger objectives of political, commercial or technocratic elites has only exacerbated this lack of confidence amongst other stakeholders, including civil society, NGOs and the academic community (Havlicek 1999 eco022; Howard 1999 ecoweb003; Lohmann 1999 eco034; McCully 1996). This view has not been helped by the lack of transparency, participation and accountability typically associated with such studies (Klassen 1999 ecoweb002; Lohmann 1999 eco034; O’Connor ecoweb). Further, charges that the costs associated with large dams are systematically underestimated and the benefits overstated have led many to explicitly question the continued utility of large dams as a development option (Bosshard 1999 eco040; Havlicek 1999 eco022; McCully 1996). Industry associations and funding agencies, whilst acknowledging the occasional selection of poor projects, maintain that large dams are a crucial element in strategies to meet growing needs for food, electricity, water supply and flood management) and an important tool for promoting regional development (ICOLD 1999).

Indeed, much of the debate over controversial issues such as the need for, and legitimacy of “extended” cost-benefit analysis with its incorporation of the valuation of environmental and social impacts, serves to obscure the continued need to improve even the evaluation of the direct costs and benefits of projects (Bacon and Besant-Jones 1998; Young 2000 eco066). This is nowhere more evident than in the case of the monitoring and evaluation of economic performance over time where current practice leads to large inefficiencies in project operations (Howard 2000). The role of economics in current debates in some developed countries over decommissioning is also yet to be clearly defined. In the United States while millions of dollars are spent examining the costs and benefits of removing publicly owned dams, relicensing of private facilities goes forward based purely on financial and environmental grounds (US Army Corps of Engineers 1999 env137; US Department of Interior Staff 1999 eco054).

In sum, although economic methods have improved considerably in many areas over the past three decades and new innovations hold continued promise, it can be questioned how far practitioners have managed to incorporate these advances into current practice in dams planning and evaluation. While the exact weight of cost-benefit analysis in decision-making will vary from one situation to the next, its use as a standard for assessing projects raises the likelihood that the failure to apply available economic methods has led to misleading net benefit estimates, leading in turn to poor project decisions. Using more advanced economic techniques would provide greater accuracy to the net benefit estimates of projects, thereby furnishing parties with a better information basis from which to make decisions. Further, improvements in the process under which such studies are undertaken might increase their acceptability.

Still, as argued in this paper, the difficulties inherent to incorporating all relevant project information and criteria – particularly those that are founded on discussion and deliberation by project stakeholders not quantitative analysis – into a single measure of project worth constrain the level of improvement that can be attained. In turn, this suggests the need to move to an explicit approach based that recognises the multi-objective nature of public choice and the multi-stakeholder, multi-criteria nature of options assessment and project evaluation processes.

However, there is currently little consensus amongst the parties to the large dams debate on what should constitute good practice for the financial, economic and distributional analyses of dams and their alternatives. This paper examines the reasons for this unfortunate situation and explores the options for resolving the current impasse.

1.1 Brief Overview of Financial, Economic and Distributional Analysis

Financial, economic and distributional analysis can be applied at many different levels. They can be used to assess a wide variety of activities including the use of macroeconomic instruments, sector
plans, specific projects or policies, and changes in land use. Indeed they can be used to evaluate the respective change in outcomes associated with any change in behaviour. Consistent with the objectives of the WCD process (see the Foreword), the focus of this paper is on the use of these techniques in options assessment and dam project evaluation. This implies a focus on planning and the project cycle. In the options assessment context “planning” implies the need to compare different “baskets” of projects. Thus there is the need for a primary emphasis of the paper on methodologies for project evaluation, but also the need to consider methods that are applied to evaluate groups of projects in the energy and water resources sectors. Examples of the latter are power sector expansion models that examine the cost efficiency of different expansion plans involving different combinations of projects.

The evaluation of individual projects or groups of projects may of course be undertaken at any point in the project cycle. Prior to the initiation of a project any number of planning and project evaluation stages may be postulated, however, for the purposes of this paper these are approximated to sector planning, pre-feasibility, feasibility and appraisal. Overlap between the first three may occur in a given case, however, appraisal is defined as the point at which the project is formally appraised with a view towards allocating financial resources to the project. In the case of dam projects “completion” reports are typically written once the project is commissioned, i.e. once construction and impoundment are complete and the project begins offering services. Still, given their long length of life, dams are often monitored and their operations regularly re-evaluated to the point where a decision is taken to shut down operations, i.e. decommissioning the dam. Throughout these stages financial, economic and distributional analysis will also have a role to play.

To understand the conventional rationale for the use of financial and economic analysis it is useful to clearly define their content in the project context. Financial analysis refers to the use of data on the expenditure and revenues associated with a project as these accrue to project participants. Financial analysis may be used for a number of purposes including:

- projection and monitoring of cash flows for the project to ensure that the project entity has the financial resources to meet its operating commitments;
- to assess the financial affordability of the project to those taking a financial stake in the project (i.e. project developer, contractors, equipment suppliers, financiers, etc);
- to determine the prices for goods that must be charged given projections of output and demand to ensure financial viability of the enterprise; and
- assessment of the overall profitability of the project (both ex ante and during operations) for prospective project participants, i.e. discounted cash flow (DCF) analysis.

The DCF analysis portrays the incentive for a given stakeholder to participate in the project and thus indicates the distribution of expenditure and revenue flows across these prospective participants. The term discounted cash flow analysis is used in place of financial cost-benefit analysis or financial CBA in order to simplify the presentation. CBA is then used exclusively (in this paper) to represent economic cost-benefit analysis.

In sum, financial analysis refers to the purely money flows associated with a project and will be undertaken from a number of different perspectives. The paper returns below to the issue of which perspectives are taken into account in financial analysis and hence in project decision-making.

Economic analysis differs from financial analysis insofar as the former represents an analysis of the welfare effects of a project not from the any particular perspective but from the perspective of the economy as a whole. As the welfare of society is defined as the sum of the welfare of its members, an examination of the welfare effects of a project implies the summation of its impact on all members of society. For the purposes of the analysis of economic profitability, the “economy” has traditionally been interpreted as the national economy. However, economic costs, benefits and impacts may be assessed (and integrated) at other levels as well, be they the global, state or community levels.
To further the distinction between financial and economic analysis (as with distinction between DCF and CBA) the terms “costs” and “benefits” will be applied to those figures which are presumed to be representative of economic costs and benefits. The terms expenditure and revenue are used for financial figures that are not adjusted to or do not reflect their economic counterparts.

Economic analysis may be used for a number of purposes in planning and project evaluation, including:

- identification, quantification and valuation of the economic costs and benefits associated with a project
- identification of the distribution of costs, benefits and impacts (i.e. quantities) of a project or sector plan across different actors in society (both spatially and over time)
- assessment of the extent to which a project or sector plan meets specific economic objectives such as employment generation, regional development, macroeconomic stability, stabilisation of exchange rates, etc;
- assessment of risk and uncertainty associated with project costs, benefits and impacts;
- assessment of the economic affordability of the project to the economy;
- determination of cost-efficiency; and
- determination of overall profitability to the economy, i.e. economic cost-benefit analysis.

Of these purposes, the determination of economic profitability is the sole textbook indicator to be used in decision-making as it represents the net welfare change to the economy associated with the project. In reality, many other non-economic objectives may drive project selection and planning and thus a number of different indicators may be used in the decision-making process. That said, these objectives are often stipulated in addition to – not in place of – the requirement that the project be a profitable use of societal resources.

In practical terms, economic analysis as applied in the analysis of policies, plans, projects, etc. differs from financial analysis in a number of respects including:

- economic or “shadow” prices are used to value input and output quantities in place of market prices where markets are distorted by policies (such as taxes, subsidies and quantitative restrictions) or where markets are imperfect (such as in the case of monopoly or common pool resources);
- non-marketed goods and services such as health impacts, ecosystem services, and cultural values are accounted for through non-market methods of valuation;
- an economic opportunity cost of foreign exchange is used where the market exchange rate does not reflect the equilibrium between the supply and demand for the currency; and
- a social rate of discount is used in place of the market-derived opportunity cost of capital.

As with financial analysis, economic analysis provides a means of examining who gains and who loses from a project, though in this case from an economic perspective. For example, commercial farmers or fishers downstream from a proposed dam may see their financial profitability reduced as a dam is constructed and water flow regulated, thus causing them to shift to their next best productive activity. The dam has altered the expenditure and revenues stream of these enterprises. Compared to the pre-project scenario – and assuming no compensation – they are worse off in financial terms. These changes may be mitigated if any of the benefits of the project are captured by these enterprises, such as lowered rates for electricity.

An analogous situation can be posited with the exception that subsistence farmers or fishers are affected by the dam. In this case the change in productivity experienced by the farmers does not result in a change in financial flows as the crops produced are not marketed. Yet, the farmer must still feed his or her family and thus must also turn to the next best productive activity. If such an activity...
exists it is likely, for instance, that the farmer will need to spend additional time labouring to produce the same amount of subsistence. If alternatives do not exist the farmer’s family may need to shift to inferior subsistence goods or simply go without. Regardless, it is clear that the welfare of the household will have suffered a turn for the worse due to the construction of the dam.

In this manner it can be seen that distributional analysis will rely on both financial and economic analysis. It is also clear that the more the livelihoods of those affected by a dam are of a subsistence nature (i.e. non-marketed inputs and outputs) the more economic, as opposed to financial analysis, will be required.

Due to the interwoven nature of the economic system, the economic impacts of a project do not simply stop with the use of direct project inputs and the production of direct project outputs but ripple through the large economy. Thus, the analysis of the distributional impacts of a dam project will go far beyond the immediate affected and interested parties. Regional and macroeconomic models that trace through these complex interrelationships are thus one way to conduct distributional analysis. Still, there will be many social and environmental interlinkages and effects that do not pass through markets and thus a full distributional analysis will require an even more comprehensive analysis. This will inevitably involve impacts that can only be identified or can be identified and quantified in some fashion but not valued in financial or economic terms.

In sum, financial analysis tells project developers whether the project is viable from the perspective of private investors, economic analysis, in particular cost-benefit analysis, assesses whether a project would improve the overall economic welfare (or well-being) of a region or country. Distributional analysis complements financial and economic analysis by evaluating how net financial and economic costs and benefits would be apportioned across different populations or entities directly or indirectly affected by a project. Clearly these types of analyses, when conducted correctly, provide an important information base for choosing between dam projects and alternatives.

The preceding discussion defined the nature and purpose of financial, economic and distributional analysis as background to the ensuing discussion in the paper. A number of conclusions emerging from the presentation are worth emphasising:

- DCF analysis and CBA represent just one type of financial and economic analysis, respectively, and are oriented exclusively towards estimates of private and social profitability
- In addition to their use in estimating financial and economic profitability (DCF and CBA), financial and economic analysis may be used for many purposes including viability of project cash flows, financial and economic affordability, determination of the distribution of the wider economic impacts of projects and the valuation of direct project impacts.
- Distributional impacts have both financial and economic dimensions with the economic valuation of distributional impacts providing the more robust indication of changes in individual or group welfare
- Distributional analysis should include but not be limited to financial and economic analyses (both CBA and economic impact analysis) of the gains and losses experienced by affected and interested parties as many of the impacts will not be valued in the context of project evaluation.

1.2 Objectives and Approach

The overall objective of the paper is to contribute recommendations on financial, economic and distributional analysis for consideration in the derivation of principles, criteria and guidelines for options assessment and the evaluation of dam projects by the World Commission on Dams. The paper is not intended as an all-inclusive treatment nor a “handbook” on dam project evaluation issues; instead it focuses on key controversies surrounding financial, economic and distributional analysis in the dams context.
As indicated in more detail in the Foreword, this paper is one of a number of complementary inputs to the Commission’s deliberations and is not, and was never intended to be, a review of the economic costs and benefits of dams. As such the paper confines itself to an examination of the methodologies for economic, financial and distributional analysis. However, in making recommendations for the future it is important to consider the efficacy of actual practice. As a means to this end the paper examines how ex ante (prior to the project) projections of the costs and benefits of dam projects compare to the results actually achieved. This analysis of projected versus actual performance is a distinct process to that of comparing the actual costs and benefits of dam projects with a view towards assessing their development effectiveness.

The paper therefore has the following specific objectives

- to examine historical practice and its effectiveness when viewed from today’s context
- to document current good practice, agency guidelines, and innovative practice in order to identify areas where current practice could be improved
- to assess the adequacy of various economic tools for addressing the key controversies in the analysis of dam projects, including an assessment of their strengths, weaknesses and limitations
- to provide examples that illustrate the different types of methods that have been used in the past and are available today.
- to assess the role of process issues such as performance incentives, participation, information disclosure and accountability in today’s context

For ease of access the paper has been structured as an issues paper and treats each of the issues in sequence (as outlined in the next sub-section). In order to address the objectives listed above the following set of sub-headings is used to gather together available information for each issue. These sub-headings and the sources of data (in parenthesis) are listed below:

- historical and actual practice with regard to financial, economic and distributional analysis (using the WCD Survey of Multilateral Development Bank Practice);
- the performance of these methods in predicting project costs and benefits (drawing on WCD Case Studies and project evaluation literature);
- current good practice of funding agencies dam evaluation in the late 1990s (using examples from recent dam evaluation studies);
- current guidelines of funding agencies (using guidelines of multilateral institutions and countries – particularly those of the World Bank, the Asian Development Bank and the Principles & Guidelines for Federal water projects in the USA);
- innovative practice (from recent books, articles and grey literature);
- comparative analysis of practices; and
- summary of findings and recommendations for future practice

Practice as referred to above includes reference to both methods and the process of applying these methods. Secondary literature and submissions made to the WCD and to the WCD Web Conference on Financial, Economic and Distributional Analysis are employed throughout the paper to bring in a wide range of experiences and perspectives. In order that the text focus on the issues, only brief overviews of available methods are provided in the main body of the paper. A Technical Annex provides details and examples of the methodologies that are summarised in the main body of the report. Short reference lists in the Technical Annexes provide interested readers with additional sources of detail on methodologies and case study applications.

### 1.3 Issues and Outline of the Paper

In this paper much of the emphasis is on issues related to economic analysis as compared to financial analysis. This is primarily due to the controversial situation in which economic analysis finds itself as opposed financial analysis. This is a result of two factors. In methodological terms the power of DCF is in the degree of detail and specificity with which inputs and outputs are valued, discount rates are
calculated and risk analyses undertaken. The general methods for DCF are presented in textbooks and taught in business schools and finance departments. It is in the adaptation and application of these methods to the particular characteristics of the firm and the data and models held by the firm that generates the DCFs governing firm investment. Thus, the general approaches for DCF are well known and the specific applications of these methods in particular firms are proprietary by nature (as otherwise industry analysts could replicate firm/project valuations exactly.)

This leads to the second point which is that the exact application of DCF by a firm in valuing its own business and its future opportunities in order to make capital budgeting decisions is a closed process and is not subject to regulation. How a firm accounts for profits, etc. is regulated, but the methods the firm uses to evaluate different investment options are not regulated, nor indeed would this be feasible. Thus, the use of DCF is an area largely outside the purview of public policy. Instead policy focuses on regulating the actions that firms can take and in this manner affects the types and quantities of inputs and outputs that enter the valuation process.

Still from a policy-making perspective it is often important to understand the mechanics of DCF and other elements of financial analysis. For instance, there are cases where public agencies will want to know more or less how profitable a particular activity is to the private sector for the purposes of negotiating contracts, establishing tariffs, etc. The main point here however is that the agency will want to know how the firm sees its own interest using its own existing suite of methods and data and not how the firm should see its incentives were the best available methods employed. Thus, only a knowledge of actual practice is necessary and, again, as suggested above the ability for an external analyst to undertake such an analysis will necessarily be limited due to the proprietary nature of firm methods and data.

In comparison to the case of DCF and financial analysis it is clear that there are a host of outstanding and divisive issues in the realm of economic analysis, and not just with CBA. This is only natural due to the nature of the exercise. For example, CBA by its very nature purports to establish the overall profitability of a project to society. The complexity of the undertaking far exceeds that of assessing the profitability of a narrow set of financial expenditures and revenues to the firm. Second, the presupposition that economic analysis examines the benefits, costs and impacts on society as a whole implies that a larger range of societal actors will have an interest and a stake in the outcome of such an analysis.

While financial, economic and distributional analysis can provide useful information to decision-makers, it has its limitations and weaknesses, a number of which may be inherent to the approach and others which are a result of the manner in which it is applied in practice. For the purposes of this paper the topic areas can be grouped according to whether they concern questions regarding:

- economic valuation methods for evaluating project costs and benefits
- issues of discounting, risk and uncertainty that arise from the long-time periods over which these costs and benefits accrue
- methods for evaluating and macroeconomic and regional economic impacts
- methods and issues related to the analysis of distributional impacts
- decision-making frameworks for project evaluation and options assessment

The key areas identified by WCD for discussion are presented below, highlighting the questions involved and indicating the section of the paper in which the topic is addressed.

**Economic Valuation of Project Costs, Benefits and Impacts.** Past economic assessments of dam projects have been criticised for underestimating costs, over-estimating direct benefits and failing to include environmental and social impacts into the CBA framework. An indicative typology of these costs, benefits and impact is provided in Table 1.1. Chapters 2, 3 and 4 take each of these topics in
turn to derive findings and recommendations for improving actual practice. The key questions here are

- To what extent can economic analysis take into account the many and varied costs and benefits that result from dam projects (e.g., environmental and social impacts)?

Table 1.1. Indicative Costs, Benefits and External Impacts of Dam Projects

| Direct Costs                  | Capital costs of construction |
|                              | Resettlement costs            |
|                              | Environmental mitigation      |
|                              | Operating and maintenance costs|
|                              | Future decommissioning costs  |

| Direct Benefits               | Power                        |
|                              | Irrigation                   |
|                              | Municipal and industrial water supply |
|                              | Flood control                |
|                              | Navigation                   |
|                              | Recreation and fisheries     |
|                              | Mine tailings storage*       |

| External Impacts: Environmental, Social and Health Costs, Benefits and Impacts (+ or -) | Water quality impacts |
|                                                                                     | Impacts on commercial and non-commercial (subsistence) agriculture, timber, wildlife, and fisheries |
|                                                                                     | Impacts on ecosystem and biodiversity |
|                                                                                     | Impacts on emissions of pollutants |
|                                                                                     | Impacts on water-borne disease risks |
|                                                                                     | Social impacts including impacts on cultural/historic sites, cultural identity, social cohesion, access to social services, etc. |

Valuing Dam Project Impacts Over Time and Under Uncertainty. Dams have long project lives, which requires that assessment procedures be able to evaluate costs and benefits occurring at differing points in the future. Discounting of these flows is widely used to convert future impacts to present day values, but there exists a variety of perspectives on how best to apply this technique. Further, lack of certainty regarding project costs and benefits typically increases over time and thus the analysis of risk associated with the costs and benefits of dams will be particularly important. Finally, the uncertainty and irreversibility associated with large dams, both in terms of capital investment and the resulting social and environmental impacts require careful consideration.

Chapter 5 describes issues involved in discounting dam project costs and benefits and examines the controversial relationship between discounting and sustainability. Chapter 6 examines the methods and procedures that can be used to assess the risk associated with dam projects. Chapter 7 presents a discussion of the manner in which the uncertainty and irreversibility associated with large dams is not accounted for through CBA and illustrates emerging thinking and methods in this regard. The key questions here are:

- What discount rate should be used in economic analysis? How should it be derived?
- What types of sensitivity analysis should be required as part of CBA?
- How can uncertainty be better accounted for in the economic analysis of dam projects?
- Given stylised facts about dams how might uncertainty and irreversibility weigh into the decision-making process

Accounting For Regional and Macroeconomic Impacts. Cost-benefit analyses of dam projects do not account for macroeconomic "ripple" effects (i.e., effects in secondary and tertiary markets). Given the economic scale of large dams projects and their potential impacts on society and the economy analysis of these secondary economic impacts may be useful in assessing distributional impacts and effects on key macroeconomic indicators. Chapter 8 describes potential macroeconomic
effects from dam projects in more detail and discusses the extent to which available economic approaches can account for these effects. Key questions addressed are:

- What methods are available for analysis of regional and macroeconomic impacts?
- Should regional and macroeconomic impact analysis be undertaken as part of dam project assessment? When?

**Distributional Impacts.** Cost-benefit analysis typically only assesses the economic efficiency of a project (i.e., net benefits); it does not address who may be paying project costs and who may be reaping the benefits (i.e., project winners and losers). Considerations of distribution and equity, however, can be just as critical as efficiency criterion to decision-makers. Chapter 9 discusses methods that may be used to examine the distribution impacts of large dam projects. Key questions include:

- What contribution can economics make to the debate over equity concerns in dams projects
- Should a distributional analysis be mandatory? For whom and at what stage in options assessment and project evaluation?

**Decision-Making Frameworks.** Historically, decision support systems used in the evaluation of large dams supported by public funds have relied exclusively on economic approaches, in particular CBA and cost-effectiveness analysis. Increasing recognition of the importance of social, environmental, macroeconomic and distributional impacts and consequences of large dams projects raises the issue of whether project-level CBA is the best way to accommodate the multiple objectives and criteria on which these projects are based. Chapter 10 examines existing and alternative decision-making frameworks, addressing a number of questions, including:

- What are the areas in which current CBA falls short as a measure of efficiency?
- What other concerns about CBA are raised and how can they be accommodated by other means?
- How can impacts that cannot be practically valued in economic terms be incorporated in decision-making?
- To what extent is CBA a necessary and sufficient basis for decision-making?
- What is the alternative?

The paper then goes on to a concluding section which summarises what is required in order to integrate participation, transparency and accountability into the process of undertaking financial, economic and distributional analysis?

In addition to the main text of the Thematic Review and the Bibliography, there are five Appendices. Appendix 1 contains a list of the contributing papers commissioned by the WCD as inputs for the FEDA thematic. A full listing of the WCD submissions received for this thematic are presented in Appendix 2. These direct submissions to the WCD Knowledge Base are identified in the citations in the text by denoting them by the name of the person making the submission, the year of the submission and the relevant code and submission number (ecoXXX for submissions and ecowebXXX for web conference submissions). While many of these have been incorporated into the flow of the chapters, further work is required to adequately portray the range and richness of these submissions. Following the submissions, the comments received from reviewers of the previous versions of this paper are included in Appendix 3. The original scoping paper for this thematic appears as Appendix 4 and a summary of the WCD Web-Conference for this thematic is set out in Appendix 5.

The Technical Annexes provide further information and detail on the issues contained in this Thematic Review. The Annexes have their own table of contents and the reader is referred to this source for further information. References to the Annexes are made at appropriate points in the course of the chapters in the main body of the paper.
2. Valuation of Direct Costs

This chapter presents a brief overview of the direct costs of dams and highlights issues of policy or methodological significance in this regard. As with any other large infrastructure project large dams involve the commitment of significant resources to the planning and construction phase. The investment required entails the deployment of financial capital, physical capital, technology and human resources.

To varying degrees, large dams also result in changes to social and natural capital, which, when having negative impacts, represent another category of economic costs of dams. An example is resettlement of peoples inhabiting the area to be flooded by a reservoir. Over time resettlement has changed from an afterthought in project planning to an integral element of the planning and budgeting process for dam projects. Resettlement has thus moved from being an economic consequence of dams – where displaced persons experiencing a loss in welfare were provided with no monetary compensation – to one where these costs are increasingly internalised in the budget of dam projects. Similarly, efforts to mitigate environmental damages that would be caused by dams are increasingly being built into the project planning cycle or incorporated when operations are re-evaluated or relicensed. As resettlement and environmental mitigation efforts increasingly represent direct costs to project owners they are included in the discussion below.

There are of course other social and environmental costs (and benefits) associated with dam projects. However, the effort made here is to distinguish between those costs (and benefits) that have been and currently are incurred by project owners as part of the investment and operations and those that remain external to the owner’s perspective. The latter are external to the financial process of decision-making (therefore the term “externalities”). The methods for the evaluation of changes in economic welfare associated with these social and environmental impacts are documented in Chapter 4. Note that simply because a given cost, such as resettlement, is internalised in project budgeting does not imply that the resulting budget figure accurately portrays the change in welfare (or marginal opportunity cost to society) experienced by those affected.

In this sense, common practice in including the financial costs of such measures into the economic analysis implicitly suggests that these figures are a proxy for the economic damages that would be occasioned by the project (absent mitigation). In actuality, mitigation measures represent an effort to nullify a project impact. This is a distinct process from that of assessing the costs and benefits of different mitigation measures with a view towards choosing an efficient mitigation option. Further, there is no guarantee that mitigation measures approximate the actual economic losses that would occur if the project were to proceed without such measures. Mitigation costs may be much less or much more than economic losses. By implication mitigation costs that are underestimates are a poor substitute for economic valuation of social and environmental impacts. Mitigation costs that exceed the economic losses are a poor substitute for direct compensation of those affected.

This discussion highlights an important distinction between financial and economic analysis and the difference between a methodological approach based on valuation and a regulatory approach based on internalisation. As this bears on the manner in which the full costs and benefits of projects are incorporated into the evaluation process, the paper returns to the issue of mitigation and associated costs in Chapter 10.

The discussion begins, then, with a consideration of construction, resettlement and environmental mitigation costs and then briefly covers operations and maintenance costs. In the re-evaluation of operations an important methodological issue is the treatment of sunk costs. Decommissioning costs are also an increasing topic of conversation and are discussed at the end of the section.
2.1 Construction

The major contributor to the present value of a dam project’s total direct costs is, invariably, the cost of its construction, and the construction or installation of associated canals, turbines, transmission lines etc. Many of the costs depend on the unique physical characteristics of the site and the project configuration and thus only limited generalisation is possible about the investment costs of dams. For example, Head (1999) suggests a cost breakdown of a typical hydroelectric project will be:

- civil works: 60-70%
- equipment: 25-35%
- engineering: 5-10%

In most low-income developing countries where dams are constructed by foreign contractors with foreign plant and imported fuel, etc. (e.g. Uganda or Laos), local costs probably don’t amount to more than 50% of civil works costs. On the other hand, in middle income countries with their own sophisticated construction industry, (e.g., Brazil), most civil works costs are local. For budgeting purposes then many projects divide investment costs into local currency and foreign currency (typically denominated in US dollars) components.

Dam projects may cost from a few million to billions of dollars. Table 2.5 presents the actual investment costs of the WCD Case Studies standardised to 1998 US Dollars. The investment costs of hydropower projects are often expressed in $/KW terms. Head (1999) suggests a range of from $1,000 to $3,000/KW and Ljung (2000) selects a range of from $1,500 to $2,250/KW for estimating financial flows to hydropower.

Guidelines and Actual Practice in Construction Cost Estimation

Derivations of projected investment costs as based on World Bank guidelines is typically undertaken in the following fashion (as cited in Bacon et al. 1996). Design characteristics for the dam are converted into input requirements which are then transformed into quantified schedules and unit cost rates from which the estimated costs (not expected costs which the record, as shown in this Chapter, shows a substantial difference between these values) of construction are derived in constant price terms (usually of the year in which the estimate is made). To this base cost estimate is usually added a physical contingency (typically of 10 to 15%) to cover the costs of items not quantified and the costs of any actual minor changes to the project scope and construction method from those on which the cost estimate is based. A contingency for price inflation is then added over the project construction period to the sum of the base cost and physical contingency that produces an estimate of the construction cost in current price terms (i.e. in terms of the currency of the years in which they will be expended). The sum of base cost and physical contingency in constant price terms is used for the project economic analysis, whilst the sum of base cost, physical and price contingencies in current price terms is used for the project financial analysis. In principle, in order to obtain the economic cost, inputs should be valued using shadow prices and converted to a constant price level (e.g. to 1998 dollars).

The WCD Survey of World Bank appraisal documents shows that only recently have the financial costs of dam projects been converted into economic costs and that this process is often only partial in nature. Many cases particularly in the earlier years up to the 1980s simply remove transfer payments and inflation effects from the project cost estimates. Some shadow pricing was done for labour but it is unclear in other cost items. One exception is the Aslantas project in Turkey which presented a relatively comprehensive analysis in the Staff Appraisal Report (SAR) of 1973. In the 1990s projects, there was evidence that financial flows were adjusted for input and output distortions, transfer payments, shadow exchange rates, and shadow wage rate. The review of Asian Development Bank (ADB) appraisals reveals a similar pattern of limited removal of transfer payments, with occasional
efforts to make further economic adjustments such as employing the opportunity cost of labour for the wage rate.

In the case of the Ghazi-Barotha project (Pakistan 1995), it is not clear whether conversion of financial costs to economic costs was done correctly as an adjustment was noted only for local costs being converted to border prices using a standard conversion factor. There was no distinction between traded and non-traded components. This reflects the convention in practice of applying a standard conversion factor (SCF) to local costs in order to obtain border prices in economic terms (Jenkins 1997). This practice has been accepted as a workable compromise when the evaluation numeraire is free foreign exchange in the hands of the government – in other words the opportunity cost of local inputs, except for capital, is public investment. This approach assumes that shadow conversion factors for key local inputs do not vary substantially around the SCF. This assumption has become the consensus presumption with increasing use of this approach.

In addition, (most) project economists realised that too much detail in the evaluation produced spurious accuracy in the presence of substantial uncertainty about estimates of costs and benefits that overwhelm any gains in precision from strict adherence to shadow pricing). The pendulum on this issue appears to be swinging back with the rising concern about poverty alleviation, which implies that the distributional effects of investments – which income groups reap most of the benefits and which ones suffer most of the costs – are important. The use of an SCF has the disadvantage of obscuring the distributional impacts of a project on specific inputs, particularly labour.

2.2 Resettlement

The flooding of a reservoir may involve the dislocation of communities and livelihood opportunities. For example of the 26 Asian Development Bank projects reviewed two-thirds involved displacement. No water supply projects involved resettlement.

Whereas before, project design did not provide for the relocation of displaced persons, in recent years compensation and resettlement programs have increasingly become an integral project component. For example, in the Asian Development Bank’s Hunan Lijin project (ADB Report and Recommendation of the President (RRP) 1994), the resettlement program which gave equal importance to income restoration and physical relocation, was considered a development challenge rather than a burden on project resources and the State. In another recent project in China – Zhejiang-Shanxi Water Supply Project (Phase I), (ADB RRP, 1997) – the ADB has required extensive monitoring of the resettlement and the resettled groups for three years after the resettlement program has been completed. International advisors on resettlement are to be engaged by the borrower to assist those resettled to regain their pre-Project standards of living. In addition to, or in place of, resettlement costs, compensation for affected parties are also being internalised in project budgets. This is the case in Kenya where government policy dictates that compensatory measures be limited to cash payments connected with land acquisition (Kenya-Third Nairobi Water Supply Project World Bank SAR 1989).

A study of hydropower projects built in the 1980s found that resettlement costs were usually larger than estimated during project design (Gutman, 1993). Cost overruns on resettlement components were large, averaging 40%, and were considerably larger than overall cost overruns. At the time, since these costs were usually a minor proportion of the total costs (i.e. below 10%) the projects usually could withstand these cost increases and still be profitable at appraisal. On the other hand when resettlement costs were high at the beginning of the project (over 10% of the estimated costs) significant cost overruns may jeopardise the project rate of return, and a more careful cost estimation at the assessment stage is necessary. For the Zhejiang-Shanxi project (ADB RRP 1997), even with resettlement costs accounting for 23% of total funding requirements, the project was estimated to generate an economic rate of return of 15.5% at appraisal. In the 1996 OED study of 50 dam projects, it was found that doubling resettlement expenditures would not change the economic assessment of any project. On the other hand if a threshold is established whereby “a major negative impact in the
environment or the local population is considered unacceptable” a good 25% of the projects would have been considered unacceptable (OED 1996a). A further example of the size of resettlement costs relative to total project budget is provided in Box 2.1 below.

Box 2.1. Example of Resettlement Costs as Component of Mitigation Costs, Xiaolangdi Dam, China

The Government of China with the Yellow River Water and Hydropower Development Corporation as project developers is building the Xiaolangdi hydroelectric project. Construction is slated to be completed in 2002. The project is designed to have a dam 154 meters high with an installed capacity of 1,800 MW and a reservoir that will extend 128 km upstream. The mitigation measures that have been considered are the resettlement of 181,000 people, an archaeological salvage program, and a public health mitigation program. The cost of the mitigation measures described are roughly 25% of the total project cost, with the resettlement operations representing approximately 93% of that total. (Mahoney 1999 env182)

2.3 Environmental Mitigation

Often times, when the environmental impacts of a dam project cannot be avoided there is an attempt to mitigate or compensate affected people. Several tools are available for environmental mitigation, and they vary from site to site and according to the type of impact being addressed (for further information on the effectiveness of environmental mitigation see Chapter 5 in the WCD Thematic Review II.1 Dams, Ecosystem Functions and Environmental Restoration). Examples of tools that have been used for these purposes are fish passage facilities, instream flow requirements, and habitat restoration.

As the mitigation measures can be implemented at varying times throughout the life of a project, the costs will be allocated according to the phase of the project cycle in which they are incurred. Therefore such costs could be accounted as study, capital, operation and maintenance (O&M), or opportunity costs.

2.3.1 Environmental Mitigation as a Study Cost

Study costs are those incurred when doing the background analysis and design of a mitigation measure. The project cycle phases of Options Assessment, Feasibility, and Design are where many of the study costs are allocated. For example, the Environmental Impact Assessment (EIA) is one such type of study. In the specific case of mitigation measures, study costs can be incurred in drawing up mitigation plans during the feasibility phase of a project. Similarly, pre-impoundment biological inventories of the area to be flooded are accounted for as study costs. Study costs can be part of any of the phases of the project cycle. For example, there are several studies on environmental mitigation that must be done when evaluating the possibility of dam decommissioning.

The study costs of a project can be high. For example, in 1991, the US Department of Energy conducted a study on the environmental mitigation at non-federal hydropower projects. It focused on four environmental mitigation measures: upstream and downstream fish passage, dissolved oxygen, and instream flows. Information on specific mitigation practices was obtained from 280 projects, more than 40% of all projects licensed during the 1980s that were identified a priori as having the mitigation requirements of interest. Environmental mitigation costs were estimated based on information provided by the hydropower developers. Because of the large ranges for mitigation costs, they are represented by power capacity categories. For all project class sizes except those >100 MW, study costs was the second highest cost after capital costs (see Table 2.1).
Table 2.1. Average Cost of Environmental Mitigation Measures by Size of Hydropower Project and Type of Expenditure, Non-Federal Hydropower Projects, USA

<table>
<thead>
<tr>
<th>Project Size Class (installed capacity)</th>
<th>Capital</th>
<th>Type of Cost (US$ 1991)</th>
<th>Study</th>
<th>O&amp;M</th>
<th>Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 MW</td>
<td>$134,500</td>
<td>$21,700</td>
<td>$5,124</td>
<td>$5,900</td>
<td></td>
</tr>
<tr>
<td>1-10 MW</td>
<td>$233,900</td>
<td>$153,200</td>
<td>$25,420</td>
<td>$11,800</td>
<td></td>
</tr>
<tr>
<td>10-50 MW</td>
<td>$1,511,300</td>
<td>$452,800</td>
<td>$33,000</td>
<td>$31,200</td>
<td></td>
</tr>
<tr>
<td>50-100 MW</td>
<td>$1,266,200</td>
<td>$1,084,000</td>
<td>$9,600</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>&gt;100 MW</td>
<td>$50,569,000</td>
<td>$307,000</td>
<td>$1,439,400</td>
<td>$176,700</td>
<td></td>
</tr>
</tbody>
</table>

Note: The mitigation measures included in the costs analysis are four: upstream and downstream fish passage, dissolved oxygen, and instream flows.
Source: Sale et al. (1991)

In the following figure the costs are allocated by cost type and are presented as percentage of the total average cost for the sum of the four mitigation measures. This demonstrates that capital costs of mitigation make up the bulk of mitigation costs, followed by study costs. O&M and reporting mitigation costs are only a small fraction of total mitigation costs.

Figure 2.1. Mitigation Cost as a Percent of Total Mitigation Costs

2.3.2 Environmental Mitigation as a Capital Cost

Environmental mitigation costs may form part of the up-front investment for the project, usually incurred during the construction phase of the project cycle. Capital costs for environmental mitigation include, for example, the construction of fish ladders and other types of fish passage systems. Structural modifications as in the case of variable-level water intakes or preventive measures such as silt traps during construction can also be considered capital costs.

Mitigating environmental impacts can have important implications for the overall capital investment. Two examples of capital costs incurred for the purpose of environmental mitigation at dam projects are given below.

Skuifraam Dam, South Africa

Investigations into the building of the Skuifraam Dam in the Western Cape province have been ongoing since 1985. Integral to the investigations is the estimation of instream flow requirements (IFR) in order to size and design associated outlet works. Depending on the volume of instream flow...
chosen, the outlet work will have to meet different requirements and therefore have different costs. The costs associated with the various alternatives of outlet design, given in the table below, are considerable.

Table 2.2. Capital Cost of Environmental Mitigation, Skuifraam Dam, South Africa

<table>
<thead>
<tr>
<th>Purpose of Outlet</th>
<th>Required Flow Capacity of Outlet (m³s⁻¹)</th>
<th>Cost as Percentage of Total Dam Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam Safety Purposes</td>
<td>30</td>
<td>11%</td>
</tr>
<tr>
<td>Current Design for Larger Releases</td>
<td>70</td>
<td>13%</td>
</tr>
<tr>
<td>Required IFR Releases for the Ecosystems</td>
<td>160</td>
<td>20%</td>
</tr>
</tbody>
</table>

As can be noted, the lowest cost for the outlet works is that with the lowest water flow. It meets the requirements for dam safety but not for ecological purposes. If the largest IFR option is chosen, construction costs would be much higher. One of the suggestions to try and resolve the issue of which is the best and most feasible alternative was to hire an independent consultant who could link the views of conservation and water resources management. This would allow the assessment of the integrity of concerns and practicality of mitigation with a justified recommendation on peak outlet capacity requirements. (Fick 1999 env199)

**Bokaa Dam, Botswana**

This 30-m dam was completed in 1994 for the Government of Botswana. It has an impoundment area of 660 ha at full supply level and 1,100 ha at full flood level. Although there was no environmental legislation in Botswana at the time, a full environmental impact assessment was carried out in 1988. The overall cost of the project was roughly £23-£25 million while the cost of the environmental and social components was approximately £1 million (or 4%).

One of the environmental impacts of the dam operations was that the constant reservoir draw down would affect the shoreline habitat. It could also pose a risk to animals trying to access the reservoir for drinking water. As a mitigation and compensation measure, two subsidiary small dams were proposed as watering for cattle and wildlife. This measure had a cost of £250,000 (1% of project cost) and was used to overcome the problems of draw down and to create subsidiary stable lake margins for macrophytes. It also provided a more stable nutrient load than the more heavily worked main reservoir, which is expected to benefit fisheries that use the vegetated margins for spawning. (DFID/Mott Macdonald 2000 env203)

2.3.3 Environmental Mitigation as a Cost of Operations and Maintenance (O&M)

During the operational phase of a dam project, there are environmental mitigation costs. The most evident are those related to monitoring of mitigation measures and maintenance of mitigation structures. Activities like constantly cleaning the fish screens of debris are necessary to maintain the effectiveness of mitigation measures. The study from the US as reported above suggests these costs are marginal compared to capital and study costs in the case of the four mitigation measures investigated. However, this result cannot be generalised as annual expenditures in the Columbia and Snake river systems on transport of juvenile salmon is a significant expense.

2.3.4 Environmental Mitigation as an Opportunity Cost

This type of cost occurs when project benefits are foregone in order to ensure environmental mitigation. An example of an opportunity cost for environmental mitigation purposes is the diversion of water from project purposes to ecosystem conservation. This has happened when creating artificial floods to maintain habitat functions, where all the water flowing downstream can not be used by the project. In this sense, it could be said that the benefits are transferred from the project to the

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
ecosystem and therefore only represent an opportunity cost to humans. Two examples are provided below.

**Glen Canyon Dam, USA**

Floods maintained natural beaches in the Colorado River. By regulating floods, the Glen Canyon Dam has affected the natural beach renewal process. In order to mitigate this impact, natural floods can be recreated. Many variables contribute to the cost of a beach-building flow. But because not all the flood water can be passed through the hydropower turbines, some water that could have been used to generate electricity is lost as an opportunity cost. An estimate of the foregone benefits, in 1994, was approximately $4 million. But because the habitat maintenance flows occur once every five years and the dam produces annual revenues of $140 million, the mitigation measure would represent only half of one percent of the gross receipts from operations of the dam. (Collier et al. 1996).

Opportunity costs can also be incurred during the design of a project, where the maximum expected benefits are reduced in order to minimise the environmental impacts of the project. An example of this type of opportunity cost is given below.

**Animas-La Plata Irrigation Project, USA**

The Animas-La Plata project is an example of accepting a project of lower project benefits in order to reduce downstream impacts. There have been three proposals for the project, and it still has not been funded for construction. The various proposals each have different mitigation packages and project benefits. The more recent the project version, the more comprehensive the mitigation program and the smaller the project size. It should also be noted that the net benefits of the project have also declined over time. A recent analysis of the current proposal suggests that the project is not viable from an economic perspective (USDOI and USBR 1995).

<table>
<thead>
<tr>
<th>Year of Project Proposal</th>
<th>Project Cost (in 1996 US$)</th>
<th>Mitigation Costs as % of Total Costs</th>
<th>Water Storage at Ridges Basin Reservoir (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>$ 715 million</td>
<td>7%</td>
<td>280,000</td>
</tr>
<tr>
<td>1996</td>
<td>$ 686 million</td>
<td>10-12%</td>
<td>270,000</td>
</tr>
<tr>
<td>1999</td>
<td>$ 132 million</td>
<td>N/A</td>
<td>90,000</td>
</tr>
</tbody>
</table>

Source: Mitchell (1999 env187)

### 2.4 Performance of Capital Cost Estimates

The performance of investment projections is one of the more talked about aspects of dam projects. Perhaps the most cited study is that of some 70 World Bank-financed hydropower projects commissioned between 1965 and 1986 (Bacon et al. 1996; Bacon and Besant-Jones 1998), in which costs at completion were on average 27% higher than estimated at appraisal. In comparison, average cost overruns in a sample of 64 thermal power projects was only 6% higher, and in a sample of over 2,000 development projects of all type it was only 11% higher. On the other hand, schedule slips were smaller in hydropower than in other types of projects (see Table 1.1). The World Bank Operations and Evaluation Department 1996 report also calculates cost indicators and selecting out the data for 10 multipurpose dams, average cost overruns came to 39% (OED 1996a).
Table 2.4. Cost Overruns and Schedule Slips in Large Dam Projects

<table>
<thead>
<tr>
<th>Project Group</th>
<th>Sample Size</th>
<th>Cost Overruns</th>
<th>Schedule Slips</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean (%)</td>
<td>SD</td>
</tr>
<tr>
<td>1. World Bank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Development projects</td>
<td>2,000</td>
<td>11</td>
<td>45</td>
</tr>
<tr>
<td>b. Thermal power projects</td>
<td>64</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>c. Hydropower projects</td>
<td>71</td>
<td>27</td>
<td>38</td>
</tr>
<tr>
<td>d. Multipurpose projects</td>
<td>10</td>
<td>39</td>
<td>54</td>
</tr>
<tr>
<td>2. IDB Dam Projects</td>
<td>56</td>
<td>45</td>
<td>64</td>
</tr>
<tr>
<td>a. Hydropower</td>
<td>32</td>
<td>50</td>
<td>64</td>
</tr>
<tr>
<td>b. Irrigation</td>
<td>15</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>c. Multipurpose</td>
<td>8</td>
<td>38</td>
<td>44</td>
</tr>
<tr>
<td>3. ADB Dam Projects</td>
<td>23</td>
<td>16%</td>
<td>66</td>
</tr>
<tr>
<td>a. Hydropower</td>
<td>11</td>
<td>19%</td>
<td>70</td>
</tr>
<tr>
<td>b. Irrigation</td>
<td>4</td>
<td>-31%</td>
<td>27</td>
</tr>
<tr>
<td>c. Multipurpose</td>
<td>5</td>
<td>61%</td>
<td>76</td>
</tr>
<tr>
<td>d. Water Supply</td>
<td>3</td>
<td>-9%</td>
<td>8</td>
</tr>
<tr>
<td>4. AfDB Dam Projects</td>
<td>10</td>
<td>2%</td>
<td>17</td>
</tr>
<tr>
<td>a. Hydropower</td>
<td>6</td>
<td>9%</td>
<td>16</td>
</tr>
<tr>
<td>b. Multipurpose</td>
<td>4</td>
<td>-8%</td>
<td>14</td>
</tr>
<tr>
<td>5. IRN List</td>
<td>14</td>
<td>247%</td>
<td>162</td>
</tr>
</tbody>
</table>

Notes: SD: standard deviation

Source: 1a. Bacon et al (1996); 1b and 1c Bacon and Besant-Jones (1998); 1d OED (1996); 2 Inter-American Development Bank; 3 Lagman (2000); 4 African Development Bank (1998); 5 McCully (1999 eco061)

Other estimates of cost performance have been gathered or submitted as part of the WCD process, although these have not been subjected to as rigorous an analysis and review as those of the World Bank sample. The Inter-American Development Bank has reviewed its portfolio of dam projects from 1960 to 1999 and the results suggest an average cost overrun of 45%. In a similar exercise the WCD has reviewed the portfolio of large dam construction projects financed by the Asian Development Bank between 1968 and 1999 (Lagman, 2000). Of the 23 completed dam projects that fall in this category there is an average cost overrun of 16%. From a review of the African Development Bank’s experience in the financing of dam projects (1998), an average cost overrun of only 2% was calculated for 10 projects. McCully (1999 eco061) submitted a list of dams with cost performance data which shows a 247% overrun for 14 projects; eight projects in India dominated the results in this group with an average overrun of 262%.

The WCD Case Study dams indicate a tendency towards cost overruns as well (see Table 2.5). Of these dams only the earliest hydropower projects: Grand Coulee Dam and Kariba came in under budget. Nevertheless, the Stage 2 components of these two projects came in at 287% and 178% of original costs. Note also that the experience is not limited to very large billion dollar projects as the four smaller, million dollar projects in the Glomma-Lagen Basin reviewed as part of the WCD Case Studies cost some 60 to 185% more than projected. The WCD Crosscheck Survey will provide additional data on cost performance from dams in the WCD Country Study basins in order to “crosscheck” these localised experiences as well as data on a much wider range of experiences from around the world.
### Table 2.5. Projected vs Actual Investment Costs: WCD Case Study Dams

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Coulee Dam – Stage 1</td>
<td>$180</td>
<td>$270</td>
<td>50</td>
<td>2,670</td>
<td>$800†</td>
</tr>
<tr>
<td>Grand Coulee Dam – Stage 2</td>
<td>$390</td>
<td>$730</td>
<td>87</td>
<td>2,930</td>
<td></td>
</tr>
<tr>
<td>Columbia Basin Project</td>
<td>$208</td>
<td>na</td>
<td>189¹</td>
<td>3,600</td>
<td></td>
</tr>
<tr>
<td>Kariba – Stage 1</td>
<td>£80</td>
<td>£78</td>
<td>-3</td>
<td>1,220²</td>
<td>$1,161¹</td>
</tr>
<tr>
<td>Kariba – Stage 2</td>
<td>$55</td>
<td>$147</td>
<td>178</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>Norway – Fundin</td>
<td>NOK6</td>
<td>NOK9.6</td>
<td>60</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Norway – Raudalsvatn</td>
<td>NOK3</td>
<td>NOK5.1</td>
<td>70</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Norway – Olstappen</td>
<td>NOK2</td>
<td>NOK5.7</td>
<td>185</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Norway – Mjosa</td>
<td>NOK11</td>
<td>NOK19</td>
<td>73</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Tarbela - Stage 1</td>
<td>$828</td>
<td>$1497</td>
<td>81¹</td>
<td>8,800</td>
<td></td>
</tr>
<tr>
<td>Aslantas</td>
<td>$327</td>
<td>$447</td>
<td>37</td>
<td>1,300</td>
<td></td>
</tr>
<tr>
<td>Tucurui – Stage 1</td>
<td>$4,254</td>
<td>$7,513</td>
<td>77¹</td>
<td>5,500</td>
<td>$1,383</td>
</tr>
<tr>
<td>Tucurui – Stage 2</td>
<td>R$1,350</td>
<td>Underway</td>
<td>-</td>
<td>1,230²</td>
<td></td>
</tr>
<tr>
<td>Pak Mun</td>
<td>$155</td>
<td>$260</td>
<td>68</td>
<td>285</td>
<td>$1,739</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>14</strong></td>
<td><strong>Average</strong></td>
<td><strong>SD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Case Studies</td>
<td></td>
<td>89%</td>
<td>59%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydropower (HEP)</td>
<td>11</td>
<td>85%</td>
<td>57%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-purpose (MP)</td>
<td>2</td>
<td>102%</td>
<td>78%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation (IRR)</td>
<td>1</td>
<td>189%</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: WCD Case Studies Circulation Drafts. Conversions to $1998 based on IMF exchange rates and US CPI.

Notes: ¹CBP projected costs were spread over 60 years and thus the figure shown is a comparison of constant dollar figures not current dollar figures. ²Figures converted based on conversion factor for year of completion. ³Projected costs. ⁴Figures for two stage projects are calculated using total cost and total MWs.

#### 2.4.1 Causes of Cost Variations

Many different reasons exist for the occurrence of cost overruns. Bacon et al. (1996) group these into three categories: (1) poor development of estimates and supervision by sponsors, (2) poor implementation by suppliers and contractors and (3) changes in external conditions (economic and regulatory). Part of the difficulty in developing accurate projections for construction costs of large dams is that the geotechnical conditions at a site (in terms of the quality of the rock for the foundations of the major structure and for tunnels, and of the quality of the construction materials) cannot be determined precisely until construction is underway. Discovery during construction of less favourable site conditions than those assumed in the engineering designs and construction plans can lead to, sometimes large, cost overruns. Construction problems encountered also often result in delays in project commissioning. Among other factors that can lead to commissioning delays are lateness in delivery of essential equipment, unrealistic construction schedules, contractor and construction management inefficiencies, labour unrest, and protests and legal challenges by affected groups. Commissioning delays lead directly to increases in interest accumulated on funds borrowed for construction activities, and to delays in revenues accruing to the owner from the completed project.

The samples cited above also include a number of projects that have cost underruns as well as cost overruns. For example in the ADB dataset 16 projects had cost underruns and the average underrun was 16%. Considering then that both overruns and underruns occur the proximate causes of divergence from projected costs (whether as underruns or overruns) are:

- schedule slip
- divergence of actual inflation rate from projected inflation for project inputs
- changes in project components (inclusion/exclusion of projected components)
- change in design of dam (due to technical, social, environmental, etc reasons)
- geotechnical variations
natural disasters and civil disturbance

A number of examples of these that emerge from the Asian Development Bank dams surveyed above include:

- Huai Mae On dam in Thailand had a cost underrun of 51.6% partly due to a lowering of the dam by 2 meters.
- Batang Ai in Malaysia had a cost underrun of 20% with a prime cause being keen international competition for the buyer’s contract.
- Andong dam in Korea had a cost overrun of 40% in large part attributable to civil works, turbines and resettlement costs.
- Samrangjin dam in Korea had a cost underrun of 31% in part attributable to a change in type of dam (from concrete face rockfill type to a clay core rockfill type) and modifications in the layout of water conveyance systems.

Many different factors will of course affect a particular project leading to the overall effect on cost performance. The components of the cost overrun for Kariba – Stage 2 are documented below. What does not appear in such a table is that Stage 2 was built at a time when the Federation between present day Zambia and Zimbabwe was dissolving and Zimbabwe was entering into a protracted internal struggle following the Unilateral Declaration of Independence by the Rhodesian government.

<table>
<thead>
<tr>
<th>Component of Overrun</th>
<th>Million US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in civil contractor</td>
<td>20.8</td>
</tr>
<tr>
<td>Price escalation</td>
<td>23.8</td>
</tr>
<tr>
<td>Interest during construction</td>
<td>8.7</td>
</tr>
<tr>
<td>Rerouting and delays</td>
<td>9.0</td>
</tr>
<tr>
<td>Changes in exchange rates</td>
<td>17.5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4.6</td>
</tr>
<tr>
<td>Total</td>
<td>84.4</td>
</tr>
</tbody>
</table>

Source: Kariba Case Study

Bacon and Besant-Jones (1998) conducted an econometric investigation of the factors that determined cost overruns in the World Bank dataset of hydropower projects. The study found that half the hydropower cost variations could be explained by the dam technical characteristics, the size of the project (curiously the larger the project, the smaller was the percentage of cost overruns) and economic factors (like price inflation). The other half of the cost variations could not be systematically explained and is therefore attributed to uncertainty. Regarding how to reduce the difference between actual construction costs and estimates of construction costs at project appraisal, the study points out the problem that the sample exhibits a large variance (see Table 2.1 for examples), and hence the simple expedient of multiplying the estimated cost by an adjustment factor to overcome bias in cost estimating will not significantly improve the reliability of cost estimates. The study concludes that more sophisticated methods of estimation are required, based on straightforward applications of probability distributions of construction costs for this class of projects. However, even these approaches do not eliminate a substantial residual uncertainty about the reliability of estimates for the cost of large dam projects.

In terms of implementation experience, a 1995 report of the ADB that synthesised post-evaluation findings in the irrigation and rural development sector found that all except two programs and one project, experienced delays averaging at 3 years of about 80% of the estimated implementation period (ADB 1995). Irrigation projects had an average time overrun of 3.7 years, mainly due to the following: (i) implementation delays arising from shortage of counterpart funds, institutional deficiencies including poor co-ordination among executing/implementing agencies, and land acquisition and procurement difficulties; (ii) optimistic assumptions of implementation period made at appraisal; (iii) repairs and remedial works; (iv) changes in scope and design; (v) lack of farmer
participation during implementation; and (vi) other external factors such as civil disturbances, political instability, inadequate capability of local contractors, and shortage of local supplies and materials.

About half of the projects in the irrigation and rural development sub-sectors experienced major changes in their original designs and scopes during implementation. These changes were largely the result of inadequate planning; paucity of geographical, topographical, and hydrological data; and lack of understanding of the sociocultural ethos and practices of the local communities (ADB 1995).

2.4.2 Implications of Cost Overruns

The potential implication of persistent cost overruns would be the loss of economic justification of the project (Bacon et al. 1996). In a couple of studies the post-construction costs and benefits estimates have been taken into account and the projects economic viability re-assessed:

- The 1996 OED post-construction reassessment of cost and benefits of 50 dam projects, found that 5 of the projects (10%) would be economically unjustified by the new figures (at a 10% discount rate).
- Another study of 32 hydropower projects completed between 1984 and 1992 found that after construction cost overruns the rate of return fell below 8% in one third of them (Gutman 1993). For this reason it is important to adequately account for the likelihood of these overruns in project appraisal, particularly in terms of a sensitivity analysis of the susceptibility of project viability to overruns in the range experienced to date.

Projections of costs that are unreliable (whether in a positive or negative direction) will also affect efforts to determine tariff levels. For example, overruns may lead to underpricing and increase the likelihood of poor project cost recovery (Bacon et al. 1996). A further impact of overruns is the need to obtain additional financing to cover additional costs and the burden this may place on the utility, government or developer (Bacon et al. 1996)

A number of lessons learned and recommendations emerging from ADB’s experience with cost overruns are as follows:

- ADB study on Social and Environmental Impacts of Hydropower Projects: develop and implement formal procedural requirements to address significant changes in project design between the loan approval and completion of construction; Improve procedures and scheduling of the consultative process to make it more transparent and to allow adequate opportunities for comprehensive responses for comments received from outsiders (ADB 1999b).
- The ADB’s irrigation sector study suggests that the long gestation period required for irrigation and rural development projects to yield their full potential warrants a design mode that favors the adoption of a process approach which enhances opportunities for phased implementation and improvement of performance (ADB 1995).
- An ADB (1994) post-evaluation study on water supply and sanitation suggests that water supply system costs should lie within the capacity of the water district community to pay. Also, with the availability of computer-based analytical techniques, the financial and social impact of overdesign on small low-income communities can be prevented.

2.5 Operations and Maintenance

Operations and maintenance (O&M) costs of large dams projects are typically not treated as a contentious issue. For hydropower projects these annual expenditures are sometimes simply projected at anywhere from 1-3% of capital costs. However, according to a study of several hundred North American dams, hydropower dam operating costs, on average, rise significantly about 25-35 years

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into operation due to increasing repair costs (Wong 1994). For irrigation projects these O&M costs may be more expensive given the need to maintain the infrastructure associated not with the dam but rather the delivery of water to farmers. A 1995 ADB irrigation sector study noted the importance of effective O&M of facilities for ensuring sustainability of operations and benefits. Adequate and sufficient O&M of the facilities became difficult in many projects because of poor cost recovery. Often direct project revenues (irrigation fees etc) are not earmarked for the O&M. Howe and Dixon (1993 eco062) note that, especially in the case of irrigation, user fees, which can be set to cover O&M, provide incentive for users to demand good performance. The institutional setting though must allow for determining accountability for the O&M.

The WCD Case Studies provide fairly detailed investigation of the projected and actual costs of O&M costs for a small number of hydropower, irrigation, multipurpose dams. Projections of O&M costs often underestimated what the costs would be in the initial phase of operation. In some cases, problems arose in the initial stages of operation, which diverted funds from O&M to special repairs. Thus actual O&M costs were higher than projected. For the Tarbela multipurpose project in Pakistan, actual O&M costs were roughly 1% of capital costs and 212% of projected O&M costs after five years. After fifteen years O&M costs were still only 2.6% of capital costs, but had risen to over 500% of projected O&M costs. This suggests that the study design simply assumed constant O&M costs. There may be a need to ensure that an allowance is built in to O&M cost projections for real increasing costs over time. Further work may be necessary to assess the factors that underpin these changes as a means to providing rules of thumb for making such projections.

O&M costs are not always clearly separated in project accounting from other annual costs such as interest payments on capital. This pushed apparent actual O&M costs up to 5-7% of capital costs in some of the WCD Case Study Circulation drafts. A different example emerges from the Aslantas Case Study. Considering the multi-purpose project as a whole, the realised O&M expenditures appear to have been lower than expected.

### 2.6 Sunk Costs

A sunk cost is a cost that has already occurred (or been irrevocably committed) and cannot be avoided by future decisions. It should not be included in the appraisal of a dam project. Sunk costs typically become a controversial issue in cases where a decision about a dam is being revisited. For example, new information about the costs or benefits of a proposed dam project may result in the reconsideration of the project years into the planning or early construction phases. Alternatively, dam owners/operators may be seeking a new license for an existing dam.

Expenditures that have created financial obligations for the future should not be used to justify continuing a project that is being reconsidered. The decision should be evaluated based on the costs and the benefits of the project going forward. Any debt from planning, assessment, or construction costs will be owed whether or not the dam project continues to go forward; the debt is not relevant to the decision on the project. The relevant question is whether future costs that would be incurred if the project is undertaken (or relicensed) are expected to be lower than future benefits.
Box 2.2. Incorrect Treatment of Sunk Costs: the Tennessee-Tombigbee Waterway

The Tennessee-Tombigbee Waterway project was intended to provide a shorter route than the Mississippi River for coal travelling from the Midwest of the United States to the Gulf of Mexico. The U.S. Army Corps of Engineers first provided $323 million in funds for the project in 1971 when the benefit-to-cost ratio was estimated at 1.6 to 1. By 1976, the ratio had dropped to 1.08 to 1, and costs leapt to $1 billion by 1981. In addition, the U.S. General Accounting Office noted a further $960 million in costs not recognised in the projects cost-benefit analysis that would be necessary to straighten and widen the canal.

Despite the higher costs, which made the net benefits of the project negative, the U.S. Congress voted in 1981 to continue with the project on the grounds that construction work on the canal had proceeded too far to put an end to the project. The sunk costs of the project should not have been used to justify continued funding. From an economic standpoint, the appropriate decision would have been to cancel the project as its forward-looking costs significantly outweighed expected project benefits.


2.7 Decommissioning

Dam decommissioning occurs at the end of a project’s lifetime and is defined as anything from ceasing to produce electricity to removing the dam and taking measures to restore the river to its pre-dam state (see Box 2.3). Decommissioning may be necessary due to safety concerns or because dam owners no longer view the dam as profitable to operate. For example, owners of a hydropower dam may decide to disconnect their dam from the power grid and discontinue power generation if dam maintenance or repair costs exceed expected power revenues. As noted above evidence from North American dams shows that hydropower dam operating costs rise significantly about 25-35 years into operation. Likewise, owners of multi-purpose or non-hydropower dams must weigh maintenance costs as well as the costs associated with the loss of storage capacity due to sediment against the revenue generated from providing water supply, navigation, or recreation.

Box 2.3. Decommissioning the Elwha and Glines Canyon Dams

The 30-meter Elwha and 70-meter Glines Canyon dams on the Elwha River in Washington State were built 80-90 years ago for the purpose of power generation. In addition to 19 megawatts of combined installed capacity, the dams nearly destroyed the once-rich steelhead trout and salmon fisheries of the Elwha. Removing the two dams and the sediment that has built up behind them is estimated to cost from $67 million to $80 million. Sediment removal, which represents the most significant problem, would be done through a combination of dredging, allowing some sediment to wash downstream, and stabilising sediments higher up on riverbanks with vegetation. Agreement has recently been reached by the U.S. Congress and Department of the Interior to decommission these dams and restore the Elwha ecosystem and native anadromous fisheries.

Decommissioning Costs

Although numerous small dams have been removed, little is known about the feasibility and costs of removing large dams. With respect to feasibility, the main challenges are how best to dismantle the dam and remove/manage sediment that has accumulated behind the dam (especially if the sediment contains heavy metals and toxic contaminants). The expected costs of decommissioning will differ significantly depending on several factors, including:

- **The expected type of decommissioning.** Simply stopping the generation of power at a dam is clearly less costly than dam removal and river restoration. However, predicting the decommissioning preferences of future generations may not be appropriate or possible. In such cases, costs should be considered under different plausible decommissioning scenarios.
- **The structure of the dam and nature of the project area.** Decommissioning costs will vary depending on the size and type of dam, as well as the unique characteristics of the river and project site.
- **The expected project life of the dam.** Project life may be dependent on a variety of factors, including sedimentation rates and dam construction and safety (see Box 2.4).

**Box 2.4. Examples of Factors Affecting the Project Life of a Dam**

<table>
<thead>
<tr>
<th>River sedimentation reduces the storage capacity of a dam reservoir and can affect the efficiency of a dam’s turbines or cause damage to turbine blades. The rate of storage loss depends on the amount of sediment flowing in the river and the size of the reservoir. However, storm events can also dramatically affect reservoir sedimentation. For example, the storage capacity of Nepal’s Kulekhani hydropower dam was reduced by about one-tenth by a storm that scoured sediment off of upstream mountainsides during a 30-hour storm in July 1993. Sedimentation rates are predicted to be significantly higher for the next several years due to the large amounts of sediment deposited by the storm near riverbanks that will be washed down by future floods. Completed in 1981, the dam had been forecast to have a project life of 75-100 years. Due to the higher than expected sedimentation, the dam may be out of operation by early next century.</th>
</tr>
</thead>
<tbody>
<tr>
<td>While some dams may remain safe for several hundred years, others may begin to have safety problems after just a few years, depending on dam construction, maintenance, and geological factors. For example, the Inguri dam in the republic of Georgia is the world’s third highest dam. It was completed in the 1980s, but by 1994 inspectors from Hydro-Quebec found the dam to be “in a rare state of dilapidation.” Among other problems, they noted that turbine galleries were flooded by water leaking through the concrete arch dam and the spillway was “defective.”</td>
</tr>
</tbody>
</table>


A Proper Economic Analysis of Decommissioning and the Need for Decommissioning Funds for Dams

While dam construction and operation and maintenance costs are included in economic analyses, future decommissioning costs are typically not estimated or included. As all dam projects will face the costs of decommissioning sometime in the future, these costs are real and should be included in economic analyses. At present decommissioning costs are difficult to gauge due to the uncertainty surrounding the various parameters affecting these costs and the lack of practical experience in this regard. Still, this is not an excuse for leaving decommissioning costs out of economic analyses as risk and uncertainty is inherent to the evaluation of dam projects (see Chapters 6 and 7). In addition, as more large dams are decommissioned over the coming years, more data on dam decommissioning and removal costs will become available.

Clearly the choice of discount rate will significantly affect the influence of the magnitude of decommissioning on the overall analysis of project costs and benefits for a given project. While
discounting is treated later in the paper (see Chapter 5) it is worth recognising that the lower the rate applied the more that the cost of decommissioning will count in a cost-benefit analysis. Still, for long-lived dams, decommissioning costs at inception will be negligible. At relicensing of facilities (which may occur every 30-50 years) the need to include this cost becomes more pressing.

Marcus (1997) analyses current practice in the economics of relicensing under the US Federal Energy Regulatory Commission (FERC) that is responsible for regulating private power projects. While the treatment of the decommissioning option is cursory, a number of points emerge from the FERC experience about the manner in which the assessment of the decision to decommission would typically proceed from both a financial and economic standpoint. From the perspective of the owner, the alternative of relicensing incurs additional mitigation costs (as agreed upon at relicensing), and continued power benefits and O&M costs. In some cases the net effect of these figures will be negative. However, as decommissioning would incur the total costs of decommissioning the analysis from the owner’s perspective will involve a comparison of decommissioning costs with the continued net benefits (or costs) of continuing to operate.

Clearly, the owner will prefer to lose less rather than more money and will thus often end up settling for relicensing in place of decommissioning. Marcus (1997) reports that in 40% of the FERC cases reviewed the FERC analysis finds the project to have negative value when mitigation measures are included. Yet FERC policy (as reflected in the Mead Decision of 1995) states that negative net benefits are not a reason for license denial.

While the owner will simply weigh net operating benefits against costs of decommissioning, society would prefer to structure the problem as an economic comparison between two alternative courses of action, or options. Under the first option the dam continues to operate and generates economic benefits equivalent to the cost to society of avoiding investment in alternative power. The net benefits of relicensing are then the power benefits minus the O&M costs. Where modifications to the operating regime to accommodate environmental or social concerns and/or continuing welfare losses due to operations will detract from these net economic benefits. This “relicensing” option must then be compared to the “decommissioning” option. In this case the benefits of decommissioning, i.e. the benefits of environmental restoration are compared to the costs of decommissioning.4

As there are only two course of action and one must be chosen, the decision rule will be to choose the result with the highest net benefit. If the net benefits of decommissioning at relicensing are positive and greater than the net benefits of continued operation then the recommendation that improves economic welfare would be to decommission.

The owner of the dam will then have to pay the costs of the decommissioning. However, the owner will be unlikely to capture all the subsequent benefits of decommissioning. This is a consequence of river flows and water having public good characteristics. For example the dam owner will not capture the recreational value that rafters, hikers and sportsfishermen may experience once the river is restored. As a result owners will be naturally reluctant to bear the costs of decommissioning.

In the absence of any licensing, regulation and decommissioning rules, the incentive for dam owners would be simply to operate until the net marginal benefits of operation become negative and then abandon the dam, in essence leaving it as a pollution externality. Thus, the third option, then, is that the owner simply defaults on obligations and leaves the dam to society to handle. Indeed, many smaller dams in the United States have been abandoned by their owners. For example, the Michigan Department of Natural Resources (MDNR) reports that several abandoned dams in Michigan have been washed out by storms in recent years, causing significant environmental damage, including severe erosion, destruction of aquatic habitat, and loss of fisheries. The cost of removing several other abandoned dams has been borne by Michigan taxpayers (via the MDNR), while the dams’ ex-owners have not faced any financial liabilities (Hydropower Reform Coalition, 1994).
In other words, if dam owners are not required to set aside funds for decommissioning, they may have an incentive to continue operating their projects even though the projects are no longer competitive, efficient, or safe, simply to avoid large decommissioning costs. This appears to be the current situation in the United States, where close to 1,000 private dams built decades ago will be up for relicensing. Absent such regulation there is little incentive for the owner to undertake such action and decommissioning will represent a large unfunded mandate at the end of the dam’s life or at relicensing.

As explained above there are very good, economically sound reasons for requiring appropriate regulation to resolve this incentive problem. Licensing bodies, such as FERC, already recognize the need to internalise environmental problems of dams in operation through up-take of mitigation measures. Developing regulatory measures to ensure that dam owners provide for decommissioning costs is simply an extension of this concept. One solution would be to ensure that funds are set aside for decommissioning at commissioning and/or during the period the project is under license and generating revenues. Given the power of compound interest, this amount need not be an onerous one in terms of its effects on the assessment of private profitability. Such decommissioning funds are already accepted practice with nuclear power plants in the United States and other countries.

With such a fund in place, when the project comes up for relicensing the financial analysis from the perspective of the dam owner would not be perversely skewed by the large unfunded mandate of decommissioning. Instead the analysis would be undertaken based on the marginal net benefits of operating, and the costs of additional mitigation measures.

Such an arrangement is appropriate in the case of private dam owners and public regulatory agencies, but it raises the question of how the rules would change when governments are the owners of dams. In theory, governments can simply self-insure against the event of decommissioning and can spread both the risk, cost and benefits of decommissioning across society in an equitable way. At this point it is too early to comment on the degree to which governments will comply with their responsibilities in this regard in a timely and efficient manner. For many countries that have only begun building dams in the last decade or two, this problem may seem remote. However, when the time comes to decommission a series of dams concerns may emerge – just as the public investment in building a dam raises questions about potential macroeconomic impacts and risks (see Chapter 7 and 8).

2.8 Findings and Recommendations

The section on direct costs of projects yields the following findings:

- Performance data suggests that dam projects often incur substantial cost overruns, however, not all samples of such data found to date demonstrate such a bias. Still the overwhelming evidence is that multilateral projects are prone to substantial cost overruns. Only a small sample of projects from the African Development Bank do not demonstrate this tendency.
- Operations and maintenance costs of dams are low compared to capital costs (1-3%) yet are likely to rise over time as facilities age and efforts to mitigate the negative effects of sedimentation are undertaken.
- A very limited set of performance data available at this time suggests that projections of operations and maintenance costs are approximately within 1-3% of capital costs, though they rise as the dams age.
- Resettlement costs are highly variable depending on site-specific characteristics of the dam and the environs within which it is situated. In some cases, resettlement costs may approach 10-20% of capital costs.
- Environmental damages caused by dams are increasingly recognised and efforts to internalise these in the form of mitigation projects are growing in the form of capital expenditure, O&M expenditure and/or opportunity costs of lost production. Data on the costs of these measures is...
still unreliable, particularly as the effectiveness of the measures themselves is often questionable. The costs of studies on environmental mitigation may be a significant budget item.

- Decommissioning costs are real costs that every dam project will face sometime in the future, although experience is yet limited in terms of evaluating their exact magnitude. Decommissioning will also generate benefits in terms of environmental restoration.

Based on the analysis of these findings the following policy principle can be offered:

- Funding agencies, the projects of which demonstrate a consistent bias towards cost overruns in dam projects, should implement additional procedures to ensure that risks of cost overruns are properly accounted for in both the financial and economic analysis of the project; and
- For privately sponsored dam projects a decommissioning fund should be mandatory and initiated at commissioning.

A number of recommendations for operational principles and their methodological implications can be made with regard to direct project costs:

- Estimates of project costs should be derived from straightforward applications of probability distributions of construction costs for the relevant class of projects;
- Study and monitoring of economic data on O&M and decommissioning costs should be undertaken to provide guidance to practitioners in accurately projecting dam life;
- Sunk costs should not be included in economic analysis of dams when they are relicensed, rather the decision should be evaluated based on the forward-looking costs and benefits of the project;
- Decommissioning costs should be estimated and included in the economic analyses.
3. Valuation of Direct Benefits

As seen in the previous chapter the valuation of the financial costs of building dams can be subject to considerable error. Opponents of dams often claim that not only are dam costs under-estimated but dam benefits are over-estimated. The discussion below highlights that the valuation of the direct benefits of dam projects is not a simple task and, thus, merits further investigation. As there are substantial differences between the goods being valued and the methods applied it is worth taking the major categories of benefits one-by-one and examining the actual practice, performance of methods, guidelines and good practice (as per available information at the time of preparation). Prior to this specific inquiry, however, it is important to set the scene by discussing the economic characteristics of the goods and services provided by dams and the technical issues that arise in the lead up to benefit valuation.

3.1 Rivers and Water: Generic Challenges in Economic Valuation

Water is a heterogeneous good with unique physical, and typically location-specific, characteristics. It has numerous and varied uses, some of which are largely consumptive, such as in agriculture (for irrigation, flood recession agriculture and livestock management) and urban supply (for domestic and industrial use), while some are primarily non-consumptive such as hydropower, fisheries, navigation, recreation and pollution control. Other uses, such as in wetland habitats, can be partially consumptive (due to evaporation). In cases where one or more uses is non-consumptive, the opportunity may exist to re-use the water in another application (e.g., water passing through hydro turbines can be abstracted downstream for irrigation or water supply).

The valuation of changes in water regulation, storage and use occasioned by a dam project can be complicated for the following reasons:

- multifunctionality of water – i.e., sheer number of uses
- trade-offs between uses, where they are consumptive
- changing preferences of society for the uses of water over long time horizons
- variation in daily and seasonal values of water for power and irrigation
- variation in values due to varying chemical and biological qualities of water
- characteristics of river water, water regulation and flood control services as a public good
- characteristics of large-scale provision of water and energy services as natural monopolies

The first five of these reasons are practical complications but the last two provide an analytical basis for understanding why financial estimates of direct benefits are likely to differ from economic estimates, or why financial estimates may be hard to come by at all. The regulation of river flows in most countries is guided by the principle that water is the property of the state. From an economics perspective this principle is given expression through the analytical concept that river water, its flows and its quality are public goods. At the same time, the historical trend was to recognise the large-scale provision of water and energy services as a natural monopoly. The large up-front costs of infrastructure associated with these services led to the expectation that if they were left to the private sector these activities would not serve the public good – either in terms of failing to supply services to poor communities or by exerting monopoly power through charging exorbitant prices.

The result of these two factors has been a lack of competitive markets for the exchange of dam services, either at the point of production or distribution. State agencies or public utilities have administered the tariffs charged for hydropower, irrigation water, and municipal and industrial water supply. As a result the tariffs charged at the wholesale or retail level do not provide an accurate indicator of their economic price. Since river water displays public good characteristics, there are also typically no markets for its abstraction from rivers for consumptive uses (water supply) or partially

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consumptive uses (hydropower). There is also, therefore, no market data on which to base payments from a water user, such as an irrigation scheme or a hydropower plant, to the provider of the water – i.e., the dam owner. Nor, of course, is there any corresponding market for the exchange of rights in river regulation that occurs in re-regulating the river through dam construction. Historically, the situation has been dealt with through vertical integration. The state – which controls water usage and distribution of electricity and water – builds the dam and operates the hydropower plant.

Current trends towards private sector participation and improving efficiency in the provision of energy and water services are beyond the scope of this paper (but see the Thematic Review on International Trends in Financing). Still, the unbundling of state monopolies implies that the direct benefits of a dam project in the future may not be power (in the case of hydropower dams) delivered to consumers but rather water delivered to a hydropower generation company. In the event that dam and power complexes remain vertically integrated, market prices will emerge as power is delivered to a transmission company or a power pool (as is increasingly the case in many developed and developing regions). Water supply is also facing similar market pressures and this may similarly improve the data upon which the economic benefits generated by water supply dams may be based. Although irrigation is subject to efficiency concerns there is certainly not such a trend towards private sector participation so it remains to be seen how far reforms and market development will proceed. Valuation of irrigation benefits is thus likely to continue relying on methods that infer the value of irrigated water from its contribution to marketed agricultural products (or the value of agricultural land).

The case of flood control and navigation are slightly different. The effect of dams on floods is provided directly by the dam without any intermediary. Given the difficulty of excluding downstream beneficiaries from capturing the benefits of flood control it has remained very much a public function where it is the main purpose of a dam. Non-market valuation methods are thus required. While these are relatively well developed, data problems, particularly in developing countries make such methods of limited reliability.

The mere act of installing a dam on a river will have considerable impact on river navigation. In the first instance most dams effectively make the river impassable for water transport. Yet the addition of locks to a dam not only can restore the passage but also can make previously unnavigable river stretches navigable due to the regulation of flow (as in the case of the Columbia and Snake Rivers in the Northwest of the US). Dams may also be used to provide water for the very act of navigation (witness the Madden and Gatun dams which support the Panama Canal). In most cases, the use of locks to convey river transport from one side of a dam to another provides an effective means of excluding potential users and creates the option for establishing a market (albeit a natural monopoly) in the navigation services provided by the dam. Still, pre-project assessment of navigation returns is not easy. For instance in assessing the potential benefits of installing locks at the Tucurui dam, a principal difficulty will be assessing the quantity of traffic that the locks will attract (at different price levels).

Dams may also provide direct benefits in terms of commercial fisheries, subsistence fisheries, recreational fisheries and pure recreation (boating, swimming, etc). Valuation of these benefits is rarely undertaken where these are considered as secondary benefits. However, market prices and non-market valuation techniques are available for this purpose. As recreation is typically considered an environmental good, these methods are covered in the next chapter.

## 3.2 Technical Issues

The following paragraphs highlight some of the non-economic, technical challenges faced in valuing the direct benefits and environmental and social impacts associated with a dam project.
The benefits from a dam project depend to a great extent on the hydrological regime of the river basin in which it is located and any future changes that might occur to that regime due to phenomena such as deforestation (and associated soil erosion and reservoir sedimentation), upstream abstractions of water from the river and diversions from other watersheds into the basin. The hydrological characteristics that are important are the average annual volume of water flowing at the site, the seasonal pattern of that volume, and the year-to-year variations in the annual and seasonal amounts.

Although streamflow gauging stations usually exist on the river in question or on adjacent rivers, it is less common to find long-term measurements at the dam or water intake site. This means that a long-term streamflow record at the site has to be synthesised using records from nearby gauging stations, often supplemented by meteorological and physiographic data.

In addition, many actual streamflow records are of dubious accuracy, particularly in remote areas and in developing countries. Inexact streamflow records translate directly to uncertain estimates of the amounts of power and water available for sale and, consequently, of the financial revenues that will accrue to the owner, as well as of the economic value of the project outputs.

Given the variability of streamflow, the value of water supply and power available from a dam project depends on the reliability of supply (or probability of meeting demand). In other words, that portion of the flow that can be supplied with a high degree of probability is worth more (often much more) than that portion whose supply is less certain.

For example, the water supply to an irrigation system may be designed to provide, on average, water in four years out of five but, when the water available is less than design, the consequences for users, who have become reliant on the system for their livelihoods, can be significant. Similarly, the reliable supply of hydropower from a dam project may be designed for nine years in ten, and particularly in developing countries which tend to experience chronic power shortages, during years of failure the other generating resources connected to the power grid may not be sufficient to avoid prolonged power outages, thus resulting in lost industrial production, and reduced domestic and commercial consumption. The physical, as well as the economic, consequences of supply failure are often difficult to evaluate.

The construction of a dam often creates a storage reservoir that can be used to regulate the natural variation of downstream flows in the river. Although this can add to the inundation of communities, and agricultural and mineral resources, and can have detrimental effects on those downstream water uses that depend on natural streamflow fluctuation (e.g., flood recession agriculture and seasonal flooding of wildlife habitats), the ability to ameliorate the effects of floods and increase flows during the dry season can add very substantially to the value of water supply and hydroelectric production from the project. Also, a reservoir formed at the site in question can enhance the value of outputs from downstream projects. All of these effects must be estimated in physical terms before they can be evaluated in the financial and economic analyses.

The physical effects of chemical and biological impacts can also be difficult to estimate accurately and satisfactorily. For example, acid rain emissions from thermal power plants that may be avoided by developing and operating hydroelectric projects, can be readily measured in terms of annual tonnes of the various gases emitted (e.g., sulphur dioxide). However, it is a much more difficult, costly and time-consuming task to transform these emissions into actual costs of health and physical damages, and losses in production at the points of deposition. The same problem exists for emissions of greenhouse gases (e.g., carbon dioxide).

The paragraphs above describe some of the complexity and uncertainty inherent in estimating the physical values of the direct costs and benefits that will result from development and operation of a dam project. The conclusion from this discussion is that the uncertainties associated with dam project assessment do not begin (or end) with economic analysis. Instead they are present in all the activities.
associated with project evaluation and decision-making, beginning with the technical studies that underpin the project proposal and forecast the physical outputs that the project is to provide.

### 3.3 Hydropower Benefits

#### 3.3.1 Actual Practice

Examples of early practice in hydropower benefit valuation come from the WCD Case Study dams. Early dams, such as the Grand Coulee in the United States, did not incorporate an estimated valuation of power benefits for evaluating the project against other alternatives directly. For the Kariba project in the 1950s in Zimbabwe and Zambia, power benefits were valued as the fuel cost savings and avoided cost of thermal capacity that would be needed with the alternative thermal plants. The analysis was carried out over an eleven year period, or until the running total of fuel savings from using hydropower outweighed the higher capital costs of the hydropower option. In the 1960s and 1970s the power benefits of the Tarbela (Pakistan) and Aslantas (Turkey) projects in Turkey were also valued by applying the alternative thermal plant method to estimate avoided costs. In the Aslantas case, the avoided costs were derived from the comparison of alternatives employing a system expansion optimisation model. Planned under a military dictatorship, the Tucurui dam was approved with no projection of power or power benefits. The Pak Mun dam in Thailand was studied over a period of decades using a range of methods, including simulation of the least cost expansion plan using a system expansion optimisation model.

In the WCD Survey of multilateral development bank (MDBs) project appraisals, a similar trend towards the use of more advanced valuation techniques, including those based on the willingness to pay (WTP), for power is noted in the 1990s. Berke Hydropower (World Bank SAR 1992) and Daguangba Multi-Purpose (World Bank SAR 1991) calculated benefit estimates based on long-run marginal cost while Nathpa Jhakri Power (World Bank SAR 1989) presented a detailed calculation of consumer surplus. Meanwhile, Ertan II Hydroelectric (World Bank SAR 1995) used an economic price equivalent to the price paid by the system at the consumer level of alternative supply (electricity purchased from joint investment and independent power producers) as a minimum proxy. Power benefits from the multi-purpose Zhejiang-Shanxi Water Supply (ADB RRP 1997) were valued based on the purchasers’ price as reflected in the electricity purchase agreement. This tariff is higher than the long-run marginal cost of electricity.

Prior to the 1990s, it was generally recognised that since benefit valuation is largely based on average tariffs, the EIRRs are only minimum estimates. Malaysia’s Batang Ai Hydropower (ADB RRP 1981) notes that the incremental power sales revenues used as a proxy for the true economic benefits probably understate those benefits and suggests that consumers’ WTP is virtually impossible to evaluate.

Generally, the project appraisals did not make an explicit distinction between incremental (project outputs meeting new or additional demands) and nonincremental supply (project outputs replacing existing supply). In the case of Ghazi-Barotha Hydropower (World Bank SAR 1995), power benefits for residential consumers consisted of consumer surplus (incremental demand) and resource cost savings (nonincremental demand). For other consumer categories, benefits were valued in terms of avoided cost from diesel generators.

At the Asian Development Bank (ADB), although nonincremental and incremental supply was not specifically mentioned, consumer surplus and resource cost savings were calculated in five out of six of the 1990s hydropower projects. Benefit estimates were based mainly on avoided costs of alternative supply for firm energy, and on fuel and O&M savings for secondary energy as in the case of China’s Hunan Lingjintan Hydropower (ADB RRP 1994). Exported power from Lao PDR’s Nam Song Hydropower (ADB RRP 1992) was valued at the current export tariff while domestic power was valued at resource cost savings and consumer surplus. For the Fujian Mianhuatan Hydropower (ADB
RRP 1995), detailed calculation of the weighted WTP based on alternative sources of electricity (small petrol generator for commercial consumers, rechargeable electric lamp for urban residential consumers, and kerosene lamp for rural residential consumers) was presented, which was found to be higher than the average tariff. The Lao PDR’s Theun-Hinboun (ADB RRP 1994) which involved power exports to Thailand, valued economic benefits as the total revenues received by the Government in terms of share of net profits, royalties and tax while costs comprised the Government’s equity investment in the project. This is equivalent to a discounted cash flow (DCF) analysis from the Government’s perspective.

For China’s Tongbai Pumped Storage (World Bank SAR 1999), dynamic benefits analysis was undertaken involving chronological simulation through the generation of an optimal dynamic simulation model.

Where the costs of alternatives are considered to be indicative of project benefits it is useful to recall that the financial cost of a project may not be equal to its economic cost. As far as conversion of financial to economic costs is concerned, the WCD Review of MDB appraisals shows that many cases particularly from the 1960s up to the 1980s simply remove transfer payments and inflation effects from the project cost estimates. Many appraisals do not specify whether any adjustments are made at all to either the dam project or its alternatives and, thus, it is difficult to verify the accuracy of the benefit estimates. Improvement in the 1990s dam projects was noted, with financial flows being adjusted for input and output distortions, transfer payments, shadow exchange rate, and shadow wage rate. However, remains unclear if such adjustments are also made to the projects used in deriving estimates of avoided costs.

### 3.3.2 Performance

Examination of the performance of benefit estimates from the WCD Case Studies suggests that insofar as installed capacity and power generation indicators are concerned, hydropower has performed reasonably well and, in some cases, even better than expected. This obscures two important issues. First, the volatility of hydropower generation is quite high. Indeed, peaks and troughs may persist over time as climate cycles ebb and flow. Thus, although capacity may be installed and average GWh may be more or less on target, a project may encounter difficulties, particularly if dry periods occur at project inception. These would tend to be overweighted in terms of project profitability given their occurrence in the short term. A second difficulty is revealed in the case of Pak Mun Dam where installed capacity and generation are as expected but the dependable capacity is less than anticipated. Again, this can have an important impact on the economic value of project benefits and, as demonstrated in the Pak Mun case, a significant impact on project viability.

**Table 3.1. WCD Case Studies: Hydropower Performance Indicators**

<table>
<thead>
<tr>
<th>Case Study Dam</th>
<th>Installed Capacity (MW) Predicted</th>
<th>Actual</th>
<th>Actual as % of Predicted</th>
<th>Generation(GWh/annual average) Predicted</th>
<th>Actual</th>
<th>Actual as % of Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Coulee</td>
<td>1575</td>
<td>6,494</td>
<td>412%</td>
<td>7008</td>
<td>8,383</td>
<td>119%</td>
</tr>
<tr>
<td>Kariba</td>
<td>1,200</td>
<td>1,266</td>
<td>106%</td>
<td>6,720</td>
<td>6,400</td>
<td>95%</td>
</tr>
<tr>
<td>Tarbela</td>
<td>2,100</td>
<td>3,478</td>
<td>166%</td>
<td>11,300</td>
<td>14,300</td>
<td>127%</td>
</tr>
<tr>
<td>Aslantas</td>
<td>138</td>
<td>138</td>
<td>100%</td>
<td>500</td>
<td>653</td>
<td>131%</td>
</tr>
<tr>
<td>Tucurui</td>
<td>2,700</td>
<td>4,000</td>
<td>148%</td>
<td>22,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pak Mun</td>
<td>136</td>
<td>136</td>
<td>100%</td>
<td>289</td>
<td>290</td>
<td>100%</td>
</tr>
<tr>
<td>Glomma and Laagen</td>
<td>3,764</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: WCD Case Studies.

Central to the achievement of targets is the realisation of project demand. Critics of hydropower and power planning in general contend that forecast energy demand is often much too high, leading to a substantial perceived supply gap and then eventual oversupply in power grid (McCully 1996). A
This submission from India (see Box 3.1) provides an example of how sector forecasts may be the first of a series of actions that favour large projects, including hydropower projects.

Box 3.1. Perspective on Energy Sector Planning in India and Hydropower

Sant and Dixit (1999 eco013) provide an example of energy sector planning in India which skews the outcome to favour large projects. First, there is high demand forecast, especially a shortage of peaking capacity (with hydropower seen as suited to fill peaking capacity). Since there is such a high demand being forecast, the only way to fill the supply-and-demand gap is to implement a large project. Less costly smaller projects are viewed as insufficient to fill the supply gap. Politically expedient but often poorly targeted (and large) subsidies are offered for the tariff. This provides a disincentive for consumers to be efficient. So subsidy-induced demand feeds back into the high demand forecasts (which also do not incorporate the tariff sensitivity of demand). Yet due to subsidies and too-low tariffs, operating losses in the sector lead to an inability to add generating capacity, exacerbating the supply gap (real and forecast).

3.3.3 Guidelines and Good Practice Toolchest

The financial valuation of power benefits will be more or less complicated depending on the market into which the power is sold and to what extent the producing entity is vertically integrated with transmission and distribution networks. In the simple case, prices for power are well known, either through government price controls or a power purchasing agreement (between an independent power producer and a utility for example). In a competitive market situation, such as a power pool where power is bought and sold on contract and spot markets, price is free to fluctuate due to changes in supply and demand. In the latter case market analysis may be required using tools such as econometric analysis.

Good practice in the economic valuation of hydropower is often undertaken in two steps: first the least cost option is chosen from among available project and, second, economic benefits are calculated using a measure of willingness-to-pay for power). Handbooks and texts illustrating these methods are often produced by agencies even though they may have no specific policies or guidelines for hydropower valuation, per se. For example the World Bank and ADB have no specific guidelines for the economic analysis of power projects, but have published a number of publications that address these issues (Ali 1989 and 1991; Young 1996). In Technical Annex 7 a thorough treatment of hydropower valuation is provided including both power and other social and environmental impacts.

Indeed, the value of hydroelectric production from a dam project can be determined with reasonable accuracy only by conducting detailed power system expansion studies including macroeconomic projections, forecasts of electricity demand, estimates of demand-side management activities, and identification of the most cost-effective configurations of the system to meet demand, with and without the dam project, followed by simulations of (usually) monthly system operation with and without the project. The optimal timing of project development is also investigated in these studies. This can be a very significant piece of work in itself.

In very simple terms, that portion of hydroelectric output from a dam project that can be generated almost continuously, for both base- and peak-load generation, from year-to-year and from season-to-season (firm power) has a value equivalent to the total cost of developing and operating alternative power supply options (which vary depending on the location and the make-up of the generating system). However, in many mixed hydro-thermal systems, output that is available with less certainty, or only at particular times of the year (secondary power), typically has a value equivalent only to the incremental savings obtained from not producing that output in thermal plants that exist at the time. In this example, the value of firm power is equivalent to the long-run marginal cost of alternative supply, while that of secondary power is the short-run marginal cost of alternative supply (mainly fuel savings).
To obtain economic benefits, willingness-to-pay for incremental supply (supply to consumers previously unserved) can be estimated through a demand curve indicating different quantities of power that could be consumed at different price levels between the without-project level of demand and the with-project level of demand. The economic value of incremental consumption is the average value derived from the curve multiplied by the quantity of incremental supply. Where there is inadequate data to estimate a demand curve, the alternative is to use existing tariffs as a conservative estimate of willingness-to-pay. Alternatively a contingent valuation methodology will be necessary to estimate WTP. Alongside WTP for incremental power supply there may be nonincremental power supply which would is valued at resource cost savings.

This two-step process is designed first to ensure that the least cost option for power generation is chosen and second to ensure that the project will actually generate sufficient economic benefits to ensure that the project is worth undertaking.

3.3.4 Comparative Analysis of Practice

At present relatively sophisticated good practice methods for the economic evaluation of power benefits are often employed in sector planning and project selection, particularly with regard to the widespread use of system-wide optimisation models. These models, however, represent a least-cost approach as discussed below. It should also be noted that forecasting future fossil fuel prices is fraught with uncertainty and this will continue to make it difficult to reliably carry out least cost options assessment. As far as benefit estimation is concerned, increasing deregulation and private sector participation in power markets will gradually ease the task of economic valuation of power benefits in the future. Prices emerging from power pools will represent competitive prices and may be used in economic analysis.

It is important to recognise the limitations of both of these approaches. The least cost approach may engender confusion due to its name. The obvious question when referring to “least cost” is least cost of what precisely? Least cost maybe taken to mean an exploration purely of the alternative financial costs of power generation technologies or it may include not just the costs of power generation but associated mitigation measures. Alternatively it may include economic valuation of social and environmental impacts. Thus, it is important to be consistent in the application in order to avoid double-counting or the comparing of different measures. If least cost refers simply to the avoided financial cost of the power alternative then this must be made clear, as the results may not demonstrate that the least cost project is in fact the one with the lowest societal cost. If it is power costs loaded with the external costs and benefits of environmental and social impacts then it needs to be clear how these are derived and that proper account has been taken of financial and economic considerations. For the purposes of options assessment it may be most useful to restrict the meaning of least cost to the power component and bring in the other “costs” of the project through a multi-criteria process where these other impacts are identified, quantified and valued as appropriate (as discussed in Chapter 10).

3.4 Irrigation Benefits

As with hydropower benefits most agencies do not prescribe specific methods for irrigation benefit valuation but rather provide guides and handbooks to supplement agricultural economic texts that describe available methods (Young 1996).

The benefits of supplying water for irrigation can be estimated in terms of the net value of the resulting increase in crop production. Gross benefits are measured in terms of the physical outputs that the project is estimated to produce, and the forecast prices for these products. When combined with cost data on purchased inputs (variable and fixed) a first cut at a financial net benefits is obtained. In order to yield economic (or shadow) prices, the prices for inputs and outputs obtained in markets need to be adjusted to account for policy distortions. Assuming that all other inputs...
(including capital) have been assessed at their marginal opportunity cost the resulting net gain may be attributable to the presence of irrigation water. This method and other good practice methods for valuing irrigation water are explained in Technical Annex 5 and are not repeated here. Instead, the discussion examines actual practice and performance of methods, followed by a brief discussion of the difficulties that are encountered in this endeavour.

3.4.1 Actual Practice and Performance

The WCD Case Studies provide just a few vantage points on actual practice in the evaluation of irrigation benefits. Valuation of net irrigation benefits was carried out, after a fashion, in the 1932 planning studies for the Columbia Basin Project. The value of production under irrigation was compared to the “without project” benefits of dryland agriculture. However, only a financial internal rate of return was calculated from the accompanying investment costs and net financial returns. In the case of Tarbela (1964) and Aslantas Dam (1973) a more comprehensive analysis was carried out including, economic analysis of net returns to farmers participating in the schemes.

In the WCD Survey of MDB project appraisals the valuation of irrigation benefits are generally based on incremental net value of production. Although irrigation and rural development projects supported by ADB until 1994 contributed significantly to improving agricultural performance, actual achievements in terms of cropped or planted areas ranged mostly between 60 and 85% of appraisal projections. On the other hand, most projects were able to achieve an average of about 180% cropping intensity as compared with 150 to 300% at appraisal. Yield per hectare improved substantially during and after project implementation, in some cases exceeding appraisal targets by 10 to 30%. However, overall crop production fell short of appraisal projections in many projects. Altogether, the re-estimated EIRR at post-evaluation were generally below appraisal estimates, except in the case of Andong Dam Multipurpose Development (1971). The major reasons for the shortfall in EIRR were: (I) reduction in cropped/irrigated area, (ii) implementation delays, (iii) cost overruns, (iv) delays and shortfalls in the realisation of project benefits, (v) increased opportunity cost of water, (vi) unexpected and/or increased recurrent costs, and (vii) lower output prices. (ADB 1995).

There is considerable uncertainty concerning many of the assumptions that go into this analysis in terms of future cropping patterns, input prices, crop yields, crop prices and farmer behaviour. One must consider that the development of the irrigation system may take a considerable time and this structural change will have an influence on farmer behaviour. (Sancho Marco 1999 ecoweb010) A more reliable water supply for irrigation can enable perennial production (as opposed to being limited to annual production because of an unpredictable water supply. (Miller 1999 ecoweb008)

3.5 Water Supply Benefits

The historical tendency to provide water as part of a program of government services has meant that competitive market prices, and hence willingness to pay, are not directly observable. The WCD review of MDB appraisals reveals that all ADB water supply projects (1970s) and the WB-funded Nairobi’s Third Water Supply project (World Bank SAR 1989) and Ceara Urban Development and Water Resource Management (World Bank SAR 1994) valued water supply benefits at average water tariff. As this is only a proxy for willingness to pay, these estimates understate the project’s net economic benefits. The ADB’s Sector Synthesis of Post-Evaluation Findings in the Water Supply and Sanitation Sector notes that the common practice in the past was to approximate the FIRR of water supply projects as the lower limit of the EIRR (ADB 1994).

An alternative method, as with hydropower, is to employ the costs of the next best alternative as a measure of project benefits. ADB’s Manila Water Supply (ADB RRP 1974) presented such a valuation based on cost of alternative supply. Additional benefits were incorporated through other means such as health impacts (based on reduced labour time lost and avoided medical expenses),
reduced fire damages arising from the availability of water for fire fighting, and property values (based on increase in land values).

In the last decade, the contingent valuation method (CVM) has been increasingly applied to directly estimate willingness to pay for water supply. A pioneering study in Brazil demonstrates how surveys of actual and hypothetical water-use practices can provide estimates of WTP that vary according to household socioeconomic characteristics, qualitative differences in water supply and delivery systems (Briscoe et al. 1990). As CVM is frequently applied in environmental and social valuation further discussion on the technique is provided in the next chapter, which covers environmental and social valuation. Good practice with respect to this method is presented in Technical Annex 7.

As with hydropower it is important to distinguish between the value of new supply and that supply that replaces existing supplies. The gross benefits of supplying water for domestic, industrial and other uses (except irrigation) consist of resource cost savings for nonincremental supply and willingness to pay for incremental water consumed. The gross benefit stream should be adjusted for the economic value of water that is consumed but not paid for such as bad debts and non-technical losses. With increasing privatisation of the water supply business and, therefore, increased attainment of cost recovery, if not regulated profits, market data may be increasingly available for econometric investigation. The WTP for incremental supply can then be estimated through a demand curve indicating different quantities of water that could be consumed at different price levels between the without-project level of demand and the with-project level of demand. In simple terms, the economic value of incremental consumption is the average value derived from the curve times the quantity of incremental supply.

With respect to guidelines, the Asian Development Bank published a Handbook for the Economic Analysis of Water Supply Projects in 1999, which provides a comprehensive set of illustrations, calculations, and good practice examples on the design and evaluation of water supply projects, including valuation. In sum, while valuation of water supply benefits may be a time-consuming task, and actual practice may not yet be synonymous with good practice, it is fairly straightforward in conceptual terms and there is little debate in this regard.

### 3.6 Flood Control Benefits

The valuation of flood control benefits relies heavily on a damages avoided approach in which flood frequency curves are linked to flood damage curves. Project benefits are then derived based on the differences between the “with” and “without” project scenarios. Good practice in flood benefit valuation is reviewed in Technical Annex 6.

The WCD review of MDB appraisals found that flood control benefits are consistently valued based on reduced or avoided flood damages. Still, valuation of flood benefits is rare. None of the WCD Case Studies report on efforts to appraise the benefits of this function. Out of 6 ADB projects where flood control benefits were identified, benefits were quantified only in Indonesia’s Wadaslintang Multi-Purpose (ADB RRP 1981) and valued in China’s Zhejiang-Shanxi Water Supply (ADB RRP 1997) and Korea’s Andong Dam Multi-Purpose (ADB RRP 1971). In the case of the World Bank, flood control benefits were valued in five of the 26 projects surveyed. In the case of China’s Xiaolangdi Multipurpose project (World Bank SAR 1995), flood control benefits were estimated based on a flood frequency simulation model.

The ADB’s post-evaluation study of irrigation and rural development projects noted that the provision of flood control facilities reduced the incidence of flood and encouraged farmers to intensify production (ADB 1995). This in turn suggests an increase in the scope of benefits from flood control, which may not necessarily be limited to damage avoided. However, the sustainability of flood control benefits remains an issue due to the poor maintenance of related infrastructure such as sluice gates and heavy siltation in the drainage canals.
3.7 Other Direct Impacts

Other direct impacts of dam projects include navigation, recreation and tourism, etc. In the WCD Case Studies and the WCD Review of MDB appraisals little evidence was found of efforts to value any of these subsidiary benefits. Further, in the WCD survey of MDB appraisals the only example of such valuation that was found was that of Nigeria’s Kainji project (World Bank SAR 1964). In that project, navigation benefits were valued based on real cost savings of alternative transport. Fisheries benefits were also valued based on net value of production.

3.8 Findings and Recommendations

A number of consequences for the ease of benefit valuation follow from this analytical approach to the public good character of water and the provision of services derived thereof:

- tariffs (i.e. financial prices) for power, municipal and industrial water supply are not necessarily a good indicator of the economic price of these goods;
- increasing private sector participation in power markets will gradually ease the task of economic valuation of power benefits as prices emerging from power pools, etc. will represent competitive market prices that serve as economic prices;
- similar developments in water supply markets will also gradually eliminate the need to depend on willingness to pay surveys in the economic valuation of water supply;
- economic valuation of the value of water in irrigation will remain a complicated and difficult affair requiring substantial survey data and/or complex computational techniques;
- flood control benefit valuation will continue to rely on non-market techniques due to its nature as a public good;
- economic valuation of navigation services provided by dams may be based on market prices where tolls are charged, although adjustments may be necessary where substitutes are absent (i.e. road, rail or air transport) or policy distortions exist in transport markets; and
- other direct benefits of dams such as commercial, subsistence and recreational fisheries and general recreation can be valued using market or non-market methods, but will need to account for the loss of such opportunities were the dam not have been built.

A number of conclusions on the actual and best practice and the performance of benefit valuation may be offered:

- the prediction of the timing and magnitude of water availability will play a very important role in direct benefit valuation and will depend largely on quality and extent of historical hydrological records
- sophisticated best practice methods for the evaluation of power benefits are often employed in dam appraisal and these methods appear to be relatively reliable in predicting performance, however exceptions do occur, particularly where a simple alternative power plant method is applied;
- valuation of irrigation benefits remains problematic due to the difficulty of correctly estimating the respective contribution of irrigation water to augmenting productivity given the vagaries of accurately projecting hectares that will be brought under irrigation, crop choice and crop yield;
- water supply projects are typically evaluated using a least cost analysis, thus avoiding the difficulty of actually valuing these benefits;
- flood control components are typically valued based on reduction in expected average annual damage
- navigation, fisheries and recreation benefits are rarely valued in dam appraisals where these uses are secondary benefits
- valuation of direct benefits is typically undertaken as a technical exercise in which beneficiaries do not necessarily participate, except as respondents in surveys.
The conclusion that emerges from this discussion is that in many cases the methods are available to undertake more comprehensive, good practice valuation of direct benefits. In developed countries valuation tends to be more comprehensive as access to data, economic expertise, and resources is more pronounced. In addition, the use of willingness-to-pay surveys is easier and more likely to produce reliable results in developed market-oriented economies than in countries where potential respondents (i.e. consumers of services) are only marginally incorporated into the market economy.

Given that economic valuation of direct benefits requires substantial data, expertise and effort beyond the calculation of financial benefits the following policy principles can be offered:

- Economic analysis of dams should not rely on valuations derived from tariff information unless competitive market conditions exist or the tariffs represent a conservative estimate of willingness-to-pay and are sufficient to show that the project is profitable.
- When financial benefits of service provision appear to outweigh costs this should not be taken as indicative of the economic merits of a project as alternative options must be assessed in order to find the least cost option in terms of direct costs and benefits (i.e. prior to incorporation of external social and environmental costs and benefits).
- The resources devoted to the valuation of these benefits should not be reduced as a consequence of efforts to value other social and environmental impacts.
4. Valuation of Social and Environmental Externalities

The two previous chapters covered the direct costs and benefits of dam projects; that is the financial and economic valuation of the project as perceived from the perspective of the project owner, or developer (where the project is a concession to the private sector). Due to their size and complexity, as well as the regulatory framework within which a dam is planned and built, dam projects will often have a series of additional impacts that affect societal welfare but that do not accrue to the owner of the project. These are typically project impacts that are social or environmental in nature, but that lead to real gains and losses for specific groups and the economy as a whole. These may include water quality impacts, wildlife, fishery, and ecosystem impacts, avoided pollution benefits, resettlement costs and health effects (due to increases in the incidence of water-borne diseases). These impacts are often termed “externalities” because they are external to the investment decision of the project owners.

Cost-benefit analyses of dam projects are often criticised for failing to incorporate externalities into net benefit calculations. Dam critics hold that these impacts are largely negative and that, as a result, project decisions based on these analyses have often been biased in favour of the project due to overestimates of net benefits. Dam proponents, while acknowledging that there are negative external impacts, also point to the positive impacts that are not captured by the project owner.

This chapter begins by characterising the nature and types of externalities and then moves on to consider actual practice and guidelines in the valuation of these effects. Good practice methods and examples are then covered to demonstrate the range of alternatives available for the economic valuation of these impacts. This leads to a comparison of methods and processes for valuing externalities in the case of large dams, particularly for proposed dams in developing countries. Finally, a recounting of divergent views on extending cost-benefit analysis for this purpose is presented and the policy choices in this regard are highlighted. Finally, a series of operational recommendations are provided for the case where decision-makers or stakeholders wish to engage in the valuation of social and environmental impacts.

4.1 Social and Environmental Externalities of Large Dams

In moving from a financial to an economic analysis, a number of adjustments are made to the financial costs and revenues, principally consisting of the valuation of direct inputs and outputs of the project at their shadow prices or marginal opportunity costs to society. A further step in the economic analysis is the inclusion of externalities, that is those that affect the economic welfare of society as a whole even if they have no impact on the project cash flow.

The valuation of externalities impacts is often equated with the valuation of non-marketed environmental goods and services. This is an over-simplification and one that may lead to undue prejudice against the undertaking of an economic analysis of these impacts. The goods and services affected by dams that are external to the dam owner may be classified as private goods, public goods, common pool resources, etc. Therefore, these goods may be allocated effectively by markets or subject to various degrees of market failure or policy distortion. The level of difficulty in valuing these “externalities” in economic terms has as much to do with their economic nature and the extent of policy intervention in relevant markets as with their being “external” to the dam project.

When a dam alters the cash income of upstream or downstream fishermen this is a market impact – the fish are sold in a “market.” Where the regulation of flows affects the aesthetics of a river this may be a non-market impact as “scenic values” are not directly traded in markets. In both cases the extra step is identifying how the dam will lead to impacts on the fishery and on flows. The difficulty of this notwithstanding it is clear that the “closer” to a market a given impacts is, the easier it will be to value. In particular, the analyst will have observed market behaviour from which inferences as to the value of external impacts may be drawn. In any event, both market and non-market valuation methods will be employed in valuing the external impacts of dams, oftentimes serving to complement
each other. As non-market methods are equally applicable to the valuation of the uses of water and energy as they are to environmental and social impacts, the discussion of methods also bears on the benefits of dam projects previously discussed in Chapter 3.

In examining the types of externalities and the argument for their valuation it is useful to trace through the impacts beginning with those physical impacts that result from the construction of the dam. As streamflow may be left to flow freely, be regulated by dams or abstracted for consumptive use, the alternatives that immediately present themselves for the use and regulation of rivers will have environmental, social and economic consequences. In economic terms, the existence of many alternative uses for streamflow implies that a given use of water will have an opportunity cost – represented as the marginal opportunity cost to society of foregoing one use of water for another. Similar arguments apply to changes in social, aquatic, terrestrial and atmospheric systems occasioned by the insertion of a dam into the riverine environment.

The opportunity cost of re-regulating or diverting streamflow may have important effects on downstream ecosystems and the goods and services that they provide to producers and consumers. Where such costs are significant in relation to the direct net benefits of the project they indicate the need to consider alternative project designs that avoid, mitigate or compensate for these impacts of the project. Where such costs overwhelm the direct net benefits of the project they suggest that implementing the project would not lead to a net gain in societal welfare and that alternative projects should be considered. The Hadejia-Nguru wetlands in Nigeria provide an example where the net benefits associated with the installation of a dam for irrigation appears less profitable in economic terms than the alternative of allowing the river to flow naturally to a wetland downstream. The wetland provides a series of goods and services to local communities but incurs no direct capital or O&M costs (see Box 4.1).
Financial, Economic and Distributional Analysis

Box 4.1. The Opportunity Cost of Streamflow in Different Uses: Hadejia Nguru Wetlands

In Northern Nigeria, extensive floodplains exist where the Hadejia and Jama'are Rivers converge. The floodplains provide essential income and nutrition benefits in the form of agriculture, grazing resources, non-timber forest products, fuelwood and fishing for local populations, and helps to recharge the regional aquifer which serves as an essential groundwater source. However, in recent decades the floodplains have come under increasing pressure from the construction of the Tiga and Challawa Gorge dams upstream. The maximum extent of flooding has declined from 300,000 ha in the 1960s to around 70,000 to 100,000 ha more recently and there are plans for a new dam at Kafin Zaki.

Economic analysis of the Kano River Project, a major irrigation scheme benefiting from the upstream dams, and the floodplains, showed that the net economic benefits of the floodplains (agriculture, fishing, fuelwood) were at least $32 per 1000 m$^3$ of water (at 1989 prices). However, the returns per crops grown in the Kano River Project were at most only $1.73 per 1000 m$^3$ and when the operational costs are included, the net benefits of the Project are reduced to $0.04 per 1000 m$^3$.

A combined economic and hydrological analysis was conducted to simulate the impacts of these upstream projects on the flood extent that determines the downstream floodplains area. The economic gains of the upstream water projects were then compared to the resulting economic losses to downstream agricultural, fuelwood and fishing benefits. Given the high productivity of the floodplains, the losses in economic benefits due to changes in flood extent for all scenarios are large, ranging from US$3 million to US$24 million. As expected, there is a direct trade-off between increasing irrigation upstream and impacts on the floodplains downstream. Full implementation of all the upstream dams and large-scale irrigation schemes would produce the greatest overall net losses, around US$20 million.

These results suggest that the expansion of the existing irrigation schemes within the river basin is effectively ‘uneconomic’. The introduction of a regulated flooding regime would reduce the scale of this negative balance substantially, to around $16 million. The overall combined value of production from irrigation and the floodplains would however still fall well below the levels experienced if the additional upstream schemes were not constructed.


The construction of a dam and the resulting environmental and social impacts are not limited to downstream opportunity costs of water. Dams may degrade water quality and the aquatic environment, with consequent effects on biodiversity, such as fish and waterfowl. These concerns apply not only downstream, but also in the reservoir area and upstream. Disruption to fish migration and the creation of reservoir habitat that supports disease vectors are just a few of the potential environmental impacts that may in turn lead to significant social and economic impacts.

Dams also have terrestrial, atmospheric impacts as well, as they involve the loss of land and its associated resources and environmental services. The creation of reservoirs leads to the displacement of people living in the impoundment area. This leads to a series of social, cultural, environmental and economic impacts. Where resettlement programs are not undertaken or such programs fail to effectively counter the potential impacts programs the long-term effects may be significant and long-lived.

Reservoir flooding also destroys habitat and resident flora and fauna at the reservoir site. Flooding of biomass and the turbination/spilling of reservoir water may result in net releases of carbon dioxide (CO$_2$) and methane (CH$_4$) relative to background conditions. Meanwhile power generation from hydropower dams may offset thermal power generation leading to avoided emissions of nitrous oxides (NOx), sulphuric oxides (SOx), particulate matter and carbon dioxide. All of these may have impacts on global climate and localised air pollution problems. Dam projects may also have a series of
impacts on the social environment. These may be caused through the environmental impacts of dams or directly through the economic, social and cultural changes that result from the planning, construction and operation of large dams. These may include negative or positive impacts, such as those direct and indirect impacts from the provision of dam-related services and those resulting from resettlement of people in the reservoir area.

Clearly there is quite a range of potential impacts on streamflow and the aquatic, terrestrial and atmospheric environment. As an indication, Technical Annex 7 provides an exhaustive table of the types of impacts that can result from the construction of a hydropower dam. An indicative table of types of impacts and their values is provided in Table 4.1. The social and economic consequences of such changes are therefore of relevance in assessing the full economic costs and benefits of dam projects. This applies across the planning and project cycle, from sector planning and options assessment, to appraisal and on to relicensing.

### Table 4.1. Economic Impact of Changes in River Profiles

<table>
<thead>
<tr>
<th>Environmental characteristic</th>
<th>Economic effect, cost or benefit identified (C/B)</th>
<th>Examples of economic impacts resulting from ecosystem changes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upstream Impacts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil erosion and reservoir sedimentation</td>
<td>Reduced storage capacity, decrease in power, lower water quality. Loss of use, option and existence values.(C)</td>
<td>Watershed protection values found to be greater than timber productivity in British Columbia (Canadian Ministry of Environment 1995)(^1)</td>
</tr>
<tr>
<td>Chemical changes in reservoir water quality</td>
<td>Loss of fishery production, change in treatment costs. (C)</td>
<td>Water quality improvements in the Danube estimated to have floodplain benefits of $458/ha. p.a.(Gren 1994)</td>
</tr>
<tr>
<td>Loss of productivity of flooded area</td>
<td>Loss for timber/non-timber products, grazing. Loss of use and option values. (C)</td>
<td>Forestry in Indonesia valued at US$67/ha/p.a. (Ruitenbeek 1992)</td>
</tr>
<tr>
<td>Increased evaporation rates over open water area</td>
<td>Possible impact on water availability up-slope from the dam. Change in use and option values. (C/B)</td>
<td></td>
</tr>
<tr>
<td>Changes in flow rates out of dam</td>
<td>Changes in energy output from dam - change in use value (C)</td>
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<td>Impacts on cultural heritage sites</td>
<td>Cultural heritage sites lost through dam construction, loss of social capital. (C)</td>
<td>Cultural value of Warrumbungles National Park in Australia estimated to increase regional income by $323,400 p.a. (Ulph and Reynolds 1984)</td>
</tr>
</tbody>
</table>

Source: Sullivan (1999 ecoweb013)

Notes: The studies reviewed here are in no way a complete coverage of all the literature on the subject, but an attempt has been made to provide a cross-section of views. There is no doubt that an important common theme in all of them is that the valuation of river systems and modifications of them are extremely complex and difficult, and as a result, any values obtained must be treated with caution.

### 4.2 Actual Practice and Guidelines

This section discusses actual practices and agency guidelines starting with public agencies and multi-lateral development banks in developing countries and then moving on to public agencies in developed countries.
Public Sector Agencies in Developing Countries

An environmental impact assessment (EIA) of dam projects is typically conducted in projects sponsored by developing country agencies. However if resources are limited, its scope may not be particularly far-reaching. An EIA will cover areas such as effects on non-renewable resource use, land use, water use, bio-diversity and environmental capacity. It will also include the environmental impacts of alternative sources of supply. For example, if the dam project will produce hydropower, and the alternative is developing and operating equivalent thermal power plants, the impacts of these plants, such as atmospheric emissions, aquatic discharges and discharges of solid wastes, are incorporated into the overall EIA. Where possible, environmental impacts are presented in terms of changes in physical quantities, such as decreased tonnes of sulphur dioxide emissions from fossil-fuelled thermal plants. Only rarely are these impacts valued in economic terms.

The same is usually true for distributional effects and other social impacts, including the psychological effects associated with involuntary resettlement, the disruption of communities and cultures, the loss of traditional heritage sites and artefacts, the positive and negative impacts on the economy of the local region (during both the construction and operating stages of the project), the costs and benefits experienced by distinct socio-economic and cultural groups, etc. These impacts are usually addressed qualitatively, and independently of the financial and economic analyses, in a socio-economic impact assessment but, with the exception of effects on the local economy (e.g. employment and income), little or no attempt is made to convert these into monetary values.

Multilateral Development Banks

The WCD survey of multi-lateral development bank (MDB) projects found that only four out of the entire sample of 55 projects quantified environmental pollutants. Of these, three World Bank projects (Pakistan’s Ghazi-Barotha Hydropower, China’s Ertan II Hydroelectric, and China’s Daguangba Multi-Purpose) quantified environmental impacts, performing detailed simulations of with and without-cases. These impacts however were not valued in economic terms.

Instead of undertaking economic valuation, the MDBs appear in practice to have preferred to include environmental mitigation costs in project cost estimates (as discussed in Chapter 2). Internalisation of resettlement/land compensation costs has been generally practised for dam projects, with a noticeable increase in the practice from the 1980s. Incorporation of environmental mitigation costs began in the 1980s but has only taken hold in 1990s, as the conduct of environmental impact assessments (EIAs) has become general practice. In five projects where mitigation costs were not explicitly stated, mention was made of incorporation of mitigation measures in project design.

In general, the MDBs have been strong supporters of the valuation of social and environmental impacts. Many of them – but especially the World Bank - have provided guidance in the form of handbooks, working paper series and books that cover the methods and provide examples of social and environmental valuation. Indeed, the late 1980s and early 1990s saw the World Bank hiring large numbers of established environmental and natural economists. By the end of the decade the Bank was bringing on increasing numbers of younger economists emerging from the established and newer programs in this field.

Still, agency guidelines remain fairly general in their support for this effort. The Asian Development Bank guidelines acknowledge that not all environmental impacts may be valued, although there is support for making these values explicit (ADB 1997). For projects where beneficial environmental effects are expected – and are the objective of the project – the ADB states that they should be valued. In other cases – and this would apply to the case of large dams – ADB (1997: 45) suggests that such benefits and costs should be “valued as far as possible, and incorporated into the economic analysis, together with related mitigation or monitoring costs.”
Financial, Economic and Distributional Analysis

The World Bank’s Operational Manual (OP 10.04 September 1994) clearly states that the “economic evaluation of Bank-financed projects takes into account any domestic and cross-border externalities.” It does not however, specify how this is to be done. With respect to global externalities (such as emissions of greenhouse gases or impacts on biodiversity) these are to be included in the economic analysis when the project is financed by the Global Environment Facility or there are payments under an international agreement. Otherwise they are to be assessed to the extent possible as part of the environment assessment process and incorporated in this fashion into project design and selection.

Although many of the large dam appraisals included in the WCD survey were undertaken prior to the ADB and World Bank statements repeated above, it is clear that the gap between past practice (and indeed ongoing practice) and the policy and guidelines currently in effect is considerable.

In practice, few attempts have been made to value the environmental and social impacts of dam projects in developing countries. Most of the studies of this nature received by the WCD are fairly recent in origin (Anderson 1997; Klasen 1999 eco065; Satyanarayan 2000 eco042, BCEOM 1999, Reid 1999 eco056; Simpson and Sedjo 2000). An example of the use to which these methods may be put comes from the Lesotho Highlands Water Project where a detailed study of the social, environmental and economic impacts of the diversion of water to the Gauteng area of South Africa is in its final stages. Such information may be useful for defining environmental flow requirements or more specifically in defining remedial or compensation measures necessary at different levels of release.

The wider application of the tools of non-market valuation in developing countries is a phenomena of the 1990s. At the beginning of the decade the number of environmental and natural resource economists with experience in valuation was quite limited. Expansion of university and training programs in both Northern and Southern countries in the 1990s, funded primarily by aid donors, particularly the bilateral donors, has led to an increasing concentration of expertise in these techniques in developing countries. At the same time, the continued increase in innovation in methods and application to new problems in both the developed and developing world provides a rich array of techniques and literature from which agencies may draw.

However, lack of familiarity with these tools within the dams “industry” has no doubt affected the rate at which these methods have been adopted in the application to dams. Also, it is worth noting that the EIA has typically been conducted independently of the financial and economic analyses reducing the likelihood of arriving at the integration necessary in environmental and social valuation. Currently, the trend is to integrate these types of analysis.

Public Agencies in Developed Countries

In the last few decades, government agencies in developed countries have attempted to apply techniques to monetise many project externalities. This is particularly true in the case of the US. This reflects the early development of natural resource and environmental economics disciplines in the US land grant universities in the mid-1900s. The development of such capacity in Europe followed at a later date, gaining increased prominence only in the 1990s. In the last decade numerous graduate and university research programs in this field were initiated in Europe. As a result, many of the examples cited below of good practice come from dam projects in the US experience. This is also driven, in part, by the current interest in the US on the part of environmental groups in decommissioning which has spawned further interest in the comparison of direct project benefits with the value of free-flowing rivers.

The US Principles & Guidelines governing federal water projects state that positive external economies – read externalities – and uncompensated, unmitigated adverse costs of the project to the economy should be included in the assessment of the National Economic Development impacts of the projects. In his analysis of the P&G (and its predecessor the Principles & Standards), Shabman (1993) confirms this interpretation by emphasising that the NED accounts are expected to be a measure of the

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value people attribute to all the other services of a watershed – not just the project benefits. Implicitly, the inability to fully value all these impacts is reflected in the position that those social and environmental impacts that cannot be valued in monetary terms are to be covered under the Environmental Quality (EQ) accounts.

### 4.3 Good Practice Toolchest

In this section the principle good practice methods for market and non-market valuation are summarised and illustrated using cases from dam projects or efforts to value intact rivers. The description of the methods is indicative only as they are explained in greater detail, along with further examples in Technical Annex 7.

Methods for economic valuation may be classified into four categories according to combinations of two sets of characteristics: 1) whether they are based on observed behaviour in real markets or on hypothetical behaviour in “constructed markets”, and 2) whether they yield monetary values directly or whether such values must be inferred indirectly based on models of individual behaviour and choice. Direct observed methods include the use of competitive market prices and accompanying shadow-price adjustments and can be more simply labelled as “market price” methods (see Table 1.1). When possible the use of such techniques is preferred, as the valuation outcome will be based on actual, not hypothetical, choices, and does not require the analyst to make assumptions and inferences about people’s behaviour.

<table>
<thead>
<tr>
<th>Observed Behaviour:</th>
<th>Hypothetical Behaviour:</th>
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<tbody>
<tr>
<td><strong>Direct:</strong></td>
<td></td>
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<tr>
<td>Competitive market prices</td>
<td>Contingent Valuation (dichotomous choice, willingness-to-pay, bidding games)</td>
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<tr>
<td>Shadow-pricing</td>
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<tr>
<td>Revealed Preferences (Indirect Observed)</td>
<td>Choice Modelling (Indirect Hypothetical)</td>
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<tr>
<td>Productivity methods</td>
<td>Contingent referendum</td>
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<tr>
<td>Avertive (defensive) expenditure</td>
<td>Contingent ranking</td>
</tr>
<tr>
<td>Travel cost</td>
<td>Contingent behaviour</td>
</tr>
<tr>
<td>Hedonic pricing</td>
<td>Contingent rating</td>
</tr>
<tr>
<td>Substitute goods</td>
<td>Pairwise comparisons</td>
</tr>
</tbody>
</table>


The remaining approaches illustrated in the table: revealed preferences, stated preferences and choice modelling are applied in valuing goods and services that either do not pass through markets, or the market prices of which are not effective guides to their opportunity costs to society due to problems of market failure.

The indirect observed methods are commonly referred to as revealed preference methods as they rely on the actual observation of individual behaviour in real markets. For example, the production function approach is used to determine the value of environmental or natural resource inputs that are inputs into production processes. A drop in river water quality will have an impact on water treatment plants. By observing behaviour in input and output markets and understanding relevant biogeophysical processes it is possible to value the marginal productivity of – and hence economic benefits provided by – the natural input.

Hypothetical techniques that involve the creation of contingent, or hypothetical, markets are often grouped together under the heading of contingent valuation methods (CVM). Dichotomous choice, in which respondents are presented with a proposed price and are asked to accept or reject it is generally agreed as the preferred method of eliciting responses to willingness-to-pay questions. Indirect hypothetical approaches consist of a series of methods that involve not only the construction of
hypothetical markets, but further inferences from survey data to arrive at economic values. For example, tourists may be asked how their behaviour with regard to site visits would change with a rise in entrance fees. The analyst may then infer from the change in behavior, how the respondent values the site. More frequently, however, this information is used directly in the design of products, services or policies, rather than as simple value estimates.

A further set of secondary methods including replacement cost approaches and benefits transfer are available when data, resources or modelling expertise are not available.

Below, a brief overview of the concepts and assumptions underlying the primary methods that are applicable to dams is provided as well as examples of how these methods can be applied to different categories of dam project impacts. Secondary methods are also briefly treated. The limitations of each of the methods is also discussed. The treatment here can only be cursory. As noted earlier the Technical Annex provides a more precise description of the methods and provides indicative references to the large literature on this topic.

Finally, it should be noted that the choice of a valuation method depends on a variety of factors, including the specific nature of the impact, the availability of data, expertise, time and resources. In practice, multiple approaches may be possible for valuing a given impact and the ultimate choice of a method will be case specific.

### 4.3.1 Market Methods

Most of the emphasis in this chapter is on valuation approaches for non-market impacts of dams. As indicated earlier, many of the social and environmental impacts of dams are conveyed through physical, chemical or biological changes brought on by the construction of the dam. Thus, even where the end result is a change in market values, the valuation effort often goes beyond simple market methods. However, given that many of the products and services that will be affected are traded in markets and can be assessed using productivity methods (as discussed in the next subsection) which itself relies on market data it is useful to briefly review market methods. The accuracy of market estimates depends on the extent to which the goods or services of concern are regularly traded in a competitive market. That is, the market must be characterised by several buyers and sellers and must not be constrained in undue manner. The correct measure of net benefits using this method is the change in consumer and producer surplus associated with the resource/impact of concern.\(^{13}\)

The data generally required to calculate consumer and producer surplus changes include the quantity of the resource or service of concern demanded at different prices and the quantity supplied at different price levels. These data are considered both before and after the expected impact. Through modelling of supply and demand curves, economists can estimate changes in consumer and producer surplus and arrive at the benefits or costs of the impact.

A number of the impacts of dam projects that result from the flooding of the reservoir may be valued using market approaches – such as the loss of commercial timber and non-forest resources, and the creation of a reservoir fishery. Where these are bought and sold in markets, supply and demand modelling – or more straightforward assessment of quantities and unit prices – can be employed to develop net benefit estimates. For example, a dam project may result in external benefits such as the creation of a new reservoir fishery. In this case, a simplified market-based approach may be taken whereby net benefits are calculated based on estimates of the commercial harvest levels and prevailing market prices. This approach can be taken when the impact is not expected to significantly affect market prices or the resources devoted to harvesting fish (i.e., production costs, level of effort by fishermen). However, a more sophisticated analysis is required if the new fishery is expected to cause large-scale changes in the regional catch that affect market prices and the commercial fishing effort. This approach estimates the changes in consumer and producer surplus based on modelling of supply and demand interactions in the commercial fishing market.

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The data and resource demands associated with developing a supply and demand model can be significant. Demand curve estimation may require a significant amount of data on consumption of a good or service at different price levels (e.g., demand for fish at different market prices). Likewise, supply curve estimation may require detailed information on production costs and supply conditions (e.g., capital cost, labour cost, and catch information for different types of commercial fishing vessels).

### 4.3.2 Revealed Preference Approaches

Revealed preference techniques are premised on the economic concepts of “substitute” and “complementary” goods. For instance, similar ecotourism sites may be substitutes for each other; if the environmental quality of one site declines, people may make more visits to the other site. Likewise, environmental amenities and property values are complementary goods; if environmental amenities improve, property values will generally increase. By analysing individual behaviour in substitute and/or complementary markets, economists can infer values for the non-market resource or impact of concern.

#### Productivity Methods

Productivity methods essentially look to value changes in output using market prices if these are available, or using unit values for the output derived from other methods. The process of quantifying the output changes can, however, be quite involved and typically, in the case of dams, will involve specialists in other disciplines and affected groups working with economists to derive the relevant linkages between the dam and the economic activity that is affected. The productivity method is best suited to valuing changes in outputs such as forestry, fisheries and agriculture but can be applied to a wide range of frequently affected activities.

The example from Hadejia-Nguru cited above in Box 4.1 provides an excellent example of the application of productivity methods to effects of dams on productive wetland downstream. Such efforts may be expert-driven in nature or participatory in nature. For example, Adaya et al. (1997) present the results of a participatory appraisal of the economic importance of wild foods in the same Hadejia-Nguru wetland area.

The productivity approach may also be used to value health impacts. For example, reservoirs created by dams can result in higher incidences of water-borne diseases, such as schistosomiasis and malaria. Estimates of the costs of illness may be developed to value these losses. It should be noted that the cost-of-illness method does not attempt to measure several other significant types of losses associated illnesses, including pain and suffering, lost leisure time, and the cost of any efforts people have made to avoid the illness altogether. Therefore, the cost-of-illness approach is often considered a lower bound on the true cost of higher incidences of disease. To account for the full range of impacts from a higher incidence of illnesses, a willingness-to-pay to avoid illness study can be undertaken. This approach, which is often considered an upper bound estimate on illness, is described in more detail below (see Stated Preference Approaches).

Productivity methods may also be used to value the benefits of avoiding additional increment of pollution in terms of the expected environmental damage. This would apply in particular to the atmospheric externalities, whether positive or negative, of dams. Potential damages include health

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impacts, materials damage, reduced agriculture production, global warming, and other effects. However, while several studies have been conducted to estimate the monetary damages per ton of various air pollutants, the results of these studies are subject to a high level of uncertainty. Not only are damage estimates based on many estimated parameters, but damage values tend to vary depending on the (proposed) location of the alternative power generation facility. For instance, a facility located near a large population centre will have greater impacts than a facility located in a rural area.

The economic linkages between catchment land use and reservoir operations, and the need for watershed management are also captured by productivity approaches. Models linking land use to hydrological variables that subsequently influence dam operations and economic benefits can be used to assess a variety of upstream-downstream linkages including those transmitted through sedimentation, changes in water yield and timing (Chomitz and Kumari 1996; Enters 1998; Gregersen et al. 1987). Reviews of the valuation literature and the policy implications for watershed management suggest the need for revision of standard assumptions employed in catchment management programs associated with large dams (Aylward 2000; Kaimowitz 2000). In a recent study the gains in water yield for hydroelectric production from pasture – as opposed to forest cover – were an order of magnitude larger than the loss from higher sedimentation rates under pasture (Aylward and Echeverría In press).

The ExternE approach is presented below in Box 4.2. ExternE represents an effort to derive damage costs associated with different fuel cycles, including hydropower. While it is based on the productivity methods, it is intended to be used as a benefit transfer mechanism (as discussed further below).
Box 4.2. ExternE: Externalities of Energy

The ExternE project, a research project of the European Commission, is the first comprehensive attempt to evaluate the external costs associated with a range of different fuel cycles, using a consistent ‘bottom-up’ methodology. The project results provide a basis for examining the comparative effects of alternative fuels for electricity production. Started in 1991 in collaboration with the US Department of Energy, the project is now contributing to a more efficient and sustainable economy with the integration of the environmental dimension. The main objectives of the project are to apply the methodology to a wide range of different fossil, nuclear and renewable fuel cycles for power generation and energy conservation options, and a series of National Implementation Programmes to implement the methodology for reference sites throughout Europe. The multidisciplinary and multinational work involves teams of economists, ecologists, environmental scientists, energy technologists, health specialists, atmospheric chemists and modelers, and computer software specialists.

To date, the accounting framework has been completed for 12 fuel cycles, including hydro. For each fuel cycle, the framework includes the application of the methodology, detailed quantification of the impacts and their evaluation in monetary terms. Impact assessment and valuation are performed using the ‘damage function’ or ‘impact pathway’ approach. The approach uses the most appropriate data and models available, ranging from simple statistical relationships to a series of complex models and databases. It requires a detailed definition of both the fuel cycle and the system within which the fuel cycle operates, with respect to both time and space, involving technological and emissions data. The legal framework governing emissions, health and safety, etc involve specification of the fuel used, meteorological conditions affecting dispersion of atmospheric pollutants, demographic data, condition of ecological resources, and the value systems of individuals which determine the valuation of non-marketed goods. The project has recognised the importance of selecting the most appropriate dose response functions and models for the assessment of pollution impacts. The functions to be used for damage assessment in human health, building materials, crops, forests, freshwater fisheries, and biodiversity, has been identified by international groups of experts.

The overall results across the fuel cycles indicate that hydro is the third lowest among 10 fuels with the “highest damage”, and is the top among the 10 fuels with the “lowest damage”. In contrast to other fuels, the study of the hydro fuel cycle assessed the impact of construction and dismantling in more depth. Most of the burdens of the hydro fuel cycle are placed on the environment due to changes in river flow and the artificial barriers created. The impacts include changes in water quality, in hydrological systems, in flora and fauna, and the loss of amenity. These impacts are much larger in the case of reservoirs, as valleys may be flooded, thus affecting a large extension of terrestrial ecosystems. Large dams also cause a greater alteration of river flow, and have a higher failure risk. The project however did not assess the impacts on population resettlement and land loss which are alleged to be usually internalised. The study also noted that not only negative impacts arise from the hydro fuel cycle but cited that run-off-river systems provide flood prevention, and regulation of river transport and that reservoirs provide water for irrigation and domestic use in a regulated way. Further, since hydro is site specific, the results are very difficult to extrapolate to other sites and that differences may be produced depending on the site and technology choice.

Source: Adapted from ExternE website at http://externe.jrc.es

Avertive Expenditure Method

The avertive expenditure method (also known under the guise of avoided costs, defensive expenditures or preventive expenditures) is typically used to value non-market environmental goods or services that enter into the household activities – though it may also apply to commercial production. The technique involves identifying the manner in which an

Examples of External Impacts that may be Valued using Avertive Expenditures
- improvement in water quality
- avoided emissions
- ecosystem restoration
improvement in environmental quality (i.e. reduction in noise pollution) leads to households switching away from the purchase of a conventional market input due to the environmental improvement. In such a case the “defensive” expenditure that is no longer necessary provides a valid measure of the benefits of environmental improvement.

The avertive expenditure method is often used to value the benefits of pollution control. It would be a logical extension then to use this method to examine the benefits of improvements in water quality (i.e. reductions in expenditures on water treatment) or other changes in defensive expenditures related to hydrological outcomes such as investments in flood control measures. The technique is implicitly used to value the benefits of catchment management where dredging (of dams, irrigation canals, etc.) is avoided through a reduction in sediment levels.

The averted cost approach can also be used to estimate the pollution costs avoided by constructing hydropower capacity rather than combustion-based alternatives.

It is important to stress the importance of the direction of change in the relationship between the inputs. The change must be from a pattern of expenditures aimed at avoiding welfare reducing effects of poor levels of environmental quality or service provision. In other words, the environmental damage must already be the status quo and defensive behaviour must be observed. This is different than assessing what expenditure would be necessary were a (new) degradation of environmental function to occur. The latter is essentially the basis for the replacement cost approach (covered below). As a result, this technique may be of limited usefulness for the negative social and environmental costs of dams. It may, however, be of use in the analysis of the benefits of ecosystem restoration following a change in operations or decommissioning.

**Travel Cost Method**

Travel cost models are analytical tools frequently applied to assess the value of recreational opportunities, as well as value the quality and characteristics of these opportunities. For example, the recreational values of a river or reservoir eco-tourism site can be estimated by analysing the travel and time costs incurred by individuals visiting the site (or a similar alternate site). This approach assumes that individuals' time and travel costs serve as proxies for the value that individuals’ place on recreational activity at the site.

A travel cost model typically examines the location from which visitors to a recreational site travelled. The analysis considers the number of trips taken to the site for a given travel distance. This essentially represents the quantity of the resource demanded (i.e., recreational activity at the site) at a given price (i.e., travel cost). Using data on multiple visitors, economists can construct a demand curve for the recreational activity at the site and estimate consumer surplus (i.e., the area under the demand curve).
Box 4.3. Travel Cost Methods and the Economic Losses from Reduced Catch on the Snake River, USA

Loomis, et al. (1986) considered the potential economic impact of several small-head hydropower dams on Henry's Fork, a tributary of the Snake River in Idaho, United States. One component of the study was a travel cost model that estimated total trips per person as a function of angler characteristics (e.g., income), the availability of substitute sites, and site quality. Henry's Fork was one of 51 Idaho cold water fishing areas included in the model. Over 1,900 licensed anglers responded to a survey that mapped out the fishing areas and asked the respondents to record the number of visits to each site. Anglers were then re-contacted by phone and asked to provide information on travel costs and catch rates.

Loomis, et al. pooled the data and estimated a single recreational fishing demand curve for the region. The estimated equation measures changes in fishing trips (and associated consumer surplus) for changes in catch rates and other factors. Studies of similar dams revealed reductions in fish populations and catch rates of 50 to 75 percent. Loomis, et al. used this range of catch rate reductions to estimate the decrease in fishing trips to Henry's Fork and the total loss in consumer surplus associated with construction of the proposed dams. Specifically, the authors predicted an annual loss of $920,000 for a 50 percent reduction in fish catch and $1.36 million for a 70 percent reduction in fish catch.


Additional Methods

Many additional revealed preference methods and models beyond those discussed above are possible. Chief among these are hedonic pricing and substitute goods approach. These are discussed further in Technical Annex 7. It is only worth mentioning that the substitute good approach may often be of value in valuing subsistence goods in a rural economy. Where a non-marketed good has a close substitute which is marketed the value of the non-marketed good can be roughly approximated by the observed market price.

Revealed preference approaches are limited by the quality of the underlying behavioural and biophysical data and models. For instance, recreational demand models rely on individual perceptions of changes in recreational opportunities and/or quality. Valuing changes in environmental quality is possible where the changes have an obvious effect on popular recreational activities, but using recreational models may not be appropriate for measuring changes in environmental quality that are difficult for the public to observe. Similarly, where the ability to predict or assess the environmental changes—be they physical, chemical or biological—that are effectuated by dams is limited, the reliability of valuation efforts will be similarly circumscribed.

4.3.3 Stated Preference Approaches

Stated preference approaches attempt to measure willingness-to-pay values directly. Unlike revealed preference approaches, which rely on markets to infer values for environmental and social factors, stated preference methods develop values by conducting surveys to directly elicit information about respondents’ preferences for non-market factors, i.e., respondents “state” their values. Contingent valuation (CV), is the most frequently employed stated preference technique and can be used to measure a variety of dam project impacts.
Box 4.4. Using Contingent Valuation to Estimate Willingness to Pay for Preserving Instream Flows and Avoiding a Dam: An Illustration

González-Cabán and Loomis (1995) considered the potential economic benefits of preserving instream flows in the Río Mameyes and avoiding a dam on the Río Fajardo in Puerto Rico. A contingent valuation survey was conducted via in-person interviews with a sample of 600 households covering 47 municipios throughout Puerto Rico. They found a annual willingness to pay of $21 per household to prevent 10 million gallons per day water extraction from the Río Mameyes and implement the proposed alternative (i.e., repair of the water distribution system lines and in-home water conservation program in Puerto Rico). Similarly, households would pay $21 per year to avoid a dam on the Río Fajardo and implement the proposed alternative (i.e., dredging of the two major reservoirs to the San Juan metropolitan area.

Generalising to the Island as a whole and over the five years that households were asked to pay, this represents an economic value that ranges from a low of $44.5 million to a high of $111 million for the Río Mameyes, and a low of $43.6 million to a high of $106.8 million for the Río Fajardo. In addition, visitors to Río Mameyes indicated they would reduce trips by 93 percent if 10 million gallons per day were withdrawn from the river. The survey found the most common reasons given by households to protect the rivers were: maintaining rivers for future generations, clean air, protecting the environment, preserving plants and animals, protecting natural beauty, water supply, and protecting fish habitat.

Based on the study’s conclusions, the authors recommend that the Puerto Rico Aqueduct and Sewage Authority consider alternative ways. They suggest that repairing water lines, reducing illegal connections, dredging the Carraizo and La Plata reservoirs, and replacing water inefficient shower heads and toilets could reduce the unaccounted for water losses from about 40 percent to about 15 percent. This savings would translate into over ten times more water than what would be extracted from Río Mameyes.

CV is a versatile method because survey questions can be developed to elicit willingness-to-pay values for specific non-market environmental and social factors. For instance, willingness-to-pay values can be estimated for increased flows at a dam site to improve the aesthetic values of a scenic waterfall for eco-tourism. In addition to values that humans realise through direct or indirect use of a resource (e.g., viewing the waterfall), CV can be used to measure intrinsic values (e.g., knowing the waterfall exists or has been preserved). Intrinsic values are the economic values that accrue to those who do not directly or currently use a resource and perhaps never intend to do so. Thus, a key advantage of CV is that it can capture the full range of values associated with a resource.

The technical components of a CV study include:

- Creating a hypothetical market that provides survey respondents with a description of the good or service being valued;
- Developing a contingent situation under which the good would be provided;
- Creating a hypothetical payment vehicle; and
- Providing respondents with an opportunity to express a value for the good or affected service.

The analyst then compiles the survey data and applies statistical techniques to estimate average willingness to pay (i.e., consumer surplus) associated with the non-market factor under consideration.

Table 4.3 provides some examples of how the CV method may be applicable in measuring the impacts of dam projects. Whether an effective CV study can be designed to value these impacts depends on a number of factors, including the specific nature of the impact and the likelihood that respondents can accurately estimate their willingness to pay for (or to avoid) the impact. For
example, it may not be possible to design a CV study that elicits peoples' true willingness to pay to avoid socio-cultural losses. The impact is difficult to define adequately and to the satisfaction of all concerned parties and complex to convey through survey questions. Moreover, respondents may not be capable of providing reliable estimates of intangible factors given the public's lack of experience valuing such impacts. It is important to recognise that the examples provided in Table 4.3 may be appropriate valuation approaches for some dam projects and inappropriate for others.

Table 4.3. Examples of the use of Contingent Valuation in the Context of Large Dams

<table>
<thead>
<tr>
<th>Service or Resource to Be Valued</th>
<th>Example Scenario</th>
<th>Modelling Approach</th>
<th>Model Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-commercial fishery impacts -- subsistence and/or recreational fishing</td>
<td>Dam expected to affect subsistence and/or recreational fishing downstream from the project.</td>
<td>Survey affected populations and/or recreational anglers using the river regarding their willingness to pay to preserve current catch rates.</td>
<td>Average willingness to pay to avoid losses for affected populations and/or recreational anglers; total expected losses in consumer surplus.</td>
</tr>
<tr>
<td>Loss of ecosystems, loss of biodiversity, species extinction</td>
<td>Dam expected to destroy ecosystems and threaten species</td>
<td>Survey could present a hypothetical program to preserve similar ecosystems and species and assess respondents' willingness to support the program.</td>
<td>Average willingness to pay to preserve the ecosystems and species of concern; total expected losses in consumer surplus.</td>
</tr>
<tr>
<td>Increase in water-borne disease risks -- increase in incidence of malaria due to creation of reservoir</td>
<td>Dam reservoir expected to result in higher incidences of malaria.</td>
<td>Survey potentially affected populations to assess their willingness to pay to avoid an increase in the risk of contracting malaria. These estimates will reflect medical costs and lost wages, as well as non-market factors such as pain and suffering and lost leisure time.</td>
<td>Average willingness-to-pay to avoid malaria for the potentially affected population; total expected costs associated with higher incidences of malaria due to the dam.</td>
</tr>
<tr>
<td>Non-market resettlement costs -- loss of cultural/historic sites</td>
<td>Dam reservoir inundates area with cultural/historic sites that cannot be moved (e.g., cave paintings)</td>
<td>If similar sites exist, survey could assess respondents' willingness to pay to preserve the substitute sites.</td>
<td>Average willingness to pay to preserve the cultural/historical sites of concern; total expected losses in consumer surplus.</td>
</tr>
<tr>
<td>Aesthetic value of scenic waterfall</td>
<td>Reduced flows below the dam expected to diminish the aesthetic qualities (e.g., sight, sound, spray) of a scenic waterfall.</td>
<td>Survey could present (computer generated) photographs of the falls at various flow levels and elicit willingness to pay for viewing different flows.</td>
<td>Estimates of individual willingness to pay for flow increases and changes in the number of trips to the falls; estimate of total potential consumer surplus from flow increases.</td>
</tr>
</tbody>
</table>

Although the CV method can be used to value many different types of non-market factors, and CV remains the only established method for assessing intrinsic values, the reliability and validity of CV has been the subject of much controversy. For a variety of reasons, respondents' stated intentions may not equal their true willingness to pay. The debate primarily focuses on whether respondents can provide reliable estimates of the value of non-market goods, given that the public has little or no experience with purchasing such goods. While respondents may be able to express values for more tangible dam impacts, they may be unable to express values for more abstract effects (e.g., community fragmentation). Indeed, it may be extremely difficult to develop a survey instrument free of bias that yields meaningful responses for such impacts. For instance, since CV surveys seek only hypothetical willingness-to-pay values, respondents may not carefully consider personal budget constraints when stating willingness to pay. The problem of bias may be especially difficult to avoid for projects where a charged political atmosphere already exists.

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The detailed procedures associated with a CV survey and analysis generally require a significant commitment of time and resources. Costs are sensitive to factors such as the survey design, survey sample size, the type of survey instrument (i.e., interview, mail survey), the nature of data analysis, and other factors. In practice, the investment made in CV surveys is usually proportional to the resource values in question, i.e., more complex surveys are done to support larger resource management decisions.

### 4.3.4 Choice Modelling

Choice modelling techniques are not discussed in any detail here. These models are typically used in consumer research to examine the attributes of goods and services upon which consumers confer value. In other words they involve asking hypothetical questions of respondents which only indirectly shed light on the value of a good or service.

Application in the case of dams would be in the assessment of changes in recreation or tourism or in the case of subsistence resource use (where other methods are not available). For example, Chase examined how tourists to three Costa Rican parks would alter their itinerary in response to changes in park entrance fees. While this type of contingent behaviour model may be used to derive benefit estimates the emphasis is typically on examining finer aspects of policy and valuation issues and, thus, is needlessly complicated where the objective is purely on valuation. Lynam et al. (1991) applied the contingent ranking approach to assess smallholder values for multipurpose tree resources in Zimbabwe. By ranking smallholder preferences for the subsistence uses of tree resources and anchoring these to two traded commodities Lynam et al. were able to derive the willingness-to-pay for a number of non-marketed forest goods and services.

### 4.3.5 Secondary Methods for Valuing Dam Project Externalities

#### Replacement Cost (or Potential Expenditure) Approaches

The replacement cost method is essentially an accounting procedure provides an estimate of the cost to replace a good, service, or resource affected by a dam project with an alternative. The replacement alternative will be a good, service, or resource (e.g., similar agricultural land) or monetary compensation that provides the same level of benefits. This of course, begs the question of whether it is worthwhile to undertake the replacement. This is an approach receiving considerable coverage in the practitioner literature and essentially no mention in academic texts.

Ecological services are often said to be “valued” using the replacement cost approach. For example, ecological services provided by wetlands include flood control by storing runoff, water quality protection and treatment, and water supply to groundwater aquifers. Evaluating the loss of these services due to dam-related impacts can be difficult because wetland services are not traded in markets. One approach to estimating the value of wetlands is to consider the cost of constructing man-made alternatives. For example, to assess wetlands’ water quality protection services, the cost of constructing a wastewater treatment plant that filters wastewater in a manner similar to wetlands can be assessed. Likewise, the value of wetlands might be reflected in the cost of building flood control structures such as levees. Some or all of these costs could be avoided if wetland areas were preserved or restored. Although the results are highly site-specific, estimates of the annual per-acre value of wetlands ranges from about $100 to over $1,000, based on the avoided cost of providing lost services through engineered means (Barataria-Terrebonne National Estuary Program, 1996).
Again, this approach begs the question of whether the replacement cost is worth undertaking as the results have no basis in consumer behaviour – i.e. that might reveal preferences for such an arrangement. The technique makes the implicit assumption that the replacement cost is worth paying, in other words, the technique involves making an inference regarding choices that would be made by consumers or household. Of course, the weakness of the technique stems from the fact that there is often little basis for making such an inference.

**Benefits Transfer**

Benefit transfer valuation methods do not require primary data gathering (e.g., surveys) or other primary economic research. Rather, they involve the application of unit value estimates, functions, data and models from existing studies to estimate benefits associated with the resource or impact under consideration. The main advantage of benefits transfer, compared to primary research, is that it can reduce both the time and resources needed to develop net benefit estimates. Benefits transfer involves three basic steps:

1. **Identifying and characterising the resource or service to be valued.** This step can be challenging because the resource or service may depend upon unique site conditions and complex ecological factors.
2. **Reviewing existing valuation literature to identify potentially applicable studies.** This step entails identifying primary studies that evaluate similar resources and/or services as those expected to be affected.
3. **Conducting the benefits transfer and calculating economic benefits (or losses).** This step involves application of the values, functions, data and/or models from appropriate existing studies.

In general, benefits transfer estimates will be more meaningful and defensible if the benefits transfer has the following characteristics:

**Reliance on high-quality studies.** The benefits transfer analysis should incorporate results from high-quality studies, based on adequate data, sound economic methods, and correct empirical techniques.

**Consistency between the resource to be valued and the resource in existing studies.** Evaluating the applicability of existing studies to valuing a dam project resource or impact involves comparing the characteristics of the resource or impact with those in the existing studies. If these characteristics differ, it will be necessary to consider whether the differences are likely to have a significant effect on the valuation, and if so, whether adjustments can be made to account for these differences.

**Consistency in the characteristics of the affected population.** The characteristics of the population holding values for the dam project resource or impact should be comparable with the population included in the existing studies. Relevant characteristics include, but are not limited to age, income, education level, proximity to the site and the level of environmental concern.

**Accurate estimate of the size of the population holding values for the dam project resource or impact.** Each dam project resource impact will have a geographic area over which its users are drawn. An important component of economic benefits estimation is defining the size of the population that holds values for the dam project resource or impact. This assessment will affect the magnitude of net benefit estimates.

Obviously, within the limitations of what constitutes a credible transfer of benefits this method is applicable to a wide range of external impacts of dams. An example of the transfer of estimates for the “passive” use values (otherwise known as non-use or existence values) in the case of the Snake River is provided in Box 4.5.
An analysis was conducted to estimate passive use values or existence values for both endangered salmon and steelhead stocks and also a free-flowing lower Snake River. As passive use values cannot be estimated using market data, stated preference methods, such as contingent valuation (CV), are used to measure passive use values. A survey was designed and pretested, but was never implemented because of controversy surrounding the pretest mailing and the CV methodology. Instead, passive use values were estimated using a benefit-transfer approach based on existing passive use value estimates.

Three approaches were used to transfer benefits from four existing studies to estimate the change in passive use value for lower Snake River salmon populations. All three approaches meet the criteria for benefit transfer. All four studies measure the same resource. Three of the studies estimate passive use values for salmon in Washington State; and they all estimate these values based on willingness-to-pay (WTP). The existing studies however do not precisely match the policy setting of the Lower Snake River Juvenile Salmon Feasibility Study, which puts the results on the conservative side when a benefit transfer method is used.

The first approach estimates a WTP function from salmon through regression analysis based on the results from all four existing studies. This function is derived using incremental existence values per salmon calculated from four CV studies of West Coast residents’ WTP for increasing salmon populations. This function is then used to calculate the change in annual total passive use values with different levels of wild salmon and wild steelhead recovery for non-user households in the Pacific Northwest and California to avoid any double counting of passive use values and recreation use values. Passive use values were calculated for each of the four alternative projects being considered for the Snake River. With respect to Alternative 4, dam breaching is expected to increase wild salmon and steelhead populations by 66% more relative to existing conditions. Based on the regression analysis, the increase in stocks would result in an average annual increase of $879.3 million in passive use values.

The other two approaches each apply the results from just one of the four studies. For the second approach, the household value calculated from a nationwide survey or residents’ WTP for salmon on the Elwha River was applied to non-user households in the Pacific Northwest and California while the value obtained for Washington residents in the Elwha study was applied to Washington non-user households. The benefit transfer involved some adjustments. The third approach used the most recent stated preference survey of Washington residents where residents were asked to rate four different scenarios that involved three different generic stocks of fish species in two geographic areas.

The findings suggest that there is a passive use value associated with increases in wild Snake River salmon and steelhead stocks, but the wide possible range identified for this value underlines the difficulty in estimating this type of value from benefit transfer.

With regard to a free-flowing river, estimate of the passive use value was based on two existing studies which measure the same resource but address rivers located in Colorado and the upper Snake River in Idaho. The first study involved a mail survey of the willingness of Colorado households to pay to preserve free-flowing rivers. The other study was a CV estimate (based on telephone interviews) of preserving the Black Canyon of the upper Snake River by not allowing development. The findings suggest that a passive use value likely exists but should be viewed with caution because the existing studies on which it is based evaluated different geographic conditions and operated under a different policy setting.

The preceding discussion makes it clear that a key limitation of benefits transfer lies in the ability of the analyst to locate appropriate results from existing studies and apply them to the dam project resource or impact of concern in a sophisticated manner. Close attention must be paid to the consistency of key factors of the case being studied and existing studies, such as physical and geographic attributes, the availability of substitutes, and socio-economic characteristics.

Likewise, the quality of the benefits transfer will depend on the number of relevant studies; relying on average values from multiple studies is likely to be more reliable than transferring values on the basis of one or a few existing studies. It follows that the ability to develop defensible benefits transfer estimates in the future will depend on investments in primary research on the economic valuation of dam impacts today. By building a "library" of primary studies, future valuation of economic valuation of dam project impacts could be performed via less expensive benefits transfer techniques.
4.4 Comparative Analysis of Methods

As noted in Chapter 2, dam projects increasingly budget for environmental mitigation measures and resettlement programs. These financial budgets are subsequently carried into the economic analysis as costs to the project. Thus, current practice is towards expanding the notion of what the project entails and, consequently, reducing the externalities associated with a project. The first point to make is, however, that many of these efforts simply seek to mitigate (i.e. reduce) not eliminate impacts. The second point is that the WCD Thematic Reviews on Social and Environmental Issues suggests that many of these mitigation and resettlement programs fail to attain their objectives. While the direction and magnitude of externalities, cannot be generalised it is reasonable to suggest that in the assessment and design of dam projects there will often remain a series of social and environmental impacts that are “unaccounted” for by a straightforward analysis of direct costs and benefits.

The principal findings (so far) of this chapter with regard to the valuation of externalities are that – perhaps with the exception of the USA – a gap presently exists between current practices for the analysis of dam project externalities and the methods that make up the good practice toolchest. This suggests that increased use of available economic methods for valuing project externalities would significantly strengthen net benefit estimates, making them a more valuable input in project decision-making. This section examines first how the good practice toolchest would best be applied to this task and then reviews the debate over whether such efforts should be undertaken, ending up with a discussion of what this implies for the options for future practice.

Applying the Good Practice Toolchest

The first statement that must be made is to acknowledge the limits of economic valuation methods – particularly in the context of project evaluation. It needs to be clearly stated that even applying good practice methods it will not be possible to value all of the externalities of a complex project such as a large dam. This is a consequence of many factors, but the following five are a sufficient basis for drawing such a conclusion

- the sheer number of external impacts that may occur;
- the lack of ability to predict the physical, chemical and biological changes that will occur following construction and impoundment
- the difficulty of applying economic valuation methods to the more intangible of social and environmental impacts such as psychological effects and the loss of biodiversity
- the complexity of cumulative social and environmental impacts in a river basin with multiple dams; and
- the limited time and resources available for project preparation.

Given that all impacts of dam projects cannot be valued, the question remains of whether a sufficient number may be valued and, if not, how can the project decision-making process best extend beyond net benefit measures to fully account for these factors.

With regard to the methods themselves, it is worth emphasising that while some valuation methods are widely accepted by economists, others carry less currency and, may indeed, be controversial to a larger audience. As a rule, the more a method relies on observed behaviour, the more accepted is its use. Therefore, market and revealed preference methods that rely on observed behaviour in real markets tend to provide more defensible estimates than stated approaches, which rely on information from hypothetical behaviour in contingent markets. Choice modelling which relies on hypothetical behaviour and inferences is less attractive still. Secondary methods may offer a cost-effective way of quickly valuing impacts, but their use must be subject to careful scrutiny as they may easily lead to results that are off target by orders of magnitude if inappropriately applied.
In terms of the process associated with valuation studies it may be argued that good practice with regard to consultation with stakeholders and the use of participatory methods is imperative. Studies of this nature should be located within the framework of a recursive consultative interaction with project stakeholders that allows for the identification, prioritisation, selection and valuation of project impacts (see Box 4.6). The process should involve at a minimum three steps: a scoping exercise to identify and select impacts to be valued, valuation studies that are consultative in nature and participatory in methodology wherever possible, public meetings to report back to stakeholders on the results of the studies.

**Box 4.6. A Recursive, Stakeholder Based Approach to Appraising the Socio-Economic Significance of a Water Resource**

A key part of any economic evaluation work is to define the passage between the (very heterogeneous) scientific information that is available, or that can potentially be obtained at reasonable cost, on the water resource system, and the socio-economic knowledge and decision-support requirements for identifying, evaluating, and managing the "services rendered" by the hydro-system to society, today and in the future. In a schematic way, a recursive cycle of analysis can be proposed as follows:

1. Diagnosis of Stakeholder Interests and first specification of the resource management “problems to be solved”
2. Scientific Analysis of the Hydrological System (Hydro-system Modelling, Population ecology, etc)
3. Analysis in biophysical terms of the “Environmental functions” of the resource
4. Quantification of Socio-economic Significance of Environmental Functions (“Services rendered”)
5. Economic analyses (cost and benefit assessments of options, constructed on a platform of Multi-Criteria Appraisal and Scenario Analyses)
6. Communication of Results (resource management options, evaluation results, etc.)
7. Stakeholder appraisal of results
8. Re-specification of problems and options (RETURN TO STEP 1)

The “stakeholder” interests usually are quite diverse. They include the direct “users” of the water as a resource, whether as an in situ use or an extractive one, and also the various agencies presumed (whether in the public eye or by duly constituted authority) to have competence for managing the water resource and surrounding lands. By “scientific” information is understood both formalised and “informal” knowledge, the latter being typically held by members of local communities (viz., categories of stakeholders) without necessarily being abstracted or theorised into systematic models.

An interactive stakeholder-linked approach stresses the need to present and discuss scientific and socio-economic findings to interest groups with a range of different interests, on a permanent (i.e. recursive) basis. An important aspects of such an analysis is stakeholder mapping and scoping of the study.

For each resource study, a scoping study must be carried out, which we call a stakeholder mapping, which furnishes the platform for an analytical treatment of selected valuation/decision topics. The stakeholder mapping is a type of institutional analysis, which is carried out, typically, through documentary analysis and selected interviews (these may be formalised or informal). This identifies significant social actors and their interests, concerns for the future, and the various stakeholders’ opinions about de facto entitlements and the rights and wrongs of these, in regard to water resource use benefits, including jurisdiction over water flows and water uses. Here, we see value statements about the water resource as emerging out of existing social conditions of management, often involving controversy and conflict reflecting underlying preoccupations and social divisions of the society.

**Divergent Perspectives on Externality Valuation**

For many practitioners, decision-makers and other stakeholders involved in the dams debate, these approaches are not well-known or understood. When combined with the perception that these methods can be, and are being, extended to value all of the social and environmental impacts of a project, opposition is often voiced on ethical grounds.

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In particular the validity of applying some of these (quasi-market-based) methods to the measurement of socio-cultural impacts such as the psychological disruption caused by involuntary displacement of indigenous or other minority groups, or the loss of unique heritage sites or biological species, has been questioned. The Snake River case cited in Box 4.5 provides an opportune example as opposition to the application of a contingent valuation survey to the existence values held by stakeholders for salmon and a free-flowing Snake River led the study team to adopt a benefit transfer approach.

Moreover, critics of the extension of neoclassical economic theory to social and environmental impacts object to the use of these studies in decision-making on methodological grounds – i.e. that market values for consumer goods are not commensurable with public goods such as environmental quality (Lohmann 1999 eco034). Finally, the studies themselves are often seen as “expert” approaches that are non-participatory and non-transparent to stakeholders, and thus have limited use and acceptability in practice.

As with CBA in general, the attraction of valuing externalities is that it permits a more explicit calculation and comparison of the benefits and costs of a dam by calculating both the direct costs and benefits, and the impacts that are external to the project in the same numeraire (means of expressing value). For every stakeholder in the dam debate that oppose valuation, there are those that find it a useful, and often necessary, endeavour (Sullivan 1999 ecoweb013, Spurgeon 1999 ecoweb006). In theory, this permits a more informed decision regarding the economic consequences of choosing one option over another, and of the impacts of the chosen project. The latter may then be instrumental in designing impact mitigation programs and determining compensation to those who are adversely affected.

**Practical Alternatives for Incorporating Externalities in Decision-Making**

To explore this conflict of views and proposals further the analysis provided in the US context by Shabman (1993) remains a useful departure point. As outlined earlier, Shabman begins by noting that the Principles & Guidelines that regulate Federal water projects in the US accept the notion that all impacts should be valued where possible. Shabman (1993: 43) reviews a number of the conceptual, practical and philosophical critiques (outlined above) of the use of valuation techniques in monetising these values and proposes an alternative approach that draws on the Army Corps of Engineers’ experience in the Pacific Northwest in the late 1980s:

“... instead of trying to measure preferences of individuals by interpreting market negotiations, a new emphasis has been placed on initiating and structuring interest group negotiation as the way to establish tradeoffs groups are willing and able to make in matters such as restoration of habitats for endangered species. Value is established as a consequence of group negotiations in political forums, instead of by individual negotiations in market exchanges ...”

Focussing on the decision of whether to restore ecosystems or not, Shabman concludes that valuations undertaken by analysts of the environmental restoration is not needed in this context as valuation of environmental services using stated preference methods is a substitute for a public bargaining process. As a result it is suggested that the analysis that should be undertaken is a “net opportunity costs” of restoration approach that includes the direct costs of restoration and the benefits foregone by restoration. According to Shabman, Corps good practice in this case consists of then identifying the alternatives plans for providing different levels of mitigation and selecting the most cost-effective. These are then brought forward and the exact level of mitigation is negotiated between Federal agencies and affected parties.

Shabman (1993) states that the measured benefits of restoration (including stated preference measures) would not be introduced directly into this process but would rather be kept “on the side” and presented as a point of reference in any negotiation where large restoration costs are being considered. Further, Shabman suggests that these benefits (and costs) would be assessed not just from
the perspective of society as a whole but from that of different groups (akin to distributional analysis as per Chapter 9 of this paper) as a starting point for reaching agreement on compensation.

This “net opportunity cost” approach provides an interesting model for decision-making and the potential role of information on the value of externalities within this context. Further discussion of this approach in the context of decision-making is thus taken forward in Chapter 10. For the purpose of this chapter it is only necessary to focus on the role of the valuation of externalities. The degree to which they are undertaken, undertaken but kept “on the side,” or undertaken and featured explicitly is the central point. The simplest argument against not valuing such effects wherever possible is to emphasise that despite having invested close to $2 trillion in large dams in the last half-century, there appears to have been very little consideration of to what extent these investments have been to the betterment of societal welfare, all impacts considered (more of which in Chapter 10).

With regard to Shabman’s proposition of keeping such analysis at arms-length from project negotiations there are two points that should be considered in applying such an approach. First, if the negotiation process is limited in terms of the number or representation of participants and stakeholders then serious consideration should be given to which of the “substitute” methods is preferable. The advantage of a formal contingent valuation approach is that all groups are surveyed and respondents are chosen randomly. The formal approach thus provides more analytical rigor to the concept of participation. After all, every individual in such a survey is provided the opportunity to express their opinion. What formal CV studies lack – but the negotiated approach attains – is an open discourse and deliberation that can only happen in a stakeholder forum. This hampers collective learning and action amongst the parties involved (Bishop 2000, pers. comm). Clearly, a poorly organised negotiation process where some groups are not represented or where particular groups have a louder voice or more influence will not necessarily be a better “substitute” for a well-conducted and statistically significant survey.

Second, it has been emphasised above that economists generally prefer market or revealed preferences methods because they are based on actual choices made in actual markets and not on a hypothetical response in a contingent market. The criticism of the latter is that the choice made often bears little consequence for the respondent. Expanding Shabman’s “negotiation” somewhat, it is readily apparent that an informed and participatory deliberation conducted in good faith is an improvement over traditional top-down decision-making with regards to dams. However, such an approach still suffers from the potential pitfalls of a hypothetical approach – i.e. to become dislocated from practical and market realities.

Shabman feels that studies of environmental values should not be presented because they are a substitute to the “real” hypothetical method inherent in the negotiation process. However, in many cases with dams – and particularly in rural areas of developing countries where hypothetical methods are more difficult to apply – the alternative valuation method would be one based on observed market behaviour. Where such information exists or can be developed at a reasonable cost it is ignored at the peril of pursuing courses of action that may have rhetorical value but may be a poor fit with revealed preferences of the groups involved. To be blunt, a poorly conducted and poorly informed negotiation may lead parties to think that certain options are affordable or desirable when they are not.

To promote sound and transparent decision-making with regard to the external impacts of dams the consequences of choices under consideration and discussion are best brought into the open. This is not to say that past expressions of preferences in markets do not preclude future alterations in these same preferences and behaviour – nor should they if advances are to be made – but rather that they should inform the public deliberations and choices. So external impacts should be identified, quantified and where possible valued as support to the choices made.

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4.5 Findings and Recommendations

The section on valuation of external impacts of projects yields the following findings:

- evidence of the application of the tools of valuation to social and environmental externalities to large dams is limited to the last two decades, with most experience coming from the US;
- there is a small, but growing number of applications in developing countries, primarily to environmental impacts;
- as a result of the limited application there can be no comprehensive statement about the overall costs and benefits of large dam projects where these have identifiable externalities;
- the methods for valuation of social and environmental impacts, including non-marketed goods and services are well-developed but are not widely understood or trusted by the general public; and
- stakeholders in the dams debate often have strong feelings either for or against the valuation of social and environmental externalities.

Based on the analysis of these findings the following principles can be offered on the valuation of externalities of dam projects:

- Wherever possible, external impacts should be valued in financial and economic terms provided that a participatory scoping suggests they represent either a significant economic impact or a significant impact on a vulnerable group.

Finally, a number of recommendations for operationalisation of these principles through suggested methodological improvements, process enhancements and/or changes in institutional incentives can be made with regard to environmental and social valuation:

- In the case of dams the valuation of external impacts should be driven by a recursive consultative process involving project stakeholders (to include developers and affected people);
- The valuation process should involve at a minimum three steps: a scoping exercise to identify and select impacts to be valued, valuation studies that are consultative in nature and participatory in methodology wherever possible, public meetings to report back to stakeholders on the results of the studies; and
- For the valuation of a given impact the methods to be applied should be given rough priority in the following order: market methods, revealed preferences, hypothetical methods, benefits transfer and replacement costs.
- The information generated through valuation studies should be explicitly tabled so as to inform the negotiations between stakeholders and decision-makers.
5. Valuation of Impacts over Time: Discounting

The long-lived nature of large dams raises the issue of how to assess the costs and benefits that will occur over time, whether in the short- to medium-term or over the course of future generations. Philosophers, economists, environmentalists, policy-makers and others view this question in different ways. In order to sum the impacts that occur over long time periods in a consistent manner financial and economic analysts employ a discounting procedure. In simple terms, the discount rate is simply a relative price that enables a comparison of current and future bundles of goods and services.

The choice of a discount rate can have a significant influence on whether or not a dam is found to be economically efficient and/or financially viable. In practice, the lower the discount rate, the more prominent future costs and benefits become in computing the net present value of a project and, hence, in the decision-making criteria. Assumptions made in discounting can, therefore, have a significant influence on whether a dam is viewed as economically viable. Where CBA or related methods, such as least-cost analysis, are used in decision support for long-lived projects, the choice of discount rate can become the overriding methodological decision in determining viability.

The concept of discounting has been widely accepted by the economics community since the origins of cost-benefit analysis. Yet disagreement and confusion is not limited to the non-economist. At a 1966 conference aimed at establishing the appropriate rate of discount for evaluating water projects in the US there was little agreement on the conceptual basis for choosing a rate. However, with the publication of the primer on discounting in Lind (1982) there has been more or less general agreement on the theoretically correct approach to the practical problem of selection and application of discount rates in cost-benefit analysis (Portney and Weyant 1999).

Given the emergence of climate change on the policy agenda, recent years have seen a renewed debate – amongst civil society and policy circles, as well as within the academic community – as to how to best cope with the long-term effects of current investment decisions. Critics of CBA often state that discounting of future impacts is generally inconsistent with equity goals; in particular, it is felt that discounting thwarts the goals of environmental sustainability and intergenerational equity. An extension of this argument is relevant to the case of large dams and, as a result, discounting has become a controversial factor in the planning and evaluation of dam projects. At a more mundane level, the drivers of this larger debate are reflected in continued differences of opinion, and confusion over, the exact method or rate to apply in actual practice. Such practice stills varies considerably from that recommended in 1982 by Lind, as documented below for the appraisal of dam projects.

Certainly, the plethora of different and overlapping terminologies present in the literature do not serve to facilitate understanding by the interested reader. The objective of the current chapter is to restate the debate, provide an indication of the alternative choices that can be made in selecting (or not) a discount rate and to review how current practice in the evaluation of dams compares with established theory and good practice. Still, in the space available it would be difficult to do justice to such an objective and, thus, references are provided so that the reader may examine the different arguments at leisure. No review of the mechanics of discounting is presented in the text below, however, relevant technical explanations and formulae are provided in the notes.

The chapter begins by explaining the significance of discounting to the evaluation of dam projects. An introduction to the theory and methods of discounting is then presented to facilitate a consistent terminology and approach in the ensuing discussion of the debate regarding the use and choice of discount rates. Actual practice and guidelines are then contrasted with available theory and good practice methods in order to provide a set of recommendations for future direction and practice with regard to discounting in options assessment and project evaluation for dams.
5.1 Dams and Discounting

Large dam projects have very long project lives, many times measured not just in decades but centuries, and thereby create costs and beneficial impacts that occur at a variety of points in time. Small changes in the discount rate may therefore have important effects on the projected profitability of a dam project.

Time Path of Dam Costs and Benefits

The direct benefits of large dam projects, such as power, irrigation, water supply and flood control will typically persist for the length of life of the capital assets involved, i.e. the dam wall, power station, power turbines, irrigation canals, etc. Over time, sedimentation of the dead storage (the volume below the outtake) and the live storage (volume above the outtake) will affect operation of dams that have storage capacity. Eventually the loss of capacity may take the utility of the dam below the point where it is worth operating, at which point it must be decommissioned. This suggests that the benefit stream of a dam project will be long-lived but decay over time in accordance with its physical and economic characteristics.

In practice there is yet little experience with what happens when large dams “fill-up” with sediment. For a perspective on this topic see Jacobsen (1999) who suggests that high discount rates provide a disincentive to build-in measures to ameliorate the effects of sedimentation (e.g. flushing capability), since the benefits of such investments will only occur far in the future. This will be an issue only in the case where the decision not to undertake the measures is irreversible in the sense that once the up-front investment in such measures is not undertaken, future possibilities in this regard are foreclosed. Jacobsen, therefore, has identified a legitimate drawback of discounting and CBA. The failure of conventional CBA to account properly for irreversible investments is covered in Chapter 7.

As with the benefits, the costs of dam projects are also realised at different points in time. Capital costs of dam construction, for example, are incurred at the outset of a dam project's lifetime, whereas decommissioning costs are incurred at the end of a project’s lifetime. The social and environmental impacts of dams are also spread out over time, though they cannot be generalised in terms of their time path. The financial and social costs associated with resettlement are realised during project planning and construction and may persist over time either in the form of continued investment in mitigation/development efforts or continued deleterious social impacts. If resettlement provides real development opportunities to communities, then the social costs of resettlement may well decrease over time. Environmental impacts may be immediate (e.g., inundation effects) as well as long-lived (e.g., degradation of wetlands and river deltas, changes in flora and fauna). Even where the impact is immediate the cost or benefit may be long-lived (e.g. loss of biodiversity from inundation). In some cases, such as the emission of carbon dioxide or methane from reservoirs, the immediate impact may grow rapidly over the first few years, reach a peak for a number of years and then decay over time. In such cases the environmental impacts will accumulate over time although at changing rates. The social impacts associated with alteration in ecosystem function and changes in livelihoods of affected and interested people may also be long-lived as communities adapt to new or gradually evolving environmental conditions.

Having indicated, to the extent possible, the general time-paths of the costs and benefits streams associated with dams it is possible to consider the practical significance of the debate over higher or lower discount to the case of dams. Given that many critics feel discount rates employed are too high it is useful to focus this discussion on the question of whether a lower discount rate would make dams appear more or less profitable?
Why Low Discount Rates favour Dam Projects: Literature and Numerical Example

The issue of dams receives remarkably little attention in the discounting literature. Markandya and Pearce (1988) do point out, however, that hydroelectric dams will be more profitable with a lower discount rate as dams have large up-front costs and long-lived benefits. In their example, a higher discount rate will favour the thermal alternative, which would consist of a sequence of power plants with costs spread over a number of years, shorter construction periods and the same benefits. Lind (1982) notes that private, investor-owned utilities that compete with public utilities will argue for a high public sector rate of return requirement equal to that in the private sector as otherwise it will appear as if publicly-produced power is cheaper than private power – even though they may require the same amount of capital.

Writing on behalf of the World Bank, Birdsall and Steer (1993: 6) indicate their concern that “too low a rate – by changing the ranking of projects - will induce a capital intensive pattern of development and promote investments with high up-front costs, such as dams, that could be harmful to the environment.” Further, it has been observed that if the discount rate used by the Army Corps of Engineers in approving dam projects in 1962 was raised from 2.5% to 8%, that 80% of the projects that were approved would have been rejected (Page 1977 in Hanley and Spash 1993). Indeed, Lind (1982) observes that with regards to water resources projects in the US, environmentalists found themselves in an unusual coalition with fiscal conservatives in arguing for higher rates and fewer projects. This, as environmentalists more commonly argue in favour of lower rates in the area of energy and resource policy.

The impressions that lower rates favour dam projects are easily substantiated using the rough time paths of dam project costs and benefits set forth above. A project costing $500 million spread out over 5 years of construction with annual benefits of $40 million that extend through 95 years of operation (i.e. to year 100) will yield a negative net return of $130 million at a 10% discount rate. When the discount rate used is 5% the project will have a positive return of over $180 million. If decommissioning costs are incorporated that are equal to the costs of construction (i.e. $500 million) and occur at the end of the life of the facility (year 100) the figures on returns under both scenarios barely change – in the 5% case the return falls by only $4 million. If benefits are assumed to decay at 1% per year (to simulate storage loss) the returns under the 5% discount rate scenario fall more significantly than those under the 10% scenario, but the basic result stays the same. The project is profitable at a 5% rate but not at a 10% rate.

Further inclusion of additional costs and benefits is possible. However, only when additional costs to the project are long-lived and increasing does switching from a higher rate to a lower discount rate make a profitable project become unprofitable. For example assuming the same construction, benefit and decommissioning scenarios as above, but setting annual benefits to $80 million gives positive returns of $70 and $600 million respectively for the 10% and 5% discount rate scenarios. If an annual cost equal to $2 million – such as an environmental or social cost – is assumed to begin at commissioning (year 6) the returns drop only marginally in both scenarios. In order to skew the time profile of these costs sufficiently to produce the contradictory result, it is necessary to assume that these costs increase at 8% per year (over the hundred-year period). When this is the case the returns at 5% discount rate become negative (and highly so), while the returns at 10% remain in positive territory.

If a zero discount rate is used an impact that occurs up to the end of the capital life of the project is implicitly assigned an equal weight as the same impact that occurs tomorrow. For example the effect of employing a zero discount rate in the example above leads also to positive returns at low growth rates for the social costs. The decommissioning costs now count as equal to the construction costs yielding a total cost of $1 billion. However, each year of benefits is counted at full value as well. By implication the project need only generate annual benefits of roughly $20 million, not the $80 assumed earlier, to break even. In other words, at a zero discount rate the benefits of dam projects need not be as large in order for the project to have a positive return. If the exercise of
simulating the effect of rising social costs is repeated for the zero discount rate case, then the return takes on a negative value when the annual compounded growth rate reaches 5%.

Thus, it can be concluded that unless there are negative and rapidly increasing net social and environmental costs associated with a dam project, the use of a lower discount rate will lead to a dam project having a higher return.27

5.2 Discount Rates: Theory and Good Practice Toolchest

5.2.1 Discounting in Economic Analysis: Theory

Discounting of cost and benefit flows associated with a particular project or set of projects allows the comparison of monetary flows that occur in different periods. This adjustment is derived from the need to account for the time value of money. Economic theory (and behaviour expressed in markets) suggest that consumers have a time preference for consumption (e.g. goods and services), that is they will require a higher amount of consumption in the future to compensate for consumption foregone in the current period. This is called the “consumption rate of interest” (CRI), and reflects the rate at which the value of consumption falls over time. Similarly, investors will have a preference for the same amount of capital now as opposed to later as in the intervening period it may be invested and return income. The return to investment at the margin is called the “investment rate of interest” (ROI).28

The term “social rate of time preference” (SRTP) is often used interchangeably with the consumption rate of interest. However, Lind (1982) clarifies that the social rate of time preference is the rate “at which society, through government action, is willing to trade benefits and costs today for benefits and costs in the future.” Thus, the consumption rate of interest, as observed from the market behaviour of individuals, may be taken as the social rate of time preference, but the CRI and SRTP are conceptually distinct entities. For example, where the state has different preferences and objectives to its citizens a politically determined social rate of time preference is an alternative. Another case, discussed later in this chapter, is the case where it is desired to incorporate ethical concerns into the discount rate.

The “opportunity cost of public investment” is the value of the private consumption and investment forgone as a result of the public investment. The “opportunity cost of capital” (OCC) applicable to public investment is often mistaken to be equal to the investment rate of interest. However, as public investment may displace consumption (through additional taxation) as well as private investment (through borrowing) these two are not necessarily the same.

It is often stated that the consumption rate of interest will equal the marginal rate of return on investment under the assumption of perfect markets, in other words the CRI and the ROI would be the market-clearing price in capital markets (Lind 1982). In other words they would be equal to the market rate of interest and, according to many but not all economists, they would be equivalent to the SRTP. However, taxes on corporate and individual investment income, amongst other market distortions, will drive a wedge between these two prices as actually observed so that the observed CRI will be less than the ROI.29

Lind (1982) points out if a public investment is financed by resources withdrawn from private investment, i.e. by borrowing from the private sector, the opportunity cost of capital would be the ROI.30 However, if the investment is financed purely from current consumption (i.e. through taxes) the opportunity cost of capital would be the CRI.31 In the long-run finance for public projects is paid out of taxes, which displace both consumption and investment. As a result a “social discount rate” that reflects the weighted shares of displaced investment and consumption would be applicable.32
A further real-world complication is the existence of risk. Private investors will bear risk insofar as the variability of a new project affects the variability of the investor’s portfolio. Similarly, from a public perspective the extent to which a project affects the variability of national income is of concern. The addition of risk to a risk averse or risk-neutral portfolio implies a cost, the cost of risk-bearing or, where insurance is available, the cost of insuring against risk. The reduction of risk implies a benefit, akin to free insurance against existing portfolio risk. Thus, for a risk averse or risk neutral investor a project that increases risk implies additional cost and thus a lower expected rate of return. Other things equal, a higher rate of return is thus required for a project with a higher level of risk.

The question then comes of which rate or combination of rates, to use in discounting in financial and economic analysis. As the preceding discussion suggests the discount rates for use in financial (DCF) or economic (CBA) will not be the same. According to Gittinger (1982) financial discount rates reflect the marginal opportunity costs of funds (including risk) as perceived by different individuals and groups in society (i.e. individuals, households or firms). An economic measure of discount (more typically referred to as the social rate of discount) entails a discussion of what would be the market clearing rate for capital once the influence of market imperfections and policy distortions on the CRI and ROI are taken into account. As employed within the context of economic analysis, such a rate must be consistent with other economic (efficiency or shadow) prices that are used to infer the worth of a particular undertaking from the perspective of national income.

5.2.2 Financial Discount Rates for DCF: Theory and Good Practice

Relatively little variation of opinion exists regarding the theoretical basis for the development of financial discount rates. As stated by Freeman (1993), in the absence of taxes and other capital market imperfections, utility maximising individuals borrow or lend so as to equate their marginal rates of substitution between present and future consumption with the market rate of interest. The private marginal opportunity cost of capital will be the interest rate at which the respective entity can borrow funds. Where returns are taxed the corporation will demand a pre-tax return that reflects the marginal tax rate and the cost of borrowing. If the entity is a firm that also relies on equity capital then a weighted average cost of capital (WACC) that accounts for both borrowing rates and the need to attract equity capital will be used in investment appraisal (Gittinger 1982; Brealey and Myers 1988).34

The cost of borrowing will be clearly defined in loan agreements, but the cost of equity is not so readily available. Another textbook method, the capital asset pricing model (CAPM) can be used to derive this component of WACC. Thus, the richness of the WACC method unfolds only as it is adapted to the particular situation of a company, in particular data that is closely held by the firm. Rates employed will vary with the country context and the risk associated with a project. A single company may have many WACCs if it chooses to calculate one for each country in which it participates. Similarly, where projects are financed without recourse to the company’s balance sheet (e.g. limited recourse financing), but involve a mixture of equity and debt, a WACC may be calculated for the project as a whole. A corporation’s (or project’s) WACC is closely guarded as it is the key that unlocks the valuation of the company (or project) as undertaken from the perspective of the investor and is, therefore, a critical number in negotiation and valuation of the stock of the company.

Actual rates used will vary considerably from one industry to the next and from one country to the next. The pre-tax, inflation-adjusted average rate of return in developed countries may be roughly 10-15% (see Table 5.1). To the extent that the share of investment comes from lower-cost debt (i.e. loans) the WACC will be lower than this rate. Still, the private sector discount rates applied in analysing the DCF of hydropower projects by the private sector are said to be roughly around 15% and equity investors from overseas may seek returns of up to 25-30%. These numbers reflect the risk associated with these investments and the countries in which they are undertaken. Assessment of country risk alone may add 10% or more to the private discount rate (Smith 1995).
### Table 5.1. Sampling of Inflation-adjusted Discount Rates, by Type of Method/Approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>Values in Developed Countries</th>
<th>Values in Developing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Discounting not legitimate</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2. Consumption Equivalents Approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2b. “ethical” SRTP</td>
<td>1.5% (Cline 1999)</td>
<td>General: 6-8% (Cline 1999)</td>
</tr>
<tr>
<td>2c. CRI based on market returns</td>
<td>USA: riskless 0% (Lind 1982) USA: risk-adjusted 4.6% (Lind 1982) USA: for energy 3% (Lind 1982) USA: 6% risk-adjusted (Nordhaus 1999)</td>
<td></td>
</tr>
<tr>
<td>3. Economic opportunity cost of capital</td>
<td></td>
<td>Philippines 1993: 11.5% (ADB 1997) Indonesia (Bello et al. 1998)</td>
</tr>
<tr>
<td>5. Riskless Savings Rate (after-tax)</td>
<td>USA 1926-86: 0.3% (Cline 1992) USA 1926-94: 0.6% (Brealey and Myers 1988) G7 1960-90: 0.3% (Cline 1992)</td>
<td>Philippines 1993: 2.2% (ADB 1997) Indonesia 1993: 5.6% (Belli et al. 1998)</td>
</tr>
<tr>
<td>6. Pre-Tax Return on Common Stocks</td>
<td>USA 1926-78: 6.4% (Lind 1982) USA 1926-94: 8.8% (Brealey and Myers 1988)</td>
<td></td>
</tr>
<tr>
<td>7. Marginal cost of foreign borrowing (nominal)</td>
<td>3-month LIBOR 6.7% US Federal Funds Rate: 6.5% US Prime Rate: 9.5%</td>
<td>Philippines 1993: 8% (ADB 1997) Indonesia 1993: 9.3% (Belli et al. 1998)</td>
</tr>
<tr>
<td>7. Corporate WACC</td>
<td>USA 1977: 11-12% (Corey 1982)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: The rates suggested are merely indicative of ranges and should not be taken as applicable in any particular country or context. LIBOR is the London Interbank Borrowing Rate. The developed country rates in (7) are for 6 July 2000 from http://www.bloomberg.com/markets/rates.html. Figures not adjusted for inflation and, thus, the comparable real rate may be currently 2-3% less.

### 5.2.3 Discounting in Economic Analysis: Good Practice

Theory suggests that the consumption rate of interest, the investment rate of interest and the opportunity cost of capital all need to be incorporated into the process of discounting. Two methodological approaches to the application of discount rates to cost and benefit streams appear in the project appraisal literature.
Consumption Equivalents Approach

The approach presented by Lind (1982) separates the issue of time preference from that of the effect of public investment on stimulation of private capital formation and the opportunity cost of the displacement of private investment. The approach can be called the consumption equivalence approach (or the shadow price of capital approach). In Lind’s formulation it involves two steps. In the first the shadow price of capital that is applicable to different costs and benefits is calculated. As costs and benefits may displace private consumption and private investment to different degrees (as suggested above) a number of different adjustments to the costs and benefits to bring them into consumption “equivalents.” In the second step the consumption flows are discounted by the consumption rate of interest (or SRTP).

Cline (1992) expands this approach into three steps as follows:

1. all costs and benefit flows are identified according to their effect on private consumption and investment;36
2. investment flows are converted into “consumption equivalents” by multiplying them by the shadow price of capital; and
3. all consumption and consumption equivalent flows are added together and discounted by the SRTP.37

Cline’s formulation differs slightly from that presented by Lind (1982) in that it does not try to internalise step 1 into a series of shadow prices of capital that are then applied to cost and benefit streams that displace private investment and consumption in different ways. Rather, a single shadow price of capital is calculated and the analyst must then identify the share of cost and benefit flows that displace private consumption as opposed to private investment. Cline (1992) also provides guidance on the correct calculation of the shadow price of capital which will depend on the length of life of capital, the SRTP and the marginal rate of return on investment.38 While there is no conceptual difference between the two approaches proffered by Lind and Cline, the latter is valuable for making the step 1 explicit. This step is a significant one in the process, yet one that may be difficult to undertake in practice as discussed further later in this chapter.

The SRTP can be based on observed market behaviour of the CRI, ethical prescriptions about the SRTP, and/or expectations about the SRTP emerging from the optimal growth path of the economy. In the latter two cases the SRTP is often formulated as the sum of the pure rate of time preference and the product of the elasticity of the marginal utility of consumption and the expected growth rate of consumption.39 The pure rate of time preference accounts for the extent to which consumers have an inherent preference (ignoring actual conditions) to consume now-as-opposed-to-later. The other terms refer to the actual utility of consumption growth over time. As seen below, the ethical debate revolves around the value of the pure rate of time preference. The incorporation of the consumption growth rate provides an intuitive rationale for why the SRTP may be higher in developing than developed countries, as the former are growing at a more rapid rate.

Economic Opportunity Cost of Capital Approach

In a second method, developed by Harberger and others a weighted average of the marginal rate of return on investment in the private sector, and the consumption rate of interest is derived accounting for market distortions such as taxes (Harberger and Jenkins 1986; Hanley and Spash 1993: 131). This economic opportunity cost of capital (EOCC) is applied to the discounting of all flows in the economic analysis. As this is the method recommended by the proposed World Bank handbook on economic analysis and the Asian Development Bank examples of this method can be found in Belli et al. (1998) and ADB (1997). The example from Belli et al. (1998) is reproduced in Box 5.1. Note that the EOCC will be higher than the SRTP as the effect of the marginal rate of return on investment is already implicitly included in the EOCC, whereas with the consumption equivalent approach it comes through the shadow price of capital weighting given to investment flows.

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
Implicitly, then, both the consumption equivalents method and the EOCC approaches shy away from a singular reliance on either the CRI or the ROI and both incorporate the concept of the opportunity cost of public investment. However, it can be seen that the EOCC approach does not address the issue of the reinvestment of project benefits, and becomes “imprecise” where this occurs (Ray 1984). A few of the values found in the literature for both of these approaches are provided in Table 5.1.

**Treatment of Risk**

The role of risk in discounting of public investment is investigated by Arrow and Lind (1970). The authors draw the conclusion that as the risks associated with a public investment are spread over a large number of people (the public) the total cost of risk-bearing is negligible. In other words, where the government bears the costs and benefits, no risk premia (above the “certainty” rate or that associated with the market portfolio) will need to be added to the CRI. Lind (1982) proposes that unless the investment project has a risk that differs from the larger market portfolio, the risk-adjusted CRI consistent with the market portfolio should be applied (in this case 4.6%). In other words, the SRTP in the consumption equivalents approach will reflect the risk-adjusted CRI. Similarly, the application of the Harberger method makes no adjustment for risk and, thus, implicitly the EOCC is risk-adjusted (not riskless). This explains why figures for the CRI are considerably higher than the corresponding figures for real riskless rates of interest (as shown in Table 5.1).

Lind (1982) suggests that investments in energy function as insurance. When energy prices rise, the rate of return to energy production also rises, but the return on investments as a whole will fall. On this basis Lind argues for a lower consumption rate of interest for energy investments (he chooses 3%).

Arrow and Lind (1970) make another observation that is pertinent to the case of dams, the case of public investment where the distribution of costs and benefits has not always been even across society (see Chapter 9). Where the distribution of risk, in terms of the costs and benefits of a project, varies across different individuals in society the discount rate associated with these costs and benefits may also vary. Arrow and Lind conclude that where a public investment results in some individuals bearing the cost of the investment and others receiving the benefits the former should be discounted at a lower (than certainty) rate and the latter at a higher than certainty rate.
Box 5.1. Worked Example of the Opportunity Cost of Capital in Indonesia

The World Bank's Handbook on Economic Analysis of Investment Operations provided an example on estimating the opportunity cost of capital (OCC) in Indonesia in 1992, prepared by Jenkins and El-Hifnawi. Their calculations are summarised in the table below. The authors began by separating investors and savers into households, business, government, and foreign savers. From the national accounts, they calculated the shares of investment and savings for each group, as shown in column 1.

Next they estimated the marginal nominal return on investment for each group on the assumption that at the margin the return to investment is equal to the cost of borrowing. For households, the authors estimated the nominal after-tax return on investment as 23% - the average rate for loans to small-scale enterprises - and the marginal nominal return for business at 19%. Government investment was assumed to be independent of the interest rate.

On the savings side, for households the authors used the expected 6-month deposit rate, 16%. For businesses, they estimated the return on equity at 18.9%. Government savings was assumed to be independent of the interest rate. Finally, they estimated the cost of borrowing abroad at LIBOR plus 3 points, or 9.28%.

Next, they calculated the relevant returns for each group (gross returns for investors and net returns for savers). This is the return that "re incorporates" the proportion of return paid out in tax. Column 2 expresses the after-tax return which in the case of households is 23%. This is adjusted to reflect a 15% income tax rate (Column 3) paid on 70% of the household's gross return (30% of the gross return is assumed to be sheltered from tax). The gross return is the "Relevant" return (Column 4) for each sector to be included in the OCC calculations. In the case of the Savings Sector, the Nominal return in Column 2 has the tax subtracted (at the different rates for households, business etc. in Column 3), and the result is the Relevant return in Column 4. For the foreign savings sector, the authors used a weighted average of fixed and variable interest rate loans. The Relevant return for each sector is adjusted for inflation (in Column5) to arrive at the Real return in Column 6.

Column 7 and Column 8, respectively show the elasticity and the weight given to each sector, which represents the shares of funds contributed at the margin by each of the sectors in response to a rise in interest rates. Finally, Column 9 shows the Real returns adjusted by the elasticity and weights. By adding the Weighted returns for each sector, Jenkins and El-Hifnawi arrive at the opportunity cost of capital for Indonesia, 11.5%, the number in the final row of Column 9.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Share (%)</th>
<th>Nominal return (%)</th>
<th>Income tax rate (%)</th>
<th>Relevant return (%)</th>
<th>Inflation (%)</th>
<th>Real return (%)</th>
<th>Elasticity (%)</th>
<th>Wf (%)</th>
<th>Weighted Return (%)</th>
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<tbody>
<tr>
<td>Investment Sector</td>
<td></td>
<td></td>
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<tr>
<td>Households</td>
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<td>23</td>
<td>15</td>
<td>25.7</td>
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<td>16.9</td>
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<td>13.4</td>
<td>2.28</td>
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<td>56.8</td>
<td>19</td>
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<td>25.6</td>
<td>7.5</td>
<td>16.8</td>
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<td>38.7</td>
<td>6.51</td>
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<td>Savings Sector</td>
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<tr>
<td>Households</td>
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<td>18.9</td>
<td>25</td>
<td>14.2</td>
<td>7.5</td>
<td>6.2</td>
<td>0.5</td>
<td>14.0</td>
<td>0.87</td>
</tr>
<tr>
<td>Government</td>
<td>8.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Foreign</td>
<td>16.4</td>
<td>9.3</td>
<td>0.0</td>
<td>9.3</td>
<td>5.0</td>
<td>5.3</td>
<td>2.0</td>
<td>22.4</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Opportunity Cost of Capital 11.5</td>
</tr>
</tbody>
</table>


In the case of Kariba and Tucurui Dams the local affected and displaced population bore considerable costs, and the benefits in terms of hydropower accrued to industry and city-dwellers far away. The implication of Arrow and Lind’s point is that the costs borne by the local communities should be discounted at a lower (than certainty) rate making their net present value larger. If power consumers are also rate-payers and tax-payers then there would not be such a simple case for raising the discount rate associated with the benefits as these same consumers would likely have borne the cost of the project. In the case of Kariba, the copper industry footed part of the bill. In the case of Tucurui the existence of subsidised prices to industry might suggest the need to raise the discount rate if offsetting costs were not incurred with respect to benefits received. However, Lind’s point about energy production as a form of insurance must also be incorporated into such an adjustment.
5.3 Discount Rates and Intergenerational Equity

Unlike the case with private discount rates and in spite of the well-developed theoretical and methodological basis (as abridged above), there continues to be a variety of views on what type of rate society should use in discounting future income and expenditure streams in economic analysis or CBA. This controversy has recently been summarised as the distinction between the “descriptive” school and the “prescriptive” school as part of the deliberations over discount rates undertaken in conjunction with the Intergovernmental Panel on Climate Change (Arrow et al. 1995 as cited in Portney and Weyant 1999). Those in the descriptive school choose a discount rate based on observation of the rate(s) of return to capital invested in a number of alternative assets. On the other hand, those in the prescriptive school select a discount rate based on “ethical principles,” or rules that define how the well-being of different generations ought to be weighed.

Members of the prescriptive school are typically responding to one of the following arguments, some of which are rather more technical in nature and some of which have more ethical content: 41

- that it is ethically indefensible on equity grounds to choose a discount rate for future generations, or even to discount the value of human lives in this generation (Broome 1991 in Pearce and Ulph 1995);
- that the goals of environmental sustainability are thwarted by discounting (Markandya and Pearce (1988);
- that the pure rate of time preference should be very low or zero (Cline 1999);
- that there is considerable uncertainty about discount rates in the “deep-future” (Weitzman 1999);

A number of solutions to these problems have been proposed including:

- lowering the discount rate to zero (i.e. no discounting)
- lowering the discount rate to reflect the interests of future generations (Markandya and Pearce 1988)
- lowering the CRI to reflect a low, if not 0, pure rate of time preference (Cline 1992)
- adding a premium to discount rates to reflect risk and uncertainty about environmental consequences of investments (Markandya and Pearce 1988)
- using a special, lower discount rate for environmental benefits (Nordhaus 1999)
- lowering the discount rate as a whole (Nordhaus 1999)
- using a sliding scale discounting strategy that involves periodically lowering the discount rate (Weitzman 1999)

A number of other authors have also suggested lowering the discount rate as time passes (Arrow et al. 1999; Heal 1996; Kopp and Portney 1999; Cropper and Laibson 1999). However, these suggestions are made with reference to an increasing number of empirical studies that show that people do discount the future but at a decreasing rate (Portney and Weyant 1999) and, thus, belong to the “descriptive” school.

Economists and non-economists alike often state that discounting of deep-future impacts in the pursuit of efficiency is generally inconsistent with equity goals (Schelling 1999; Nordhaus 1999; Bradford 1999; Wilks 1999 eco009). Still, most economists will argue for the application of one of the standard methods for economic discounting within the current generation, or for projects of less than 40 years (Portney and Weyant 1999). Further a range of contributors to the discount rate question the utility of inserting ethical concerns about intergenerational equity into the discount rate (Lind 1999, Nordhaus 1999; Schelling 1999; Toman 1999). A particularly succinct and policy-oriented view on this topic is as follows:

Ad hoc manipulation of a discount rate to achieve long-term goals is a very poor substitute for policies that focus directly on the ultimate objective . . . The dilemma of whether or how much
to override conventional market or benefit-cost criteria is not usefully informed by the use of special, low overall or sector-specific discount rates. These merely hide the underlying trade-off between the long-term objective and the economic cost . . . Focusing on ultimate objectives has the advantage of showing trade-offs explicitly, making the cost of violating a benefit-cost rule transparent and allowing public decision-makers to weigh the options rather than having technicians hide the choices in complicated and abstrusely argued second-best rules of thumb (Nordhaus 1999: 158).

5.4 Actual Practice and Guidelines

The WCD Survey of Multilateral Development Bank appraisals the following findings emerge regarding actual practice in the evaluation of dam projects:

- From the entire sample of 29 ADB projects, only the 1990s hydropower projects (5 out of 6) calculated a WACC for use as the hurdle rate for the financial analysis. For the World Bank sample, hurdle rates were not extensively discussed, but for power projects, return on rate base or return on fixed assets was mentioned.
- For World Bank projects, the economic discount rate was generally not specified – only 6 projects mentioned that the discount rate (ranging from 10 to 12%) is considered to be the opportunity cost of capital or social discount rate in the countries of China, Ghana, Kenya, Mexico and Pakistan.
- Project appraisal documents did not mention the methods used to obtain the discount rate.
- The intergenerational distribution of project impacts are rarely, if ever, considered in the evaluation, other than to mention that this might represent a problem of equity and ethics.

For economic analysis, the MDBs tend to use a discount rate for project assessment in the 10 to 12% percent range, to a large extent as a means of capital rationing. ADB guidelines explicitly indicate that projects with an EIRR of at least 12% are acceptable and that those with an EIRR between 10 and 12% are acceptable where additional unvalued benefits can be demonstrated and where these benefits are expected to exceed unvalued costs (ADB 1997). This approach is adopted as “it is difficult, in practice, to estimate precisely” what the economic opportunity cost of capital should be in each country (ADB 1997: 37). As suggested by the review of appraisals of large dams the World Bank also tends to simply adopt a fairly standard discount or “hurdle” rate for projects without regard to country specifics. In practice, then it can be said that international lending agencies tend to use the “hurdle” rate as a means of capital rationing.

Still, it is worth noting that both the new ADB guidelines and the proposed handbook on economic analysis at the World Bank recommend the use of the EOCC method and provide worked examples of the method in the case of the Philippines and Indonesia, respectively. The example from Indonesia is summarised in Box 5.1. An observation worth making of both of these examples is that they lead to point estimates of the discount rates for both countries (as shown in Table 5.1). In other words they provide no guidance on a reasonable range of discount rates to use in sensitivity analysis.

While a review of discount rates employed by national finance and planning departments in developing countries was not conducted for this paper, experience suggests that rates employed are typically in the 8 to 12% range. Gunatilake and Gopalakrishnan (1999) report that the Ministry of Planning in Sri Lanka employs a 6% rate, but this appears to be on the very low side of figures employed.

In the United States, the discount rate that is applied (to represent the social opportunity cost of capital) to federally funded projects is mandated as the cost of government borrowing. In other words, the discount rate used in practice is based on what exists in the marketplace, and places no explicit emphasis on intergenerational or other social considerations. As noted earlier, this rate was 7% in real terms in 1999 (Portney and Weyant 1999). In the case of the United Kingdom, Her
Majesty’s Treasury employs a real discount rate of 6% on projects in the public sector (Pearce and Ulph 1995).

Thus, it can be summarised that discount or “hurdle” rates actually employed in the evaluation of public investments such as large dams are currently in the 8 to 12% range in developing countries, while in developed countries rates in the range of 6% are typically applied to public investments. Again, such a difference can be explained by the higher growth rates (or potential thereof) of developing as opposed to developed economies.

5.5 Comparative Analysis of Discount Rates Approaches

Table 5.2 provides a summary of a number of alternative approaches to the selection of a discount rate as discussed above. The rejection of the validity of discounting and, hence, the application of a zero discount rate may be attractive as an ethical response to the seemingly perverse results of applying discount rates to decisions that are taken today but only yield results in the far distant future. It may also be an ethical response to the idea of discounting future flows that are far from being typical consumption goods – such as biodiversity or cultural heritage. However, as suggested earlier this approach – however valid the ethical content – is unlikely to lead to an improved economic input into the decision-making process.

As argued above and returned to later in Chapter 10 it is preferable to provide space for such concerns in the decision-making process as a whole, rather than to attempt to impose such a restriction on economic analysis as a whole. The use of a zero discount rate effectively implies that individuals and society are indifferent between current and future consumption. In other words as long as an investment of $100 today would lead to the recouping of a fraction more than $100 in a years time – or even in a hundred years time, society would prefer to invest rather than consume today. In such a world the consequence is of course that once society had finished financing “profitable” investments there would be no money left over for current consumption. While it is theoretically possible for the rate to be zero or even negative in a particular case (Dasgupta et al 1999), it makes little sense to maintain that it could be zero in general for the economy as a whole.
Table 5.2. Summary of Alternative Approaches to a Social Discount Rate

<table>
<thead>
<tr>
<th>Approach</th>
<th>Arguments in Favour</th>
<th>Arguments Against</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Discounting not legitimate (rate set to zero)</td>
<td>Gives future generations equal standing to that of the current generation Is assumed by proponents to favour projects that better preserve specific classes of environmental amenities (e.g., scarce natural resources)</td>
<td>Investments/projects that represent &quot;best and highest&quot; use of society's current resources may be forgone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In actuality, does not necessarily favour environmental amenities or projects – instead simply leads to a bias towards investment at the expense of consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weights uncertain events occurring far in the future equally to those occurring in the short-term, predictable future</td>
</tr>
<tr>
<td>2. Consumption Equivalents Approach (approach as a whole)</td>
<td></td>
<td>Practical difficulties include that of identifying how current or future costs and benefits will displace private consumption and investment</td>
</tr>
<tr>
<td>2a. with SRTP from optimal growth</td>
<td>Theoretically, the best method</td>
<td>Practical limitations are in determining the optimal growth path of an economy and/or estimating the parameters of the SRTP equation</td>
</tr>
<tr>
<td>2b. with an “ethically” defensible SRTP</td>
<td>Avoids a reliance on purely “market” indicators of the SRTP</td>
<td>Does not account for the fact that the opportunity cost of capital may be much higher</td>
</tr>
<tr>
<td>2c. with a CRI based on market data</td>
<td>Ensures consistency with actual market conditions and in developed countries data is at hand</td>
<td>More difficult to obtain figures for developing countries Market figures may overstate optimal growth if user costs and externalities are not accounted for</td>
</tr>
<tr>
<td>3. Economic opportunity cost of capital (EOCC)</td>
<td>Takes into account both the supply and demand price for capital Can be estimated empirically and is then easily applied to cost and benefit flows</td>
<td>Does not account for the reinvestment of income</td>
</tr>
<tr>
<td>4. Marginal rate of return on private investment</td>
<td>Ensures that investments/projects that represent “best and highest” use of society's current resources are chosen</td>
<td>Does not account for the fact that investment and resulting benefits will often displace consumption and not just private investment</td>
</tr>
</tbody>
</table>

Comparison of Consumption Equivalents and Economic Opportunity Cost of Capital Approaches

As discussed earlier the principle methodological contenders for the calculation of discount rates are the consumption equivalents approach and the economic opportunity cost of capital approach. The table summarises their advantages and disadvantages which can simply be summarised by acknowledging that although the consumption equivalents approach is theoretically the best approach it suffers from practical difficulties, difficulties that the EOCC approach avoids by virtue of its estimating a single rate applicable to all flows. Ray (1984) accepts that the EOCC approach is by far the simplest approach. Kolb and Scheraga (1990) suggest that the consumption equivalents approach has not met with broad acceptance in US federal agencies in part due to it being more difficult to explain and implement than conventional discounting. Clearly, the need to examine cost and benefit
streams and determine the degree to which they displace private consumption and investment places an additional analytical burden on the project analyst. The EOCC approach has the advantage that once the national rate is calculated it can be applied across the board to projects in that country, without being subject to project-specific manipulation by analysts.

Either approach, when correctly and consistently applied across the portfolio of project in a given country context would be acceptable. However, it is clear that the EOCC avoids a source of subjective bias in project appraisal and reduces the analytical effort required at a project level. As Kolb and Scheraga (1990) point out arguments about discounting may often have more theoretical than practical significance. With regard to large dams, the current paper identifies many areas for improvement in economic analysis. In this regard, improving the coverage of social and environmental impacts is likely to be far more valuable than attempting to implement the consumption equivalents approach – particularly when a reasonable close substitute in the EOCC is readily available and applied in many countries.

Of course, as the EOCC is not fully consistent with the consumption equivalents approach it will be important to understand the potential direction and magnitude of any potential bias of using the EOCC method. Kolb and Scheraga (1990) provide a brief comparison of standard discounting (at 10%) with a variant on the consumption equivalents approach. While this is not a direct comparison of the EOCC and consumption equivalents approach the authors do yield some insight into how the consumption approach and a standard negative exponential discounting process will yield differing results. The authors conclude that for short term projects of 20 years where investment costs are directly followed by consistent benefit flows there is no difference in results between the two approaches. However, they do find that the standard approach will yield inexact results as the length of life of the benefit stream of a project is extended. For projects for which a lag exists between the cost and benefit streams, the standard approach may lead to significant undervaluation of public investment when compared to the modified consumption equivalents approach.

Kolb and Scheraga (1990) find that in these cases that the discount rate used in applying the standard rate would need to have been lower than the original 10% used in order to mimic the results obtained using the modified consumption equivalents approach. As the rates used are purely hypothetical and not reflective of a calculated EOCC the only conclusion that can be drawn for large dams (which are long-lived and may have lags between costs and benefits) is that the EOCC approach is likely to undervalue projects – in other words the EOCC rate will be too high.

A further area of concern that remains is that where methods for calculating discount rates are based on observed rates of pre-tax return on investment and after-tax returns to investors, they will reflect the current growth rates of economies. In many contexts, particularly in rapidly growing developing economies with nascent environmental regulation and enforcement capacity, these growth rates will not reflect the consumption of natural capital and the degradation of environmental quality. As a result these rates will overstate the social rate of discount, biasing project selection against capital investment and in favour of short-term returns.

Kellenberg and Daly (1994) and Daly (1994) point out that project analysis needs to account for the opportunity cost of the depletion of natural capital (i.e. the user cost of natural capital). Here the implication of this point are merely extended to the observed rates of return that are employed in calculating the economic opportunity cost of capital. For example, in the aforementioned worked example for Indonesia a real marginal rate of return on private sector investment of 17% is employed in reaching an 11% weighted average opportunity cost of capital. However, the 17% includes the high returns achieved by depleting natural capital at an unsustainable rate. While there are difference in how economists estimate user cost, one estimate of the cost of the depreciation of the forest stock through rapid deforestation and timber extraction in Indonesia, for example, amounted to 4% of GDP (Repetto et al. 1989) This argument may be extended to the depletion of natural capital in many developing countries (see Barbier 1998).

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
In sum, it is recommended that the current trend towards adoption of the EOCC be implemented in the case of large dams and further supported by additional empirical work. Such work would involve assessing the extent to which the failure to adequately assess the effect of reinvestment of project income might bias results from the EOCC, as well as to improve the understanding of what would be a reasonable range of rates for use in sensitivity analysis.

On the basis of the brief discussion above it appears that there is good reason to expect that current methods for calculating discount rates based on market data may over-estimate the discount rates to be applied to public investments. Where the EOCC method is applied it appears likely that the bias will also be of a similar direction. The conclusion is, therefore, that economic analysis should include the application of a range of discount rates in project sensitivity analysis, in particular of rates on the lower end of the range.

Finally, some have suggested that in applying sensitivity analysis a wide range of discount rates, say between zero and 15%, should be investigated. In practice, using an extreme range of discount rates will greatly increase the chances of the different types of CBAs yielding conflicting results. Rather than clarifying an already complicated situation, this is more likely to throw more confusion into the process and, in practice, be of little assistance to decision-makers. Rather emphasis should be devoted to improving the application of existing methods for developing these rates (as suggested above) with a view towards arriving at defensible estimates and confidence ranges for this critical parameter.

**The Impact of Differential Private vs. Social Discount Rates on Decision-Making**

As pointed out earlier in this Chapter, the lower the discount rate the more a large dam will appear as a profitable investment. Similarly, it should now be clear that the discount rates that should be used in economic analysis will be lower than those applied in financial analysis. The rate used in economic analysis accounts for both the opportunity cost of lost consumption and investment and assumes only market levels of risk, while discount rates applied in financial analysis will respond only to the opportunity cost of capital and will fully price in the level of risk involved in the undertaking.

If the rates diverge enough, the economic analysis of a project may suggest a project is worth undertaking yet it may be financially unprofitable. In other words, it may be the correct choice for the economy but the private sector will not be interested in funding the project if it must pay market rates of interest and, in high risk countries, pay a risk premium. What should be done? Gittinger (1982) writes that it is best to “break the link between choosing projects and financing them – to choose the best selection of projects . . . and then to set out to obtain the best terms possible for external financing.”

Essentially there are three alternative principles available to guide public policy with respect to large dams and alternative investments with regards to their financing. First, is to allow financing to drive project selection. Given that large dams have important consequences on the allocation of services provided by rivers – which themselves have public good characteristics – and may raise significant social and distributional issues (see Chapter 9) all of which are neglected in financial analysis this is an inappropriate policy response.

A second principle would be to limit project selection to those projects that are profitable in economic terms and then to allow finance to flow to the projects that are most attractive in financial terms. Third, public funding or public/private partnerships (risk-sharing or subsidies) may be developed in order to ensure that preferred alternatives are not only selected but financed. While the latter would be preferred the distinction between these last two principles may be blurred in reality for various reasons, including the difficulty of accurately assessing the relative economic returns of different alternatives prior to their full design. However, the main point to emphasise here is that where the divergence between private and social discount rates leads the private sector to prefer different project to those favoured by society, there is justification for altering the incentive structure to ensure that the economically-preferred project is implemented.
5.6 Findings and Recommendations

Finally, a number of findings emerge from the discussion of discounting:

- Discounting is an appropriate tool for addressing costs and benefits of dam projects characterised by long project lives, but there is little consensus over how to choose a discount rate.
- Economic theory can account for scarcity and recognises that for some natural assets capital substitutability may be limited or not possible, but more primary research is needed on the relationship between economic analysis and sustainable development.
- Other things equal, the use of a lower discount rate will favour dam projects over alternatives due to their high capital costs, low operational costs and long-lived benefits.
- The lower the discount rate the higher the weight placed on events that will occur farther into the future and that, are, by their very distance more uncertain.

The discussion suggests that it would be misplaced to abandon the practice of discounting or to arbitrarily lower discount rates in order to attempt to cope with the very serious question of how decisions taken in the current generation will affect future generations. Any attempt to hide such a major distributional concern in the manipulation of the discount rate is an inferior choice to promoting public deliberation on these issues within the context of multi-criteria processes. As a result of these findings, it is recommended that decision-makers and stakeholders explicitly consider the impact of project alternatives on future generations as a regular part of the consideration and evaluation of project impacts.

A number of specific recommendations to agencies with respect to current practice and guidelines can be made. In particular it is recommended that agencies make a renewed effort to ensure that staff follow their own guidelines by undertaking the following:

- investing in empirical research to identify country specific discount rates and assessing their likely range and variation
- harmonising the use of such rates between national and international agencies
- calculating net present values for projects and not just internal rates of returns (IRRs)
- conducting sensitivity and risk analyses of the response of project expected net present values

These efforts are important for a number of reasons. An increased emphasis on options assessment implies the need to rank projects based on least-cost and cost-benefit analyses. In selecting the best option(s) net present values should be used in place of IRRs, as IRRs do not give correct rankings for mutually exclusive projects.

With respect to good practice methods the economic opportunity cost of capital approach is currently favoured by major multilateral agencies. There are objections to this approach, i.e. that it fails to deal with the issue of reinvestment of project benefits. Still, the alternative approaches – such as the consumption equivalents approach – while theoretically more appropriate often require heroic assumptions on the part of analysts as to the investments displaced by the project and the reinvestments produced by project benefits. Further, there is no evidence to suggest that the different approaches yield radically different results in an operational context.

However, it appears that no allowance is made in the methods and data applied in actual calculations of the economic opportunity cost of capital to accurately ‘price’ the extent to which current economic activity is sustainable in terms of natural resource use and the environment. Where rapid economic growth is fueled by non-sustainable consumption of natural capital it would be advisable to consider the discount rates currently employed as an upper limit and place considerable emphasis on sensitivity tests conducted with lower rates.
6. Valuation of Impacts over Time: Risk and Uncertainty

In the debate over dams and development, it is often asked whether economic analyses sufficiently account for and report the numerous risks and uncertainties associated with dam projects. Economic valuation and CBA are typically framed in terms of a single expected value i.e. the expected value of hydropower or the expected net present value of the project. However, the valuation of costs and benefits over time introduces not only the issue of time preference but of risk and uncertainty. Given circumscribed knowledge of the behaviour of social, economic and environmental systems and the long time scales involved future prediction of outcomes associated with dams will always be uncertain to a degree.

Still there are some occurrences for which the probabilities of different outcomes can be established based on observed behaviour. Thus, using historical records of streamflow future probability distributions for streamflow may be forecast. The Modern Dictionary of Economics defines risk as outcomes for which probability distributions can be identified, while outcomes for which there is no probability distribution are cases of uncertainty (Pearce 1986). This distinction has a certain logic and utility in permitting the disaggregation of events into those that are risky and those that are uncertain. Still, for practical purposes even probability estimates have a degree of potential error or from the opposite point of view a limited degree of confidence.

Effectively, then, there are few future events originating out of the behaviour of natural systems (including human systems) regarding which full certainty exists. From this perspective all events are uncertain to some degree. Yet, even two data points may serve to define (if loosely) a probability distribution. Effectively, then there may be considerable overlap between risk and uncertainty when viewed from a technical perspective and this may explain the commonplace tendency to use risk and uncertainty in an interchangeable fashion. In this regard it is worth noting that even financial and economic texts that present theoretical and methodological approaches to the evaluation of risk and uncertainty use these terms interchangeably (Varian 1993; Dixit and Pindyck 1994).

The analysis of risk and uncertainty can be an important component of project evaluation in both financial and economic terms. Given an expected rate of return, investors are typically expected to choose the project that has less risk. The corollary is that in order to accept a project with higher risk, investors will want to be compensated by a higher rate of return. Further, investors will want to know to what extent they are exposed to specific risks so that they may seek insurance for this risk or hedge this risk through their portfolio of activities. Where there is uncertainty about the impacts of a project society may wish to protect against such uncertainty to some degree. Where there is uncertainty about the effectiveness of environmental mitigation, for instance, a risk averse strategy would be to plan for the worst. For example, where environmental interactions are poorly understood a dam project with potential negative consequences on a downstream wetland area might want to provide for an environmental flow requirement that is 2-3 times larger than the “guesstimate” of the level required to maintain ecosystem function. In this case, the exact amount of “insurance” is not known so society may factor in a “safe minimum standard.”

This section examines how economists attempt to account for the risks and uncertainties associated with dam projects. Following an elaboration of the types of risks that are incurred in dam projects a review of actual practice and guidelines is offered. A discussion of the performance of actual practice leads into an overview of available methods and recommendations for improving practice.
6.1 Dam Project Risks

The parties involved in building and operating a dam are all subject to new risks. The insertion of a dam into a local economy and environment may also affect those not directly involved in the project. Table 6.1 provides an illustrative list of the sort of risks and uncertainties that various interested and affected groups may bear in association with a dam project.

Table 6.1. Risks borne by Interested and Affected Groups in a Dam Project

<table>
<thead>
<tr>
<th>Group (Type)</th>
<th>Risks and Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population to be resettled</td>
<td>Social and cultural defragmentation; loss of culture; loss of work place; substandard soils in resettlement area; no access to river water for irrigation; loss of fishery; loss of recession agriculture; exposure to new diseases</td>
</tr>
<tr>
<td>Other people affected</td>
<td>Reduced fishery (possibly leading to reduced protein intake); loss of recession agriculture; deterioration of water quality (may be unfit to be used as drinking water); drop in groundwater levels and therefore tubewells due to riverbed degradation; in case of diversion projects: loss of river navigation</td>
</tr>
<tr>
<td>Environment</td>
<td>Disappearance of unique habitats; changes in biodiversity; upsetting seasonal migration routes of certain species; riverbed degradation downstream; reservoir sedimentation; increased poaching as a result of better accessibility</td>
</tr>
<tr>
<td>Local Government</td>
<td>Upset of regional economy (especially during construction period); increase in prices for land and food; influx of foreign workers; labour conflicts; health impact on regional population; upset of political stability by local conflicts, resistance and protests</td>
</tr>
<tr>
<td>National Government</td>
<td>Distortion of economy; exchange rate risk; inability to convert sufficient quantities of local currency revenues into foreign exchange; danger of increased inflation; tension with downstream countries about water abstractions; danger of overcommitting funds to one sector curtailing for example education and health programmes; overcommitting funds to a particular area curtailing development in other parts of the country; upset of political stability by local conflicts, resistance and protests</td>
</tr>
<tr>
<td>Developer or Owner</td>
<td>Cost over-runs; delays in completion; lower than expected streamflow; reduction of early year benefits/revenues due to reduced growth in power demand, late commissioning of new irrigation areas, coincidence of early operation period with cluster of dry years; exchange rate risks; risk that consumers or clients cannot or do not pay for services rendered; risk of inflexible regulator not allowing to raise tariffs to commercially healthy level; possibility of nationalisation or other hostile take-over</td>
</tr>
<tr>
<td>Contractors and Manufacturers</td>
<td>Cost over-run in fixed price contracts; delays and extra costs due to insufficient co-ordination of parties involved in construction; labour unrest and strikes; flooding of construction site due to unforeseen flood events; major geo-technical mishaps such as cave-in of underground excavations, unforeseen water intrusions, tunnel boring machine getting stuck; failure of acceptance test for major equipment; inability or unwillingness of developer to settle bills and legitimate claims</td>
</tr>
<tr>
<td>Investors and Financiers</td>
<td>Inability of developer to pay back loans due to a variety of reasons, such as difficulties converting local currency income into foreign exchange, too low tariffs, lower than expected streamflow, higher than expected costs, etc.</td>
</tr>
</tbody>
</table>

The following sections deal predominantly with monetary risks. Social and environmental risks are dealt with in the WCD Thematic Reviews on Social and Environmental Issues.

6.2 Main Monetary Risk and Uncertainty Factors affecting Dam Projects

The main risk and uncertainty factors that confront the developer (whether a private sector or public sector developer) for dam-projects can be grouped under a series of technical categories:

Hydrology
- Occurrence of floods higher than the diversion flood during construction (damage to construction works and machinery, delay in commissioning)
• For large reservoirs: failure to be filled by the time of commissioning (less and later income during beginning of project operation period)
• Mean flow is below what has been expected (lower than expected output of project)
• Clustering of wet and dry years and the effect on income, especially occurrence of a prolonged dry period during the first years of operation (lower than expected project income)
• Statistical and conceptual shortcomings in determining the design flood, effect on dam safety and on project design (affects project cost and expected damage costs)
• Higher than expected downstream damages during release of major floods due to infrastructure encroachment of flood plains (may increase compensation payments)
• Faster reservoir sedimentation than expected (reduced income)
• Effects of global warming on hydrological cycle (may affect income)

Topography
• Inaccuracies in ground elevation, especially if no terrestrial survey was done (difference in area inundated, production, etc.)

Geology
• Poorer foundation and/or excavation conditions than expected (higher project cost due to extra cost and time for excavation and support measures)
• Unforeseen seepage from reservoir (extra costs for grouting, loss of revenue as reservoir cannot be filled to maximum level)
• Occurrence of landslides (delay of construction, stop of project services such as power production)
• Reservoir induced seismicity (may interrupt reservoir filling or project services, may cause damage to infrastructure including the project itself)

Technical Cost Estimation
• Higher quantities of work than expected, or unforeseen items (increase in project costs)
• Higher unit costs than expected (increase in project costs)
• Longer period of construction than planned (higher interest payments, delayed income)

Environmental Issues
• Errors and deficiencies in baseline data (the basis for calculating environmental costs)
• Uncertainty about impacts and unexpected impacts (may increase environmental costs)
• Uncertainty about functionality of mitigation measures (remedial costs)
• Longer time needed to implement mitigation measures than planned (higher interest payments, possibly cost increase)
• Higher mitigation and compensation costs than expected
• Delays due to public protest or inter-ministerial disagreement about environmental issues (higher interest payments, possibly cost increase)

Social Issues
• Underestimate of number of people to be resettled (delays, project cost increase)
• Underestimate of number of people otherwise affected by the project
• Problems in finding adequate land for people to be resettled (delays, cost increase)
• Underestimate of resettlement, compensation and other social costs (cost increase)
• Delays in implementing social mitigation measures causing delay of overall project (higher interest payments, loss of income)
• Labour unrest and strikes (delays of commissioning date, cost increase, lost income)

Other Issues (after financial close)
• Insufficient contingency funds to finance cost over-runs (additional sources of funding, probably at less attractive conditions. Could further increase project cost)

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
• Consequences of failure of acceptance tests for main equipment (delayed commissioning, extra interest payments, lost income)
• Effect of political measures, such as market liberalisation which upsets tariffs and market for project services

The table demonstrates that there is a tremendous variety of risks. Whereas some risks can be mitigated, for example by carrying out more fieldwork, others cannot. Some of the risks can be estimated with reasonable accuracy, such as the likelihood that the reservoir would not fill to the desired level at the time of commissioning. Other risks are subject to almost complete uncertainty, such as the possibility of nationalization or other hostile take-over.

6.3 Guidelines and Actual Practice

In order to investigate the potential risks of a project a developer may conduct sensitivity and/or risk analyses. Sensitivity analysis involves set a likely range changing the values of each of the key input variables used in the base-case analysis, and measuring the corresponding impact on the results (NPV and FIRR). The range of values employed may emerge from knowledge of underlying probabilities of events or best estimates of the likely range where systematic data do not exist. The developer may also perform a more comprehensive risk analysis by assigning probabilities to key variables and recalculating the NPV and/or FIRR. The probabilities may be derived from observed values, expert opinion or stakeholder perspectives.

In the WCD survey of MDB appraisals, the general practice in economic analysis was to test the sensitivity of the decision criterion to standard changes in total costs and total benefits, instead of key decision variables. The appraisals, do not themselves, provide the rationale for the magnitude of the changes in the key variables selected for analysis. For those projects including sensitivity analysis, when significant risks emerged measures to mitigate risks were subsequently identified.

Of four ADB irrigation dam projects surveyed, two (both from the 1970s) tested the sensitivity of the EIRR to key variables such as price, crop yield, crop intensity, and foreign exchange rate. This practice was simplified, but not necessarily improved, in the 1980s as standard variations in costs and benefits, and delay in implementation were employed in the other two ADB irrigation projects. Two out of five ADB multi-purpose projects surveyed tested key variables beyond standard changes in costs and benefits including changes in wage rate, crop yield, crop intensity, prices, tariff, and life of the power station.

At the World Bank, only three the projects, all of them recent, went beyond a simple sensitivity analysis in the economic analysis. The appraisals for China’s Xiaolangdi Multi-Purpose (1995) and Pakistan’s Ghazi-Barotha Hydropower (1995) carried out a risk analysis for changes in key variables, as identified in the Project Design Summary. (The case of Ghazi-Barotha is covered later in this section as a good practice example.) In China’s Tongbai Pumped Storage (1999), there was an analysis of critical risks, indicating the risk rating (using a probabilistic method) and risk minimisation measures.

With regard to financial discounted cash flow analysis (DCF), five out of six ADB hydropower projects in the 1990s conducted sensitivity analysis for the FIRR using the common +/- change in total costs and total benefits and implementation delay. One project also tested the robustness of both the FIRR and EIRR with respect to the effects of a 10-year drought, and to tariff. For the 1970s and 1980s, only half the projects included had sensitivity analysis of the DCF.

For China’s Zhejiang-Shanxi Water Supply project (1997), sensitivity test was performed for the maximum long-term debt-equity ratio, debt service coverage ratio, average net income, and average cash flow. Also this is the only multi-purpose project which calculated the weighted average cost of capital (see Chapter 5) as the hurdle rate for the FIRR.
In most of the WCD case studies simple sensitivity analyses of cost-benefit analysis results were carried out, but for none of the projects was a proper risk analysis undertaken.

### 6.4 Historical Performance

Economic analyses of dam projects often fail to account adequately for the risk and uncertainties associated with estimates of project costs and benefits, project life, appropriate discount rates and other variables. Critics point to the many dam projects that have faced cost overruns, revenue shortfalls and shortened project lives. Some of the difficulties associated with determining the physical factors used to estimate the costs and benefits of dam projects are presented in Chapter 3.1.

Failure to appropriately assess dam project risks and uncertainties can provide misleading optimistic or pessimistic results that, in turn, can affect decision-making.

A common area in which dam project risks and uncertainties are not sufficiently taken into account is in the specification of baseline conditions. An economic analysis compares “the world with the dam project” to “the world absent the dam project” (i.e., the baseline scenario). Costs and benefits of the project are measured by the differences between the results of these two scenarios. Therefore, the specification of baseline conditions can have a profound influence on the estimation and interpretation of results. For example, if the baseline scenario forecasts strong energy and irrigation demand, then a dam project's power and irrigation values will be higher than if the baseline scenario projects excess energy capacity and water supply for the region. That there is usually considerable uncertainty concerning the baseline conditions is an important factor that will effect the reliability of best estimates of costs and benefits associated with any large dam project.

The current practices for conducting sensitivity analyses are generally correct from a technical standpoint. That is, analysts identify key variables, define assumptions, probability distributions, and correlations, and determine optimistic and pessimistic scenarios. However, the estimates, assumptions, and probabilities included in sensitivity analyses are in danger of being biased or flawed, resulting in hot discussions between dam opponents and proponents, as shown in the divergent views in the two boxes that follow regarding dam projects in Laos.
**Box 6.1. Review of the Economic Impact Analysis of Nam Theun 2**

A review by Foresight Associates of the sensitivity analysis of the Nam Theun 2 project in Laos conducted by Louis Berger International, Inc. indicates that “the net present value of the project remains positive under all but the most pessimistic of scenarios.” However, according to Foresight’s review of Louis Berger’s analysis, net present value only remains positive under the “pessimistic” or “nightmare” scenario because Louis Berger has made several questionable assumptions. Most significantly, this scenario excludes any consideration of sedimentation in the reservoir, limits its worst case construction cost overrun to 20%, and does not consider single or multi-year construction delays.

With respect to sediment impacts, the Louis Berger study acknowledges that sedimentation "may pose a risk to future NT2 generation output and therefore the revenues and benefits associated with NT2." However, Louis Berger does not attempt to consider sedimentation scenarios in the sensitivity analysis, citing a lack of data on sediment loads. As the reviewers suggest, data exist for a variety of reservoirs in Asia with similar geological and hydrological characteristics. These data could be used to develop approximate assumptions for sedimentation rates and corresponding economic impacts.

The 1998 Lahmeyer-Worley Study of Alternatives for the Nam Theun 2 projects addressed the risk of sedimentation. The analysis showed that a 10-fold increase of the current sedimentation rate would reduce active storage in the reservoir by less than 3% and lower the net present value of the project by less than 1%. It is also worth noting that the entire Nam Theun 2 catchment was recently declared a National Park.

For the base case analysis, Louis Berger assumes no cost overruns; the pessimistic scenario assumes 20 percent cost overruns. Foresight Associates points out that hydropower projects supported by the World Bank have experienced cost overruns averaging close to 30 percent (see Chapter 2 of this paper) and argues that the pessimistic scenario should assume at least 30 percent cost overruns. Indeed, it could be argued that 30 percent cost overruns should be the base case and pessimistic scenarios assume even higher cost overruns. As factors leading to possible construction delays and cost overruns, reviewers of the economic impact assessment note geological uncertainty, which will “affect tunnelling operations, and possibly require structural shoring or ‘plugging’ of the hills which will form the basin rim as the reservoir begins to fill.”

On the other hand, the Lahmeyer-Worley report argues that the risk of cost over-run and delay are minimal. All construction contracts will be the result of an open turn-key bidding process. The turn-key contracts would cover geological risk, material price fluctuations, and the risk of currency fluctuations. Furthermore there would be heavy contractual penalties for delays in the completion project, and a bonus for early completion. Thus practically the entire risk associated with construction is to be covered by the contractors and not by the developer, which includes the Government of Laos. Should bidding prices be higher than anticipated, the project would simply be cancelled, with no risk for the Govt of Laos.

Box 6.2. Review of Nam Theun-Hinboun Project Revenue and Capacity Estimates

In a 1996 review by Borealis Energy Research Centre of a 1994 Asian Development Bank (ADB) study of the Nam Theun-Hinboun hydropower project found that the ADB analysis had inadequately accounted for risks to project revenue. Although the ADB report indicates that the other major hydropower facilities in Laos, Nam Ngum and Xeset, generate average revenues of 3.5 U$e/kWh and 2.9 ¢/kWh respectively, ADB estimates revenues for the Nam Theun-Hinboun project were based on 4.3 ¢/kWh. This, it was argued, represented a price 23 percent to 48 percent higher than the value of electricity from existing hydropower projects in Laos. ADB’s sensitivity analysis only assesses how a 10 percent reduction in prices may affect project profitability. The study suggested that the ADB analysis should have used a lower base case for the price of electricity, and then test for how project revenue would be affected under optimistic and pessimistic scenarios.

In addition, the Borealis reviewers noted that Nam Theun-Hinboun could be subject to higher levels of revenue risk because 95 percent of the project’s output is dedicated for export to Electricity Generating Authority of Thailand (EGAT). Moreover, EGAT is the customer for 50 percent of all of the electricity output of Laos. As such a large customer for Laos’ electricity, EGAT holds a strong bargaining position with respect to negotiating electricity prices. This would increases the risk that, once the project is completed, EGAT would want to negotiate lower prices.

An update of this case since the publication of the Borealis review shows that the Nam Theun-Hinboun project was commissioned in March 1998. The construction costs remained under budget and the negotiated tariff was 4.5 ¢/kWh, with a 3% annual escalation. The project is currently one of the most important foreign currency earners for the Government of Laos.

The Borealis reviewers also found ADB annual capacity factor estimates to be unduly optimistic. Nam Theun-Hinboun was expected to produce at an 85% annual capacity factor (actual output divided by theoretical output assuming continuous full production). In comparison, Nam Ngum and Xeset have experienced average annual capacity factors of less than 48% to 64% respectively. According to the ADB report, the design of Theun-Hinboun is similar to the Xeset project, which has virtually no electricity output during extended periods in the dry season. Moreover, the ADB report describes a program to release water to the downstream Theun during the dry season rather than divert the water to the Nam Hinboun, in order to mitigate impacts on downstream fish populations. Such releases during the dry season would be inconsistent with achieving the targeted capacity factor. Given the experiences of existing hydropower projects in Laos, as well as the Nam Theun-Hinboun’s planned measures to mitigate impacts to fisheries, the reviewers conclude that there appears to be little likelihood that the Nam Theun-Hinboun project will achieve its target capacity factor.

However, the ADB appraisal for the project explains that the capacity (installed MWs) of Theun-Hinboun was optimised assuming that in later years the upstream Nam Theun 2 project would be built. With Nam Theun 2 in place flows to Theun-Hinboun would be reduced. The optimisation therefore, called for reducing the installed capacity at Theun-Hinboun. As a result, the capacity factor in the short-term was bound to be quite high. By comparison had Theun-Hinboun been optimised for the full flow, it would certainly have had a higher installed capacity (and thus a lower capacity factor) than as planned.

Due to delays in the implementation of Nam Theun 2 the Theun-Hinboun project can make use of unrestricted flows much longer than expected, with a consequentially higher than predicted energy output and income.

6.5 Guidelines

The World Bank’s Operational Policies on the “Economic Evaluation of Investment Operations” (OP 10.04 September 1994: 2) highlights the uncertainty involved in project economic analysis and states that project evaluations should therefore consider “the sources, magnitude, and effects of the risks associated with the project by taking into account the possible range in the values of the basic variables and assessing the robustness of the project’s outcome with respect to changes in these values.” Further the Bank clearly signals that the objectives of the sensitivity analysis are to improve project design, increase the project’s expected value and reduce the risk of failure. Clearly, then the risk that remains at appraisal stage is risk that has not been avoided through iterative design and testing of different project scenarios.

The Bank’s Operational Manual Statement (OMS) on “Economic Analysis of Projects” (2.21 May 1980:14) also clearly defines risk analysis, but states that this should be undertaken only in special cases, such as “relatively larger and more complex projects or for projects having exceptional risks.” The Asian Development Bank’s “Guidelines for the Economic Analysis of Projects” makes essentially the same recommendation insofar as when risk analysis should be applied (ADB 1997: 40). The Principles & Guidelines for federal water projects in the USA recommend the use of sensitivity analysis and refers to risk analysis as the use of probability distributions to assess risk (US Water Resources Council 1983). No suggestions are provided as to in which cases such risk analysis should be performed. The P&G do however indicate that analysts may wish to explore public preferences in order to explore how such preferences and existing uncertainties may be combined to offer better project designs.

The World Bank’s OMS goes on to indicate that where the risks of all public sector projects are “pooled,” the expected net present value remains the correct measure of project worth. In other words, the risk of the project as measured for example by the variance of the net present value would not factor into the decision criterion. However, the OMS clearly states that this does not apply where the risk of a project falls on a “relatively small section of the population.” However, no guidance is provided on what steps should be undertaken in such a case. It is arguable that large dam projects that involve involuntary resettlement would therefore qualify as cases where risk analysis should be carried out and where the results of such analysis should be incorporated into the decision process.

The proposed “Handbook on Economic Analysis of Investment Operations” of the Bank provides a thorough treatment of sensitivity and risk analysis, pointing out pitfalls and limitations of the different methods (Belli et al. 1998). More importantly, it returns to the issue of whether net present values are acceptable decision criterion in cases where large projects, “correlated” projects or projects that affect particular groups are concerned. The explanation provided by Belli et al. (1998) is repeated in full in Box 6.3 as it provides a concise rationale for avoiding projects where risks of this nature are extreme. Belli et al. (1998) go on to conclude that even in such cases the inclusion of a risk “premia” would typically affect net present values by a fraction of one percent. As evidence they cite the case of one of the largest Bank projects where the capital cost of the project came to 30% of the country’s GDP and where both GDP and project benefits were correlated with the weather. The resulting adjustment to the net present value of the project was to lower it by 11%. The authors do not, however, provide any guidance on whether the risk premia attached to a project that proportionately affects particular groups can be calculated in a similar manner. Indeed, from the description provided in Box 6.3 it seems likely that this case would require an ethical rather than a quantitative judgement.
Box 6.3. Cases where Risk Invalidates NPV as a Decision Criterion

| Large Projects: Some projects may be so large relative to the economy that they may make a significant difference to the national income – for example, the discovery and development of new mines or oil fields. For these projects, risk-neutrality may not be the appropriate posture; if there is a shortfall, the potential loss may have dire consequences, whereas if there is a windfall, the benefits may not be equally appreciated. The country should, therefore, be prepared to accept an alternative with a lower, but more certain, expected NPV [net present value].

Correlated Projects: If the national income of a country fluctuates widely (because of uncertain rainfall, fluctuations in the prices of primary commodities, etc.), then a given increase in income is more valuable when the national income is lower than when it is high. Hence a project that performs better in times of distress (say, irrigation in years of low rainfall) may be preferable to another project that performs better in good times (say fertilizer in years of good rains), even when the latter is expected to have a higher NPV.

Projects that Affect Particular Groups. Finally, although most projects are small when compared to the country’s income, many projects are large with respect to a particular region or particularly groups of people. Consequently, while better- or worse-than-expected project results may cancel out for the country as a whole, they are unlikely to do so for particular beneficiaries. Unless the country is quite indifferent as to where the impact of a project falls, the regional impact should be taken into account. The expected value rule would not adequately reflect a country’s preference for a “safe” project with a lower NPV to one with a higher expected NPV entailing risks of distress for relatively poor people.


Belli et al. (1998) conclude that the primary function of risk analysis is to improve project design and, is therefore, of most value during the formative stages of a project. The US P&G suggest that sensitivity analysis is best applied early in the planning process with probabilistic analysis and modelling of public preferences and decision-makers’ attitudes coming at the phases of detailed design and final presentation of alternatives (US Water Resources Council 1983).

6.6 Good Practice Toolchest

As revealed by the discussion of guidelines it would appear that while large dams are a likely case for ensuring a full risk assessment, actual practice on the part of MDBs has consisted historically of simple sensitivity analysis. The survey of MDB appraisals suggests that at least at the World Bank, risk analysis has been applied in a couple of cases in the 1990s (see Box 6.4 for an example). Good practice then is largely known, but apparently not always applied. The brief presentation of good practice, thus, is not terribly different from that advocated in existing guidelines and handbooks.

Sensitivity analysis provides a systematic methods for changing the values of input parameters in dam project financial and economic analyses to test the resulting impact on the net benefit estimate. Sensitivity analysis should also be used to identify switching values (i.e. values for parameters at which the net benefit from the project becomes zero). In the case of risk analysis, where probabilities of occurrence are known, or are assigned on the basis of experience, such analysis should be used to identify risk-return trade-offs and to assess how project outcomes may vary over likely ranges of values for key parameters. These types of analyses provide additional information to decision-makers on the possibility of different project outcomes, beyond a single net present value estimate.
Box 6.4. Good Practice: Ghazi-Barotha Quantitative Risk Assessment

World Bank experience with large scale hydroelectric projects indicates that there are substantial risks related to: (i) macroeconomic performance, (ii) possible excess amount of private power supply, (iii) project implementation (arising from non-mobilisation of financing requirements, unsatisfactory resettlement; relocation, and compensation and delay in implementing steps identified to mitigate negative environmental and cultural heritage impacts; construction delay; and geological and hydrological uncertainties). For each of these risks, mitigating measures have been designed in order to safeguard the viability of the project.

In addition to sensitivity analysis, a quantitative risk analysis has been deemed important given that a combination of such risks could occur. This approach also provides a good understanding of which outcome is more or less likely.

The risks have been summarised under the following scenarios: (i) demand uncertainties (high, base, and low scenarios), (ii) cost profiles (no cost overruns, 15% cost overrun, and 30% cost overrun), (iii) schedule delay (no delay, 1 year delay, and 2 year delay), and (iv) amount of additional capacity provided by private projects (3100 MW, 5200 MW, and 7200 MW). Probabilities have been assigned to each scenario, so that a weighted average ERR can be obtained. The total possible number of outcomes is 54. For each outcome, the expected value of the EIRR, calculated as probability times its own EIRR, is then summed over all outcomes to give the expected EIRR. A probability distribution of EIRR has then been calculated for the overall power sector program and for the project alone.

The results indicate that the risk-weighted EIRR on the overall investment program is 18.5%, which is lower than the Base Case estimate, but considerably higher than the opportunity cost of capital at 12%. The probability of the EIRR falling below the opportunity cost of capital is estimated at 8%. The risk-weighted EIRR is quite robust to changes in the basic probabilities.

For the project alone, the risk-weighted EIRR is over 23% and its probability of failing the opportunity cost of capital is zero. This is because under any unfavourable scenarios considered the EIRR is always in the range of 18% to 30%. In particular, in the event of an excess of private projects commissioned by FY2001, the consequence to the project will be a delay in its commissioning date, which is not considerably affecting its economic viability.


Important elements of risk and sensitivity analyses, in general, include:

- **Identifying Key Variables.** A sensitivity analysis should include input parameters that are critical to the net benefit estimate (i.e. when a plausible deviation from the best estimate of a variable's value is both possible and could result in a significant change in net benefits).

- **Defining, or Assigning, Probability Distributions and Correlations.** Probability distributions specify the likelihood of selected values within defined ranges. Where two or more variables are known to be correlated, these relationships should be defined in the analysis (as conditional probability entities).

- **Running Simulations.** In theory, once all the assumptions, probability distributions, and variable correlations have been set, probabilistic methods can be used to develop a range of simulations.

The variables that should typically be included in the sensitivity analysis of a dam project are:

- construction cost (including effect of exchange rate changes);
- delays in project completion;
- demand forecast;
- water and/or power output and price;
- the cost of alternative electricity generation (for power projects);
- cost of agricultural input and output over time (for irrigation projects);
- discount rate;
In sensitivity analysis the analyst should check to see if the range of possible values would alter the decision as taken based on the expected NPV/IRR (i.e. whether the NPV becomes negative or the IRR drops below the hurdle rate). An alternative to actually specifying a range of values in sensitivity analysis is to calculate the switching value for each of the variables considered as an indication of the potential susceptibility of the profitability of the project to the variables. This is the value of the variable that pushes the NPV into negative territory or the IRRs below the hurdle rate.

The developer should also perform a more comprehensive risk analysis by assigning probabilities to key variables and recalculating the NPV and/or IRRs. The probabilities may be derived from observed values, expert opinion or stakeholder perspectives.

It is important to distinguish between conditional (related to each other) and unconditional (independent of each other) probabilities. The probability that a major unforeseen geological disturbance will hamper construction and will increase the project cost and lead to delays in implementation, are related, these are conditional probabilities. The chance of encountering an unforeseen geological disturbance is however unrelated to the likelihood that the first years of operation coincide with a spell of dry years and, thus, these are unconditional probabilities. For each key variable of the cost and benefit side to be included in the risk quantification analysis it is required to:

- specify a set of pairs of probabilities coupled to expected values, in such a way that the total probability is 1.00 and the weighted average equal to the average expected value; and
- determine whether it is a case of conditional or unconditional probabilities.

The result of the analysis is a probability distribution for the NPV or IRR, which yields, for example, the probability that the IRR will exceed the 10% hurdle rate. If the developer finds that the project assessment yields consistently positive results over a reasonably broad range, then the project is typically accepted from a risk point of view.

The relevance of these analyses depends largely on available data and the plausibility of the analyst's assumptions, probability distributions and variable correlations. Therefore, it is important that the assumptions, methods and results of an analysis, as well as any known biases and omissions, are presented in a clear and transparent manner that is useful to stakeholders. If the results of an initial analysis are insufficient to support dam project decisions, the analysis may still serve as a useful screening tool, providing information on which of the more uncertain variables require more extensive research.

For the long-term investigation of major sources of uncertainty, qualitative scenario analyses may also prove useful. In such analyses, a number of visions of the future are developed and the effect of these “futures” on the results of the project assessment are rigorously deliberated and presented as an additional aid to decision-making.
6.7 Findings and Recommendations

The assessment of current practice with regards to the analysis of risk and uncertainty yields the following findings:

- Historical practice in MDB dam appraisal has relied on simple sensitivity analysis of standard +/- fluctuations in a limited number of variables.
- Actual practice is improving at MDBs but often still falls short of practice recommended in guidelines, which themselves are a reasonable guide to good practice.
- Current good practice in quantifying risk, involves the application of probability distributions of different variables in calculating probability distributions of IRRs or NPVs.
- Performance and implementation of sensitivity analysis is mixed, but there are areas in which consistently inadequate selection of ranges or variables have led to bias, e.g. the bias evidenced in cost over-runs in Chapter 2.
- The characteristics of large dam projects – i.e. as very large capital projects that are correlated with rainfall and weather and that involve placing a series of risks on local affected populations – suggest that risk analysis will often be an important element in project preparation.
- Where local populations, particularly the poor, bear project risks the use of the expected net present value as a decision criterion should be supplemented by consideration of how the potential variance in impacts to be felt by these groups may lead to a risk premia on the project or a discussion regarding the ethical nature of the potential for an asymmetric allocation of risk.

Where data and modelling expertise permit, the undertaking of a full risk analysis is highly recommended, concentrating on the factors listed in the earlier section on good practice.

Finally, a number of recommendations for methodological improvements, process enhancements and/or changes in institutional incentives can be made with regard to sensitivity and risk analysis:

- the range of +/- variation that should be included in sensitivity analysis of key variables needs to accurately reflect actual experience with large dams and, at present, this suggests that the ranges in current use are too narrow;
- experts in the respective fields should give best guesses of probabilities of deviations from the average for the most important input variables;
- risk and sensitivity analyses should involve consultation with stakeholders in order to discuss expert and their own perceptions of the levels of risks and uncertainties associated with different alternatives. Agreement should be reached on the setting of the most important parameters or the derivation of utility functions that reflect stakeholder and decision-maker preferences;
- it should be investigated what benefits individual risk reduction measures can bring about, and at what cost. Attractive measures should be implemented; and
- it is necessary to compare major projects to a set of smaller projects with the same overall capacity. Even though the multi-project solution may be more expensive, it may have considerable advantages from a risk point of view.
7. Valuing Dams over Time: Uncertainty and Irreversibility

The previous chapter considered the effect of risk and uncertainty on project valuation. The objective was to indicate how, in the face of risk and uncertainty, the expected net present value should be complemented by sensitivity and risk analysis. This section turns to an even more complete consideration of the investment environment, an environment that includes not only uncertainty, but the potential irreversibility of financial investment and its consequences (e.g. social and environmental impacts), and a choice of timing of investment. Dixit and Pindyck (1994) provide an innovative and comprehensive application of the use of modern options theory to investment decisions involving issues of uncertainty, irreversibility and timing. This chapter is simply an attempt to repeat the general theory and arguments advanced by these authors, indicate the potential relevance of the theory and methods to dams, and conduct an exploratory application of these ideas to water and energy resources development. The latter is intended to suggest the potential qualitative implications of applying the theory, given that the quantitative methods go beyond the intentions of this paper.

7.1 The Theory and Argument: The Incompleteness of CBA in the Presence of Uncertainty, Irreversibility and Choice of Timing

According to conventional theory and practice, a positive expected net present value (NPV) returned by CBA or DCF tells the investor to go ahead with an investment. Dixit and Pindyck (1994) describe two hidden assumptions that underpin this approach. The NPV rule assumes that one of two cases apply. In the first case, the investment is reversible insofar as the investor can exit from the investment and recover the expenditure if the future (i.e. market conditions) turns out worse than expected. In the second case, the NPV rule assumes that if the investment is irreversible that there is no choice of timing, i.e. the investment is a “now or never” proposition. Not only do most investment decisions of course not fulfil either of these assumptions, but irreversibility and the possibility of postponing investment are very important characteristics of investments faced by firms and by society.

As indicated above the “simple” net present value rule does not account for the ability to delay an irreversible investment. The value of delaying investment is equivalent to holding an “option” to invest – the right but not the obligation to invest – and, thus, can be called an option value. When an irreversible investment is made the investor exercises the option, or, in so many words “kills” the option. At this point the investor has effectively given up the opportunity to wait for additional information, i.e. to reduce the uncertainty over the present worth or timing of the expenditure. The central point made by Dixit and Pindyck (1994) is that the decision to go ahead with the investment implies the loss of this option value. This is an opportunity cost of the decision to proceed with the project that standard CBA does not count. Thus the NPV rule needs to be reworked so that the decision to invest is taken only when the benefits of the investment exceed the standard costs of investment plus the value of keeping the option alive.

Dixit and Pindyck (1994) suggest that the opportunity cost represented by the value of an option to invest will be very sensitive to uncertainties, such as the risk and uncertainty of realising future cash flows. Given that the growing literature on these options values shows that they can “profoundly affect” the decision to invest, they argue that these uncertainties may therefore be better at explaining variation in investment behaviour than variables such as interest rates. They also find that this may explain the large gap between private sector “hurdle rates” and the cost of riskless capital – thus explaining why firms tend not to invest until prices are well over long-run average costs (as conventionally measured) and why they do not exit immediately upon prices falling under this level. Instead, there is an area of profitability the upper and lower threshold of which must be exceeded for entry and exit, respectively, to occur. This phenomenon, whereby investment decisions fail to reverse
themselves when the underlying causes are fully reversed is called economic hysteresis (Dixit and Pindyck 1994).

Dixit and Pindyck (1994) suggest that this advance in thinking undermines the theoretical foundation of standard neoclassical investment models. The authors, however, do not seek to overturn the analysis of costs and benefits of a decision, but rather to expand the notion of costs and benefits to include the option value associated with uncertainty and irreversibility. In other words this is another case of standard CBA omitting another type of value. Indeed, there is a somewhat parallel stream of thought in the environmental economics literature which posits the existence of a “quasi-option value” that is associated with the irreversible decision to develop an environmental resource under uncertainty. Arrow and Fisher (1974: 319) summarise the general methodological implications as follows:

. . . the implication, however is not the overthrow of marginal analysis. Just because and action is irreversible does not mean that it should not be undertaken. Rather, the effect of irreversibility is to reduce the benefits, which are then balanced against costs in the usual way . . the point is that the expected benefits of an irreversible decision should be adjusted to reflect the loss of options it entails.

In terms of the application of these ideas it should be clear that they are not only useful in evaluating a particular investment but in comparing alternative investments or, more simply, alternative courses of action. Clearly, the characteristics of a given alternative in terms of its flexibility of timing, its degree of reversibility and its level of uncertainty will affect the option value associated with the decision to invest or not at the present time.

Both types of literature – the financial investment literature and the environmental economics literature on quasi-option value – emphasise the dynamic nature of uncertainty and information. For the purposes of valuation it is not simply the degree of uncertainty that is important but how it will change over time. Other things equal the more uncertainty associated with an alternative, the more it will pay to postpone the decision. However, if uncertainty is unlikely to be resolved over the relevant decision period then this will also affect the value of the option. In the case of a financial option one of the determinants of the value of the option is the expected volatility of the price of the underlying asset (such as a stock). If there will be no “news” that will affect the stock price during the option period then there is, implicitly, no expected volatility and the value of the option will be zero. Thus, if there is no additional information expected over the relevant period about the timing of the decision that will “reduce” the uncertainty then the value of postponing the decision over that period will be marginal. On the other hand, the theory suggests that where additional information will become available as to the profitability of the intended course of action, the most economically sound strategy may be to “wait and see.”

7.2 Relevance of the Theory to Dams

The fairly obvious first point to make regarding how relevant these ideas are to water resources and energy development is that dams, particularly large dams, are a case of an irreversible financial investment. Dixit and Pindyck (1994) indicate that investment expenditures are sunk costs – and hence irreversible – when they are firm or industry specific. In other words, once infrastructure is built it has little value for alternative uses or in terms of salvage value. Clearly, as physical structures and equipment, a large dam that cannot fulfil its purpose will have a very low salvage value. Further consideration is required in the case of dams that are multi-purpose or that have the potential for multi-purpose use. A hydroelectric reservoir built in an area with little to no irrigation potential could be said to be industry specific. However, in the case of a multi-purpose facility a fall in the price of agricultural prices leading to a decline in irrigation demand may lead to a switch in water use from irrigation to power generation. Thus, reversibility must be carefully interpreted with respect to the
financial investment in dams, but many dams will certainly have strong characteristics of irreversibility in this regard.

In addition to the dam itself, it should also be clear that there are a series of social and environmental impacts of dam construction that exhibit irreversibility. Certainly, the negative impacts of resettlement, flooding of reservoir land, biodiversity and upstream/downstream ecosystems will be regarded as having irreversible characteristics. Henry (1974) characterises an irreversible decision as one that “significantly reduces for a long time the variety of choices that would be possible in the future.” Whether the same statement can be made of the environmental and social benefits generated by dams requires further consideration. In many cases, it would appear that these (such as reservoir fisheries and spin-off social effects of regional development) would either disappear or be at risk were the dam removed. Yet, interestingly, if the dam is removed, many of the negative impacts will persist. Ecosystems are not easily or quickly regenerated, nor is social cohesion.

With regard to decommissioning it is also worth pointing out that the implications of the hysteresis argument. Once the irreversible decision is taken and investment made, the activity may have to fall to a lower than expected profitability before the investment is abandoned. Here again the option to exit carries with it an option value that reflects the benefit of waiting. In this case the option to “sell” is analogous to a put option in financial terms. Decommissioning of a dam is irreversible and as discussed in Chapter 2 is characterised by a high degree of uncertainty. The debate over the likelihood that the decommissioning of the Lower Snake dams (in the US) will bring back the salmon runs is indicative of this uncertainty. Thus, even if a dam is unprofitable the operator may wish to wait before exiting the activity as waiting may provide additional information that resolves uncertainty regarding the future profitability of the enterprise. In this case then, the option value provides an extra incentive (above and beyond the standard CBA result) not to exit the activity.

So the construction of a large dam may involve both a large financial investment and a significant divestiture of environmental and social assets. In terms of uncertainty, there are clearly uncertainties and risks associated with the financial investment as highlighted in previous sections of this paper, but it is probably fair to say that the uncertainties are significantly larger when it comes to the social and environmental divestiture. Thus, it is clear that the argument made by Dixit and Pindyck (1994) warrants further exploration in the case of dams.

7.3 Implications for Water and Energy Resources Development

The implications of this application of the theory of investment under uncertainty and irreversibility for water and energy resource development can be highlighted by briefly exploring a hypothetical example. The example is based on some stylised facts about two alternatives for power generation: a large hydroelectric reservoir that involves large social and environmental consequences and a combined cycle thermal power plant. The analysis consists of a qualitative exploration of how the two alternatives compare in terms of irreversibility, uncertainty and the timing of investment.

To motivate the example it is assumed that alternatives to supply future demand for electric power are limited to the hydropower and thermal power alternatives. Both involve a considerable irreversible investment of financial capital. The siting of the thermal plant involves a minimum of social irreversibility compared to the hydropower project as the latter leads to a significant resettlement program. Many of the previous hydropower plants in the country are beset by continuing conflict with social movements representing displaced communities. Thus, the outcome of the resettlement program is uncertain. The hydropower project will flood a large area of biodiverse forest, disrupt flows that are “used” by downstream wetlands and communities, and block of the river to upstream passage of migratory fish species. A fish ladder is included in the mitigation measures but its effectiveness is quite uncertain. The thermal plant as costed involved the latest emissions prevention technology, but will emit a large amount of carbon dioxide. For the time being it is assumed that the flooding of forest and subsequent net emissions of carbon dioxide and methane from the reservoir are
approximately equal in terms of their global warming potential to the emissions of carbon from the thermal plant.

Assuming a conventional cost-benefit analysis is carried out and the results favour the hydropower project by a relatively narrow margin, what does options theory suggest in rough qualitative terms? Recall that the theory suggests that the more the investment is irreversible or the more uncertainty associated with it, the more it will pay to postpone the decision. Of course if additional information is not likely to be forthcoming from one period to the next to “reduce” the uncertainty then the value of postponing the decision over that period will be marginal. Barring alternative uses for the dam, the effects of the capital investments more or less cancel out as they have the same characteristics in terms of timing and financial irreversibility. If the level of certainty over the accuracy of the predicted costs of the two projects is different – as suggested by the cost overrun data in Chapter 2 – then there may be a slight differential in option value for the hydropower versus the thermal power plant. This will depend on the extent to which the decision to postpone the hydropower investment will improve certainty over costs.

With regard to resettlement the hydropower project fares poorly, with the decision to build leading to a potentially irreversible situation complicated by uncertainties over the likely success of the resettlement effort. Loss of social cohesion, sense of place and community structure, amongst other social impacts, may be long-lived. The effects of emissions on global climate are the same under both alternatives so no advantage is gained in this regard. The WCD Thematic on Global Change and Dams suggests, however, that scientific uncertainty over the amount of net emissions from hydropower is much larger than for thermal power. This would imply a higher option value for hydropower; implying an increased value for postponing investment and, thus, favour thermal power in the comparison of alternatives. In terms of the evaluation of hydropower alone it also suggests that there is considerable value in resolving the uncertainty. Accelerated efforts to develop a sound information base on this issue would greatly assist in overcoming a “wait and see” attitude with regard to hydropower and climate change.

The fish, wetland and downstream effects on communities display varying degrees of irreversibility and uncertainty but they have no counterpart in the thermal project so they would count against the hydropower project in relative terms. Under this rather extreme scenario it appears that the difference in the option values would suggest that the hydropower plant faces an opportunity cost in terms of the benefits of waiting that are not faced by the thermal plant. As this effect works counter to the result obtained by conventional CBA, i.e. that the hydropower plant is preferred, then caution should be exercised in taking the CBA results as indicative that this project should go forward in place of the thermal plant.

A couple of quick modifications of the scenario above drive the potential use of this method home even further. It is well known that one of the advantages of new thermal power technologies is their flexibility in terms of size. Thus, if instead of comparing a lumpy investment in combined cycle technology the scenario were changed to reflect the possibility of making a series of smaller investments over time, it can be seen that this approach yields the intuitive result. Flexibility in design – or lack of irreversibility – is not as much of an option for hydropower as it is for thermal. Still, the phasing of installation of turbines and powerhouses is often a characteristic of large hydropower dams. Four of the six large dams covered in the WCD Case studies opted for a phased design (e.g. Tucurui, Grand Coulee, Tarbela and Kariba). This points to the importance of considering the scale and phasing of investment as an element of irreversibility. Again, if one alternative is much more inflexible than the other standard CBA results might lead to poor project selection.

The reversibility of the effect of emissions from hydropower and thermal power alternatives requires further thought. It appears that as emissions are a continual process they may not actually be an “investment” per se, yet, in the case of greenhouse gases their contribution to climate change persists over time, thus they are irreversible in this sense. Still, in the case of scrapping of the thermal plant the physical emissions would stop, however, in the case of the dam this may not be the case as the

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission
reservoir may be maintained following decommissioning of the power plant or the process of rapid liberalisation of carbon from dead biomass may continue following the draining of the reservoir. Again, other things equal, such considerations may tilt the option value in favour of thermal power.

In this fashion the use of a qualitative comparison of these option values for different alternatives for water and resource development could be a useful input into the assessment process. Ideally, this would take place early in the assessment of alternatives as a means of identifying the principle irreversibilities and uncertainties of the options under consideration. As selected projects proceed through to feasibility and appraisal the possibility exists of expanding and deepening the qualitative analysis. Quantitative methods for looking at these option values do exist. These consist of dynamic programming approaches or a contingent claims approach in which the methods developed for valuing financial options are applied. A growing literature on the latter – the valuation of “real: options – exists. Indeed it is notable that the literature, both qualitative and quantitative, includes a number of innovative applications to the fields of energy, climate and forestry fields. However, no significant mention of the application of these ideas to dams appears in the literature reviewed for this paper.

### 7.4 Findings and Recommendations

The application of the theory of investment under uncertainty and irreversibility to dams, and to water resources development more generally is novel at this stage. Further investigation is needed to determine the applicability of these ideas to the project planning and evaluation process. Still, it seems likely that at least the insertion of a qualitative discussion and analysis of different alternatives in this regard may be useful at an early stage in the screening and ranking of projects. Indeed, it is possible to argue that stakeholder discussion of different scenarios for water and energy resources development should include these issues in an explicit fashion, given that they may have significant bearing on the CBA outcomes.

In terms of specific areas for further investigation, it would be worth considering the extent to which, in practice, the passage of time is likely to significantly reduce the uncertainty about future values of the irreversible investments and divestitures associated with different options, particularly the environmental and social impacts. Attention should examine how the costs and benefits of investments may differ in terms of irreversibility, uncertainty and timing. The objective here would be to see if the different components of the alternatives under consideration are likely to have the same characteristics in this regard and, thus, can be bypassed or whether important differences between alternatives are expected and should be accounted for in the decision process.

Pending efforts to apply the quantitative methods available to dams and their alternatives, this remains an area for ongoing strategic thinking and research, particularly given that there is an emerging literature pointing the way.
8. Regional and Macroeconomic Impacts

A broad range of economic impacts can occur as a result of a large dam project. Regional and macroeconomic impacts refer to the effects of a project that result because of linkages among the various markets and sectors making up an economy. The introduction of a dam into an economy leads to a shift in the supply of water and energy services. This may in turn lead to changes in demand and prices for those goods (e.g. electricity or irrigation water), which will have repercussions in related markets (e.g. industrial production, agricultural inputs and outputs, and agricultural processing). Whether these effects will be significant enough to alter macroeconomic conditions and performance is determined by numerous factors, such as the overall size of the country’s economy, the mode of financing (private, public or mixed) involved, and the overall magnitude of the project relative to the economy as a whole.

In the past, decision-making for dam projects has been criticised for incorporating little or no explicit understanding of potential macroeconomic effects. Cost-benefit analysis has a singular focus on the supply and demand relationships in input or output markets directly affected by the project. For the purposes of estimating the welfare changes produced by a new project this approach is sufficient given certain standard assumptions, particularly that resources are fully employed. Where such standard assumptions are not valid, the net benefits of the project may not be fully captured by CBA. However, even where such assumptions are valid, regional and macroeconomic impacts will still occur. The question explored in this section is when do these impacts matter and how should they be measured.

The chapter begins by laying out the content of economic impact analysis, per se, and then moves on to a consideration of actual practice and guidelines in the planning and evaluation of dam projects. Review of the performance of actual practice and dam projects suggests instances where evaluation of regional and macroeconomic impacts is of importance. A description of the analytical tools economists apply in assessing secondary market effects is then presented, followed by a discussion of their comparative advantages. Findings and recommendations bring the chapter to a close.

8.1 Economic Impact Analysis

Whereas cost-benefit analysis is concerned exclusively with comparisons of benefits and costs to society created by a dam, economic impact analysis examines the distribution of the full range of economic impacts and outcomes that may occur as the result of a project, policy or other intervention. Major categories of potential economic impacts of dam projects are described below:

- **Changes in economic growth and productivity:** Negative impacts on regional or national productivity and economic growth can result if investment in a dam project creates significant opportunity costs, such as "crowding out" of investments at a reasonable cost of capital. Alternatively, dam outputs may improve the overall productivity of capital.

- **Price impacts:** Dam projects may create a significant supply of outputs that may in turn stimulate shifts in supply or demand for related goods. During the operational life of a dam, for example, irrigation water supplied by the dam may affect markets and prices for substitutes (e.g., water conservation equipment) and complements (e.g., equipment for higher-value irrigated row crops).
Table 8.1. Conducting Economic Impact Analysis of Dams: Examples of Economic Impacts

<table>
<thead>
<tr>
<th>Category of Economic Impact</th>
<th>Typical Groups Considered</th>
<th>Key Questions Addressed</th>
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| Changes in Economic Growth and Productivity | • Industry sectors (e.g., agriculture, manufacturing)  
• Consumers  
• Labour  
• Government agencies | • Do dam inputs and/or outputs create shifts in productivity in various sectors?  
• Does the dam create changes in aggregate output at the regional or national level relative to the baseline?  
• If so, by how much do economic growth and productivity change?  
• Within the most affected sectors, what are shifts in factors of production? |
| Price Impacts | • Consumers  
• Producers  
• Upstream and downstream industries | • Which markets for goods or services are affected?  
• What is the magnitude of price changes in these markets?  
• How do these impacts make specific groups of consumers and/or producers better (or worse) off?  
• How are markets for substitutes and complements affected? |
| Production and Employment Impacts | • Industry and employment sectors  
• Labour  
• Government agencies | • Which industry sectors experience improved outlook for business? Which sectors experience decline?  
• What are the implications of production changes for labour markets and wages?  
• What groups of labour will be affected most (e.g., seasonal workers)? |
| Changes in Government Revenues and Expenditures | • Government agencies  
• Taxpayers  
• Creditors  
• Other sectors dependent on government (e.g., subsidised agriculture, public education) | • Is the dam project financed with public funds?  
• If so, how significant a component of overall government borrowing does it represent?  
• How will the project's impacts on economic growth affect tax revenues and groups dependent on revenues? |
| International Trade and Competitiveness Impacts and Regional Balance | • Labour  
• Exporting industries  
• Consumers  
• Government agencies  
• Creditors  
• International development agencies | • How do other impacts affect exchange rates (demand for currency), export demand, trade balances?  
• What groups are most reliant upon the export sector?  
• How does project alter strategic balance between regions? |

- **Production and employment impacts:** When dam construction requires significant capital, workers, and construction materials, this may create shortages in related markets for labour and other factors of production (i.e., land, capital). Involuntary resettlement of groups, on the other hand, may induce abandonment of farms and small business closures, thereby creating regional unemployment.

- **Changes in government revenues and expenditures:** If a dam is financed with public funds, this may require large fiscal outlays by the host government that may in turn have repercussions on the money supply, inflation, and government indebtedness. Conversely, a dam located in a depressed area may boost regional economies (through household and business incomes) and generate higher tax revenues for the government.
International trade and competitiveness impacts: If a dam project is large enough to increase productivity and lower the cost of production at a national level, a country's exchange rate, export outlook, balance of payments, and international competitiveness may improve.

Regional balance: A dam may alter the balance between regions in both a strategic sense, and an economic sense as it may alter trade patterns, competitiveness and the terms of trade between regions.

Table 8.1 displays these major categories of impacts, the groups that would typically experience them and key questions and issues addressed through the analysis of these impacts.

8.2 Actual Practice and Guidelines

Project assessments and appraisals conducted by consultants working in developing countries do not typically include detailed modelling of the regional and macroeconomic impacts of dams. Often, the funding agencies will themselves often perform some form of qualitative macroeconomic impact. The effect of crowding out of government spending on other infrastructure and social programs is often ignored. None of the appraisals for the WCD Case Study dams contained any formal evaluation of regional or macroeconomic impacts. In the WCD review of World Bank and Asian Development Bank appraisal reports of dam projects, no affordability analysis from the perspective of the borrowing country was found beyond the presentation of key macroeconomic and fiscal data. The exception is Ghazi-Barotha in Pakistan (World Bank SAR 1995) where the impact of the project on the fiscal and balance-of-payments position of the country was extensively analysed (see Box 8.1).

That these models are not presented in the appraisal documents does not imply that they are absent in the larger sense. In particular, in the case of irrigation and multi-purpose projects that form part of larger water resources planning efforts such models may have been part of larger planning exercises in project identification and selection processes. For example, a major regional planning study for North China funded by UNDP developed a macro-economic water planning model which took into consideration the benefits of conflicting demands on limited water resources, and balance economic, environmental and social considerations (Research Center of North China Water Resources 1994). This approach which utilised comprehensive input-output relationships linking the macro-economy to water resources planning, was subsequently applied at the regional level in North Xinjiang where it provided an important basis for project selection and design, notably relating to an inter-basin transfer sought from the Ertix river (Research Center of North China Water Resources 1995).

An additional set of models that are used in the planning process are not purely macroeconomic models but are rather studies that employ economic optimisation and mathematical simulations. The World Bank has funded a series of such studies in member countries to provide analytical backing at a regional level for scheduling irrigation and related projects and programmes. The first major study was undertaken in the early 1980s for the Indus Basin in Pakistan, being related to programs to exploit the irrigation and energy potential of Tarbela dam. The modelling capability was subsequently applied to the evaluation of the then-proposed Kalabagh project. A further study was undertaken for the Nile basin in Egypt, which led to an understanding of the impact of the High Aswan Dam on the opportunity cost of water at different points in the system. Most recently the Yellow River Basin Investment Planning Study in China established transparent links between the simulation of the hydrological system and optimisation techniques for irrigation development at a sub-regional level. Again opportunity costs for water at different points in the basin were calculated and the modelling capability was used in assessing the economic justification of the Xiaolangdi dam and, subsequently also that of the Wanjiaxhai inter-basin transfer to the Fen river basin in Shansi province.
Box 8.1. Macroeconomic Analysis and the Ghazi-Barotha Project Appraisal

An assessment of the macroeconomic sustainability of Pakistan’s Ghazi-Barotha Hydropower Project (GBHP), which was approved by the World Bank in November 1995, involved a comparison of key macroeconomic projections for FY1995-210 resulting from the investment program of WAPDA (the electric utility) with and without GBHP, using data on investment costs, import requirements, and financing plan for the project. Macroeconomic and structural reforms were assumed to be slower than the proposed Government’s reform program. The expected total cost of the GBHP at appraisal was $2.25 billion spread over an 8-year implementation period. This represents between 0.3 and 1% of gross domestic product (GDP).

The analysis showed that: (1) the share of WAPDA’s investment program with GBHP in the Public Sector Development Program would not exceed historical levels even at the peak of project investments in FY 1998, and would decline significantly thereafter, as new thermal power plants are to be built by the power sector; (2) the budgetary public investment/GDP ratio would decline from 4.5% in FY 1995 to 4% by FY 2000 due mainly to the policy of no new public sector investments in thermal power plants; and (3) the external current account deficit is expected to worsen during project implementation but would improve over time in line with expected improvements in export and economic performance.

The project’s local currency requirements during the construction period and the debt service for the foreign loans were expected to be met from the cash flow of WAPDA. Hence, it was expected that there should be no direct impact on the Government of Pakistan’s finances and no direct crowding out of other priority public investment projects, including social projects. The World Bank Staff Appraisal Report (SAR) did note, however, that if budgetary resources would be required for project financing, there could be a reduction in the local counterpart funding of other high priority projects (which has been a cause of time overrun in previous World Bank-financed projects). This concern may have arisen because at the time of appraisal, co-financing from other sources ($900 million) was still indefinite. The remaining resources were to come from the World Bank ($350 million) and WAPDA ($1 billion).

There was further concern that if a significant deterioration in the macroeconomic performance were to occur in the medium term, the overall sustainability of the balance-of-payments could be further worsened by the project. A lower export growth, in particular, would lead to debt servicing difficulties and deterioration in creditworthiness over the medium-term. Finally, emphasis on macroeconomic analysis in the appraisal may have been related to the government’s decision to slow the pace of power sector reform program in 1996 which raised a number of uncertainties, and resulted in a sharp deterioration in Pakistan’s balance-of-payments position during the July-October 1995 period.

The SAR emphasized the need to closely monitor the consistency between the power sector investment program and the overall macroeconomic targets, as well as the adequacy of the funding of the Government of Pakistan’s Public Expenditure Program and the Social Action Program, subject to annual review with the World Bank.


While the focus in this section is on models used to analyse the wider economic impacts associated with a particular dam project – both prior to and during a project – there may be cases where linkages to such larger regional planning models can be productively employed to this end.

Multilateral Development Bank guidelines and policies consulted for this paper (primarily World Bank, Asian Development Bank and Inter-American Development Bank) did not explicitly mention the use of macroeconomic models to examine regional or national economic impacts. The World Bank Operational Policy 10.04 (September 1994) on “Economic Evaluation of Investment Operations” does not mention wider economic impacts and sets forth CBA measures of welfare for its decision-making criteria. The Bank’s Operational Manual Statement (May 1980) on “Economic Analysis of Projects” does discuss “multiplier effects,” indicating that multiplier effects related to
general excess capacity are not generally relevant to project analysis. This is the line of argument for excluding these impacts from CBA stated at the outset of this chapter.

In justifying this position, the Manual very clearly states that it does not consider that less developed countries find themselves in a situation of general excess capacity (i.e. underemployed resources). Still the Manual goes on to indicate that where specific excess capacities may exist, such as in particularly lines of agricultural or industrial activities then the effects of different patterns of second-round expenditures out of incomes generated by the projects should be allowed for in the estimation of efficiency (economic) prices. No methods for this purpose are suggested in the Manual, nor in the draft “Handbook on Economic Analysis of Investment Operations.” The latter document does not contain explicit reference to this issue, focussing exclusively on project-level impacts (Belli et al. 1998).

In developed countries analysts have tried to estimate in detail the regional economic impacts of capital-intensive projects. In the case of the US the objectives, procedures and methods are clearly laid out in the “Principles and Guidelines” (P&G) that guide the planning for Federal water resource projects in the United States (US Water Resources Council 1983). The P&G have an explicit account for regional impacts: the Regional Economic Development (RED) account. The RED accounts examine the distribution of regional economic activity resulting from a plan or project. Regional income and regional employment are the measures employed for RED. Note that the RED accounts are not necessarily required as part of the overall economic analysis and that they are explicitly excluded from the decision-making process itself. The RED accounts are excluded from decision-making as they do not reflect the criteria of economic efficiency, but instead deal with distributional effects (Simon 1999 eco053). An example of the impacts covered in a RED is provided below in Box 8.2.
Box 8.2. Regional Economic Development Accounts: Input-Output Models for the Snake River Dams, USA

Four projects to improve juvenile salmon migration are being considered in the Snake River: Alternative 1 (base case or existing condition), Alternative 2 (existing conditions with maximum transport), Alternative 3 (major system improvements), and Alternative 4 (natural river drawdown or dam breaching). A regional economic analysis was undertaken to assess the net regional economic impacts of changes in projected spending over a 100-year study period. The impacts were evaluated in terms of business sales (gross receipts), employment (full-time and part-time jobs), and income (wages, salaries, social insurance, and profit received by individuals) using input-output models.

The input-output models were constructed based on the 1994 IMpact analysis for PLANning (IMPLAN) computer system originally developed by the U.S. Forest Service. The regional models are based on technical coefficients from a national input-output model and localized estimates of total gross outputs by sector.

For the study, 8 input-output models were developed one for each of the affected states: Washington, Oregon, Idaho, and Montana; and one for each of the subregion areas: downstream, reservoir, upriver and the lower Snake river study area. The subregion models were developed to examine cases where impacts are relatively localized. The state models were used to evaluate impacts, such as increases in electricity rates that occur at a larger scale. In addition, a Fishery Economic Assessment Model (FEAM) based on IMPLAN technical coefficients was used to estimate the economic impacts of changes in anadromous fish harvests.

The input-output models assessed the direct, indirect, and induced regional economic effects of the alternatives by resource category, as follows: (i) power, (ii) recreation, (iii) commercial and ocean recreational fishing, (iv) transportation, (v) water supply, (vi) implementation expenditure effects, and (vii) avoided cost expenditure effects. The short-term and long-term effects on business sales, employment, and income, were then summarized at the state level and by subregion. In addition, the main component of the regional economic analysis is a qualitative discussion of potential impacts to regional industries that could not be addressed using the input-output methodology.


8.3 Historical Performance

Box 8.3 presents the example of the Nam Theun 2 hydropower project, which demonstrates the need for consideration of macroeconomic impacts in project development in the case of a small country seeking to earn export revenue from hydropower. This effect of the size of the project alone on macroeconomic performance is sufficient to diminish the credit standing of Lao PDR in international lending markets. While there are typically no formal studies of the effect that the failure to adequately assess macroeconomic impacts of such a project can have, there is typically tacit acknowledgement of the importance of these impacts in the descriptions of the macro setting in which such projects are developed.
Box 8.3. Potential Macroeconomic Impacts of the Nam Theun 2 Hydropower Project

Nam Theun 2 (NT2) is the largest hydropower project planned for Laos with the estimated costs of the project projected to exceed $1 billion. By comparison, in 1997 the Lao PDR’s national budget was $341.5 million and the country’s GDP was $1.7 billion. The World Bank’s 1997 Public Expenditure Review noted the potential macroeconomic impacts of the project:

“The dimension of NT2 is large relative to the size of the economy, with total costs representing over 70 percent of 1995 GDP. By virtue of its size, the project will affect Lao PDR’s credit standing and debt service burden. Despite Lao PDR’s impressive growth performance in recent years, the country’s weak economic position would not allow it to meet the contractual obligations of a counter-guarantee, should it be called in the case of default.”

The Executive Summary of the most recent independent economic impact study of the project, conducted by Louis Berger International, clarifies, however, that as the Lao PDR’s equity in the project is only $80 million (the remainder being private debt and equity which will be the liability of the Ownership Company: Nam Theun 2 Electricity Consortium) the macroeconomic risks need to be scaled down accordingly. The project is effectively an enclave project that will import most of its inputs and export its output: electricity. As a result, concludes Berger, Lao PDR government deficits will be only marginally larger with the project and risks thereof need to be weighed against potential cash inflows that will accrue to Lao PDR from sales of NT2 power to the Thai utility EGAT.

The most recent estimate from the developers of the project is that the project will generate $235 million in annual revenues from electricity sales, of which the government of Laos will receive approximately $30 million each year for the first five years. The share accruing to Lao PDR increases every five years to almost 50% – or $100 million per year – by year 15 of the project. While critics of the project argue that these inflows do not account for the macroeconomic costs associated with debt servicing and reduced credit standing, the Berger report finds that the current account deficit and the debt-service ration would remain within acceptable ranges even under the most pessimistic of scenarios for tariffs and hydrology.


The Nam Theun 2 case vividly illustrates the debate over the impacts that large dam projects can have on a region’s or nation’s economic conditions and performance. In the case of large dams a number of impacts that may occur as intended or unintended results of a project include:

- public investment in a large dam project may preclude, or “crowd out,” investments in other projects or programs, or otherwise affect a nation’s ability to issue debt;
- risk of foreign exchange liabilities incurred as a result of agreements entered into in terms of the repatriation of local currency derived revenues for dams financed by international private capital;
- direct and indirect effects may substantially affect a nation’s balanced of payment in terms of export revenues from power sales or import leakages from expenditures on fuel, equipment and technology stemming from the choice of hydro-based generation capacity versus other renewables or thermal;
- dam construction jobs and involuntary resettlement affect national and regional employment levels;
- flooding of agricultural areas as part of impoundment and/or increased supplies of irrigation water may result in large-scale changes in agricultural markets and thus related secondary markets;
- production of hydropower may lower household and industrial prices for electricity, leading to secondary effects in related markets;
• distribution of the wider economic impacts of the project on affected people or vulnerable income groups; or
• project objectives with regard to redistribution of regional income or regional development.

Clearly a large dam project may have a broad range of economic impacts on a region or nation. Whether these effects will be significant is determined by such factors as the country in which the project is located, the mode of financing (private, public or mixed), and the overall size of project (e.g., in terms of power produced, acres inundated, etc.). In particular, the scale of a dam (or its alternative) relative to the macroeconomy (e.g. a very large dam in a small country) will be an important indicator of the potential risk of the project in a macroeconomic sense (Sullivan 1999 env089). Meanwhile, certain project will have explicit objectives that relate not to economic efficiency but regional development or other distributional goals. As mentioned earlier CBA is not designed to evaluate macroeconomic performance. Traditional macroeconomic models, however, can provide useful insights into these distributional impacts (Sancho Marco 1999 ecoweb018).

While the examples above highlight the need for analysis where such analysis may not be found at present, there is also the case where analysis is undertaken but is a poor predictor of project impacts. Where projects have regional development as an objective or tout the regional economic impacts of projects as a justifying rationale for the project, there remain issues with respect to the adequacy of the methods employed to estimate these regional impacts. With reference to the US case, Hyde (in Zilberman 1994) states that many projects routinely overstate these multipliers because they do not take into account countervailing multipliers. The multipliers of a project are used without consideration of whether they pertain to previously employed resources. If these resources would have been used in the absence of a project, for example in another region, then the appropriate multiplier to use in association with the realised project would be the difference in the multipliers (i.e. between the with project multiplier and the without project multiplier). In this fashion Hyde (in Zilberman 1994) concludes that many studies of regional impacts in the US fail to apply the P&G for Federal water projects correctly. The P&G state that a complete set of regional accounts should include both the positive induced and indirect effects in one region and any negative effects occurring in other regions.

Here it is useful to observe that the point is not whether or not the multipliers occur and have large impacts in the regions in which the project is built. For the purposes of identifying the economic impact of the project in terms of its distribution of secondary benefits to the project region the multipliers are not necessarily invalid. What Hyde is referring is the implicit tendency of project promoters to trumpet the success of regional impacts of a project, to ignore the fact that these are merely gross, not net secondary impacts of the project. Further, these multipliers are not welfare measures and, thus, their use as an indication of the welfare change induced by a project is a spurious argument.

Still, as noted earlier where standard assumptions regarding full employment of resources are violated in a specific industry segment the secondary effects may be admissible as welfare indicators. In this regard, projects that have regional development goals in rural areas of developing countries where underemployment may exist may wish to consider the wider economic impacts of the projects. Of course, as the objective of the project – i.e. regional development – has an inherent distributional objective models for the evaluation of regional impacts should be considered as a tool in project planning, monitoring and evaluation in any event.

## 8.4 Good Practice Toolchest

Several analytical economic tools are available to assess "ripple" (secondary and tertiary market) effects on the economy of the region or nation. These tools, known as "general equilibrium" models, attempt to capture the interactions of a project's direct and indirect impacts throughout the economy. Three general equilibrium approaches for assessing macroeconomic effects include:

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This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
Input-Output (I-O) Models. These models characterise the interdependence of sectors within an economy by generating figures on multipliers and leakages. Multipliers show that the contribution of a particular sector to the regional/national economy is larger than the value associated solely with that sector's output. Leakages indicate where economic impacts, such as project revenues, move (“leak”) from one region or economy to another. Box 8.2 contains an example of the I-O model used in the Snake River study.

Social Accounting Matrices (SAMs). SAMs use a matrix presentation to represent the flow of funds and the linkages of demand, production and income within a national or regional economy. SAMs can be designed with a special emphasis on social rather than economic entities (e.g. low-income households) and, thereby, also provide information about equity and distributional concerns (whilst taking into account the interdependence of a large number of economic variables). An example of a SAM from South Africa is provided in Box 8.4.

Computable General Equilibrium (CGE) Models. CGE models incorporate more realistic descriptions of consumer and producer behaviour than do I-O models and SAMs, by accounting for reactions to changes in market conditions (e.g. price). Yet, they usually ignore a detailed breakdown of industries, commodities and regions in order to achieve a feasible model solutions (by approximation).

In the discussion of the three relevant macroeconomic models and CBA, it might seem as if the analyst has a choice of completely different models, each with its individual advantages and disadvantages. However, these models are not independent, but are to a large extent an extension or variants of each other. The models are in some instances also linked in that the output of one model forms the input of the other. In order to ensure that the eventual results of the analysis would present the full economic impact of the project, these models should therefore be used in a complementary fashion where possible. A cost-benefit analysis is indispensable to such macroeconomic models as it will indicate the basic financial and economic parameters and viability of the project.

As all water projects do have an important social impact especially in developing regions a SAM will be the most appropriate model for analysing these impacts. It should also be noted that a SAM contains the input-output framework as a substantial part of the SAM model. As the SAM is a Table, models have to be constructed using economic data for calculating functional parameters. There are a number of mostly static models available for this purpose. To solve these models and to work with them, matrix inversions are necessary. By means of these models the SAM shows all the necessary repercussions on the economy not only the direct but also the indirect economic impacts.

However, all these macroeconomic models are built on data for a special point in time (e.g. year 1998). Therefore, these models are not capable of providing forecasts for economic development over a period. In order to obtain an idea of future developments a computable general equilibrium model must be employed. Although CGE models do also rely mainly on one point in time they do contain functions, such as production and consumption functions, that bridge the time gap. In reality these functions form only a substitute for the missing statistical time-series. An econometric model using time-series and built on a detailed framework such as a SAM is, however, nearly impossible to develop as most of the important statistics are normally unavailable.
Box 8.4. Good Practice: Social Accounting Matrix of Komati River Basin Development Project, Republic of South Africa

The Water Research Commission (WRC) of the Republic of South Africa constructed a SAM to quantify the socio-economic impact of the Komati River Basin Development Project (KRBDP) and to determine major impediments or opportunities for sustainable development.

**Method.** Three different regions were identified in the course of the project: Region 1: Komati River Basin – RSA; Region 2: Komati River Basin – Kingdom of Swaziland; and Region 3: The rest of RSA, the rest of the Kingdom of Swaziland, and the rest of the world.

The economic impact was quantified in terms of the following economic variables: Production/Output, Income/GDP, Factor payments (capital and labour), Income distribution (individuals), Industry Impact, and Regional Impact.

A cost-benefit analysis was performed. This database was then used to build the SAM and to compile an appropriate final demand matrix (shock the SAM system). Additional information were obtained from Household surveys, the national Input-Output Table and the national SAM, national, regional and local government budgets and reports of the South African Reserve Bank, the Development Bank of Southern Africa and Statistics South Africa. The SAM for the Komati consists of more than 300 rows and columns.

**Results.** The project has an annual impact on the GDP of the area of $96 million which is approximately a 14% increase relative to the base year. The agricultural sector together with the agricultural processing developments in both regions experience even larger expansions. In the case of the Swaziland region, a near doubling (± 79%) of agricultural activities occurs. Due to the low base as well as the limited industrialized structure of the two regional economies, the huge upturn in agricultural and related production does not really filter through to other sectors and commodities. The Study shows that small commercial enterprises would benefit the most from the project. Even the large commercial enterprises benefit handsomely, throughout the regions’ economies. From a socio-economic point of view, the substantial increase in the number of small enterprises in agriculture will do much to promote a sustained process of development affecting a wide range of interest groups such as informal/formal trade businesses and traditional financial and business services.

<table>
<thead>
<tr>
<th>Impact of project Value</th>
<th>Percent Distribution</th>
<th>Percent Impact (1993 as base year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High income groups 22,867</td>
<td>35.4 %</td>
<td>11 %</td>
</tr>
<tr>
<td>Medium income groups 32,508</td>
<td>50.3 %</td>
<td>23 %</td>
</tr>
<tr>
<td>Low income groups 9,259</td>
<td>14.3 %</td>
<td>21 %</td>
</tr>
<tr>
<td>TOTAL 64,634</td>
<td>100.0 %</td>
<td>16 %</td>
</tr>
</tbody>
</table>

The study indicates that the medium and low income groups, benefit much more than the high income group. This in turn revolves around the exceptionally rapid growth of the medium income group of commercial farmers being specifically targeted by the project from a development point of view. The upliftment of the lesser-developed part of each sub-region via this process can therefore be regarded as successful.

**Cost.** To construct the SAM and perform the macroeconomic analysis costs $120,000 (on a $470 million project) and required specialised knowledge in national accounts and computer software.

Source: David Mullins, Conningarth Consultants

Ideally then, in order to analyse the economic impacts of a project the following methodological sequence would be followed:

1. Undertake discounted cash flow (DCF) and cost-benefit analysis (CBA) to establish the financial and economical feasibility and sustainability of the relevant project.
2. Then, set up a SAM with an input-output that is as strong as statistically possible.
3. Develop a CGE model that contains functions that develop forecasts over time and relevant responses in prices.
4. Where possible obtain econometric functions to improve the quality of the CGE results.

If all four steps are completed a state of the art model will be obtained that represents the best that can be done at present to ensure that the investment in a specific dam will become an economic success. Still, these models are expertise and data intensive and require up-front investment, with the costs increasing as the sophistication increases. As shown in the example from South Africa the SAM for the Komati Basin project cost just 0.03% of the capital cost of the project. In absolute terms the $120,000 is not overly expensive given that it provides an important tool for assessing the project relative to its objectives. It must also be remembered that in the process of developing such models, a wealth of information and data about the region and its economy is gathered. In the case of the Komati Basin project much of this information was previously unknown and is now available for future applications in the monitoring and evaluation of the project and to other applications in the region.

The models presented above are well-established methods for the analysis of general equilibrium impacts of projects. This is not to imply that these are the only methods available. Wilks (1999 ecoweb009) notes that dynamic scenario simulation approaches (such as GREENSTAMP developed by the European Union) are an alternative method for portraying likely changes in economic, technical, social structures over time. The advantage of this family of models is that they are a learning tool rather than expert systems that rely heavily on data inputs (Wilks 1999 ecoweb 1999).

8.5 Comparative Analysis of Available Methods

The desirability of using the traditional macroeconomic models to examine the macroeconomic impacts of a dam project will vary with the type of project and the relevant information needs. Where projects have important distributional and macroeconomic objectives that extend beyond the output markets affected by the project then such modelling is one way to determine the likelihood that the project will achieve such objectives.

While information on the distribution of macroeconomic impacts may be useful in decision-making, it must be recognised that in theory the measurement of direct impacts will capture the relevant changes in economic welfare induced by a project. However, the nature of the assumptions that underpin this proposition must be critically assessed, particularly where project objectives (such as to decrease unemployment) bear directly on these assumptions (e.g. full employment).

In the context of options assessment it is also worth noting that what is needed is an assessment of how the macroeconomic impacts of one option trade-off against those of another option (vis-à-vis specific objectives of a project or welfare impacts). In other words, for the distributional analysis of project economic impacts it is the net macroeconomic impact that is required for project screening and selection. If the options being evaluated have roughly similar effects, then the impacts may simply be assumed to be approximately equal, and effort devoted to elaborating the direct impacts of the project. However, where options that are being compared may differ significantly in terms of their achievement of macroeconomic objectives then assessment of these effects may be a higher priority.

A sensible scoping strategy for the economic analysis as a whole at initiation of the option assessment process should therefore consider the potential nature and magnitude of all economic impacts and not just the direct impacts. This consideration should take explicit account of the project objectives and the economic conditions of potential project areas (in terms of whether resources are fully employed or not).

In this regard, it will clearly be difficult to construct traditional models at the options assessment stage, when projects are still being defined. More useful in this case, particularly where the options
assessment process is participatory, would be the use of dynamic scenario models that allow users to experiment with the effect of different assumptions, parameters and interventions on future outcomes. Such models might be a useful complement to the qualitative approaches to potential macroeconomic impacts currently employed in sector documents (and even appraisal documents). In many cases, linkages among the sectors directly affected by large projects like NT2 and other sectors more indirectly affected can make a significant difference to the overall policy implications of a dam project. At the options stage scenario analysis may be sufficient to indicate the direction and rough order of magnitude of sectoral impacts.

As project screening and feasibility analysis proceeds, traditional models with their more rigorous and empirical approach would be preferred in order to improve the reliability and depth of information available for decision-making. At some point in the process it may even be valuable to cross-link different methods. For example, simple regional input-output models might be integrated within dynamic simulation frameworks as a means of tracing through the significance of major alternatives of water use (O’Connor 1999 ecoweb014). It is also worth emphasising the need for some flexibility of approach. In cases where dam projects are expected to create wide-ranging impacts, a social accounting matrix or I-O model could be developed as an intermediate step; if results suggest that multiplier effects are significant, a full general equilibrium model could be implemented later in time using data that support the SAM.

Similarly, the construction and use of models such as SAMs may be undertaken in a step-wise fashion in terms of the reliability of their results. While the model should ideally be fully defined at inception, further refinement and reliability of results may be achieved through incremental investment in the data collection and analysis that underpins the model. For example the inclusion of demand and utility functions from different production or consumption sectors will improve these models (Sancho Marco 1999 ecoweb018)

In all cases, decision-makers must weigh the costs of incomplete understanding of the full range of macroeconomic consequences against the investment required to implement a general equilibrium approach. In this regard it should be stated that even simple, non-data intensive models will require necessary expertise and participation, with consequent budget implications.

8.6 Findings and Recommendations

The discussion above highlights that analysis of regional and macroeconomic impacts should be undertaken in the following instances:

- when standard assumptions of full employment of resources are not fulfilled;
- when there is risk that secondary market effects may have important negative consequences for the macroeconomy or vulnerable groups and, hence, have implications for macroeconomic policy and poverty alleviation;
- when projects have explicit macroeconomic goals, such as the earning of foreign exchange from hydropower exports; or
- when projects have explicit distributional goals, such as the stimulation of regional economic development.

Based on the analysis of these findings the use of appropriate macroeconomic models can be highly recommended as an appropriate methodological option in the following particular cases:

- the analysis of the distributional impacts of a project where negative economic impacts may affect vulnerable socio-economic or cultural groups, but only when they are integrated in the monetary economy and
- establishing the affordability and risk of a large project to a small country.
The chapter yields the following findings on methodologies for the assessment of regional and macroeconomic impacts:

- three methods exist for quantitative analysis of macroeconomic and regional impacts: input-output models, social accounting matrices, and computably general equilibrium models
- the three methods identified are interrelated with each building on the previous model as the complexity of the model increases, and all three depend on direct cost-benefit data on the project
- a shortcoming of both I-O models and SAMs is that they provide only a "snapshot" view of the economy for the time period that data were gathered and the model constructed.
- constructing macroeconomic models is time-consuming and data intensive, and will involve additional expenditure beyond preparation of a CBA (though inexpensive relative to project costs), but they are the only way to comprehensively address the secondary economic impacts of projects.
- of the three approaches, CGE models have the largest data needs, requiring information on national accounts, trade, employment and other factors, specifically if they are based on the appropriate and detailed breakdown of industries, commodities and regions.

Once the decision is taken to proceed with a macroeconomic model it is necessary to both choose the type of model and determine the degree of investment in the model itself (in terms of definition of the complexity of the model and the data collection required). The discussion above highlights the practicability of Social Accounting Matrices for the analysis of projects with regional development objectives. Other objectives may require other types of models. In all cases, the utility and reliability of the model should be considered with respect to its purpose and not just in terms of the appropriateness of the model for the purpose at hand, but considering its utility for future applications and the knowledge base it generates. These benefits must be traded off against the availability of suitably skilled expertise, the availability of data (and hence its cost of collection), and the overall cost of the exercise.
9. Distributional Analysis

The importance of equity and distributional issues to the dams debate is recounted in the WCD Thematic Review on Social Impacts: Equity and Distributional Issues (Adams 2000). Consideration of the equity and distributional impacts of dam projects should, therefore, logically play a much more prominent and explicit role in decision-making (Klassen 1999 ecoweb002). Unfortunately, neither cost-benefit analysis nor least cost analysis or multi-criteria analysis have the explicit objective of providing decision-makers with information about how different groups fare as a result of projects. This chapter, then, discusses the ways in which such information may be generated and presented to stakeholders and decision-makers.

Typical equity issues that concern decision-makers and society at large are unequal distributions of dam project impacts across the following: (1) income groups and socio-economic classes, (2) time (i.e. between current and future generations of affected groups), and (3) geographic regions. There are numerous other ways of thinking about and describing equity that are equally valid for various types of project (e.g. the relative political influence of affected groups). The diversity of cultural, societal and ethical opinions that make up the debate over the equity of dam projects suggest that it will be difficult to systematically evaluate whether or not the distribution of project outcomes is fair and/or just.

In cases where losses experienced by affected groups appear to be profound, distributional concerns may override the economic efficiency and financial viability results of project assessment. However, it should be emphasised that the purely analytical act of undertaking a distributional analysis should be kept separate from the normative political act of defining the equity objectives of a project (Sancho Marco 1999 ecoweb018). Mixing of the two may lead to a preoccupation with methodological issues at the cost of consideration of equity issues that many feel underlie the dams debate as a whole (Wilks 1999 ecoweb009).

Distributional analysis aims to provide information on how the effects of an activity (be it a development project, a public policy or time) would impact different groups of the society. Note that there could be many different type of effects, how to assess them, and also many ways of dividing society in different groups e.g.: (a) effects that can be priced and therefore assessed as monetary costs and benefits, (b) effects that can be partially priced like environmental impacts, (c) effects that can not be priced but yet can be assessed as a gain or a loss like empowerment changes, and (d) effects for which even the direction of the impact is contestable, for example whether modernisation of traditional societies is a gain or a loss. Likewise there are many ways to group the society, or a smaller set of stakeholders (by income, location, gender, race, economic activity, etc.).

In any event it is likely that information about the distributional consequences of dams should, at minimum, include the information provided by traditional economic tools. Where possible other impacts, whether in economic or non-economic terms, also must be specified to provide a full picture of the distributional impacts of a dam project. Thus, this chapter discusses both quantitative and qualitative approaches to distributional analysis.

9.1 Distributional Impacts and Concerns of Dam Projects

The wealth of a nation is highly dependent on the way it uses and distributes its resources, and dams are a means of transforming a nation’s endowment of these resources – human, technological, natural, physical, financial and cultural capital – into tangible products and services that respond to the needs of its citizens. Because a nation is not homogenous, different groups within society will have differing endowments of man-made capital and differing rights and responsibilities with regard to other members of society and with respect to natural resources and the environment. The construction of a dam requires an investment of man-made capital and, as a result, generates a series of benefits that are then distributed – either through political-administrative means or through markets – to
members of society. At the same time, the construction of a large dam will have profound effects (both positive and negative) on the natural and social landscape of the setting in which the dam is located. These changes will affect the de facto entitlements to natural resources and cultural stability and cohesion previously experienced by local communities and resource owners.

In cases where there has been a lack of social acceptance of large dams this is often caused by failures in process and outcomes that relate to the transformation process as characterised above. At one level, the process of investment in, and distribution of, project benefits is criticised. For example, stakeholder meetings for a number of the WCD Case Studies (e.g. Kariba and Tucurui) demonstrated that there is considerable consensus amongst stakeholders that the benefits of these projects have not been distributed in an equitable manner. However, many dam projects have also failed to acknowledge pre-existing rights and claims of local communities with respect to cultural and natural capital that are to be affected by dams. The result has been the perception on the part of some groups that not only have they not received (a fair share) of the direct project benefits but that installation of the dam has caused them to lose endowments and entitlements that they once enjoyed. In a sense then, rather than investing in the dam these groups have been de-vested by the dam, without garnering a corresponding portion of the benefits generated by the project.

The case studies commissioned by the WCD give a qualitative overview of the distributional impacts of eight large dams around the world. Together with an analysis of five World Bank dam projects as included in Technical Annex 10 this limited sample provides an indicative list of the potential distribution of the economic impacts of dams:

- benefits accrue to the intermediate and final users of the dam services: power, water, flood protection, tourism and recreation;
- the country taxpayers may shoulder a good portion of the investment and operation costs, to the extent that prices charged for the dam-related services fail to pay back investment and operation costs. This is usually the case for most dam services to the exception of power. These costs tend to be high, but since the group – country taxpayers – is large, per capita costs are usually very small;
- to the extent that some of these dams were financed with international concessional lending (such as IDA loans) part of the costs have been also supported by donor countries’ taxpayers;
- displaced populations at the reservoir and people that are curtailed from their traditional access to natural resources elsewhere in the basin incur part of the dam indirect costs, to the extent that they are not properly compensated. These non-compensated costs can go from low to significant from the developer's perspective, but on a per capita base they tend to be substantial for the affected people;
- environmentalists, whether local, national or international, may endure costs arising from changes to the natural environment;
- other distributional effects, like health, gender or regional development are more case specific.

### 9.2 Historical Approaches and Actual Practice

In the 1960s, economic texts on project appraisal suggested a number of methods for incorporating distributional concerns into project appraisal, including the use of different weights (distributional weights) for the net benefits accruing to different income groups in the belief that projects that benefit low-income groups should be preferred. Note that this distribution exercise was proposed solely for the purpose of being fed back into the cost-benefit exercise (through a weighted addition).

The use of distributional weights was proposed (primarily by the World Bank) as a way of extending Economic CBA to a Social CBA that would explicitly incorporate equity concerns. For groups that experience project losses under a strict cost-benefit test, distributional weights were to be computed on the basis of estimated values of the marginal utility of consumption for these various groups, and

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assigned to cost-benefit outcomes in order to more heavily weight the costs and benefits accruing to their accounts. The use of distributional weights is, therefore, not so much a distributional analysis as a mechanism for ensuring that projects result in a progressive redistribution of the benefits of public projects.

A more neutral approach to selecting weighting criteria suggested was to multiply net benefits accruing to each income group by the ratio of the country average income to the groups’ average income. In this way the net benefits of a project that has a distribution equal to the current national income distribution, remain unchanged.

The distributional-weights approach was also subsequently dropped by the World Bank as it was considered that (1) weighting was a subjective judgement in conflict with the (so assumed) objective nature of the economic assessment, (2) the distributional consequences of a project could not be established with accuracy and (3) it was felt that other more efficient means of achieving distributional objectives were available (ADB 1997; Devarajan et al. 1996 in Weiss 2000). Related to the latter argument, a further criticism of the distributional-weights approach is that it implicitly sought to mix the methodological and normative aspects of the problem. As pointed out by Wilks (1999 ecoweb009) such a practice might override public discussions about entitlements, social exclusion and different views about development and, therefore, fail to do justice to complex social, historical and political debates.

Weiss (2000) reviews the history of these approaches to distributional analysis at international development agencies and concludes that historically the only effort at operationalising distributional analysis was the case of the Inter-American Development Bank, which developed a series of indicators for determining the impact of projects on poverty in the 1980s.

The WCD review of MDB appraisals shows that not only was the social weighting technique not applied but that no explicit analysis of distributional impacts is included in these appraisals. In addition, a distributional analysis was not conducted as part of project preparation for any of the WCD Case Study dams. In the last twenty years distributional analysis has been used more in the assessment of fiscal or price change assessment than in the assessment of development projects assessment (Weiss 2000). This is because census and survey information on family income and budgets, makes it very easy to track what would be the impact among different income groups of, say a change in taxes, expenditure on health or a change in the price of oil. Where distribution of project impacts are considered it has typically been that of the identification of a few large groups of potential beneficiaries, usually as part of the project preparation (because it helps sell the project).

### 9.3 Current Guidelines

Distributional analysis has recently come back to the assessment of international development projects as the result of two trends: (a) an increased focus on poverty (either as poverty reduction or eradication) and (b) a widening of the decision making process that now needs to take into consideration the interest of a larger group of stakeholders.

The Asian Development Bank, in its Guidelines for Economic Analysis published in 1997 recommends a distributional analysis as part of the economic analysis of projects. This analysis is a straightforward application of cost-benefit data (and presented later in this Chapter) as developed by UNIDO in the 1970s (Weiss 2000). Given the Bank’s policies on poverty, the Guidelines also demonstrate how a poverty dimension may be incorporated into this analysis by determining the net economic benefit accruing to poor households (below the poverty line) according to the proportion of each group that is poor; and calculating a poverty impact ratio by comparing the net economic benefits to the poor with the net economic benefits to the project as a whole.
The World Bank’s Operational Policy on Economic Evaluation of Investment Operations (OP 10.04, September 1994) clearly reflects the focus on poverty as it states that the economic analysis examines the project’s consistency with the Bank’s poverty reduction strategy. Other than that, distributional or equity impacts do not impinge on project acceptability in the OP. The Operational Manual Statement on Economic Analysis of Projects (No. 2.21, May 1980) still discusses the use of distributional weights. The new, yet still unapproved Handbook on Economic Analysis of Investment Operations recognises the importance of identifying those who gain and lose from a project, as well as the need for special attention to impacts on the “poor” or “very poor” (Belli et al. 1998). The Handbook provides a series of tables indicating the ways in which costs and benefits can be broken down and presented so as to indicate who gains and who loses from a project.

The multilateral development bank position can be compared with that of federal water resource projects in the United States where two types of accounts are listed as part of the planning process for water resources: the Regional Economic Development (RED) and Other Social Effects (OSE) accounts. The RED accounts examine the distribution of regional economic activity resulting from a plan or project. Regional income and regional employment are the measures employed for RED. The OSE accounts are defined as a means of displaying and integrating information not reflected in the other accounts (i.e. in NED, EQ and RED). The categories of effects included in OSE include urban and community impacts; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation (US Water Resources Council 1983). Neither the RED nor the OSE accounts is required as part of the decision process itself. Only the NED accounts (the CBA) is employed for this purpose. The RED is discussed and an example provided in the previous Chapter of this paper. An example of a social impact analysis is provided later in this Chapter in Box 9.1. These accounts do not explicitly define a “distributional analysis” although they may provide the space for such.

9.4 Good Practice Toolchest

As indicated above relatively less effort has gone into the application of distributional analysis as a methodology of project appraisal per se so that the methodological options that are available in good practice today are either offshoots of other forms of analysis or represent initial efforts to develop new approaches. As noted at the outset of the paper, from an economic perspective, distributional analysis may be interpreted in its broadest sense as the distribution of the impacts of a project, whether they are purely financial in nature or can be valued in economic terms is not material. What is relevant is that the impacts cause a change in welfare for the affected or interested party. For this reason, the good practice toolchest discusses qualitative as well as quantitative approaches.

Distributional analysis is increasingly viewed not as an add-on to a CBA but as an independent piece of information useful in the planning and design process. Therefore the need to weight and compare different distributions is left to the participants in the decision making process and the distributional analysis focuses simply on understanding the distribution of impacts per se. Also, the sense in which distributional analysis is a “summing up” exercise (and therefore applicable as a decision criterion as with CBA), and not a measurement technique itself, is reflected in the nature of the available approaches.

Following this logic, five approaches to distributional analysis can be identified moving from the most direct and “economic” approach to the broadest assessment:

- **Economic Distributional Analysis (EDA)** – i.e. the distribution of economic costs and benefits of a project as measured in DCF and CBA;
- **Economic Impact Analysis** – i.e. analysis of economic impacts of a project using a regional or macroeconomic model;
• **Environmental and Social Impact Assessment (EIA and SIA)** – these techniques can serve to identify project impacts that fall outside the scope of CBA and macroeconomic models, but that have important distributional consequences;

• **Equity (or Poverty) Assessment** – assessment of the impacts (in economic or non-economic terms) of projects on specific sub-populations/groups of concern; and

• **Distributional Analysis** – consideration of the full range of distributional impacts, regardless of whether they are financial, social, environmental or economic and whether they are assessed in a qualitative fashion, quantified in non-monetary terms, or valued in financial/economic terms.

The first two methods are purely concerned with the quantitative analysis of economic costs, benefits and impacts. EDA is the basic approach developed in the 1970s by UNIDO and currently being taken up by agencies such as the Asian Development Bank. Further examples of how this may be implemented in practice are provided in the next sub-section. The approach to distributional analysis using regional or macroeconomic models is already covered in Chapter 8 and, thus, is not repeated here.

The remaining methods are either qualitative in nature or serve to combine quantitative and qualitative information. At least in part this results from the emphasis in these methods on covering not just “economic” costs, benefits and impacts but more indirect social and environmental impacts which are more difficult to value in economic terms. EIA and SIA are not so much distributional analyses per se as a standard process in project appraisal that may be used to yield information on the distribution of project impacts. For more on the EIA and SIA process and methods, readers are referred to the WCD Thematic Review on this topic. For the purposes of illustration an example of a social impact assessment from the US is presented in Box 9.1. It is from the same Snake River Study as that used in the previous section on regional economic impacts so as to draw out the distinction between the two types of analysis as currently practised in the US.

Equity Assessments analyse the distribution of costs and benefits for specific sub-populations of concern. Examples of sub-populations that are often the focal point in dam decisions include: indigenous groups and other ethnic minorities, women and children, the rural poor, and small economic entities (e.g., small-scale agriculture). These groups are considered at higher risk of suffering disproportionate impacts because they exhibit one or more of the following:

• heightened vulnerability or physical proximity to adverse ecological impacts;
• politically disadvantaged, i.e., less able to represent their own interests; and
• economically disadvantaged.

To get a finer sense of impacts on disadvantaged groups, an equity assessment may draw on results of both cost-benefit analysis (i.e., social costs and benefits) and economic impact analysis, and then extend these by disaggregating results according to the sub-populations of interest. For example, decision-makers concerned with the long-term outlook for small business owners such as artisans would first define groups of artisans and then disaggregate and consider the net benefits experienced by these groups. Again, this is not so much a method as an approach. Any of the first three methods and approaches mentioned above may be used to identify the nature and magnitude of impacts on these groups. The actual assessment of the vulnerability to the risks engendered by a dam project can also be analysed through a social risk assessment as described in the WCD Thematic Review on Displacement, Relocation, Reparations and Development.

The final approach, Distributional Analysis is labelled as such as it is simply a holistic approach to summing up and presenting information that may be generated by one or all of the other methods. A Distributional Analysis may be used to systematise the presentation of information on the distribution of economic, environmental and social impacts of a project across the full range of project stakeholders. Since this may involve the presentation of information on impacts expressed in different units (or numeraires) the interpretation of such model does not lend itself to numerical,
expert-driven solutions. Rather it is a decision support tool that can inform decision-making, particularly where decision processes require a high level of transparency, consultation and/or involve a negotiated solution amongst affected and interested parties. Considerations in undertaking such a comprehensive approach, as well as a practical example from the experience of the WCD Case Studies are covered in a separate sub-section below.
Box 9.1. Actual Practice: Social Impact Analysis in the Lower Snake River, USA

Four projects to improve juvenile salmon migration are being considered in the Snake River: Alternative 1 (base case or existing condition), Alternative 2 (existing conditions with maximum transport), Alternative 3 (major system improvements), and Alternative 4 (natural river draw-down or dam breaching). A social impact analysis was undertaken to examine the range of potential social impacts that may occur as a result of implementing one of the 4 alternatives. The analysis attempts to outline the distributional and equity effects on specific communities within the broader regional context. The study has been designed to meet the requirements specified in the P&G for Federal water projects (US Water Resources Council, 1983).

Scope. The potentially affected lower Snake River region was divided into three subregions to explore the differential effects of the proposed alternatives: downstream, reservoir, and upstream. The study analysed the social impacts of the alternatives on 9 communities or case studies, taking into account the phases of project development. The communities were chosen to capture a range of direct positive and negative impacts across types of communities and the geographic scope of the study area. There are 3 distinct phases to the analysis with an overall study period of 20 years. The first phase includes the planning and decision-making period from the initiation of the feasibility study and environmental impact statement scoping to the final selection of the preferred alternative. The second phase includes the implementation phase. The third phase includes the post-implementation social effects.

Methodology. The following steps were taken to obtain reliable information on potential social impacts: (i) develop an understanding of the issues raised in the original scoping and the public information meetings conducted during the study, (ii) select key focus communities to capture the range of possible direct impacts, (iii) select appropriate indicators for the types of anticipated social impacts, (iv) describe the trends and history of the region and case study communities, and (v) develop estimates of potential impacts, the magnitude of these impacts, and the range of community responses using information various information, including secondary data analysis, key informant interviews, and a thorough literature review.

The key issues addressed include: (i) what the social impacts will be and when (timing), (ii) who will be affected, (iii) how they will be affected (beneficial/adverse), (iv) how much they will be affected, and (v) how the communities may respond. The analysis is supplemented by information obtained through a series of interactive community forums, which included each of the focus communities. The community forum information includes each community’s perceptions of its history, an assessment of its current situation, and a projection of potential social impacts under each of the proposed alternatives.

The significance of the impacts in the 9 focus communities was evaluated based on 42 indicators/impact measures classified into: (i) power, (ii) recreation, (iii) transportation, (iv) water supply, (v) implementation/avoided costs, (vi) anadromous fish recovery, and (vii) other social effects. For each of the indicators, relevant evaluation criteria such as increase in employment > 1%, or increase in highway safety, or loss of bridges within 50 miles, etc were applied.

Overall Results. The results show that changes in the physical, biological, and economic human environment would have both adverse and beneficial impacts on communities throughout the study region. Each of the alternatives would create winners and losers, both social and economically, within and between communities and the subregions.

Mitigation Analysis. The study identified compensation potential for those affected in consideration of the impacts on employment, net farm income, community-level impacts, and economic activities. Potential mitigation expenditures for 3,500 dislocated workers have been estimated in the range of $45.1 million and $48.1 million to address employment losses through job retraining, income support, and academic training. Potential mitigation for 82 affected communities has been estimated at between $4.3 million and $12.9 million, based on previous Federal and state mitigation expenditures used to address the impacts of free trade, old-growth forest conservation, and dislocated workers.

9.5 Economic Distributional Analysis (EDA)

While the above discussion underlines that there are many types of distributional analysis, and a comprehensive distributional analysis should be regarded as a multidisciplinary undertaking, the EDA approach involves distributional analysis of the financial plus the economic costs and benefits of a project. This reduced distributional analysis takes into account cost and benefits that can be expressed in monetary terms. There is a close conceptual relation between an economic distributional analysis (EDA), the discounted cash flow analysis (DCF), and the cost-benefit analysis (CBA) of a project as follows:

- the distribution of monetary costs and benefits across groups is similar to performing financial analysis from the perspective of each one of these groups; and
- when adding up the economic distribution through all participant groups, the initial overall project’s cost-benefit figures are obtained, since the only monetary costs and benefits that can be distributed are either true cost, true benefits, or transfer payments, and adding up all transfer payments will result in their cancellation (since by definition what is a transfer gain to one party must be a transfer loss to another).

Conceptually an EDA is a very simple exercise that goes as follows: (1) list the costs and benefits to be considered; (2) assess them in monetary terms; (3) list the groups among which costs and benefits would be distributed; and (4) use factual allocation criteria (or acceptable proxies) to allocate “2” among “3.” Moreover if the EDA follows the DCF and CBA of a project, the latter two will provide the information on costs and benefits, so that the EDA exercise would need to complete only steps “3” and “4.” The ADB Guidelines summarise the steps as follows:

- estimate the present value of net financial benefits by participating group;
- determine the distribution of the net economic benefit by group by adding the difference between net benefits by group at economic and financial prices;

A simple example of this sort as used in the ADB Guidelines is reproduced below in Table 9.1. The original table depicted net economic benefits. The table is slightly rearranged to present benefits and costs so that the derivation of net benefits would be more evident.

Column 1 presents the discounted cash flow (DCF) of the financial analysis from the point of view of the firm, in this case a telephone company selling services to final consumers. Column 2 presents the results of the CBA and Column 3 the difference between the CBA and the DCF. The project results in 250 units of benefits accruing to consumers (consumer surplus), 120 in country losses due to foreign currency overvaluation, and 10 less in labour economic costs, because labour opportunity costs are 10% lower than market wages. Columns 4, 5, 6 and 7 distribute these economic costs and benefits among producer, the government, labour and consumers.
Table 9.1. Asian Development Bank Example of Distributional Analysis

<table>
<thead>
<tr>
<th>Benefits and Costs</th>
<th>DCF of the producer (1)</th>
<th>CBA (2)</th>
<th>CBA - DCF (3)</th>
<th>Distributional Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Benefits</td>
<td></td>
<td></td>
<td></td>
<td>Producer (4)</td>
</tr>
<tr>
<td>Sales</td>
<td>700</td>
<td>700</td>
<td>0</td>
<td>700</td>
</tr>
<tr>
<td>Consumer Surplus</td>
<td>250</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imported</td>
<td>400</td>
<td>520</td>
<td>120</td>
<td>400</td>
</tr>
<tr>
<td>Installation</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Labor costs</td>
<td>100</td>
<td>90</td>
<td>-10</td>
<td>100</td>
</tr>
<tr>
<td>Other costs</td>
<td>200</td>
<td>200</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>Net benefits A-B==</td>
<td>-100</td>
<td>+40</td>
<td>140</td>
<td>-100</td>
</tr>
</tbody>
</table>

Source: Based on Asian Development Bank (1997)

Notes: *The gross benefits to consumers consists of the 700 in product plus the 250 in consumer surplus (i.e. total consumer willingness to pay for the product is 950 but they only had to pay 700 and market prices). All figures are present values in million of local currency.

Note that in the case of the firm its financial analysis is the same as its distributional analysis (columns 1 and 4). The government sells to the firm 400 of foreign currency, but since the real cost is 520, incurs a loss of 120 (column 5). Labourers receive 100 in salaries but since their opportunity cost is 90 they make a profit of 10. Consumers pay 700 for services that are worth 950 to them and so make a profit of 250. Note also that adding up the net benefits of all four groups returns the net project economic benefits of 40 units (Column 2).

If a consistent set of project cost and benefits is available, a simplified EDA can be easily performed and may be useful to inform a discussion on the projected distributional impacts of a project. Table 9.2 summarises one such exercise for Kedung Ombo dam in Indonesia (with cost and benefits expressed on an annuity base in 1995 million dollars). Since the exercise is based on secondary information the figures are not intended to be accurate nor complete, rather they are intended to give a good idea of what an EDA is about.

A similar but more detailed approach is used in Technical Annex 10 to perform an EDA of five dam projects that were included in the 1996 study by the Operations and Evaluation Department of the World Bank. The full sets of these provide a characterisation of patterns of economic distributional impacts that may arise in dam projects.
Financial, Economic and Distributional Analysis

Table 9.2. Simplified EDA matrix of Kedung Ombo dam, Indonesia (commissioned in 1993)

<table>
<thead>
<tr>
<th>Social Groups</th>
<th>(a) Power Benefits</th>
<th>(b) Irrig. Benefits</th>
<th>(c) Urban Water Benefits</th>
<th>(d) Flood Control Benefits</th>
<th>(e) Direct Invest. Costs</th>
<th>(f) Direct Operat. Costs</th>
<th>(g) Indirect Costs</th>
<th>(h) Resett. Costs</th>
<th>(i) Fish. and. Costs</th>
<th>Net Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All urban households + business</td>
<td>+3.9</td>
<td>+12.5 (P)</td>
<td></td>
<td>-12.4</td>
<td>-0.1</td>
<td></td>
<td></td>
<td>-12.4</td>
<td>-12.4 (EU)</td>
<td></td>
</tr>
<tr>
<td>2. All rural households + producers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Same as (2) in flood protect. areas</td>
<td>+8.4 (P)</td>
<td></td>
<td></td>
<td>-2.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Farmers in the area irrigated</td>
<td>+20.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Resettled population</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Population in the project area</td>
<td>(VP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Total</td>
<td>+3.9</td>
<td>+41.8 (P)</td>
<td></td>
<td>-15.2</td>
<td>-1.5</td>
<td>-10.1 (EU)</td>
<td>-10.1 (EU)</td>
<td>+18.9 (VP)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OED (1996)

Qualitative red flags: P: Positive, VP: Very Positive and EU: may be unacceptable on equity grounds

Notes: One characteristic of EDA matrices is that while costs and benefits are mutually exclusive (no double counting should be allowed) social groups usually overlap (e.g. here a person in the flood protected area is at the same time part of a rural household). In most cases this is overlapping will not affect the analysis, and it can be removed by a further breakdown of information

9.6 Overall Analysis of Distributional Impacts

As stated earlier a full distributional analysis will cover the full range of impacts, not just the distribution of measurable effects of direct welfare effects of a project. As this involves the collation of a range of qualitative and non-quantitative information, and information on impacts that may change over time, the full exposition and presentation of such an analysis can be a very involved undertaking. Below two approaches to this problem are presented. The first approach reflects a comprehensive methodology for working through a full distributional analysis, as developed by Kyra Naudascher-Jankowski as a contribution to the WCD process. The second approach reflects the much more abbreviated approach to distributional analysis as pioneered in the WCD Case Studies.

9.6.1 Naudascher-Jankowski Approach

The premise of the Naudascher-Jankowski approach is that, at a general level, the primary questions that distribution analysis of a dam project seeks to answer include the following:

- Which individuals, groups, and entities will be most (and least) affected by the project?
- What is the original endowment of groups affected by the dam project (i.e., how well does each affected group start off)?
- How well-positioned are affected groups to take advantage of gains from the dam project (or, conversely, to mitigate project costs)?
- What is the larger context in which groups are operating that also influences how well they fare (i.e., what is the baseline)?

This methodology provides a set of templates that can be used to organise and view qualitative and quantitative data describing distribution impacts in ways that help to answer these questions. For example, different templates can be used to organise data by the following variables of aggregation:
This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
different versions of the sheet for different audiences, such as a summary sheet for stakeholder presentation and discussion. Still, the availability of more comprehensive matrices would be important to underlie simplified versions. The set-up and interpretation of these tables is briefly summarised below.

The distributional matrix employs the attributes of project impacts as follows:

- **Columns.** The type of impacts are differentiated by columns with the left side of the table referring to gains under the project and the right side to costs under the project.
- **Rows.** The spatial distribution of the impact are differentiated in rows of the table.
- **Impacts.** The information on the impact is presented in detail in the text through prose, tables, graphs, maps, etc. (of an annex as suggested below) and summarised in the value attributed to the cell itself.
- **Other Information.** Additional information about the impact can be conveyed by an attribute of the cell on the sheet such as colour, shading or a comment (the latter is used in the Orange River matrix).

Room is made in the “extent” column to provide space for a quantitative indicator of the extent or size of the impact or affected population in non-monetary terms. This column may be useful in conveying changes over time through it being divided into a “then” and “now” sub-column (as in the Orange River matrix).

Transfers between government agencies may be noted as inflows and outflows on the sheet but that in the case of other stakeholders where gains and losses are related to the same impact category it is easier to understand the matrix if only the net gain or loss should be recorded on the sheet. The Orange River matrix contains a “compensation” category that is gain/loss neutral simply in order to record who received compensation without trying to specify whether it was on balance a gain or a loss. This, as compensation may be judged to be more or less appropriate. If compensation paid is widely acknowledged as insufficient or excessive this might be recorded as a gain or loss.

Cells of the matrix may contain whatever information is available from either analysis, discussions with stakeholders or other sources. Thus, matrix cells may contain the following indicators of impact:

- a mere indication that an impact exists (just a “XXX”, for example) as opposed to an indication that no impact occurred (just a blank cell),
- a relative indicator of importance or magnitude (High, Medium or Low or X vs. XXX)
- a quantitative indicator of importance (i.e. hectares affected, number of species lost, households affected)
- an estimate of the value of the impact (again, whether it is a financial or economic value would be conveyed by the cell attribute).

Distributional analyses will differ in terms of the types of impacts and the extent to which they can be described, quantified and valued. The emphasis of the analysis, however, may usefully be to feedback such information as can be gathered or collated rapidly to stakeholders and decision-makers in order to empower an informed discussion or negotiation. While it would be ideal to incorporate present values into the matrix where available, these may be easily misinterpreted or misunderstood and thus it might be preferable to include annual value figures insofar as monetary values are concerned. The drawback of this approach is that investment costs that occurred a long time ago are difficult to present in a meaningful annualised figure that is consistent and comparable with, say, annual gross value of agricultural production. In any case, the basic principle that applies is that whatever figures or ranking that is included in the table should be internally consistent and intelligible.

The revised categories used to arrange and group impacts into rows and columns in the matrix are covered in the next two subsections.
**Distributional Impacts (Columns of the Matrix)**

First of all the impacts are separated into gains (benefits) and losses (costs). This eliminates the need for plus and minus signs in the matrix cells as a way of indicating the direction of impact. It also enables a two page (or table) format, with the ability in presentation to juxtapose the benefits (on one side) with the costs (on the other side).

The benefits and costs are divided into those associated with changes in water land, vegetation and atmosphere that result from the project and those that relate to social benefits and indirect economic impacts derived from the project. In the case of the cost matrix it is also important to include direct costs of the project.

As a way of classifying benefits associated with water, land, vegetation and atmosphere the total economic value framework applied in natural resource and environmental economics is a useful one and is lightly adapted as follows

**Direct Use Values.** The installation of a dam alters water flows, as well as land and vegetation (in and near the reservoir) and in the process generates benefits in terms of hydropower, irrigation water, flood management, water supply, navigation, recreation, etc. vegetation. For example, by impounding water a dam increases water availability for irrigation during dry periods and creates a reservoir that can be used for recreation. As irrigated water is an input into the agricultural production process and as the reservoir is used by recreationalists, the dam can be said to have a direct use values, i.e. it produces goods and services that directly enter into production and consumption.

**Ecosystem Function and Biodiversity.** This includes both indirect use values and existence values. Indirect use values include the effects on environmental functions and biodiversity that result from dam construction and subsequent alterations to flows, land, vegetation and atmosphere. Environmental functions do not actually enter into production or consumption but rather serve to support economic production and consumption, entering into the economic system in only an indirect fashion. For example, changes in land use due to migration into the upper portions of a watershed following creation of a reservoir may increase the rate of sedimentation of the reservoir. The sedimentation may ultimately have an impact on water available for use in hydroelectric production, however the function itself does not enter into or pass through end use or factor input markets. In this case the dam has altered the indirect use value of hydrological function leading to eventual impacts on the economic system. Biodiversity impacts can be included here insofar as changes in biodiversity in turn affect ecosystem function and lead to economic impacts.

Existence, or non-use, values arise simply from existence of the good or service without any regard to actual or intended use of the resource by consumers or producers. For example, certain individuals or societal groups may be willing to devote a portion of their income to avoid the flooding of biodiverse forest area or an area with great cultural significance, without ever having had plans to actually go and visit the site for touristic purposes. The degree of uniqueness possessed by the area to be converted and the degree to which such change is irreversible will of course increase this existence value.

**Social Impacts.** Analysis of positive (such as the social dimension of increases in irrigated land, food production, employment opportunities, improvements in access to social services, improvements in nutritional and health status of the population) and negative (such as position of small and marginal farmers, land concentration, loss of access to common goods, traditional knowledge, social cohesion, cultural impacts, health impacts, etc.) social impacts should be documented here, trying to avoid any double-counting of benefits or costs already accounted for in previous columns. This analysis should be conducted primarily for the project area but should also include impacts at regional and national level (food production, food security, population's nutritional status change, poverty alleviation, etc.).

**Indirect Economic Costs and Benefits.** This category encompasses the knock-on economic effects that a project, particularly a large dam project, will have on related markets and services in the larger
economy. In particular, the prime concern in this case will be with the economic multipliers associated with introduction of a dam project. In the case of very large projects, the multiplier impacts may be quite important, simply because the size of the project is large in relation to the national economy. Still, the significance of these indirect impacts will also depend on the extent of leakage in the economy. If all the machinery employed in dam construction is imported and the net revenues from production accrue to international interests then the resulting multipliers will be limited in nature.

**Arrangement of Interested and Affected Groups (Rows in the Matrix)**

Clearly, there is no way to generalize about the types of settings that will be found in the case of a particular dam project and the decision on how to identify the relevant groups will be up to those involved in the process. The generic distributional matrix (Table 9.4) however tries to convey a number of general principles. First of all, it may be possible to separate out the interests of groups that are in the “project” area as versus those of groups that reside outside of this area. Within the project area it may be possible to identify groups by whether they are those displaced by the flooding of the reservoir or those whose livelihood or assets have been affected by the creation of the reservoir. The latter groups may be divided into those located upstream, downstream and along the perimeter of the reservoir. If there are areas adjacent to the reservoir that are greatly affected by the displacement of people and economic activity, such as with encroachment of uncompensated, displaced people into upper watershed areas, the perimeter area may be extended to cover a reservoir “buffer” area.

Beyond the project area there will be some non-project areas that may be the remainder of states or provinces of a country. Identification of beneficiaries at this level and at a series of higher levels such as rest of the nation and rest of the world is also useful. Where the project affects more than one country it will be necessary to identify impacts in each of the basin countries. Again, the determination of the levels that best serve to draw out the distinctions between how benefits and costs are distributed across the full range of interests will depend on the particular case. The Orange River matrix provides an indication of how the generic matrix may be adapted to a given case.

Finally, with regard to the unit of measure of distributional impacts, it is suggested that individual interest groups be classified according to whether they are households, firms or the government. This has the advantage of providing a degree of theoretical and practical consistency with the analysis of the wider economic impacts (such as may emerge from a macroeconomic model). If NGOs, civil society groups or trade associations have direct operational responsibilities, such as managing a protected area or producing goods and services, they might also be included as a major classification group. However, in most cases these groups are organised to represent specific interested or affected parties. Thus, it would be preferable where an NGO or other organisation is communicating and lobbying for particular interests, to simply include the groups that are actually affected by the project. Thus, a representative of an environmental NGO that represents white-water rafting interest may be an effective member of the stakeholder group for a given decision process, but the households that are avid white-water rafters would be the group identified in the distributional matrix.
Table 9.3. WCD Distributional Analysis Matrix, Orange River Development Project

<table>
<thead>
<tr>
<th>Benefits or Who Gains</th>
<th>Costs or Who Loses/Pays</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types of Gains/Losses expressed in $1998 million/yr</strong></td>
<td><strong>Costs</strong></td>
</tr>
<tr>
<td><strong>Direct Use Values</strong></td>
<td><strong>Ecosystem Function and Biodiversity</strong></td>
</tr>
<tr>
<td><strong>Electricity</strong></td>
<td><strong>Social Costs and Indirect Economic Costs</strong></td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td><strong>Protection</strong></td>
</tr>
<tr>
<td><strong>Soil/Soil Depletion</strong></td>
<td><strong>Recreation</strong></td>
</tr>
<tr>
<td><strong>Water/Rel. Water Supply</strong></td>
<td><strong>Carbon Emissions</strong></td>
</tr>
<tr>
<td><strong>Recreation</strong></td>
<td><strong>Direct Economic Impacts</strong></td>
</tr>
<tr>
<td><strong>Access to Social Services</strong></td>
<td><strong>Job Creation</strong></td>
</tr>
<tr>
<td><strong>Job Creation</strong></td>
<td><strong>Compensation</strong></td>
</tr>
<tr>
<td><strong>Compensation</strong></td>
<td><strong>Construction</strong></td>
</tr>
<tr>
<td><strong>Resettlement</strong></td>
<td><strong>Erosion/Flooding</strong></td>
</tr>
<tr>
<td><strong>User Fees</strong></td>
<td><strong>Black Fly Problem</strong></td>
</tr>
<tr>
<td><strong>Change in Water Rights</strong></td>
<td><strong>Habitat alteration</strong></td>
</tr>
<tr>
<td><strong>Cultural Heritage</strong></td>
<td><strong>Education and Resettlement</strong></td>
</tr>
<tr>
<td><strong>Local Pollution</strong></td>
<td><strong>Relocation</strong></td>
</tr>
<tr>
<td><strong>Social Displacement</strong></td>
<td><strong>Economic Change</strong></td>
</tr>
</tbody>
</table>

**A. Orange River Basin**

<table>
<thead>
<tr>
<th>Group/Spatial Dimension</th>
<th>Extent Then</th>
<th>Extent Now</th>
<th>Direct Use Values</th>
<th>Ecosystem and Biodiversity Impacts</th>
<th>Social Benefits and Indirect Economic Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Reservoir Lands</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1. Appropriated Landholders - White</strong></td>
<td>36 farms</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. Displaced Farmworkers - Nonwhite</strong></td>
<td>100 families</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. Downstream</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Producers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Livestock Producers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Farmers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Property Owners</strong></td>
<td></td>
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<td><strong>Firms</strong></td>
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<td><strong>Tour Industry</strong></td>
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<tr>
<td><strong>Agricultural processing/service firms</strong></td>
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<td><strong>Provincial Government</strong></td>
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<td><strong>B. Fish/Sands Basin</strong></td>
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<tr>
<td><strong>Producers in OORP Irrigation Scheme</strong></td>
<td>49 000ha</td>
<td>61</td>
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<tr>
<td><strong>Firms</strong></td>
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<td><strong>Water-intensive industries</strong></td>
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<td><strong>Agricultural processing/service firms</strong></td>
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<td><strong>Provincial Government</strong></td>
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<td><strong>C. Rest of the Nation</strong></td>
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<tr>
<td><strong>Households</strong></td>
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<tr>
<td><strong>Visitors to OR sites</strong></td>
<td>300,000 visitors</td>
<td>XXX</td>
<td></td>
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<tr>
<td><strong>Visitors to Alternative Thermal Plan</strong></td>
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<td><strong>Conservationists</strong></td>
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<td><strong>National Parks Board - Augrabies NP</strong></td>
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<td><strong>Daytrippers</strong></td>
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<td><strong>C. Basin Countries</strong></td>
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<tr>
<td><strong>Namibia, Lesotho, Botswana</strong></td>
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<tr>
<td><strong>Payments by Tourists to OR</strong></td>
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<td><strong>D. Rest of the World - Global Interests</strong></td>
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<tr>
<td><strong>Tourists to Orange River</strong></td>
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<td><strong>Conservationists</strong></td>
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</table>

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Table 9.4. WCD Distributional Analysis Matrix, Generic Template

<table>
<thead>
<tr>
<th>Types of Gains/Losses</th>
<th>Page 1 - Benefits or Who Gains</th>
<th>Page 2 - Costs or Who Loses/Pays</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Benefits Derived from Water, Land, Vegetation and Atmosphere</td>
<td>Social Benefits and Indirect Economic Benefits</td>
</tr>
<tr>
<td></td>
<td>Direct Use Values</td>
<td>Indirect Use Values</td>
</tr>
</tbody>
</table>

**Group/Spatial Dimension**

A. Project Region

1. Project Impact Area
   a. Downstream
      i. Households
      i. Property Owners
      i. Fishers
   b. Upstream
      i. Households
      i. Property Owners
      i. Fishers

2. Rest of the Project Region
   a. Households
   b. Fishers
   c. Others

B. Rest of the Nation

1. Households

C. Rest of the World

1. Households

D. Rest of the World

1. Households
9.7 Comparative Analysis of Methods and Approaches

As indicated above, the analysis of the distribution of impacts generated by a dam project must first rely on an identification and, where possible, quantification and valuation of the impacts themselves. The alternative is to first decide on the groups of concern and simply identify and evaluate the impacts on these groups (i.e. as in an Equity Assessment). In either even it is then necessary to consider what method will be used and what type of data gathered.

In order to fully examine the economic aspects of distribution in quantitative terms both a regional or macroeconomic model and CBA is necessary. Distributional analysis is just one of the functions that can be fulfilled by macroeconomic models and thus the decision to go ahead with such a model will be dependent in part on these factors as well as the objectives underlying the distributional analysis. If the project intends to redistribute wealth to the region in which the project is to be developed or to benefit specific income groups or industries that are only indirectly related to the project then the use of such models becomes imperative for two reasons. First, in order to have the means to assess the potential impact of the project or its alternatives on the objectives and, second, as a means of monitoring and evaluating the success of the project in achieving these objectives.

With regard to CBA and project-level impacts a distributional analysis at this level becomes important in a number of ways. With regard to the direct project costs and benefits as typically measured in CBA, EDA becomes a vital means of carefully documenting the distribution of these costs and benefits across project participants. Using this type of analysis, subsidies and implicit taxes are made illuminated and, thus, can be discussed as part of the project negotiation process.

However, this is only one, small part of a forward-looking approach to economic distributional analysis in the case of dam projects and their alternatives. In many countries, these are the social and environmental impacts that are accounted for through EIA and SIA. As seen in the case of the Lower Snake River study, the economic analysis is actually incorporated within the EIA. This raises the question of what will be the “home” of distributional analysis in the options assessment and evaluation process. Is it a separate entity, apart from the financial and economic analysis, and the EIA and SIA? Or is it subsumed within the SIA or simply an extension of the economic analysis. This question may have different answers in different contexts, although there is some logic to attaching an economic distributional analysis to the economic analysis and the full distributional analysis as part of the SIA.

Further, there may be a strategic rationale for setting the distributional analysis off from the other elements. In the context of a multi-criteria analysis, distributional analysis may be a strand unto itself in the analysis. Given the lack of experience with EDA there remains the question of how to use such an analysis in decision-making. Weiss (2000) puts forward some possible ideas for decision criteria emerging out of an EDA. Two variations in this regard involve demonstrating that a project either improves the distribution of income or increases the absolute income of the poor. For projects that are targeted at poverty criteria might be to set a threshold of project benefits that must go to the “poor” whilst ensuring that the cost per unit of income transferred to the poor is not excessive (Weiss 2000). Such criteria may then be subject to a set of explicit or implicit policy guidelines on project acceptability, enter directly into an expert-driven multi-criteria analysis or serve as an information input into a multi-stakeholder, multi-criteria negotiation process. Clearly, such quantitative criteria are more easily applied in the case of an EDA than a full distributional analysis in which a large range of qualitative and quantitative impacts compete for attention.

An additional question is which projects should be scrutinised for their distributional impacts? In practice it may be that some projects are well known to have little in the way of distributional consequences or to raise equity issues. While dams would generally not fall into the latter category it may be that particular types and configurations of dams do not raise such issues. In other words, in suggesting the operational principle that distributional analysis should be undertaken it may be useful
to screen projects in order to proscribe the need to analyse distributional impacts and even the level of analysis required (i.e. just an EDA or a full Distributional Analysis). This argues for an approach similar to that employed by the World Bank (and other agencies) with regard to specifying a series of levels at which projects must undergo an EIA. In the first instance, dam projects would likely qualify for the most rigorous level of distributional analysis.

The perception that the social and environmental impacts fall unfairly on the shoulders of those who are not direct project beneficiaries often drives controversy around particular dams. As demonstrated in Chapter 4, valuation of these impacts is more frequently observed in developed country contexts. In a developing country context the insertion of a requirement to undertake an economic distributional analysis has a number of implications. First, as only a limited valuation of benefits and costs is currently conducted in such contexts it is likely that the bulk of the time, effort and resources that would be required to undertake distributional analysis would be that devoted to the valuation of social and environmental impacts. Otherwise the EDA that results will be extremely narrow in scope. Still, even if only a limited EDA can be undertaken this would be an improvement over existing practice as explicit knowledge of how the direct project costs and benefits are distributed may greatly improve the transparency of the decision process (where such results are disclosed to stakeholders).

Thus, the implication of undertaking a more robust EDA in a developing country setting implies the need to identify, quantify and, where possible, value the significant social and environmental impacts of a dam project (as discussed in Chapter 4). This suggests that an EDA will need to feed off of both the DCF and CBA of a project and the EIA/SIA process. This may argue for setting it apart as a separate undertaking, perhaps as part of a full Distributional Analysis.

Equity Assessment and Distributional Analysis are useful means of summarising, partially or in a holistic fashion respectively, the results provided by macroeconomic models, the distributional analysis of project costs and benefits and EIA/SIA. Done well and as an integral part of a multi-stakeholder negotiation process these have the potential to incorporate consideration of the distribution of both beneficial and detrimental outcomes from dam projects into decision-making in explicit and transparent ways. A holistic approach in which available information on project impacts (not just quantified or valued impacts) is gathered and presented jointly to stakeholders and decision-makers can thus be a useful component of the decision process.

In sum, in order to begin carrying out comprehensive distributional analyses it is likely that all five of the good practice tools mentioned above will be employed in a complementary fashion. The use of regional and macroeconomic models would be more or less optional, depending on the objectives and context of the project (as discussed in Chapter 8).

### 9.8 Findings and Recommendations

Findings with regard to the application and development of distributional analysis include:

- although cost-benefit analysis is a rigorous tool for organising and arraying disparate information into a clear depiction of economic efficiency, it does not provide information about who project winners and losers may be, and does not take into account whether compensation of affected groups actually occurs;
- distributional analysis has rarely, if ever, been undertaken in multilateral development bank dam projects;
- methods available for producing information on distributional impacts include macroeconomic models, CBA, environmental and social valuation techniques, and SIA/EIA;
- methods for social and environmental valuation may be an important part of developing distributional information; and
- Equity Assessment and Distributional Analysis are partial and holistic approaches, respectively, for identifying, summarising and communicating distributional impacts.

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Based on the analysis of these findings the following principles can be offered:

- an Equity Assessment process is necessary early on in the options assessment process or at pre-feasibility (perhaps as part of a strategic SIA) to ensure the identification of groups of special concern and to obtain an indication of the potential project impacts on such groups;
- an overall Distributional Analysis of large dam projects should be mandatory at the feasibility stage in order to weed out projects with unacceptable distributional impacts or to assist in incorporating in project design strategies for avoiding, minimising, mitigating or compensating these impacts; and
- given the history and potential for inequitable impacts of dam projects, cost-benefit analysis should not serve as the sole criterion for dam project decision-making.

Finally, a number of recommendations for operationalisation of these principles through suggested methodological improvements, process enhancements and/or changes in institutional incentives can be made with regard distributional analysis:

- Distributional Analysis should include results from economic analyses as well as other information that should include, at minimum, explicit consideration of key distribution impacts (e.g., distribution across income levels, geographic regions, and generations);
- Where CBA is practised the related Economic Distributional Analysis should also be carried out as part of the distributional analysis;
- The decision to implement a regional or macroeconomic model should be undertaken in consideration of the need to assess secondary impacts on vulnerable groups and the existence of a need for macroeconomic modelling in relation to macroeconomic objectives.
- Analysts should be prepared to supply subjective judgement when applying tools for distribution analysis, and should make these judgements clearly and transparently.
- Analysts should involve as many affected stakeholders as possible in an open and participatory process of conducting the Distributional Analysis.
- Stakeholders and decision-makers should carefully consider the type of insights they seek from the distribution analysis and the information requirements before selecting the approaches to be applied and allocating the budget between the selected approaches.
- If the identification, quantification and, where possible, valuation of project social/environmental impacts is part of CBA or the EIA/SIA; then Distributional analysis will not require significant additional resources for research.
- Strict co-ordination of those leading the Distributional Analysis with the team undertaking macro-modelling, CBA or SIA/EIA is necessary to ensure that these methods yield useful and consistent information.
10. Decision-Making Criteria and Methods

In 1936, the federal Flood Control Act in the US put in place a criterion that required the government to accept public flood control projects in which “the benefits to whomsoever they may accrue are in excess of the estimated costs.” By proposing that decisions be made based on the full set of national changes in welfare caused by the project – and not simply the costs and benefits accruing to the project proponent – this paved the way for the application of economic cost-benefit analysis (CBA) to water resources projects (Margolis 1959). In the international arena, CBA has become the dominant investment criterion in project assessment – with the World Bank adopting CBA as far back as the 1960s. It is also the case that the economic internal rate of return (or net present value) is the decision criterion most widely applied by government agencies and official aid donors in project appraisal today.

Not surprisingly, criticism of dam-building is often synonymous with criticism of CBA and, by inference, the neoclassical economic approach that underpins CBA (Lohmann 1999). In other words, critics feel that the historical application of the principle that the welfare gains of a project should be positive have not, in fact, led to sound decision-making in the case of dams. Criticism of this nature raises (at a minimum) three questions that are relevant to investigating actual experience with decision-making criteria and methods in the case of large dams:

1. Did the results of CBA actually guide decision-making or, alternatively, did the decision-making process guide the results?
2. Did CBA as applied accurately portray the net welfare effects of the projects as they actually unfolded?
3. Did CBA as applied fully capture the actual objectives of society with respect to large dams?

While this paper cannot address or resolve all the outstanding issues associated with CBA and project evaluation it treats these three questions as the most fruitful approach to examining the relationship between economic analysis, decision-making and large dams. This, given the emphasis on providing guidance on improving economic, as well as financial and distributional, analysis in this paper.

The extent to which each of these questions can be analysed in an empirical fashion varies. The first question is tackled by examining the politics and political economy of dams. The “evidence” here is necessarily anecdotal as much decision-making behaviour occurs behind closed doors and, therefore, is rarely documented in a comprehensive fashion.

Given that CBA is simply the effect of applying the methods discussed in earlier chapters, the bulk of the evidence on the second and third questions is contained in the preceding chapters of the paper. What remains is to examine actual practice, guidelines and performance of CBA and its results. This is done by first reviewing the methods and criteria for project evaluation, then by presenting actual practice itself. The analysis then turns to the performance of CBA as a predictor of economic profitability, leading on to conclusions on the adequacy of CBA as a decision criterion in the case of large dams. Given the weaknesses of CBA as highlighted here, and in previous chapters, an alternative approach – multi-criteria analysis is then presented as an alternative decision support tool. Finally, the chapter explores options for improving the use of financial, economic and distributional analysis in decision-making with respect to large dams.

10.1 The Political Economy of Large Dams and Economic Decision-Making

Political economy is the study of how politics (as embodied in laws and policies) drives the allocation of scarce resources as well as how the nature of the economic system and economic interests in turn drives political decision-making (as reflected in the form of government and the kinds of laws and
policies that are developed). As indicated above, some critics argue that narrow political and economic interests—not economic analysis—drives decision-making regarding large dams and that as a result CBA simply serves the purpose of justifying such decisions. This section addresses this question by examining the political economy of planning and decision-making regarding large dams. This is accomplished by examining three questions:

- the extent to which decision-making on dams is driven by purely political considerations— as opposed to economic analysis
- the extent to which the economic character of the resources involved shapes the way in which rivers, dams and water and energy services are governed; and
- the extent to which political considerations and economic interests are manifested at the level of particular institutions involved in the planning process, thereby driving the economic evaluation as undertaken by staff and consultants.

10.1.1 Politics and Decision-making on Large Dams

CBA is an analytical process that produces a number that can be judged relative to a pre-established criteria (such as a 10% internal rate of return). In theory, the establishment of CBA as a decision support system and the setting of a formal criterion for investment decisions “automates” the acceptance or rejection of a project. To say on this basis, however, that CBA (and economics and economists) have had a firm grip on decision-making regarding large dams would be an exaggeration.

The decision to undertake a large infrastructure project, including a dam, is rarely a decision based simply on technical and cost-benefit analyses. From the perspective of the final decision to go-ahead with a project, once the computations are complete the decision moves into the political arena. At this point a political calculus of costs and benefits occurs by those exercising the final authority to approve projects. Ideally, this qualitative political assessment draws on the analytical results from the various forms of CBA, while accommodating the larger political, social and economic decision-making context.

The larger point is that the political cost-benefit analysis applied by governments and state agencies responsible for water resources development has been not only the final arbiter, but also drives the planning and decision-making process in many cases. Eckstein (1958) lays out the “tenuous trail” that a navigation and flood-control project of the Army Corps of Engineers had to travel in the US context as far back as the 1950s:

- an initial request for a project would derive from a petition made by a local group to their congressman, from a Corps-led surveys of the water resource potential of the river basin, or from plans originating at higher levels of government (as with the Grand Coulee dam);
- following the initiation a long series of surveys, public hearings, and inter-agency reviews were required including an analysis of costs and benefits as required by the Flood Control Act of 1936;
- once procedural approvals was obtained a project would still need to find its way into the annual budget and survive the scrutiny and internal negotiations in the Congress to actually have funds appropriated for the project.

Lobbying by Congressmen to ensure that projects for their constituencies are included in budget appropriations and approved for funding is the final political act in the process.

Examination of the WCD Case Studies provides an indication of how larger projects have often been approved at the highest political levels, sometimes in the face of concerns regarding economic viability or in the absence of any CBA at all.

The Grand Coulee Dam and Columbia Basin Project ($9.2 billion in 1998 prices) were approved by a presidential decision in 1932—over the concerns of those who felt that the Columbia Basin Project
The two projects formed part of the federal government’s campaign to bring the country out of economic depression by providing construction jobs to thousands of people, opening up new farming land and reducing price manipulation by private power companies. Grand Coulee ended up providing cheap power that enabled the allies to win World War II.

The Kariba dam ($1.5 billion) was built to provide cheap power. The 1955 economic appraisal of the project was based on numbers showing it to be a lower cost option for supplying power than an alternative coal plants – yet for many years the topic of debate amongst economists in the region had been whether to build Kariba or the Kafue hydroelectric project. Tarbela dam ($8.8 billion) was built largely as a political response to India’s decision to exercise its control over the upper part of the Indus River. The project appraisal did involve a detailed cost-benefit analysis.

The Orange River Development Project ($2.3 billion) in South Africa was undertaken to bolster external confidence in the wake of the Sharpeville Massacre of 1960. Brazil’s Tucurui dam ($5.5 billion) was approved by a military dictatorship in the late 1970s. In neither of these two case was a CBA performed as part of the project appraisal process. In contrast the smaller, much less expensive Pak Mun dam in Thailand ($260 million) was approved by the host-country utility and the project’s funder – the World Bank – based on cost-benefit calculations.

Thus, it is clear that the past history of decisions taken to build dams have not been guided purely by CBA or welfare economics as such. Decision-making regarding large public investments – such as dams – has been, and will continue to be, a political process. The extent to which this process relies on economic information as opposed to being subject to pressure from economic or political interests varies from one case to another. The Case Studies demonstrate that for very large dams that represent a significant outlay of public expenditure this process often will be driven by the highest political authority and by objectives that do not relate to the narrow objective of economic efficiency of which CBA is the metric. This may also be the case even where the decision relates to efforts by one country to assist in the financing of dams in another country, witness the direct involvement of two British Prime Ministers – Thatcher and Blair – in financing decisions on large dams (Bakun in Malaysia and Illusu in Turkey, respectively).

10.1.2 Rivers as Public Goods and Markets for Water and Energy Services

As described earlier in this paper, the regulation of river flows in most countries is guided by the principle that water is the property of the state. From an economics perspective this principle is given expression through the analytical concept that river water, its flows and its quality are public goods. Dams re-regulate the flow of rivers and affect the distribution of river water benefits.

Dams that simply regulate water flows are flood control dams. The benefits of flood control provided by a large dam are a perfect case of a public good: a large investment is required but many benefit, and each beneficiary can neither exclude others from consuming these benefits, nor does the addition of an additional beneficiary affect the benefits garnered by others. Dams used for recreation and fishing are of a similar nature with the proviso that at a certain level of usage congestion may occur as additional boaters, anglers, etc crowd onto the lake.

Dams that provide hydroelectric, irrigation and water supply are different in that they provide tangible services, services that require generation and/or transmission and distribution systems. In many Western and Eastern political systems, the large-scale provision of water and energy services has been recognised and treated as a natural monopoly. The large up-front costs of infrastructure associated with these services led to the expectation that if they were left to the private sector these activities would not serve the public good – either in terms of failing to supply services to poor communities or by exerting monopoly power and charging exorbitant prices. As a result state agencies and utilities were created with the objective of serving the public interest through the production and provision of
these services. The tariffs that are charged for hydropower, irrigation water, municipal and industrial water supply, as well as the fees for recreation and fishing permits, have been typically administered by state agencies or public utilities. To reiterate, the concept of a natural monopoly springs from the scale of the exercise. Thus, small subsistence or indigenous communities have developed alternative institutional arrangements for service provision, such as communal management of water sources and irrigation ditches.

Historically as societies have developed and water and power needs have increased the government, its agencies or public utilities have planned, built, owned and operated dams and associated water and energy service industries. In countries where rights to the use of water are assigned to citizens and firms, private sector dams have been built as well, though nominally under regulatory supervision and licensing.

In economic terms, dams are a means of transforming a nation’s endowment of capital – human, technological, natural, financial and cultural capital – into tangible products and services. The construction of a dam requires an investment of man-made capital and, as a result, generates a series of benefits that are then distributed – either through political-administrative means or through markets – to members of society. In the case of hydropower and water supply to municipalities, the utility “distributes” power only in the sense that the location of transmission lines determines which distribution network receives the power or water. With large industrial consumers the “distribution” of hydropower and water supply and the administrative flexibility to negotiate contracts and set prices, can, and has, lead to a tendency to “distribute” the benefits of these services to large corporations at a subsidised price. The “distribution” of irrigation benefits is of a similar nature except that such projects will often involve not just major canals, but the actual distribution network itself. Here again, considerations of political economy suggest that the political-administrative distribution of these benefits will be to those who can reward those whose decisions direct the path of canals and the location of distribution networks.

The objective of stimulating local and regional development may be served in drawing industry and farmers to regions that are graced with large dam projects and used to justify the subsidies awarded. Unfortunately, the political economy of subsidies is that once they are awarded without a clear program for their withdrawal, they are quickly interpreted by beneficiaries as entitlements and become very difficult to eliminate. Further, in an economy where resources are fully employed, the resources drawn to a given region are simply resources that would have been used elsewhere and thus the perceived benefit to the dam-building region simply represents the loss of benefits that would have otherwise accrued elsewhere in the economy. Dam projects that are directed to regions that have underemployed resources can provide an important stimulus to local social and economic development. However, in other cases dams may simply serve political ends as a means of directing economic benefits to particular regions or constituencies. In such cases they serve as means of political redistribution of societal wealth. Unfortunately, where this redistribution leads to the creation of significant subsidies, the end result is likely to be an inefficient allocation of societal resources.

At the same time as dam-building may create entitlements to government subsidies (windfall profits for a set of societal groups) the construction of a large dam will have profound effects (both positive and negative) on the natural and social landscape of the setting in which the dam is located. These changes will affect the de facto entitlements to natural resources and cultural stability and cohesion previously experienced by local communities and resource owners. Further, they have consequences for ecosystem health that may be difficult to predict and there may be scale effects that undermine the basin economy from the cumulative impacts of all the interventions in a single basin.

In cases where there has been a lack of acceptance of the social and environmental effects of large dams this is often caused by the political economy of the transformation process as characterised above. At one level, the process of investment in, and distribution of, project benefits is skewed towards those who can influence the political-administrative structure of water and energy resource
management agencies. For example, as shown in the stakeholder meetings for the Kariba and Tucurui case studies there was a strong consensus amongst stakeholders present that the benefits of these projects have not been distributed in an equitable manner. However, many dam projects have also failed to acknowledge pre-existing rights and claims of local communities with respect to cultural and natural capital that are to be affected by dams. The result has been the perception on the part of some groups that not only have they not received (a fair share) of the direct project benefits but that installation of the dam has caused them to lose endowments and entitlements that they once enjoyed. In a sense then, rather than investing in the dam these groups have been de-vested by the dam, without garnering a corresponding portion of the benefits generated by the project.

10.1.3 Political and Economic Interests Driving Institutional Behaviour

Planning and decision-making with regard to dams has often been driven either by direct political interests of politicians or by the momentum established by large centralised institutions that are responsible for water and energy resource planning and development. Historically, these have been national matters and national agencies – such as the US Army Corps of Engineers or Bureau of Reclamation. However, the last few decades has seen the emergence of bilateral and multilateral agencies, such as the World Bank and the Scandinavian overseas development agencies, that as a consequence of their financial contribution come to play an important role in influencing the planning and development of dams in developing countries (Ek eco026; Usher 1997).

Integral to this process are the consulting firms, suppliers and contractors that design, develop and equip dams, and the companies and farmers that profit from low cost power and water. Within the institutional arrangements that have formed between these different actors there has been historically little participation by small end-use beneficiaries of water and power or those negatively affected by dam projects.

In political economy terms, the existence of a large number of people who benefit in only a small way – such as with retail consumers of hydropower – there are substantial barriers to collective action, either to ensure the provision of these benefits or to remediate the negative impacts that production of the services may cause. This collective action problem underpins the intervention of state agencies in the large-scale provision of infrastructure. However, the nature of the problem has also meant that retail consumers are largely distanced, and in many cases ignorant of, the choices being made on their behalf in the full sense of the benefits that they are provided with and the impacts – positive or negative of the production process itself.

With regard to affected groups, it is important to distinguish between those that are affected through markets – i.e. rivals losing market share – and those who are affected by the process of transformation set in motion by dam construction that effectively extinguishes their rights to natural resources and to socio-cultural capital. In the former case, the market serves as an institutional arrangement for allocating costs and benefits. Thus, development of an irrigation scheme in region X may lower the price received by non-irrigated farmers in the same region (or adjacent regions) for their produce. In this case the market makes the adjustment and allocates the gains and losses – which might be marginal in any event as prices are buffered by expectations regarding the larger picture of supply and demand. In the case of local people that will lose their residence, community and/or access to livelihood as a result of the dam no such institutional arrangement for remediating or buffering the impact exists – unless the rights possessed by the residents are recognised by those developing the dam and taken into account in project planning. Obviously, the more impoverished or marginal the community the less likely they will have the political-economic capital to push such an agenda. Still the 1980s and 1990s saw the rise of large anti-dam movements in a number of countries, which have opposed dams leading to delays and playing an important role in the global debate over dams.

Critics of large dams and CBA suggest that where dams reflect entrenched political and economic interests the technical and economic analyses are often undertaken with the principal, but largely covert, objective of demonstrating that the benefits of the dam outweigh its costs. In other words, it is
suggested that bureaucrats (both national and international), consultants (both national and international), and other project proponents have vested interests in supporting a continued focus on dam-building and that this drives their behaviour in project planning and evaluation (Bosshard 2000 eco024). On this basis it is argued that CBAs simply reflect decisions already taken by larger political and economic forces and that the technical analysis undertaken at an institutional level is pre-destined to arrive at the desired conclusion – i.e. that the project is economically worthwhile.

As an example, the recent revelations of the pressure exerted on an economic analyst to alter results in the case of water projects undertaken by the US Army Corps of Engineers stand as an indicator that such behaviour exists today in developed countries (Grunwald 2000). Within the international financial agencies, the Wapenhans Report led to considerable debate over existing practice at the World Bank. The report highlighted the internal incentives within the Bank that drive staff towards timely loan approval of capital-intensive projects and the tendency to undervalue the Staff Appraisal Report as an analytical document in favour of its use as a promotional document. A systematic and growing bias towards overly optimistic rate of return expectations at appraisal was also noted by the Report. Indeed as noted, earlier in this paper there is a tendency to understate the direct costs of dam projects and it may often be very difficult to ascertain the direct benefits. This topic is returned to later in this chapter as apart from direct statements that these practices occur, the only other empirical evidence for this lies in the extent to which such projects actually deliver on their projected rate of return.

Ascher (1992) examines the reasons why project appraisals at the World Bank are exaggerated by focussing on the question of how to ensure that projects that do not have adequate rates of return are screened out in the project planning process. Optimism in project appraisal and reluctance to abandon or modify problematic projects can be ascribed, in Ascher’s judgement to not only analytical limitations but the influence of individuals and institutions that are eager for projects to proceed. Both the structure of the planning process and the ‘evaluation environment’ (i.e. the incentives available to participants in the process) drive such strategic behaviour. Amongst other elements of these problems Ascher identifies:

- a bias to proceed and a bias against rigorous analysis on the part of government agencies, consultants, contractors and international financing agencies, all of whom have an incentive to maximise project grant/loan throughput;
- a limit to the capacity of technical analysis leading to large ranges in uncertainty over project costs and benefits (so that there is no risk of loss of professional and career standing from inflating rates of return);
- the distinctions between project formulator/designer and project evaluator are often blurred – as Bank evaluators provide feedback to improve project design it reduces their psychological and political detachment from projects;
- a bias to an early commitment to projects make it difficult to stop projects which are promoted on the basis of their benefits, leaving consideration of costs, particularly environmental costs, to be ‘fleshed out’ later;
- heroic impulses to take on challenges with bold, short-cut approaches often drive projects, with environmental problems considered as problems to address rather than as fatal impediments.

To counteract these problems Ascher recommends promoting program over project approaches, maintenance and rehabilitation over ‘heroic’ projects that will initiate the penetration of natural systems, and project designs that permit adaptive management. In terms of institutional processes related to project selection Ascher suggests it is necessary to:

- internalise the institutional costs of environmental risks through ensuring that those who develop projects also manage them (improving their incentive to develop projects that will perform according to expectations)
• enhance the impact of independent evaluation in order to provide an external discipline on those developing projects through, for example, independent appraisal of a random selection of projects and grading of appraisal quality by independent inspectors
• expand the knowledge base to reduce, for example through getting on with mapping out physical and biological conditions now in order to provide information to projects designed in ten years time
• institutionalise environmental caution by adopting an attitude of ‘deliberate pessimism’ with respect to the treatment of the risk of unidentifiable environmental consequences.

While many of these proposals are sound in their intent, they are notoriously difficult to implement. One reason for this may be that as long as they require a large dose of self-regulation or self-policing amongst the standard set of participants and proponents they will be tough to apply, monitor and enforce in a rigorous fashion within a given institution. In other words as long as the focus is inward-looking compliance is likely to fall short of that desired. Only by opening up the project planning and development process – including the economic studies and appraisal – to participation and scrutiny by all parties to the project (i.e. not just the proponents and financiers) can the effect of the perverse institutional incentives discussed above be neutralised.

10.1.4 Unique Characteristics of the Political Economy of Dams

Finally, it is worth noting that many of the points about political economy made above apply to large infrastructure projects more generally. In many cases, they will also apply to non-dam alternatives – for example to dam and groundwater irrigation projects alike. Perhaps what sets dams apart from other large infrastructure projects and non-dam alternatives is the combination of four factors:

• the focussed scale of the physical structure of the dam itself,
• its rural setting;
• the ability to closely control the distribution of direct benefits; and
• the potential scale and magnitude of the environmental and social impacts that can be set in motion through the building of a large dam.

Many other large infrastructure projects share one or more but not all of these characteristics. Groundwater irrigation schemes do not focus as much capital and labour in a single site as with the building of a dam. Nor are they associated with the type of potentially far-reaching environmental and social impacts of dams. Roads and other transportation infrastructure pass through rural areas and can have important social and environmental implications, but their construction effort and impact is dissipated across large areas and once built the roads are available to all – there is no control over the benefits.

Thus, there is something unique about dams as large infrastructure projects. In particular all four of the factors proposed above have significant implications for the rural communities residing in the vicinity of the project area, as well as downstream areas. In this regard it is worth noting that the forces of political economy that drive dam-building – particularly in the case of very large dams in developing countries – often are completely foreign to these communities. The alienation that results from the clash of these two cultures must be regarded as an important cause of the impasse that has emerged with respect to dams.

10.2 Actual Practice: Methods and Process

This section provides a brief review of the types of economic analysis traditionally undertaken and an introduction to the states of the project planning cycle and the project cycle itself. Actual practice is then described according to the type of institutions involved: private developer, public sector agency in developing country, international public sector, and public sector in developed country.
10.2.1 Financial and Economic Methods for Project Evaluation

The financial and economic assessment and comparison of projects of all kinds, including dams and their alternatives (as well as the various options that might be available for developing a single project) are typically conducted using a financial discounted cash flow analysis (DCF), an economic cost-benefit analysis (CBA) and, in practical terms where political approval is required, a political cost-benefit analysis.

In their various forms these analyses reflect the desire to measure the gains and losses associated with a project under consideration, aggregate these valuations, and express them as net gains (either positive or negative). If the project exhibits a positive balance of benefits over costs, then it is considered to be worth pursuing. In the case of DCF and CBA, the basic objective is to measure the costs and benefits of the project in quantitative terms, and to transform these into a single number that indicates whether or not the benefits outweigh the costs.\(^58\) For all three types of analysis the definition of what constitutes the costs and benefits attributable to a project differs – depending on the perspective taken in the analysis. For the purposes of this paper the focus is on the formal methodologies of financial and economic analysis and thus DCF and CBA are explained further below, along with least-cost and cost-effectiveness analyses which are variants of these methods. The decision criteria associated with these methods are then described.

Financial Discounted Cash Flow Analysis (DCF)

Financial analysis evaluates a project using prices as they appear in the market. Only the costs and benefits relevant to project investors are considered. A cash flow profile of the dam project is constructed that identifies all the receipts and expenditures expected to occur during the project's lifetime. For example, a financial analysis might account for a dam's receipts from power production, irrigation and/or water supply fees, and government subsidies. Project costs will include construction, operation, maintenance, and the cost of implementing measures to mitigate environmental and social impacts. Investors analyse these financial flows to determine the net financial value of the dam project.\(^59\) It is important to recognise, however, that financial analyses do not reflect all the costs and benefits of a dam to society; many of the costs and benefits of a dam (e.g., environmental and social impacts) are external to financial flows.

Economic Cost-Benefit Analysis (CBA)

Economic cost-benefit analysis, attempts to evaluate all the costs and benefits of a dam project to determine whether or not its implementation will improve the overall economic welfare (or well-being) of society. ‘Society’ is typically defined as the country (or in some cases, the region) in which the project is being implemented. Within an economic cost-benefit analysis, an investment decision is assessed based on net benefits adjusted for such factors as subsidies, taxes, and environmental and social externalities. For example, if a dam project is expected to result in environmental impacts to a fishery, those impacts are included in the net benefit calculation. The challenges and methodologies associated with estimating the economic net benefits of dam projects are addressed throughout this paper.

Least-Cost Analysis (LCA) or Cost-Effectiveness Analysis (CEA)

Strictly speaking least-cost or cost-effectiveness analysis involves the assessment of the cost of providing a given level (and quality) of output, be it a product or service.\(^60\) Implicit in the name of the techniques is the comparison of two alternatives – i.e to find the least-cost alternative or most cost-effective means of achieving a given ends. These techniques have no content outside of such a comparison – LCA of a single alternative is simply the restatement of the project cost – and, thus, it carries little information content in the appraisal of a single project. It is important to note that the definition of cost may be financial or economic, thus just as DCF and CBA are used to distinguish between two types of cost-benefit analysis there is a need to differentiate between a financial and an
economic least-cost analysis. However, in practice LCA often relies simply on direct costs expressed in market prices and is thus typically a financial LCA.

When the output of a project can be stated in terms of the units/quality of output – such as kWh of electric power – but not valued in monetary terms, LCA becomes a useful decision tool as it identifies the most efficient alternative. In the water and energy sectors, it is often feasible to value the output of dam projects (see Chapter 3) so that in project appraisal LCA is typically used as a first condition, i.e. that the project under appraisal must demonstrate that it is the least-cost alternative (ADB 1997, World Bank). CBA is subsequently applied to assess project profitability. In the case of dam projects where a series of costs and benefits are associated with the project, assessing the “cost” of the project may become a contentious issue if a financial LCA is taken as a true estimate of the economic cost of the project. As highlighted in earlier chapters, particularly Chapter 4, a mere analysis of financial outlays required to build a dam project may not be a particularly good indicator of its full economic ‘cost’; moreover such a calculation leaves aside the additional benefits – above and beyond the stated kilowatt-hours – that such a project may bring.

10.2.2 Decision Criteria: Background, Guidelines and Actual Practice

A number of decision criteria for DCF and CBA exist, the most frequently cited of which are the benefit-cost ratio, the internal rate of return (IRR) and net present value. The benefit-cost ratio compares the discounted benefits to discounted costs. The IRR uses the predicted cost and benefits streams to calculate the maximum interest rate that a project could pay for the resources used if the project is to just recover its investment and operating costs (i.e. break even). The net present value refers to the discounted net worth of the project. The IRR is thus comparable to the discount rate that would produce a net present value of zero.

Projects are considered acceptable if (1) the ratio of discounted benefits to discounted costs is greater than one, (2) the internal rate of return is higher than the chosen “hurdle” or discount rate or (3) the net present value is positive. In financial analysis the hurdle rate will be the relevant risk-adjusted weighted average cost of capital. In economic analysis it will be the chosen social discount rate or economic opportunity cost of capital (see Chapter 5).

The relative advantages and disadvantages of these three criteria are well-established and the superior method is net present value.61 Weaknesses of the internal rate of return include the potential for multiple IRRs for the same project, incorrect ranking among independent projects and the selection of mutually exclusive alternatives (Frigo 1999 ecosweb 007, Gittinger 1982). The net present value criterion does not suffer from these difficulties. The difficulty of multiple IRRs is only an occasional problem and simply requires care on the part of the analysis. The failure to correctly rank projects and select from alternatives becomes problematic only when these are specific objectives of the analysis. In other words, for the appraisal of independent projects the IRR and net present value criteria will return the same decision, absent the conditions that lead to multiple IRRs.

**Guidelines and Practice with Respect to Decision Criteria**

Despite the superiority of the net present value criterion the results of financial and economic analysis are often presented in terms of IRRs (EIRRs for the economic IRR and FIRR for the financial IRR). Standard practice at the Asian Development Bank is to use the EIRR criterion (ADB 1997). Meanwhile, the World Bank’s Operational Policy 10.04 issued in September 1994 clearly states that the net present value of the project must not be negative and that the project’s net present value must be higher than or equal to that of mutually exclusive alternatives. A footnote to the Operational Policy acknowledges that although the use of net present value has long been the Bank’s policy, standard practice has been to calculate the IRR. The footnote continues on to acknowledge that although the IRR is not satisfactory – including for the purpose of choosing mutually exclusive project alternatives – it is well understood and can be used for the purpose of presenting the results of analysis. Gittinger (1982) explains the tendency of the World Bank to use the IRR, by indicating that

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This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
the IRR avoids making a close comparison of the opportunity cost of capital in the Bank’s various member countries or setting a worldwide opportunity cost of capital.

There appears to be some inconsistency between the guidelines and policies of the World Bank in opting to use the IRR. As the IRR cannot be directly used for the evaluation of mutually exclusive alternatives this seems inconsistent with the policy that one of two basic conditions a World Bank project must meet is that it have a higher net present value than such alternatives. This can be explained as follows. First, the WCD review of project appraisals from multilateral development banks indicates that although IRRs are the predominant criteria used at appraisal, these appraisals are typically of the project being appraised and not of mutually exclusive alternatives. Thus, as there is no explicit comparison of net benefits of alternatives in the appraisals the use of the IRR is not likely to be misleading in this regard (a case of independent projects). This begs the question of how previous documentation associated with the project manages to satisfy this requirement of Bank policy. It does clarify though that improving the process of assessing dams and their alternatives (i.e. early and comprehensive options assessment) may require a shift to using net present value in place of IRR.

10.2.3 Project Planning and Project Cycle

For the purposes of this paper it is sufficient to indicate that planning for water and energy resources often begins with sector and basin-wide planning efforts and moves through to project identification and evaluation. The evaluation of dam projects is conducted at the various planning stages of the project planning cycle including screening (pre-feasibility), feasibility and appraisal. Typically the degree of detail involved in the analyses at successive stages increases significantly. Also, the cost of carrying out the assessments increases commensurately.

At the screening stage, often several dam sites and dam alternatives are under consideration, and the task is to identify the best among these. Screening studies are often conducted within the context of an overall basin master plan that seeks to identify the most effective means of developing the overall water resource of a river basin, including the individual projects that make up the optimal basin development plan. At this stage, dam sites are identified, preliminary project layouts are established, and initial estimates of direct costs and benefits are made. Analysts typically limit their assessment and comparison of projects to a simplified form of discounted cash flow analysis at market prices.

At the feasibility stage, often only one project (the best from the screening stage, or the first in the river basin master plan) is studied. The principal objectives are to identify the least-cost means of project development and to demonstrate that the project is both technically and economically feasible (e.g. in the case of a hydropower project, that the overall cost of power system expansion with the project is less than that of the best alternative expansion plan without the project, and that the timing of the project is optimal). Fairly detailed site investigations are carried out including topographic surveys, sub-surface drilling and surveys of construction materials. Conceptual designs are conducted, more detailed estimates of costs and benefits are made, an optimisation of the project configuration is carried out, and an economic cost-benefit analysis is performed. A financial analysis may also be undertaken at this stage but, since the sources and conditions of project financing are generally unknown, the scope of this analysis is usually limited. Normally, environmental and socio-economic impact assessments are also performed at the feasibility stage.

The fact that only one project is typically studied at the feasibility stage is seen by some as a significant weakness in the entire assessment and selection process. By studying only one project, momentum builds up for the project that becomes difficult to stop if problems arise. Typical (some quite false) arguments made to maintain project momentum are that much money has already been spent on study work, or that, by virtue of its relatively advanced stage in the project planning cycle, the project is the only option that can be brought on line in time to meet a looming power and/or water shortage. Some suggest that, in future, it might be prudent to study more than one option at the feasibility stage in order to avoid this trap.
In the WCD review of project appraisals, flexibility in project development has been observed in the case of Indonesia’s Wadaslintang Multi-Purpose Project (1981), which replaced the Karangsambung Multi-Purpose project. During the course of the feasibility study, the dam site was shifted to Wadaslintang after it was determined that the geology and flood control potential would be better. The optimum dam size was also decided after considering technical investigations and simulation studies on reservoir operations.

If the project continues to appear attractive at the feasibility stage, it moves to project preparation. At this stage, additional site investigations are carried out, detailed engineering designs and cost estimates are conducted, plans for construction are drawn up, and more comprehensive estimates of project costs and benefits are made forming the basis for the appraisal report. Also, details of how the project might be financed are investigated. The economic analysis is updated, and a detailed financial analysis is undertaken using specific information about the likely financing plan. The Environmental and Social Impact Assessments are also updated, and mitigation and resettlement/compensation plans established. Necessary applications to construct and operate the project are made and, if these are approved, those funding the project decide whether or not to proceed to construction. Critics suggest that, by the time a project has reached the project preparation stage, even more momentum has built up that is even more difficult to stop if the more detailed analyses suggest that the project is not attractive, or is too risky.

Once the project is approved, the construction phase begins. Regular updates of plans and budgets are undertaken and, typically, a project completion report laying out the actual construction cost of the facility is provided once the project is commissioned. The WCD Thematic on Operations, Monitoring and Decommissioning of Dams provides a comprehensive discussion of these issues. Financial, economic or distributional analysis may be relevant to decisions taken at re-operations, relicensing and/or decommissioning. The focus of this section is primarily on the project planning cycle, as many of the same principles and criticisms will apply regarding the application of the tools, regardless of the point at which they are applied.

10.3 Actual Practice: Different Actors in Project Evaluation

In this section a number of the different actors that can be involved in project evaluation are reviewed along with a general characterisation of how these may lead to different perspectives on the decision-making methodology.

10.3.1 Private Sector Developer

The allocation of dam projects to private-sector development usually depends on government policy, as well as on the willingness of private-sector developers to participate.

The expected principal goal of a private-sector developer is to maximise the return on his equity investment (i.e. maximise the DCF). Therefore, without explicit and enforced guidelines and regulations by the State, there will be a tendency on the part of a private developer to minimise the cost of conducting the assessment of a dam project. On the other hand, the developer wishes to reduce the risk exposure of his equity investment and, therefore, it can be anticipated that he will investigate the physical attributes of the site to the extent possible with a view of avoiding construction delays and cost overruns. The developer might also be expected to determine the benefits in detail in order to provide a better estimate of project revenues. However, in practice, the effort often tends to be concentrated on estimation of (the more immediate) costs rather than (future) revenues. A panel of technical experts may be appointed to ensure that the engineering designs conform to current practice, particularly with regard to safety and cost-effectiveness.
The private-sector developer’s perspective of a project can be a relatively narrow one. He is usually concerned exclusively with the costs and revenues directly associated with (internal to) the project, and with any other costs and revenues that he expects to experience during its lifetime. To the extent that he is permitted, the private developer can be expected to ignore external costs.

The developer will incur the costs of investigation, study, design and construction management; construction; operation and maintenance; and replacement of components whose lives are shorter than that of the project as a whole. Usually, the largest of these, by far, is the cost of construction.

The costs of certain items that will have to be built at the same time as the dam may sometimes be excluded from the analysis. Examples of these can be the project site access road which might be considered as part of a developing country’s planned road network expansion (and is assumed to be built whether or not the dam project proceeds), and the transmission line from the project that might be viewed as part of normal transmission network expansion. There is sometimes a tendency on the part of the private-sector developer to divest himself of such costs.

Where effective regulations exist, or regulations from other jurisdictions or international agencies are applied, the direct costs of mitigating environmental and socio-economic impacts, such as resettlement of people living in the reservoir area, will be included. This is more likely to be the case in developed countries. Even if effective regulations do not exist, the anticipation by the private developer of strong public reaction (local and/or international) can be expected to encourage him to include these costs. Invariably, decommissioning costs are ignored. Also, distribution/equity, macroeconomic and intergenerational issues are typically disregarded unless they are a condition of a concession contract, licensing or debt finance.

Before committing funds to construction activities a private sector developer will conduct a full financial analysis, using generally accepted accounting principles, as described in the Technical Annex 3 on Financial Analysis vs. Economic Analysis. This, more complex, type of evaluation, or some variation of it, to ensure that the project can be successfully financed throughout its construction and operating stages, and that it will provide an acceptable return to equity investors, while satisfying the financial performance conditions specified by debt holders.

10.3.2 Public Sector Agencies in Developing Countries

In developing countries, the financial and economic analyses of dams is often conducted for a government department or some other public-sector institution. Typically, the funding for such assessments comes, at least partially, from bilateral or multilateral development or funding agencies in the form of grants or loans.

If international funding institutions are involved in providing part of the debt financing or a loan guarantee the project assessments have to meet certain standards required by these agencies. A selected number of economic guidelines by multilateral agencies for conducting project assessments are described in the Technical Annexes. Details on other requirements, particularly in the social and environmental area, are provided in the other WCD Thematics on these topics.

The assessments conducted for public-sector agencies in developing countries are usually carried out by international consulting engineering firms, typically assisted by local staff. These firms either have on staff, or contract out to, non-engineering specialists such as environmental scientists, sociologists, archaeologists, economists, etc. The quantity and quality of data available to undertake the analyses can be quite limited.

Also, the resources available to carry out these assessments are often constrained, especially in the non-engineering disciplines. At the feasibility stage, it is typical to expect approximately 1 to 2 percent of the estimated capital cost of a project to be spent on the entire study including site investigations, conceptual designs and construction plans, estimates of project costs and benefits,
financial and economic analyses, and environmental and socio-economic assessments. So for a $1 billion dam some $10-$20 million may be spent, whereas for a $100 million dam it would be $1-$2 million. Only a very small fraction of the total study expenditures is usually allocated to the financial and economic evaluations.

Compared to assessments performed on behalf of private-sector developers, once government agencies become involved directly, the perspective of the assessments tends to widen. In theory, the assessment of a project for a public-sector organisation should be performed from the viewpoint of the country as a whole, in terms of the project’s contribution to meeting national economic and social objectives. In practice, this is more likely to occur when the local sponsoring organisation itself has a broad mandate (e.g. the national planning agency). However, when the local organisation has a single focus (e.g. the power utility or the Department of Irrigation), the perspective often remains narrow.

An assessment conducted for a public-sector organisation includes the same processes and methods as those described in the previous section for private-sector developers. However, more externalities are usually considered by public-sector agencies, and those are frequently treated in more detail. There tends to be more emphasis on determining the economic efficiency, as opposed to the financial viability, of the project, although financial viability remains a prerequisite for project funding and sustainability.

10.3.3 Multilateral Agencies: The World Bank and the Asian Development Bank

The WCD survey of large dam appraisal documents of the World Bank and the Asian Development Bank appraisal documents provide a series of observations on the actual practice of the multi-lateral development banks as regards options assessment and appraisal of projects.

Options Assessment

For the sample, quantitative options assessment (or identification and analysis of project alternatives) through least cost analysis (LCA) was undertaken in 76% of the entire sample of 55 projects. All water supply projects and majority of hydropower projects (90%) were subjected to LCA, on the basis of least-cost expansion programs. In addition, a number of hydropower projects dating from the 1980s were also examined using the equalizing discount rate (EDR) as an indicator.

For irrigation and multi-purpose projects, options assessment was not as explicit. Appraisals have mainly cited the project as one of the priorities in the countries’ national/regional development plans or were subjected to needs assessment and/or various feasibility studies. Exceptions are two multi-purpose projects (China’s Zhejiang Shanxi Water Supply, 1997, and Korea’s Andong Dam Multi-Purpose Development, 1971).

Multi-criteria analysis at the options assessment stage was also performed in a few cases. One example is the Lao PDR’s Nam Leuk Hydropower Project (1996) which was selected on the basis of three main criteria: the generation cost per kWh, the lead time to commercial operation, and the environmental impact. Environmental and social impacts were also given due consideration particularly in the 1990s as evidenced by the Lao PDR’s Theun-Hinboun Hydropower project (1994) which was selected over the top-ranked Nam Theun 2 (which was itself delayed on environmental grounds because of the potential impact of its large reservoir). Also, for Nepal’s Kali Gandaki “A” Hydroelectric Project (1996), the dam height was selected to avoid inundation of the “holy rock” and bazar upstream of the river.

Other applied methodologies during options assessment include present worth analysis (Malaysia’s Batang Ai Hydropower, 1981) and levelized cost analysis (China’s Hunan Lingjintan Hydropower, 1994, and Fujian Mianhuatan Hydropower, 1995).
**Appraisal**

In the final evaluation stage of the appraisal, CBA was the main decision-making framework (75% of all projects) and is supplemented by DCF analysis (49%). The EIRR was the main decision-making criterion, with NPV and benefit-cost ratio calculated only in six projects (1989 to 1995) and two projects from the 1990s, respectively.

CBA practice was prevalent in both institutions since the 1970s (64%) and 1980s (79%). However, during this period (up to the 1980s) little effort was made to conduct proper CBA. The assumption made was that the FIRR provides a minimum estimate of the EIRR. If any adjustments were made, these concerned only the removal of taxes and subsidies, particularly with earlier projects. The Philippines’ Sixth Mindanao Power (1979) cited the difficulty in deriving conversion factors with a reasonable degree of accuracy. Moreover, since benefits were valued at tariff, the true EIRR was obviously higher than the FIRR. In the 1990s, all sample projects have been subjected to CBA. Adjustments to financial flows involving input and output distortions, transfer payments, shadow exchange rate, and shadow wage rate were more commonly undertaken.

On the other hand, DCF analysis was undertaken in only half of the sample projects, mainly for sectors involving project revenues, i.e., all sectors except irrigation. FIRR was the main decision criterion, supplemented by NPV or payback period in only a few cases. DCF analysis was more widely practiced in the ADB than in the WB, at 72% vs. 23%. In the WB, emphasis was placed more on analysis of the project owner’s financial capability to sustain operations than DCF analysis. On the other hand, DCF analysis complemented LCA in Nepal’s Kulekhani Hydroelectric project (1975) and Kenya’s Kamburu Hydroelectric project (1971) in the absence of CBA.

CBA was conducted for all irrigation projects, particularly because irrigation projects were not generally subjected to LCA. Multi-purpose projects followed at 92%. All five ADB multi-purpose projects were subjected to CBA while 86% of World Bank projects received this treatment.

Of the ADB sample, 13 out of 16 hydropower projects used both CBA and DCF for decision-making. One project used only CBA. Indonesia’s Garung Hydroelectric (1975) and Power XVIII (1983), and Malaysia’s Batang Ai Hydropower (1981) relied on DCF analysis, as the FIRR, especially if robust, was considered as the minimum estimate of the EIRR. Since the conversion of financial costs to economic costs involved only the adjustments for transfer payments and since benefits were valued at average tariffs rather than willingness to pay (WTP) estimates, the perceived marginal difference between the EIRR and the FIRR precluded efforts for a more rigorous economic analysis.

For the ADB irrigation projects, there was an explicit distinction between financial analysis and economic analysis. For Indonesia’s Sempo Dar and Irrigation (1971), economic costs also included the value of crops and properties lost due to inundation. For Thailand’s Medium Scale Irrigation Package (1981), the economic cost included the opportunity cost of incremental water diversions which was equated with the economic value of reduced electricity generation.

### 10.3.4 Public Sector Projects in Developed Countries

The assessment of a large dam or water resource project that will be built by a public-sector organisation in a developed country is typically funded by the organisation itself. Staff employed by the organisation often undertake the analysis, the resources available are frequently considerably greater than for assessments carried out in developing countries, and the data available are usually of greater quantity and better quality.

Moreover, more effective environmental and other project approval regulations usually exist, and affected groups tend to be more empowered politically, either directly or through special interest groups. Also, very importantly, there is more likely to be a prescribed process for conducting such assessments, and a quasi-independent regulatory agency is likely to be in place to ensure that the...
regulations and the process are adhered to. Under these circumstances, the project assessment is more likely to be comprehensive and transparent, and to undergo considerable independent and informed scrutiny. As a result of these factors, analysts have tended, in practice, to take a more social efficiency perspective to the economic assessment of dams in developed countries than elsewhere. However, financial viability remains another prerequisite for project viability and acceptance.

10.3.5 Practical Considerations in Project Analysis

The accuracy and usefulness of results from any particular analysis are dependent on two important and related elements. The first is the availability of data (both quantity and quality) for use in the analysis, while the second is the theoretical and practical robustness of the methods adopted to perform it. An improvement in one area without a commensurate improvement in the other is unlikely to yield more accurate and useful results than those available previously using fewer data and less sophisticated techniques. Indeed, the use of complex methods, without having correspondingly good data to support them, can produce misleading, unjustifiably credible, results which, in turn, may contribute to erroneous conclusions being drawn.

In all types of analyses (technical and economic), including those used for the assessment of large dams, practitioners must take care to match the sophistication of the methods employed with the quantity and quality of data available. Moreover, the cost of generating and gathering additional data must be weighed against the incremental improvement in the accuracy of results that can be expected.

In the assessment of dams, there is frequently an absolute data constraint to many of the methods available, and thus in practice, the methods become more ways of structuring and organising data. This becomes more evident as the analysis moves from the physical study of a dam project’s direct costs, benefits and impacts to the financial, economic and distributional assessments, and as the data have a tendency to become correspondingly less precise.

It is very appealing from the intellectual standpoint of analysts (both practitioners and academics) to develop and apply advanced scientific (engineering, physical, chemical, biological, economic and social) techniques and methods of analysis. Indeed, such basic research is absolutely essential in the long run. However, the practical use of results emanating from the application of these advanced methods depends on increased efforts being made to obtain more and better data to support them. The measurement and gathering of data are much more mundane pursuits that require stamina, patience and attention to detail.

In cases where the increased accuracy of results does not justify the additional resources (i.e. cost and time) required to obtain better data, the particular problem being addressed should not be disregarded but, rather, less direct methods need to be employed in order that the problem can be incorporated in a practical way into the decision-making process.

Current practice in the financial, economic and distributional assessments of dams varies widely. In particular, it varies depending on whether the project is being developed by private- or public-sector investment, and whether the project is located in a developing or a developed country.

The depth and breadth of these analyses performed depend also, in large degree, on the resources (time and money) made available to conduct the assessments. In general, more resources are expended if public-sector funding is being used, particularly in developed countries. However, in developing countries, the local portion of funds available from public-sector organisations for project investigations and analyses is often quite limited.

Typically, larger amounts of, and better quality, data are available in developed countries, and this fact can often influence the scope of analysis. As discussed earlier, data constraints, especially in developing countries, often do not justify the use of the sophisticated methods available since, without

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good data to support them, their application does not markedly improve the accuracy and usefulness of the results.

In all cases, the techniques used and the value of analyses carried out depend on the experience, not only of the practitioners and analysts, but also of the managers and decision-makers, involved.

It should also be noted that actual practice is not static but is always evolving. In general, in recent years, there has been a trend to broaden the scope of analyses undertaken by practitioners in response to a growing awareness of the potentially serious impacts that large dam projects can have on affected people, the environment, and the economies of the countries in which projects are located. Some recent applications of these broader approaches to a relatively few particular project assessments may not be reflected in the general review of current practice contained in this chapter.

10.4 Actual Practice: Performance and Evaluation

Evaluation of the performance of DCF and CBA can be viewed from two perspectives. From a narrow perspective it is possible to assess whether the DCFs and CBAs conducted in the preparation of dam projects provided an accurate prediction of project performance. While efforts in this regard are relatively scarce they are briefly cited below. Little effort is expended in this regard for two reasons. First, the performance of actual practice in predicting the direct costs and benefits of dams has been covered in Chapters 2 and 3 of the paper and, thus, the evaluation of the performance of CBA can be largely deduced from these earlier chapters. Second, the methodological issues associated with the use of CBA in the case of dams are only partly associated with how CBA performs in practice (i.e. what it includes) as it is the areas that CBA does not cover (in practice) that often generate the most discussion and controversy. A broader, holistic consideration of the utility and adequacy of CBA must thus be derived based on the earlier chapters in this paper and not so much from the results of formal evaluation of historical experience.

10.4.1 Experience with Evaluation Studies at the Multilateral Development Banks

In assessing the evaluation of CBAs of dams undertaken to date, the experience of the World Bank is telling. Despite being probably the single largest financier of dam projects in the post-war period the Bank did not undertake a dam-specific review of its portfolio until the mid-1990s.64 The 1996 study by the Operations Evaluation Department (OED) examined 50 large dams financed by the Bank. The desk study suggested that a reworking of the cost-benefit ratio of these projects results in only 5 (10%) being classified as clearly unacceptable. A further analysis attempted to incorporate the effects of new policies on social/environmental impacts into the analysis alongside the economic returns. The results suggested that under new Bank policies only 26% of the projects would be considered acceptable with a further 48% potentially acceptable – i.e. were economic returns are marginal to high and no major impact went unmitigated. The remaining quarter of the sample was judged unacceptable under current policies, that is the project either had a poor economic return or had adequate economic returns but was associated with a major adverse social or environmental impact.

McCully (1997) provides an extensive critique of the OED evaluation. For the present purposes it is sufficient to note that, perhaps as a consequence of being a desk study, the OED study does not draw on actual performance of the dams in its sample. While the cost-benefit ratios are based on actual construction costs, the O&M and benefit estimates are simple projections based on a series of assumptions (see McCully 1997 for a critique of these assumptions). For example, the estimate of power benefits was based on a series of assumptions about prices and power generation and not historical data. In the case of Kariba, for instance, the OED study employed a generation figure of 8,000 GWh/yr. The WCD Case Study of Kariba shows that in 38 years of production generation from the dam has never reached this figure, with an average generation from 1961-1996 of approximately 5,600 GWh/yr.

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As far as the evaluation of large dams is concerned the OED study does not actually attempt to compare predicted economic performance with actual performance. As cost-benefit ratios are the chosen form of CBA criterion for the OED study it would not be possible to actually compare the outcome of these calculations with the original CBA estimates (reported as IRRs) from the appraisal reports in any event.

In the only other dam-specific evaluation study by multilateral agencies available at the time of writing the African Development Bank reviewed its experience with 6 hydroelectric and 4 multipurpose dams (African Development Bank 1999). The relevant findings are that only four projects (3 hydroelectric and 1 multipurpose) passed both the economic and financial viability test using a 10% discount rate with one additional hydroelectric project passing only the economic test. While a number of the projects rate of return was considerably less than at appraisal it is worth noting that in four of the projects economic and financial rates of return were not determined at appraisal.

The Inter-American Development Bank (IDB) and the Asian Development Bank also have a long history of financing dam projects. While the IDB has submitted information on its portfolio of dam projects, this effort did not extend to recalculation of rates of return. In the case of the ADB a set of case studies is underway but no dam-specific evaluation is available with respect to financial and economic indicators.

**Sectoral Evaluations**

Although they do not distinguish between dam and non-dam projects, a number of sector specific evaluation studies are, however, available in the irrigation and water supply sectors from the different agencies.

A 1994 ADB sector synthesis of post-evaluation findings of 31 water supply and sanitation projects found the following:

- of the 20 projects that had an FIRR at appraisal and post-evaluation 18 projects had actual FIRRs that failed to meet projected FIRRs and 17 of these were below 10%;
- only one of the projects had an EIRR calculated at appraisal due to the difficulty of benefit measurement (projects were approved on the assumption that the EIRR would exceed the FIRR); and
- in only two cases were actual FIRRs and EIRRs calculated and in each case the EIRR exceeded the FIRR.

A similar synthesis for 57 ADB projects in the irrigation and rural development sector indicated that for 38 projects with EIRRs at appraisal and at post-evaluation indicated that 36 of these projects had lower EIRRs at post-evaluation (ADB 1995). A total of 19 projects had post-evaluation EIRRs of less than 10% and a further 13 projects had EIRRs between 10 and 12%. Financial rates of return are not calculated for these projects although the report suggests that current ADB guidelines for economic analysis are to reject projects with an EIRR below 10% and to accept those with an EIRR between 10 and 12% only where additional unvalued benefits can be demonstrated, and where they are expected to exceed unvalued costs (ADB 1997).

World Bank OED analysis provides similar results. One study shows that almost all of 129 water supply and sewerage projects reviewed had EIRRs below 10% (OED 1992 as cited in Moore and Sklar 1998 eco048). Of 21 irrigation projects approved by the Bank between 1961 and 1978, 70% had lower EIRRs at post-evaluation than at completion (OED 1990). Presumably, these projects had acceptable economic rates of return at appraisal.
WCD Review of ADB and World Bank Evaluations

Given the lack of syntheses of evaluation work on dam projects the WCD, with assistance from ADB and the World Bank, examined project appraisal, completion reports and audit reports from these two agencies. The objective was to examine not only how projects with large dam components were faring but also to compare actual versus predicted performance. The ADB only approves projects that have an EIRR over 12%, and exceptionally those with an EIRR over 10% but less than 12%. Generally-speaking a 10% EIRR serves as the cut-off rate for World Bank projects.

From the documentation on almost 30 ADB large dam projects obtained by the WCD, only a rather small sample of 13 ADB projects had both an appraisal EIRR and either a completion report or audit report EIRR (see Error! Reference source not found.). For those projects fully 85% of the projects were projected to have an EIRR over 12%. At evaluation this number had fallen to 46% with over a third of the projects demonstrating poor economic performance with EIRRs less than 10%.

Proportionately speaking the under-performance was most notable amongst irrigation projects with 4 out of the 5 projects moving from a predicted EIRR over 12% to one of less than 12% (with 3 under 10%)

Table 10.1. Economic Performance of ADB Projects with Large Dam Components

<table>
<thead>
<tr>
<th>(% of sampled projects)</th>
<th>No. of Projects</th>
<th>EIRR at Appraisal Over 12%</th>
<th>10 to 12%</th>
<th>EIRR at Evaluation Over 12%</th>
<th>10 to 12%</th>
<th>5 to 10%</th>
<th>&lt;5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Large Dams</td>
<td>13</td>
<td>84.6%</td>
<td>15.4%</td>
<td>46.2%</td>
<td>15.4%</td>
<td>38.5%</td>
<td>0%</td>
</tr>
<tr>
<td>By Sector:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>5</td>
<td>100%</td>
<td>0%</td>
<td>20%</td>
<td>20%</td>
<td>60%</td>
<td>0%</td>
</tr>
<tr>
<td>Multipurpose</td>
<td>3</td>
<td>100%</td>
<td>0%</td>
<td>33.3%</td>
<td>33.3%</td>
<td>33.3%</td>
<td>0%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>5</td>
<td>60%</td>
<td>40%</td>
<td>80%</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Note: Evaluation means either the EIRR calculated in the Project Completion Report or the EIRR calculated in the Project Performance Audit Report, whichever is most recent.

Source: ADB project documents

Despite the small sample size it is interesting to consider the average economic performance across the sectors this time comparing EIRRs at appraisal with those at evaluation (see Table 10.2). Both multipurpose and irrigation projects appear to have dropped 5% on average from appraisal to evaluation while hydropower actually increases by 3%. Examining similar data for the FIRRs shows that for the 10 projects examined, the average FIRR falls below the break-even 10% fixture. Average figures for performance of hydropower suggest little change from predicted while water supply projects display a 5% drop in financial performance compared with expected.

Table 10.2. Financial and Economic Project Performance in Terms of Internal Rates of Return: ADB Projects with Large Dam Components

<table>
<thead>
<tr>
<th></th>
<th>FIRR</th>
<th>EIRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appraisal</td>
<td>Evaluation</td>
</tr>
<tr>
<td>All Large Dam Projects</td>
<td>10</td>
<td>11.69%</td>
</tr>
<tr>
<td>By Sector:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multipurpose</td>
<td>1</td>
<td>10.10%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>6</td>
<td>11.05%</td>
</tr>
<tr>
<td>Water Supply</td>
<td>3</td>
<td>13.50%</td>
</tr>
</tbody>
</table>

Notes: Not all sectors have had FIRRs and EIRRs calculated for all dam projects, hence the number of projects are not identical for the FIRRs and EIRRs in each sector.

Source: ADB project documents

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A similar exercise was also undertaken with the World Bank appraisal documents obtained as part of the WCD Case Study program and as the sample for the WCD assessment of economic evaluation methods referred to throughout this thematic review. The results are presented in summary form in Table 10.3 and Table 10.4 for the 26 projects that had the required documentation. The findings generally substantiate the findings in the case of the ADB projects, that is, a general tendency to overstate returns at appraisal is noticed. As opposed to the ADB dataset on hydropower, the World Bank hydropower projects display a strong tendency towards overestimation of net benefits. Just over 80% of these projects are projected to have a 10% EIRR or more at appraisal, but then at evaluation the percentage of projects estimated to have returns under 10% comes in at 64%.

Table 10.3. Economic Performance of World Bank Projects with Large Dam Components

<table>
<thead>
<tr>
<th>(% of sampled projects)</th>
<th>No. of Projects</th>
<th>EIRR at Appraisal</th>
<th>EIRR at Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>over 12% 10 to 12% 5 to 10%</td>
<td>over 12% 10 to 12% 5 to 10% &lt;5%</td>
</tr>
<tr>
<td>All Large Dams</td>
<td>26</td>
<td>77% 12% 12%</td>
<td>35% 23% 31% 12%</td>
</tr>
<tr>
<td>By Sector:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>9</td>
<td>78% 22% 0%</td>
<td>44% 44% 11% 0%</td>
</tr>
<tr>
<td>Multipurpose</td>
<td>5</td>
<td>60% 20% 20%</td>
<td>60% 0% 20% 20%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>11</td>
<td>82% 0% 18%</td>
<td>18% 18% 55% 9%</td>
</tr>
<tr>
<td>Water Supply</td>
<td>1</td>
<td>100% 0% 0%</td>
<td>0% 0% 0% 100%</td>
</tr>
</tbody>
</table>

Note: Evaluation means either the EIRR calculated in the Project Completion Report or the EIRR calculated in the Project Performance Audit Report, whichever is most recent.
Source: World Bank project documents

Table 10.4. Financial and Economic Project Performance in Terms of Internal Rates of Return: World Bank Projects with Large Dam Components

<table>
<thead>
<tr>
<th></th>
<th>FIRR</th>
<th>EIRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Projects</td>
<td>Appraisal</td>
</tr>
<tr>
<td>All Large Dam Projects</td>
<td>3</td>
<td>13.92% 9.88%</td>
</tr>
<tr>
<td>By Sector:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Multipurpose</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Hydropower</td>
<td>3</td>
<td>13.92% 9.88%</td>
</tr>
<tr>
<td>Water Supply</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Not all sectors have had FIRRs and EIRRs calculated for all dam projects, hence the number of projects are not identical for the FIRRs and EIRRs in each sector.
Source: World Bank project documents

The following 3 figures present the results on a project-by-project basis as an alternative way of understanding the comparison. Again, the observation that emerges is that the lines representing each of the projects are more often than not downward sloping (from left to right), indicating overestimated returns at appraisal for this sample of World Bank dam projects.
Figure 10.1. EIRRs at Appraisal and Evaluation, 9 World Bank Irrigation Dams

Source: World Bank project documents

Figure 10.2. EIRRs at Appraisal and Evaluation, 5 World Bank Multi-Purpose Projects

Source: World Bank project documents
Combining the data from World Bank and ADB projects with figures from the 8 aforementioned AfDB projects into a single graphic yields an overview of the changes in project EIRR from appraisal to evaluation for 47 large dams projects. In overall terms, the shift in distribution of the projects by their expected EIRRs from appraisal to a few years following construction is considerable. Prior to initiation some three-quarters were projected to have returns over 12%. Following completion, recalculated EIRRs suggested that over 60% of the projects would come in at less than 12%, and almost half of the 47 projects were projecting returns less than those ‘required’ at the outset.

Conclusions on Evaluations

The indicative conclusion that can be drawn from available synthesis of dam and sector-specific evaluations, as well as the synthesis of post-evaluation studies undertaken by WCD, is that poor cost recovery and economic performance is endemic to multi-lateral development bank projects in these
sectors and, therefore, probably to dam projects in these sectors. Further, it appears that the net effect of the methods applied at appraisal was to overstate the net benefits of these projects. These results are not unique to ADB. In Box 10.1 a number of distortions in the project process that lead to such poor performance are provided as penned by two senior economists.

**Box 10.1. A Perspective on Low Rates of Return from Water Projects in Developing Countries**

Water projects in less developed countries (LDCs) frequently are poorly operated and maintained. As a result, project benefits and development impacts fall short of plans. The problems begin in the project identification, design, and construction stages: donor and host country biases lead to inappropriate projects, unsustainable technologies, and shoddy construction. Later, operation and maintenance are then difficult or impossible. Causal factors include donor desire to build monuments and sell technology, provision of excessive capital to favored sectors or institutions, and an unwillingness to require a reasonable quid pro quo from the host country. Host country factors include excessive administrative centralization, lack of rewards for good operation and maintenance, and widespread corruption in forms that seriously distort allocative efficiency. Until individual actors on both sides can be motivated to pursue the long-run good of the LDC, Third World water projects will continue to have low or negative net payoffs.

Source: Verbatim abstract from Howe and Dixon (1993 eco062)

In terms of the failure for actual economic results to live up to those predicted at the outset, the general tendencies to understate direct costs and over-estimate benefits and some of the proximate causes were noted earlier in Chapters 2 and 3. Again, critics suggest that these tendencies are not limited to developing countries, but prevail in developed countries. For example, in the USA large water resource development agencies such as the Bureau of Reclamation appear to have the same difficulties in correctly estimating costs and benefits of water projects, including dams (Young 2000, eco066).

While the focus of this section has related to the performance of methods and projects as viewed from inception through to completion it is also interesting to note one example of the use (or non-use) of CBA during project operations, specifically at the relicensing stage. In 1997 the Hydropower Reform Coalition sponsored a review of 91 relicensing applications for private hydropower projects as conducted by the US Federal Energy Regulatory Commission (FERC). As part of the relicensing process FERC staff carries out an economic analysis of the project based on alternative costs of power and the costs of mitigation measures that need to be implemented. In 40% of the cases reviewed the projects had a net negative value when proposed mitigation measures were included (Marcus 1997). However, as FERC does not use project economics as a decision criterion, hydropower project licenses are approved for renewal without regard to whether they represent a net negative cost to the economy. For example, the Enloe Dam in Washington was relicensed in 1996 even though its forecast project cost of 54 mills/kwh was almost twice that of the alternative cost of power to the licensee of 28 mills/kwh (Marcus 1997).

### 10.4.2 Adequacy of CBA for the Evaluation of Dam Projects

The question that remains is to what extent CBA is both a necessary and sufficient means of evaluating the net impacts of a dam project on the economic welfare of society. The calculation of the decision-making criterion (whether net present value, internal rate of return, cost-benefit ratio, etc) in a CBA represents the application of the methods covered in Chapters 2-6 of this paper: the valuation over time of the costs and benefits of a project. Drawing on the conclusions of these sections, as well as the above discussion of the performance of CBA in dam projects and the water sector, the adequacy of CBA as currently practised can be questioned on the following grounds:

- projections of project costs are systematically understated;
- long-term operations and maintenance costs are understated;
decommissioning costs are not included;
- social and environmental impacts are not valued explicitly or are only indirectly accounted for through mitigation or resettlement budgets;
- difficulty in estimating the price responsiveness of outputs from large (non-marginal) projects;
- difficulty in predicting inter-annual volatility of hydrological flows, growth in demand and final design capacity (hydropower, irrigation and other benefits);
- difficulty in predicting market conditions and farmer behaviour over time (irrigation benefits);
- social discount rates employed are too high;
- sensitivity and risk analysis is inadequate; and
- the effect of uncertainty and irreversibility of investment is ignored.

In other words, the historical and actual practice of dam project appraisal often violates the conditions under which it could, in theory, provide a reliable measure of the change in economic welfare of a dam project. It is worth emphasising that it is not a foregone conclusion that the net effect of fixing all of these problems would be to lower the economic profitability of dams. As shown in Table 10.5 a number of these weaknesses of CBA may lead to understatements of the net project benefits. At the same time, it is clear that quite a number of the weaknesses can have important impacts in terms of lowering net project benefits.

Table 10.5 also suggests that there is a general lack of progress on a number of the weaknesses that are identified. These suggest that CBA continues to provide only an incomplete picture of the net welfare effects of dam projects.

There are a further series of ways in which decision-making is handicapped by an over-reliance on CBA and (implicitly) the pursuit of welfare maximization where dams have other (or additional) objectives:

- CBA does not examine wider economic impacts
- CBA does not explicitly set forth who gains and who loses from a project

Although CBA may contribute to the analysis of macroeconomic and regional impacts, as well as to distributional analysis, it is not designed for this purpose. Given the continued “partial” ability of CBA to capture even the extent to which efficiency objectives will be achieved and that equity, macroeconomic and purely non-economic objectives are often integral objectives of water resource development projects, CBA alone is not a sufficient basis for the evaluation of dam projects. This finding echoes the general conclusion of a panel of experts as reported in Box 10.2.
### Table 10.5. Summary of Weaknesses of CBA and Potential Implications for Net Benefit Calculations

<table>
<thead>
<tr>
<th>Weaknesses of CBA</th>
<th>Existed Prior to 1990s</th>
<th>Current Status</th>
<th>Basis</th>
<th>Likely Effect on Applicability of Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project costs understated</td>
<td>Often</td>
<td>No change</td>
<td>Empirical Data from Agencies and Secondary Sources</td>
<td>overstates systematically</td>
</tr>
<tr>
<td>Decommissioning costs not included</td>
<td>Always</td>
<td>No change</td>
<td>Agency guidelines, secondary Sources</td>
<td>marginal to important</td>
</tr>
<tr>
<td>Failure to account for price impacts of large projects</td>
<td>Often</td>
<td>Little change</td>
<td>WCD Case Studies, WCD Review of Bank SARs</td>
<td>marginal to important</td>
</tr>
<tr>
<td>Economic benefits of hydropower under- and overstated</td>
<td>Yes</td>
<td>Improved</td>
<td>WCD Case Studies, secondary sources</td>
<td>marginal to important</td>
</tr>
<tr>
<td>Economic benefits of irrigation overstated</td>
<td>Yes</td>
<td>No change</td>
<td>WCD Case Studies, post-evaluation studies, secondary sources</td>
<td>marginal to important</td>
</tr>
<tr>
<td>Social and environmental impacts not incorporated through mitigation</td>
<td>Often</td>
<td>Much improved</td>
<td>WCD Review of Bank SARs, WCD Case Studies</td>
<td>marginal to important</td>
</tr>
<tr>
<td>Social and environmental impacts are not valued explicitly</td>
<td>Always</td>
<td>No change</td>
<td>WCD Review of Bank SARs, WCD case studies, secondary sources</td>
<td>important</td>
</tr>
<tr>
<td>Social discount rates employed too high</td>
<td>Yes</td>
<td>No change</td>
<td>Theoretical argument, secondary sources</td>
<td>probably understates</td>
</tr>
<tr>
<td>Sensitivity analysis inadequate</td>
<td>Yes</td>
<td>Improved</td>
<td>WCD Case studies, WCD Review of Bank SARs</td>
<td>na</td>
</tr>
<tr>
<td>Effects of uncertainty and irreversibility ignored</td>
<td>Always</td>
<td>No change</td>
<td>Theoretical argument, empirical data from secondary sources</td>
<td>important</td>
</tr>
</tbody>
</table>

Notes: In the column on historical experience the approximate frequency of the weakness is indicated where known (using always, often, at times, rarely, never) otherwise “yes” is indicated where the weakness is known to have occurred.
Box 10.2. Recommendations on CBA from a Blue-Ribbon Panel of Economists

In 1996 a select group of eleven leading US academic economists (including a senior economist from the World Bank) provided the following eight principles on the appropriate use of CBA with respect to environmental, health and safety regulation:

1. CBA is useful for comparing the favourable and unfavourable effects of policies.
2. Decision-makers should not be precluded from considering the economic costs and benefits of different policies in the development of regulations and agencies should use this analysis to help set priorities.
3. CBA should be required for all major regulatory decisions.
4. Although agencies should be required to conduct CBA for major decisions and to explain why they have selected actions for which reliable evidence indicates that expected benefits are significantly less than expected costs, those agencies should not be bound by strict cost-benefit tests.
5. Benefits and costs of proposed policies should be quantified wherever possible. Best estimates should be presented along with a description of the uncertainties.
6. The more external review that regulatory analyses receive, the better they are likely to be.
7. A cores set of economic assumptions should be used in calculating benefits and costs. Key variables include the social discount rate, the value of reducing risks of premature death and accidents, and the values associated with other improvements in health.
8. Although CBA should focus primarily on the overall relation between benefits and costs, a good analysis will also identify important distributional consequences.

The authors conclude that “although formal benefit-cost analysis should not be viewed as either necessary or sufficient for designing sensible public policy, it can provide an exceptionally useful framework for consistently organising disparate information, and in this way, it can greatly improve the process and, hence, the outcome of policy analysis.”


Notwithstanding its numerous shortcomings, CBA is likely to remain an important component of the decision-support system for dam projects. DCF will obviously continue as the principal tool in financial analysis as it deals adequately with the initial financial assessment of a project from the point of view of both private- and public-sector owners. In terms of its use in examining direct costs and benefits of projects CBA can still be an important tool in providing project stakeholders with the data on expected costs and benefits that is necessary to understand the distribution of the economic costs and benefits of a project across different societal groups. Where external impacts of projects can be monetised in a generally acceptable and useful way these may also be integrated into a CBA. However, an alternative approach must be found to incorporate those impacts that cannot be monetised easily or accurately, including many social/distributional and environmental impacts, into the assessment process to the satisfaction of those affected. One such approach, multi-criteria analysis is discussed below.

As stated by Arrow et al (1996) the chief strength of cost-benefit analysis is that it provides an explicit, systematic approach to data organisation and analysis for evaluating the net benefits of a project. While individuals implicitly weigh the costs and benefits of options in making decisions, CBA makes this process explicit by organising information into cost and benefit categories and, where possible, estimating values. Ultimately, the information provided through these analyses provides stakeholders and those who have decision-making authority with a stronger basis from which to assess not only the profitability of project options and alternatives, but other concerns such as affordability and distributional impacts. Thus, it would be foolish to simply abandon CBA. Rather a more judicious use of CBA with respect to least-cost analysis may be called for and both these
techniques should serve as inputs into a wider analysis that accommodates a number of objectives and criteria.

10.5 An Alternative: Multi-Criteria Analysis

Multi-criteria analysis is a technique that allows the various impacts of a project, described in different sets of units, to be integrated and compared. For example, the direct costs and benefits of a project, measured in money terms, can be compared with the associated environmental and socio-economic impacts measured, for instance, in tonnes of sulphur dioxide emissions, hectares of land inundated, number of people displaced involuntarily, measures of income distribution, etc.

The technique also allows trade-offs among the various project costs, benefits and impacts to be evaluated. For example, increasing the height of a hydropower dam to create more storage and streamflow regulation will, in addition to adding to the project’s cost, increase its power benefits by a certain number of kilowatt-hours of energy each year. However, this, in turn, might have an adverse impact on a downstream wildlife habitat, measured perhaps in terms of the numbers of animals or birds using it annually. The net (money) benefits associated with progressively heightening the dam can be compared directly against the increasingly negative impact on the habitat.

Multi-criteria analysis requires consultation with decision-makers and stakeholders, although the degree of participation by the various groups involved can vary. On the one hand, it can be relatively “expert”-driven, with only limited inputs from decision-makers and selected stakeholders, while on the other hand, it can include a full participatory, negotiation process.

The main purpose of applying multi-criteria analysis is that, by using this transparent analytical technique, and through an on-going, effective consultative process involving all affected groups, it will be easier for stakeholders to consider their positions more openly and objectively, particularly when it comes to observing the explicit trade-offs of costs, benefits and impacts among different options and within different configurations of the same project. Where stakeholders are not the ultimate decision-makers it will also assist those with decision-making authority to reach conclusions on whether or not a project should proceed, and on what the scale of the project should be. At the same time the stakeholders themselves will possess the results of the analysis and may use it to lobby their representatives or to criticise decisions that are taken contrary to the results of the analysis.

To date, this technique has been applied in project assessments of dams in only a few instances, and the details of how it can be effectively practised on a wider scale, and within a range of contexts, still have to be fully explored. The topic of multi-criteria analysis is covered in more detail in the WCD Thematic on Planning Approaches. It is briefly presented in the box below in order to enable the ensuing discussion of how financial, economic and distributional analysis can be incorporated into multi-criteria analysis. At the end of the sub-section a good practice example is presented from Nepal.

10.5.1 A Brief Outline of Multi-Criteria Analysis

This section presents, by way of demonstration, a simple outline of the application of one (expert-driven) form of multi-criteria analysis.

The first step is to define a number of impact “accounts” that are used to sub-divide the various broad types of technical analyses. In its simplest form, such accounts would be: 1) direct costs and benefits, and 2) environmental and socio-economic impacts.
Within each impact account, a number of “indicators” (groups of similar impacts) are selected in consultation with decision-makers and stakeholders. Each indicator is used to measure the performance of the project, or of the project option, with respect to one of the national policy and/or project objectives defined earlier.

Within each account area, technical specialists conduct analyses in order to measure the magnitude of the annual impacts attributable to the project with respect to each indicator.

For each indicator, in each account, the present value of annual impacts is computed using an appropriate discount rate. Decision-makers and stakeholders should be involved in selecting the discount rate to be used. The computed present value for each indicator is referred to as its “score”. Where several options are being considered, the set of scores for each indicator usually has to be normalised to ensure that the scores for all indicators fall within a common range.

In consultation with decision-makers and stakeholders, a set of relative “weighting factors” for the indicators within each impact account is defined. The weighting factors describe the relative importance that interested parties place on each indicator (or national/project objective). Within each impact account, the sum of the indicator weighting factors is usually set to equal 100 percent. That is, if the relative weight of one indicator is changed, there must be a compensating change made to at least one of the other indicators.

For each impact account, an account “index” is calculated by multiplying the corresponding indicator scores and weighting factors, and adding the products.

Again, in consultation with decision-makers and stakeholders, a set of relative “weighting factors” for the impact accounts is selected. The weighting factors describe the relative importance that interested parties place on each account (e.g. direct cost and benefits; and environmental and socio-economic impacts). Again, the sum of the account weighting factors should equal 100%.

A “composite index” is then calculated by multiplying the corresponding account indices and weighting factors, and summing the products. The composite index describes the total, integrated impact of a project in terms of a single number. Conceptually, the composite index is equivalent to the net present value that is computed in a conventional cost-benefit analysis. If several options are being studied, it is usually convenient to normalise the composite indices in order to facilitate the comparison of options.

Any options under consideration can be compared and ranked directly on the basis of their corresponding composite indices, in a similar way that, in a CBA, options are compared in terms of their net present values.

A sensitivity analysis can be performed in which the effects of changes in the values of the key variables can be observed in terms of changes in the overall result.

More importantly, different sets of weighting factors, representing alternative views of the relative importance placed on the indicators and on the impact accounts, can be investigated and the corresponding results of the multi-criteria analysis compared. Each stakeholder can readily observe the effect on the results of the analysis of him or others changing the sets of weighting factors that are applied.

The multi-criteria analysis approach can also accommodate “scenario” analysis, where a scenario represents a particular view of the future. In practice, a scenario comprises a set of assumptions used in the analysis that concern factors that are wholly, or largely, outside the control of dam project decision-makers. These factors might include future government polices, population growth, the
magnitude and type of economic growth (both nationally and internationally), the demands and prices for project inputs and outputs, and the behaviour of consumers and producers. The differences in the results of the multi-criteria analysis for the different scenarios considered can be measured and compared.
**Box 10.3. Good Practice: Multi-Criteria Analysis: An Example from Nepal**

| Nepal’s Medium Hydropower Study Project (MHSP, 1997) is an integral part of His Majesty’s Government of Nepal’s (HMGN) efforts to ensure an adequate number and an appropriate mix of hydropower projects in the project development pipeline to meet power supply requirements in Nepal in a timely, cost-effective, and environmental-friendly manner. MHSP is divided into 3 phases. Phase I involves a screening and ranking (S&R) exercise to identify a number of hydropower projects suitable for further study or development as medium-term power supply options for domestic needs. Phase II consists of feasibility and EIA studies for recommended sites resulting from Phase I. Once Phase II is completed, the Nepal Electricity Authority (NEA) will undertake generation expansion and system planning studies. Based on the results, 2 projects from the “project basket” will be selected to proceed to detailed design under Phase III of the MHSP.

Methodology. The selection and ranking of hydropower sites in the 10-300 MW capacity range is based on: (i) an update of the nationwide inventory of sites suitable for medium-scale hydropower projects; (ii) a two-stage review of the technical/economic and environmental/social parameters of potential projects for the sites, and recalculation of parameters on a consistent basis; (iii) use of technical/economic and environmental/social screening and ranking criteria developed in a consensus-reaching process; and (iv) provision of open consultation and information sharing with government stakeholders, the professional community, NGO’s and the general public on each step in the S&R process. A key aspect of the information dissemination and consultation plan was the establishment of an Inter-Government group. The main reason for arranging consultation with HMGN stakeholders at important stages of the screening and ranking process was to build a broad consensus on the process and ultimately the selection of projects for feasibility study.

Coarse project screening of 138 medium-scale projects in the MHSP project inventory was based on the following agreed criteria: (i) exclusion of multipurpose projects as such projects are studied by other government agencies; (ii) exclusion of potential hydropower projects for various reasons with serious technical concerns, a high degree of remoteness, or significant environmental concerns; (iii) selection only of representative projects for river cascades utilising coarse screening parameters for technical, economic and environmental criteria and (iv) exclusion of projects already at feasibility level of study or higher. This screening process left 44 sites to be investigated in the next coarse screening stage.

Each of the 44 sites were then assessed in greater detail, and ranked from both technical/economic and environmental/social perspectives based on project scores resulting from the application of a set of coarse ranking criteria. Two composite preference scores were calculated for each project: (i) the technical/economic preference score (CTPS), and (ii) the composite environmental/social preference score (CEPS). These scores were then plotted in a preference ranking matrix.

Based on the coarse screening exercise, 24 sites were recommended for fine screening and ranking. This consisted of site visits and field program, fine screening, and fine ranking. The technical analysis focused on the incorporation of the results of the survey work and field programs to update and revise the project layout and parameters, and subsequently score the projects by the fine technical/economic ranking criteria, covering: (i) project layouts, (ii) cost estimates, (iii) energy estimates, (iv) levelized energy supply cost, (v) project risk, and (vi) system fit. Under the environmental/social analysis, the projects were assessed on qualitative (physical environmental impacts, biological impacts, and social impacts) and quantitative (mitigation, enhancement and monitoring costs) factors based on the site visits. In addition to the 24 unlicensed sites, 7 sites where survey licenses have been awarded to public and private developers were assessed. Project scores were then plotted into a preference ranking matrix.

Based on the fine screening exercise, 7 sites (as well as 4 reserve or alternate project sites) were recommended for full feasibility and EIA study (under Phase II) and submitted for government and public consultation.


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10.6 Policy Considerations and Economic Criteria

10.6.1 Financial DCF Analysis vs Economic CBA

It is not unusual to find that the analytical results from the financial and economic analyses of a large project differ. Even if the results demonstrate that the project is both economically efficient and financially viable, the distribution of costs and benefits among those affected might not contribute sufficiently to stated social policy goals, such as poverty alleviation and income distribution, to justify the project.

The analyses of a project from the various perspectives should be viewed as complementary. In other words, for a project to be sustainable, in addition to being both economically efficient (from the viewpoint of society) and financially viable (from the viewpoint of the project owner, either public or private), it must contribute in an overall positive way to social goals, and it must adequately compensate those who are negatively affected. Although a project may not contribute directly to social goals, it may contribute indirectly by producing economic growth, the gains from which can be applied to the pursuit of social objectives. In conclusion, to be selected for implementation, a project must be attractive from all three perspectives.

This statement, however, sidesteps a thorny issue related to financial DCF vs economic CBA. The extent to which a given project is financially viable depends not only on market prices and conditions but also on government policy and regulation in effect. A basic premise of economic CBA and ‘public economics’ is that what may be attractive from the perspective of an individual or firm may not be optimal when viewed from the perspective of the economy as a whole. Ideally, the function of public policy is to encourage the pursuit of the latter. Whether there exists sufficient incentive for the private sector to invest in publicly beneficial projects thus becomes an important question. As does understanding when the private sector may have a (perverse) incentive to invest in projects that are not economically efficient.

As the financing of large infrastructure projects such as dams is increasingly shifted to private capital (Ljung 2000) it is not sufficient to merely repeat that projects must be both financially and economically viable. What happens if a project is economically viable but is not financially attractive, or not ‘financeable?’ Purely private sector projects are of course rarely, if ever, required to undertake an economic analysis. Instead it is assumed that if the project is profitable in financial terms it must be worth undertaking (Simon 1999 eco053). How does this situation change as projects that were previously considered to be in the ‘public’ interest and, indeed, may lead to the production of public goods and bads, move into the private capital markets? In reality, many privately financed hydropower projects, for instance, are not exactly paragons of market virtue. Planning for these projects involves the allocation of a resource that is often public in nature (i.e. water and rivers) and in many countries the project simply sells the output – power – back to a government or regulated utility. How much is paid for the power produced will largely determine the financial attractiveness of the project.

In such cases, the correct decision criterion for society remains that of economic CBA or, as recommended above, a multi-criteria approach that contains economic analysis. Failing a perfect regulatory framework (and enforcement of such) a development strategy based on selecting the projects that are most easily financed by the private sector is not likely to lead to optimum results for the economy. This is particularly likely where public policy serves private interests and not public interests (i.e. corruption).

The difficulty, or pinch, of course is that in some situations governments are no longer in the position of being able to provide incremental finance – whether in the form of advantageous output prices,
direct subsidies, tax relief, etc – that is required to finance projects that have important public benefits. At the other end of the portfolio of projects, effective regulation – whether environmental or social – is of course required to ensure that projects that are financially attractive but promise significant negative externalities (or public bads) are discouraged. While the issues involved in any single case are complex and involved, the proscription is simple and unchanging, and the remedy will consist in large part of the intelligent and participatory application of economic methods.

10.6.2 Internalising Externalities: DCF vs CBA

The general trend in practice is to force large dam projects to internalise undesirable effects through stricter planning guidelines and government regulations on construction and operations. For example, the need to preserve downstream flows at a minimum acceptable level is increasingly accommodated by regulations on Environmental Flow Requirements (EFRs). The EFR is an attempt to mitigate an environmental impact by compelling dam owners to ensure minimum flows during critical low flow periods. The end result is that the dam owner cannot optimise reservoir releases with a single-minded emphasis on, say, power production. Compared to the situation without the EFR, the owner loses revenue with the EFR and the project is made financially less attractive from the owner’s perspective.

In an ideal world all social and environmental effects – both positive and negative – would be perfectly regulated and the costs and benefits of the project as internalised by the proponent would be equal to the actual economic costs and benefits of the project. In such an ideal world it would not be necessary to undertake CBA in order to determine whether a project generates net economic returns to society and therefore worthy of approval or public support. Public decision-makers could rely on their regulations to do this work for them, through the medium of DCF analysis undertaken by prospective proponents.

However, the reality is that our knowledge of how to mitigate or compensate for the environmental impacts of large dams is still in its infancy (Dugan 2000). Ability to mitigate and compensate for social impacts such as resettlement is better but still limited (See the WCD Thematics on Social Issues). Further, social and environmental regulation are rarely driven by the objective of attaining an optimal level of regulation from an economic perspective: that is the point where an additional unit of mitigation will cost society more than it will benefit society. Instead regulation is typically driven by the need to try and meet specific targets, as developed by non-economists and determined on the basis of biophysical, equity or social grounds. Or in perverse cases it is not driven by a sense of public interest at all.

An important omission from discussions of the possibility of internalising all externalities through regulation is the role of the discount rate in DCF and CBA. Discussed earlier in the paper, the discount rate employed by the private sector is typically higher (16-18%) than that employed by the public sector (8-12%). Further, many economists argue that for economic analysis the rate should used should be much lower still. Thus, the simple act of internalising previously unaccounted costs or benefits into a DCF by the private investor does not guarantee that the results of a DCF will lead to the same project selection as the application of CBA. The relevance of this point in the case of dam projects will of course depend on whether it is expected that the higher private sector discount rate will make the project more or less profitable as compared to the economic analysis. Those who point to the long-lived benefits and low operational costs of dams would suggest that a higher interest rate makes dam projects less attractive. In such a case the presumption might be that other things equal the private sector will tend to underinvest in dams and that regulation would just exacerbate this tendency.

While these points on discounting are discussed in further detail in Chapter 5 it suffices to say at this point that even in the presence of optimal regulations on social and environmental impacts, there is no guarantee of achieving optimal economic results based merely on the private sector acting on its own
analysis of the financial attractiveness of the available options. This is the case regardless of whether the impending result would be an overinvestment or an underinvestment in dams.

Thus, it is clear that the idea that all externalities can be easily internalised through regulation is far from the case with large dam projects. From a purely economic perspective the decision by a private investor to take on a dam project will not necessarily serve as evidence either that the economic benefits of the project outweigh its economic costs, or that the economically superior option has been chosen. At the same time, as documented in this paper the ability of economic analysis to correctly value all impacts is also constrained. In sum, there is no perfect methodological solution to the difficulty of ensuring that only the most economically profitable projects are selected. Instead, it is likely that a mix of regulations that internalise externalities and the application of CBA will continue to be necessary. Given the imprecision in this regard, the suggestion of expanding the decision criteria to include other non-economic criteria explicitly in the planning and evaluation process – as well as opening up the process to not only potential beneficiaries but those potentially negatively affected by a project – should be viewed as a means of improving the transparency of the process and, hence, improving the credibility of the outcomes.

10.7 Findings and Recommendations

Findings with regard to political economy of large dams and economic decision-making include:

- decision-making on dams is a political process and thus decisions are made on the basis of political considerations and economic information, although in the case of very large dams national interest as construed by authorities often supersedes economic data;
- the economic character of the river environment as a largely public resource as well as the character of large energy and water transmission and distribution systems as natural monopolies have led many societies to treat dams as part of the large scheme of public provision and production of water and energy services; and
- while firm statistics are impossible to obtain, it is clear that political considerations and economic interests as manifested at the level of institutions involved in the planning process for large dams have influenced the economic evaluation as undertaken by staff and consultants.

Previous chapters discussed the application of traditional methods of economic analysis to large dam projects in their component parts. This chapter examines actual practice with respect to economic decision-making criteria and examines the use of financial discounted cash flow analysis (DCF), least-cost analysis (LCA), and economic cost benefit analysis (CBA). These have traditionally been employed in project evaluation, reflecting a purely economic approach to appraisal. Assessment of actual practice yields the following findings on actual practice:

- options assessment using LCA appears in the case of hydropower but not in the case of irrigation and water supply;
- with respect to appraisal hydropower project decisions often rely on LCA supplemented by CBA, whereas irrigation relies on CBA and water supply on DCF;
- what little historical performance data is available suggests that the results from CBA have tended to over-exaggerate the net returns from large dams project; and
- there have been virtually no long-term evaluation studies of the net economic benefits of large dams.

Adding to these results the implications derived from previous chapters of this thematic review in terms of the adequacy of CBA yields the following conclusions.
the historical and actual practice of dam project appraisal often violates the conditions under which it could, in theory, provide a reliable measure of the change in economic welfare of a dam project and

CBA and (implicitly) the exclusive pursuit of welfare maximisation may be inappropriate where dams have wider economic or distributional objectives.

Based on the analysis of these findings the following principles can be offered:

- multi-criteria analysis (MCA) provides an attractive alternative to an exclusive focus on CBA in project decision-making support;
- as private sector participation in large dams increases the role of MCA (and CBA) remains critical to the definition of optimal project selection from the perspective of society;
- conversely the ‘financeability’ of a large dam project should not be allowed to drive its selection; and
- while regulation of external impacts of dams projects is a necessary and important component of public policy, these should be viewed as complementary to reasoned, transparent and participatory economic analysis not as a substitute for such.
11. Conclusions

This paper has reviewed the application of financial, economic and distributional analysis to the case of large dams. The review begins with the direct costs and benefits and then turns to the social and environmental external impacts of large dams. From there the discussion turned to how these flows are evaluated over time and under uncertainty. Spreading the net wider, the paper then examined the analysis of the wider economic impacts of dams and their distributional consequences. Finally, the paper examined decision-making methods and criteria.

The two principal findings of the paper are:

• that the economic analyses carried out in evaluating large dam projects have all too often failed to accurately predict the costs and benefits of these projects and
• that these analyses have often been too narrow in terms of the types of economic impacts and risks considered, and in terms of promoting an understanding of who gains and who loses from a project.

The paper thus proposes both a broadening and a deepening of what passes for economic analysis in large dam projects. Financial and economic analysis of the social and environmental impacts of large dam projects needs to be expanded and the risks, uncertainties and irreversibilities these entail for specific stakeholder groups needs to be assessed. This broadening of the analysis also leads to the need to incorporate non-economic indicators into the analysis. This should be done through the opening up of the decision framework and analysis to account for multiple objectives and multiple criteria.

But broadening by itself is not sufficient. The analysis must be deepened by making it more participatory and transparent. Only by involving stakeholders in the process can the broadening lead to meaningful results. Within a broad multi-stakeholder, multi-criteria analysis the financial, economic and distributional analyses need to be an integral part of the overall evaluation process. Economic analysis would serve not as the dominant factor as in the past, but as both a contributor of specific pieces of information and a means of synthesising and drawing together information into a common format and numeraire. By first broadening the scope of the analysis and then deepening the understanding of the impacts and their potential importance through a participatory process the analysis can do ‘more with less.’

This requires, however, a dedication on the part of not only the analysis but the proponents of the projects and the larger group of stakeholders to work together to systematically screen and rank priority areas for analysis. While the narrow, immediate objective is to enable the analysts to penetrate quickly to the key questions that require the investment of time and resources in data collection, modelling and analysis, the larger objective is to enable stakeholders to learn (alongside the analyst) about the proposed plan or project. In this manner, the product of the economic analyses becomes not just the appraisal document but an informed stakeholder group that can work through the multi-criteria analysis in an informed and confident manner. In this regard, the pressure for the economist to always produce quantitative results lessens somewhat. Qualitative assessment and argument will also serve to nourish a participatory, multi-criteria process.

Envisioning such a transition to multi-stakeholder, multi-criteria processes as the means for arriving at decisions on the selection of alternatives and of projects to meet needs for water and energy resources clearly implies a large number of challenges for economic analysis and economic analysts. For this reason the paper has made every effort to highlight good practice (whether emerging or of longstanding). The paper suggests that techniques and methods are there and, increasingly, the skills are widely available. However, the slow pace in the uptake and application of these in practice...
suggests that there is a need to speed up the transition. First, economists with the necessary methodological skills – both academic and professional consultants – need to be brought into project work to revitalise ‘project economics’ as it often exists in the context of large dam projects. Second, there will be a need for strengthening the ‘people-management’ side of the training of new and existing economists and engineers-cum-economists. Of course, conducting economic analysis and managing a stakeholder process do draw on different skill-sets and, thus, there will be a continued need for integrated, multi-disciplinary teams. Finally, as the merits of independent review are increasingly recognised, it is vital not to forget that this applies with equal importance to the economic analysis must be strengthened.
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Endnotes


2 Furthermore, adding capacity in the hydropower sector in India has not proceeded as targeted; only 27% of the planned capacity for 1992-1997 (the Eighth Plan Period) was installed (Sant et al. 1998 eco013).


4 Note that the cost of replacing the power supply is not included as a cost of decommissioning as that would double-count this cost. Whether the avoided costs of alternative power supply is considered a benefit of relicensing or a cost of decommissioning does not affect the result.

5 The establishment of legal, tradeable rights for water abstraction is part of the increasing trend towards increasing efficiency in resource use through private participation in the management of water resources.

6 Muller (1999 ecowebo8) argues that too little attention is paid to the valuation of positive externalities resulting from a secure water supply as provided by dams.

7 Please note that the question of whether externalities are included in the project analysis is distinct – conceptually and practically – from whether the externalities are internalised once the project is approved (i.e. in terms of whether the project accounts for these through minimisation, mitigation or compensation activities).

8 The reader is referred to the WCD Thematics on Social and Environmental Issues for thorough reviews of these impacts.

9 These impacts are chronicled in the WCD Thematic on Displacement, Resettlement, Reparations and Development.

10 For more on these impacts readers should consult the WCD Thematics on Dams, Ecosystem Impacts and Restoration; Dams and Global Change; and Electricity Supply and Demand Side Management Options.

11 Aylward and Echeverria (In press) provide a counter example as discussed later in this Chapter.

12 Amongst these are ADB (1996); Belli et al. (1998); Convery (1995); Dixon et al. (1986); Dixon et al. (1994); Munasinghe and Lutz (1991).

13 The concepts of consumer and producer surplus are discussed in more detail in Technical Annex 4.


15 Economists use many different terms to refer to intrinsic values, including non-use value, existence value, and passive use value. For more information on the economic analysis of intrinsic values, see Kopp and Smith (1993).

16 For more information on the contingent valuation method and survey techniques see Technical Annex 7 and associated references.

17 For a comprehensive critique of CV see Diamond and Hausman (1993).

18 See IIED (1997) for an overview of participatory approaches to valuation and, for examples, see Adaya et al. (1997), Bishop and Scoones (1994) and Campbell et al. (1995).

19 The discount rate is used to calculate a discount factor that is in turn multiplied by costs and benefits to bring them to a net present value. If the discount rate is \( r \) then the discount factor \( f_t \) in time \( t \) will be \( f_t = \frac{1}{(1+r)^t} \) and the net present value of a stream of costs, \( C \), and benefits, \( B \), from \( t=1 \) to \( T \) will be \( NPV = \sum_{t=1}^{T} f_t (B_t - C_t) \).

20 In a similar fashion the use of the internal rate of return methodology with a lower discount or “hurdle” rate increases the chance, for example, that a project with long-term benefits will be judged as profitable.

21 According to Lind (1982) those present were asked what their best estimate of the appropriate rate would be and the answers ranged from 2-4% (based on the real rate of return on long-term bonds) to 20% (based on short-term cost of credit).

22 See Portney and Weyant (1999) for a recent compilation on this topic based on a workshop held by Resources for the Future.

23 Witness two World Bank efforts from the same time period. Gittinger’s (1982: 314-315) second edition of the original 1972 “standard text” on economic analysis of agricultural projects states: “for economic analysis using efficiency prices . . . probably the best discount or cut-off rate to use is the ‘opportunity cost of capital,’” and then goes on to say: “when social weighting is used, two other discount rates become important, the accounting rate of interest and the consumption rate of interest. Since the analytical system presented here is based on
efficiency prices only, these rates need not concern us.” However the Operational Manual Statement of the
World Bank (1982: 10) contradicts either the meaning or terminology of Gittinger’s statement by maintaining that “the shadow interest rate used for discounting future costs and benefits in the traditional approach, where efficiency prices are considered the relevant shadow prices, is the ‘consumption rate of interest.’”
24 Of course, dams may be decommissioned prior to their “physical” or “economic” life due to changes in other parameters, such as changes in sociocultural values, safety requirements, etc. Hydropower dams with storage that silts up may be operated as run-of-river facilities when the live storage is filled.
25 “Return” as used here is short for the net present value of the annual cost or benefit streams.
26 Given that benefits begin in year 6 and decay at a 1% compounded rate per year.
27 Note that this assumes that discounting follows the normal practice of employing a single discount rate in an exponential fashion.
28 These two definitions are consistent with that of the World Bank’s Operational Manual Statement (1980: 10) and Lind (1982).
29 A simplified example from Lind (1982) documents how if shareholders (i.e. consumers) require a 6% after-tax rate of return and the personal income tax rate is 25 percent and all investment is undertaken by corporations taxed at 50% and all equity comes from shareholders then the corporation must earn a pretax rate of return of 16% to satisfy their equity shareholders. In this case the CRI is 6% and the ROI is 16%, as the corporation earns 16% and pays half to the government in tax, and the shareholder in turn pays one-quarter of investment income (received at 8%) in tax, ending up with a 6% rate of return.
30 In the numerical example the discount rate to be applied would be 16%.
31 In the numerical example, the discount rate would be 6%.
32 If taxes displace savings and investment in a 20:80 ratio then the social discount rate would be (20%)(16%) + (80%)(6%) = 8%
33 In this sense risk refers to cases where outcomes are not certain, i.e. that there is a distribution of potential outcomes around the expected value. The next chapter discusses risk in dam projects in more detail, the focus here is simply on how it should or should not affect discount rates.
34 The WACC is a standard textbook formula taught in finance courses. The WACC will be a weighted average of the cost of equity and debt (preferred stock may also be added) that makes up the corporate cost of capital: 
$$WACC = \beta r_E + \beta (1 - \beta) r_D$$
where \( r \) stands for the relevant interest rates, \( E \) and \( D \) for shares of equity and debt in the total value of the firm, \( V \), and \( T_C \) is corporate income tax.
35 The CAPM is based on the long-term risk-free interest rate, \( r_F \), the variability of the company’s stock with regard to that of the market as a whole, \( \beta \) and the risk premium for the equity market. The risk premium for the equity market is the overall return from the market, \( r_M \), less the risk-free interest rate. The expected rate of return on corporate equity is therefore: 
$$r_E = r_F + \beta (r_M - r_F)$$
36 For example, a benefit accruing to a consumer would be reinvested taking into account the marginal propensity to save of the individual. If this were 20% then the benefit figures would be apportioned 80% as a consumption flow and 20% as an investment flow.
37 This formulation differs slightly from that presented by Lind (1982) in that it does not try to internalise step one into a series of shadow prices of capital that are then applied to cost and benefit streams that displace private investment and consumption in different ways. Rather, a single shadow price of capital is calculated (as seen below) and the analysis
38 Cline (1992) suggests that the shadow price of capital, \( v_c \), can be calculated based on the length of life of capital, \( N \), the SRTP, \( s \), and the marginal rate of return on investment, \( r \), as follows:
$$v_c = \frac{r}{1 - (1 + r)^{-N}} \frac{1 - (1 + s)^{-N}}{s}.$$
39 A common mathematical formulation of these concepts is that the consumption rate of interest, \( s \), is determined by the pure rate of time preference, \( \delta \), plus the product of the elasticity of the marginal utility of consumption, \( \mu \) and the expected rate of growth in average per capita consumption, \( g \): 
$$s = \delta + \mu g .$$
40 See Chapter 9 and the WCD Thematic Review on Social Impacts: Equity and Distribution Issues.
41 The cited authors are not necessarily those that advocated the arguments or approaches set forth below, but rather a source of mention of the argument or approach.
42 Webster’s New World Dictionary simply defines risk as the chance of injury, damage or loss, in the sense of the possibility of an outcome (not the probability). Also, note the absence of an adjective
The safe minimum standard (SMS) refers to a constraint imposed on cost-benefit analysis that requires a safe minimum standard of conservation (e.g. of biodiversity) be maintained unless the costs of so doing are intolerably high. Randall and Farmer (1995) discuss the safe minimum standard of conservation with respect to alternative philosophical approaches and provide principles for guiding the setting of the SMS and how the level of intolerable costs might be set. Randall and Farmer define a safe minimum standard level of preservation as the minimum level required purely to maintain the stock of the resource. In the face of risk, the minimum level would plan for the stochastic lower bound. The safe minimum standard of conservation simply increase the SMS to account for the need for a sustainable use of the resource by people. In applying the concept of SMS to the case of uncertainty, the reference in the text above simply posits that, as the lower bound of probability is not known, it would be consistent to plan for the worst case scenario. Unless of course the costs are intolerable.

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44 Note that Arrow and Lind (1970) explicitly state that in the case of the discount rate, the argument for using a certainty rate in assessment of public investments depends on risk-spreading and not the pooling of risk.

45 The ADB guidelines do not mention this exception in the section on risk and uncertainty (ADB 1997).

46 This is analogous to a financial call option.

47 Dixit and Pindyck (1994) illustrate how the approach may be applied to marriage and suicide amongst others and the quasi-option literature is focused on policy choices and human behaviour with regard to the environment.


49 The only application of this theory of investment to dams found during the conduct of this thematic review is in Annex 11 of Bacon et al. (1996), where the options approach is applied to the issue of the financial cost of large dam projects.

50 The emphasis here is on the wider economic impacts of dam projects, per se, but it is worth noting that there may often be a link between regional planning, regional models and project selection. The WCD Thematic on Planning Approaches provides more insight into the planning of dams within the larger context of energy and water resources development.

51 Here it is worth recalling that there may be intermediate approaches available that effectively simulate the optimisation of resource use and, at the same time, examine input-output relationships. A number of these models and their applications are discussed above in the section on Actual Practice and Guidelines in this Chapter.

52 The WCD Case Studies may be downloaded from http://www.dams.org.

53 The methods used in both the WCD Case Study and the review of World Bank dams are presented later in this Chapter. The World Bank dams were selected from the OED study of 1996 and were chosen so as to represent different potential combinations of distribution of impacts.

54 This is a brief summary of a longer contributed paper Naudascher-Jankowski (1999) that is available from the WCD Secretariat.

55 The latter criteria reflects the reality that at some point the trade-off between reaching growth and equity objectives is such that it would be cheaper simply to raise the incomes of the poor with cash hand-outs than to fund the project (Weiss 2000).

56 For simplicity sake the discussion revolves around CBA, leaving aside the issue of Least-Cost Analysis (LCA). From a technical perspective the application of LCA is at least as old as CBA and continues to be a fundamental criterion for screening and selecting projects as discussed later in the Chapter. See the WCD Case Study of Kariba Dam for an example of the application of LCA in 1956.

57 See the WCD Case Study of Tucurui and Grand Coulee dams for examples of low-cost provision of power to a small number of industrial consumers.

58 Depending on the decision criteria adopted, the summation can be expressed as a net present value, internal rate of return or benefit-cost ratio.

59 Potential investors in dam projects include private entities, governments, and international lending authorities.

60 Some authors make a distinction between least-cost and cost-effectiveness analysis saying that the former pertains to projects where benefits can be valued or to projects where the benefits take the form of a single commodity, such as treated water or power ADB (1997), whereas the latter deals with projects where the outputs can be measured only indirectly. For the present purposes this distinction – such as it is – is of little consequence.

61 See Frigo (1999 ecoweb007) for a review of the arguments for the net present value approach.

62 See Gharavy and Jahankhani (1999) for an example from Iran.
The EDR is the IRR that results from using the costs of not building the alternative project as a measure of the project benefits. In other words it is a form of least-cost analysis.

Figures on the World Bank’s involvement in dams vary. In 1994 the International Rivers Network used Bank documentation to arrive at figures showing that the Bank had supported 527 dam-related loans for 604 dams with a total investment of $58 billion (in 1993 dollars) (Sklar and McCully 1994). The Bank’s Operations and Evaluation Department’s (OED) preliminary report on the Bank’s experience with large dams suggests that 400 dams or related facilities had been funded by the Bank through to 1985. From 1986 to 1995 the Bank approved $7.4 billion for 39 projects that included the construction of a dam (OED 1996a).

Current ADB guidelines for economic analysis are to reject projects with an EIRR below 10% and to accept those with an EIRR between 10 and 12% only where additional unvalued benefits can be demonstrated, and where they are expected to exceed unvalued costs (ADB 1997).