Contributing Paper

Survey of Multilateral Bank Practice on Financial and Economic Analysis of Large Dams

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1. Survey of Multilateral Bank Practice on Financial and Economic Analysis of Large Dams

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1.1 Introduction

This report documents actual practice in the financial and economic evaluation of large dams funded by multilateral development banks (MDBs).[2] It consolidates and summarises the findings from separate surveys conducted for projects funded by the Asian Development Bank (ADB) and the World Bank (WB), which are presented in sections 4.11 and 4.12, respectively.

The basis for the survey is the project appraisal report, which in the case of ADB is called Report and Recommendations of the President (RRP), and for the WB, Staff Appraisal Report (SAR). The list of sample projects by funding agency is presented at the end of each appendix.

Project appraisal reports being subject to space limitations, the details provided may vary from one project to another. The analysis of actual practice is therefore limited to what is reflected in the project appraisal report. It is possible that a review of various project documents over the entire project cycle (from project screening, pre-feasibility, feasibility, appraisal, completion, to post-evaluation) may depict a slightly different picture.

The survey is limited to a review of trends on the application of financial and economic analysis methodologies. It does not attempt to compare practice with current guidelines or those prevailing during project appraisal, or assess practice against project performance.

1.2 Survey Coverage

The survey covered first stage development projects with a large dam component, with the exception of one WB irrigation project in Mexico involving second stage development. Supplementary projects involving additional financing were not included. To identify trends in actual practice, the projects were classified by decade and by purpose, i.e., hydropower (HP), irrigation (IR), water supply (WS), and multi-purpose (MP).

For the ADB, this involved all projects with a large dam component, 29 dams in total. Most of ADB's dams (48%) were built in the 1970s. The 1980s and the 1990s saw reduced involvement in large dams, particularly in the water supply and irrigation sectors. This is explained in part by the shift in ADB's operational thrust towards small and medium-scale irrigation projects.[3]

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[1] Anneli S. Lagman served as an intern at the Secretariat from March to June 2000, while on leave from the Asian Development Bank

[2] As part of the World Commission on Dams' (WCD) work programme, the survey was undertaken to provide supporting information for the preparation of the Thematic on Financial, Economic and Distributional Analysis. The co-operation of the World Bank and the Asian Development Bank in providing the documentation for the Survey is gratefully acknowledged.

[3] ADB. 1995. Sector Synthesis of Postevaluation Findings in the Irrigation and Rural Development Sector.

Table 1. Number of RRPs Surveyed: Asian Development Bank

	1970s	1980s	1990s	1970s – 1990s
Hydro	6	4	6	16
Irrigation	2	2		4
Water Supply	4			4
Multi-Purpose	2	2	1	5
All	14	8	7	29

For the World Bank, 26 projects were surveyed, more than half of which are hydropower projects. Twelve of the sample are included in a desk assessment of 50 WB-financed large dams.[4] This assessment involved 31 power projects, 2 irrigation projects, and 17 multi-purpose projects, distributed across Africa (7), Asia (19), South America (19), and Europe (5). For the purposes of the current study, one each (where available) was selected by purpose and decade from the WB-OED list. Additional SARs gathered by WCD were subsequently added to increase the sample size.

Table 2: Number of SARs Surveyed: World Bank

	1960s	1970s	1980s	1990s	1960s – 1990s
Hydro	2	5	4	4	15
Irrigation		2	1		3
Water Supply			1		1
Multi-Purpose	2	1		4	7
All	4	8	6	8	26

1.3 Options Assessment at Appraisal

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%) have been subjected to LCA, on the basis of least-cost expansion programs. In addition, some hydropower projects since the 1980s have been subjected to further verification using the equalising discount rate (EDR) as an indicator.

For irrigation and multi-purpose projects, options assessment has not been as explicit. Appraisals have mainly cited the project as one of the priorities in the countries' national/regional development plans or have been 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 has also been performed in a few cases. One example is the Lao PDR's Nam Leuk Hydropower Project (1996) which has been 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 have also been 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 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.

Flexibility in project development has also been observed in one case involving Indonesia's Wadalintang Multi-Purpose Project (1981). Project preparation was originally for 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.

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[4] WB-Operations Evaluation Department (OED). 1996. World Bank's Experience with Large Dams: A Preliminary Review of Impacts.

In 8 WB projects (of which 6 were hydropower), screening has also been subjected to sensitivity analysis starting from the 1970s. The analysis was not limited to standard changes in costs or benefits but on key variables such as load growth, oil price, shadow wage rate, discount rate, and in relation to new private projects or other hydropower projects. In Nepal's Kulekhani Hydroelectric project (1975), project alternatives were further subjected to probability analysis, strengthening the case that the project is least-cost, considering that no CBA was done for the project.

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)[5].

1.4 Appraisal Decision-Making Framework

For the purposes of this report, CBA refers to economic cost-benefit analysis, involving evaluation of project profitability from the perspective of the national economy. Discounted cash flow (DCF) analysis, on the other, hand refers to financial cost-benefit analysis, i.e., assessment of a project's overall financial profitability.

For the entire sample, CBA is the main decision-making framework (75% of all projects) and is supplemented by DCF analysis (49%). CBA practice was prevalent in both institutions since the 1970s (64%) and 1980s (79%). All sample projects appraised in the 1990s have been subjected to CBA. 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. DCF analysis has been 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 has been conducted for all irrigation projects, particularly because irrigation projects have not generally been subjected to LCA. Multi-purpose projects followed at 92%. All 5 ADB multi-purpose projects have been subjected to CBA while only 86% of projects was noted for the WB.

Of the ADB sample, 13 out of 16 hydropower projects used both CBA and DCF for decision-making. Indonesia's Garung Hydroelectric (1975) and Power XVIII (1983), and Malaysia's Batang Ai Hydropower (1981) relied only on DCF analysis, as the financial internal rate of return (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.

Table 3. Decision-Making Framework for Options Assessment and Project Feasibility Analysis: Asian Development Bank

	1970s			1980s			1990s			1970s – 1990s			# of projects
	LCA	DCF	CBA	LCA	DCF	CBA	LCA	DCF	CBA	LCA	DCF	CBA	
HP	5	4	5	4	4	2	4	6	6	13	14	13	**16**
IR	1		2			2				1		4	**4**
WS	4	3	1							4	3	1	**4**
MP	1	2	2	1	1	2	1	1	1	3	4	5	**5**
All	**11**	**9**	**10**	**5**	**5**	**6**	**5**	**7**	**7**	**21**	**21**	**23**	**29**
#	**14**			**8**			**7**			**29**			

[5] Levelized cost analysis compares the unit economic costs (comprised of capital, fuel, and fixed and variable O&M costs) of the project with the alternative base load and peaking plants.

Table 4. Decision-Making Framework for Options Assessment and Project Feasibility Analysis: World Bank

	1960s			1970s			1980s			1990s			1960s-1990s			# of projects
	LCA	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	
HP	2			5	2	1	4	1	3	4	1	4	15	4	8	**15**
IR						2	1		1				1		3	**3**
WS							1		1				1		1	**1**
MP	1		1	1		1				2	2	4	4	2	6	**7**
All	**3**	**0**	**1**	**6**	**2**	**4**	**6**	**1**	**5**	**6**	**3**	**8**	**21**	**6**	**18**	**26**
#	**4**			**8**			**6**			**8**			**26**			

1.5 Impacts

In the ADB, there was general recognition of environmental, health, and social impacts in addition to direct project impacts even from the 1970s. Some projects showed more efforts to list the impacts, especially for all 5 multi-purpose projects.

In the WB, only in the 1990s was there general recognition of impacts other than direct project impacts (at least mentioned in the SARs).

1.5.1 Identification of Impacts

Indirect impacts such as environmental (e.g., protection of national biodiversity conservation area, decreased salinity, reduced pollution), health (reduction of waterborne diseases, productivity losses due to illness, and medical costs), social, employment generation, increased industrial/commercial activity, improvement in farm incomes, enhanced recreation, foreign exchange savings, etc. were identified, and sometimes quantified.

For China's Xiaolangdi Multi-Purpose (1991), a comprehensive list of impacts was provided, indicating who incurs/pays the cost or receives the benefit. The Manila Water Supply (1974) valued impacts related to health, fire fighting, and property values (see section 5.3.3).

1.5.2 Quantification of Impacts

Where environmental impacts were identified in the ADB projects, only 1 project (Lao PDR's Theun-Hinboun Hydropower, 1994) quantified SO_2, NO_x, and CO_2 avoided. In the WB, 3 projects in the 1990s (Pakistan's Ghazi-Barotha, China's Ertan II Hydroelectric, and China's Daguangba Multi-Purpose), quantified environmental impact (ash, CO_2, SO_2 emissions), performing detailed simulations of with and without-cases.

Out of 6 ADB projects where flood control benefits were identified, benefits were quantified only in Indonesia's Wadaslintang Multi-Purpose (1981) and valued in China's Zhejiang-Shanxi Water Supply (1997) and Korea's Andong Dam Multi-Purpose (1971).

1.5.3 Valuation of Impacts

Power Benefits

A significant trend towards the use of more appropriate valuation techniques based on willingness to pay particularly for hydropower projects is noted in the 1990s. There is however considerable variation on the methods for estimating WTP. Berke Hydropower (1992) and Daguangba Multi-Purpose (1991) calculated WTP based on long-run marginal cost while Nathpa Jhakri Power (1989) presented a detailed calculation of consumer surplus. Meanwhile, Ertan II Hydroelectric (1995) used an economic price equivalent to the price paid by the system at the consumer level for 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 (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 tariffs, the EIRRs are only considered minimum estimates. Malaysia's Batang Ai Hydropower (1981) notes that the incremental power sales revenues used as a proxy for the true economic benefits probably understate those benefits, and that consumers' WTP is virtually impossible to evaluate.

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

At ADB, although nonincremental and incremental supply was not specifically mentioned, consumer surplus and resource cost savings were calculated in 5 out of 6 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 (1994). Exported power from Lao PDR's Nam Song Hydropower (1992) was valued at the current export tariff while domestic power was valued at resource cost savings and consumer surplus. For China's Fujian Mianhuatan Hydropower (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 (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 DCF analysis from the Government's perspective.

For China's Tongbai Pumped Storage project (1999), dynamic benefits analysis was undertaken involving chronological simulation through the generation optimal dynamic simulation (GODS) model.

Irrigation Benefits

For the MDBs, there is consensus on the use of net value of incremental production in valuing irrigation benefits.

Water Supply Benefits

In the ADB projects (all appraised in the 1970s), water supply benefits were valued based on average tariff. The Manila Water Supply project (1974) presented an alternative valuation based on cost of alternative supply. In the WB's water supply project (Nairobi, 1989), benefits were valued based on average water tariff.

Flood Control Benefits

For all multi-purpose projects, the valuation of flood control benefits was based on reduced or avoided flood damages.

Other Benefits

For the Manila Water Supply project (1974), the value of health impacts was based on reduced labour time lost and avoided medical expenses. Benefits from reduced fire damages were also estimated, arising from the availability of water for fire fighting. In addition, improved water supply was estimated to enhance property values, with benefits valued at the increase in land values.

1.6 Financial Analysis

1.6.1 Project Aspects

Financial analysis from the perspective of project owners (i.e., involving assessment of the project entities' financial statements) is common. For all irrigation projects, financial analysis was undertaken from the point of view of project beneficiaries through farm budget analysis.

Of the 27 projects from the entire sample where DCF analysis was conducted, FIRR was the main decision criterion, supplemented by the NPV or payback period in only a few cases.

Only in the 1990s ADB hydropower projects (5 out of 6) was the weighted average cost of capital (WACC) calculated as the hurdle rate for the FIRR.

For the ADB sample, 5 out of 6 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 had sensitivity analysis. One of this was undertaken not on the FIRR but on the financial equalising discount rate.

For the Zhejiang-Shanxi Water Supply (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 WACC as the hurdle rate for the FIRR.

Financial sustainability was noted in some projects. For China's Tongbai Pumped Storage (1999), a financial analysis was carried out to determine the tariff profiles required to generate a 12% rate of return. Sensitivity of the FIRR was tested against tariff and operating hours.

1.6.2 Social Aspects

The survey of ADB projects was more extensive than the WB projects in terms of social and environmental aspects. The following observations therefore pertain only to ADB projects.

Only about 2/3 of the ADB projects involved displacement. No water supply projects involved resettlement. Internalization of resettlement/land compensation costs has been generally practised for dam projects and much more so from the 1980s. China's Zhejiang-Shanxi Water Supply (1997) has allocated the largest fund for resettlement/relocation, representing 29% of total cost. If resettlement costs are excluded from project costs, the project's FIRR would increase from 8.5% to 11.7%.

1.6.3 Environmental Aspects

The inclusion of environmental mitigation costs in project cost estimates has been pronounced starting in the 1980s. Prior to the 1990s, little consideration of environmental impacts was made especially since the conduct of environmental impact assessments (EIAs) was not common then.

Mitigation measures include partial lake regulation, extensive and accelerated logging prior to inundation, mandatory downstream releases, aquaculture and fishery monitoring program, installation of tubewells to improve domestic water supply quality, bottom outlet, reforestation, coastal embankment, tide regulation, etc.

Nepal's Kali Gandaki "A" Hydroelectric project (1996) provided a listing of environmental and social mitigation measures with associated costs for each measure. Total planned mitigation costs amounted to $5.3 million, representing only 1.2% of total project cost. In addition, the National Electricity Authority was to provide $100,000 annually for assistance programs to project affected families.

For Lao PDR's Nam Leuk Hydropower (1996), 1% of the annual revenue generated from electricity production will be used to fund for the protection and management of the national biodiversity conservation area (NBCA), and is added to O&M costs.

In 5 projects where mitigation costs were not explicitly stated, mention was made of incorporation of mitigation measures in project design.

1.7 Economic Analysis

Prior to the 1990s, little effort was made to conduct proper CBA, rationalising that the FIRR, where DCF analysis was undertaken, provides a minimum estimate of the EIRR. If any adjustments were made, these concerned only the removal of taxes and subsidies, particularly with the 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, adjustments to financial flows involving input and output distortions, transfer payments, shadow exchange rate, and shadow wage rate were undertaken.

For the entire sample, the EIRR was the main decision criterion at the final evaluation stage, with NPV and benefit-cost ratio calculated only in 6 projects (1989 to 1995) and 2 1990s projects, respectively.

For the ADB irrigation projects, there was an explicit distinction between financial analysis and economic analysis. For Indonesia's Sempor Dam 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.

For purposes of calculating the EIRR by component, the methods used in ADB multi-purpose projects include "priority of use", "separable costs – remaining benefits" or "design year usage" method, except for Korea's Andong Dam Multi-Purpose (1971) where cost allocation between irrigation and municipal and industrial water was based on equating EIRRs.

1.7.1 Economic Discounting

For ADB hydropower projects, the discount rate was not generally specified, except for Kali Gandaki "A" Hydroelectric project (1996) which cited 10% as the opportunity cost of capital in Nepal, for China's Hunan Lingjintan Hydropower (1994) which mentioned the usual cut-off rate of 10%, and for Lao PDR's Nam Leuk Hydropower (1996) at 12%. Hurdle rates for the EIRR are not commonly specified in ADB appraisal documents since the guidelines specify a discount rate between 10% to 12%, mainly used as a credit rationing mechanism.

For WB projects, no SARs mentioned any method to obtain the discount rate. Six projects mentioned that the discount rate (ranging from 10-12%) is considered to be the opportunity cost of capital or social discount rate in that particular country (China, Ghana, Kenya, Mexico, Pakistan).

1.7.2 Sensitivity Analysis

General practice was to test the sensitivity of the decision criterion to standard changes in total costs and total benefits, instead of key decision variables. For those with sensitivity analysis, mitigating measures were identified where significant risks were assessed.

Half of the ADB irrigation projects (both from the 1980s) used standard variations in costs and benefits and delay in implementation. The other half (both from the 1970s) tested the sensitivity of the EIRR to key variables such as price, crop yield, crop intensity, and foreign exchange rate.

Only 2 WB projects (China's Xiaolangdi Multipurpose, 1995 and Pakistan's Ghazi Barotha, 1995) presented a systematic analysis of risk for changes in key variables, as identified in the Project Design Summary. Probabilities have been assigned to each scenario, so that a weighted average IRR and a probability distribution for the IRR can be obtained. In China's Tongbai Pumped Storage project (1999), there was an analysis of critical risks, indicating the risk rating (using a probabilistic method) and risk minimisation measures.

1.8 Regional and Macroeconomic Analysis

No regional or macroeconomic models were applied in any of the projects, i.e., evaluating the impact of the projects on the region's or country's economy.

There was generally no fiscal affordability analysis for the entire sample, except for one project each from the ADB and the WB. For Nepal's Kali Gandaki "A" Hydroelectric (1996), fiscal affordability analysis for the country's Power Investment Program was conducted. At the macroeconomic level, the risk of the Project expenditures crowding out expenditures in the priority rural and social sectors was examined. For Ghazi-Barotha Hydropower (1995), analysis was made of the impact of the project on the fiscal and balance-of-payments position of Pakistan on the basis of a comparison of key macroeconomic projections resulting from the power investment program, with and without the project.

In some ADB cases, particularly for multi-purpose projects, macroeconomic and regional impacts were identified, such as optimal use of natural resources, improving income distribution in rural areas, increasing food self-sufficiency, balanced regional development, etc.

1.9 Distributional Analysis

For the MDBs, no quantitative distributional analysis was performed. For the Philippines' Manila Water Supply (1974), however, a more than usual qualitative discussion of benefit distribution was made, focusing on low-income households.

1.10 Summary and Conclusions

ADB and WB practice in the economic analysis of projects is generally similar, particularly with regard to the identification and valuation of impacts. There is agreement on the valuation of irrigation and flood control benefits, based on net value of production, and avoided cost of damages, respectively. A remarkable trend towards the use of WTP estimates for hydropower projects has been observed in the 1990s. More distinction needs to be made however on incremental and nonincremental supply and their appropriate valuation. Water supply benefits were valued at tariff, but then the sample included only projects from the 1970s. For both MDBs, the EIRR is the main decision criterion. Hurdle rates are generally not specified, as they are commonly the rates used by the relevant institution as a credit rationing mechanism.

Most projects, particularly hydropower and water supply projects, are selected from amongst alternatives on the basis of least-cost considerations. This LCA typically compares the costs of alternatives, including construction, O&M, and costs of mitigation measures (where applicable). Though options assessment is not common for irrigation and multi-purpose projects, these are said to be government priorities (which could be subject to internal ranking exercises) and have been subjected to feasibility studies.

The macroeconomic/fiscal impact analysis of projects has yet to become standard practice in project appraisal. Meanwhile, distributional analysis still has to be demonstrated in actual practice. This may be seen in the near horizon, particularly in view of both MDBs' current thrust on poverty alleviation.

The main differences between the MDBs' practice concern the decision-making framework and sensitivity/risk analysis. Quantitative analysis was more common at the options assessment stage for the WB and at the final decision-making stage for ADB. Good practice examples can be gleaned from WB practice with regard to sensitivity/probability analysis at the options assessment stage and sensitivity/risk analysis at the final decision-making stage.

With regard to social aspects, internalisation of resettlement/land compensation costs has been generally practised for ADB dam projects, particularly from the 1980s. The same is true for the inclusion of environmental mitigation costs in project cost estimates. There is a good practice example from ADB relating to the allocation of funds for the protection and management of a national biodiversity conservation area (Lao PDR's Nam Leuk Hydropower, 1996).

Since the survey involved only a review of practice in project financial and economic analysis, further work can be undertaken to make the survey more useful for operational purposes. One area that could be examined is to compare actual practice with actual project performance. A relevant question to ask is whether the rigor in economic analysis ensured that the chosen project generated the optimum benefits it was designed to achieve.[6] Another potential area of study is to compare practice with current guidelines or those prevailing during project appraisal. How well did project appraisal measure against prescribed or suggested methodologies? If project appraisal followed the guidelines strictly, would the project have performed better? These two areas can be synthesised, and recommendations can be made towards assessing the practicality and relevance of guidelines in the field, and optimising the use of staff resources to improve project quality and development effectiveness.

1.11 Notes on Survey of Asian Development Bank Practice

Options Assessment

- Quantitative options assessment through least-cost analysis[7] is generally practised for hydropower projects since ADB started its lending operations in the late 1960s. The project appraised is typically part of a least-cost expansion program generated from computer models such as WASP, IRELP, GESP and GOPS.
- One project (Lao PDR's Theun-Hinboun Hydropower, 1994) ranked only second in the least-cost power expansion program, but was selected over the top-ranked Nam Theun 2. The latter was delayed on environmental grounds because of the potential impact of its large reservoir.
- Although already part of the least-cost expansion program, 7 out of 16 hydropower projects (from the 1980s) were further subjected to equalising discount rate (EDR) analysis in comparing alternatives. The Batang Ai Hydropower project (Malaysia, 1981), in addition, used present worth analysis. For China's Hunan Lingjintan Hydropower project (1994) and Fujian Mianhuatan Hydropower (1995), levelized cost analysis[8] supported the EDR analysis. Only one appraisal report (Indonesia's Garung Hydroelectric, 1975) did not explain the linkage with the power expansion program.[9]
- 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.

- Out of 4 irrigation projects, only Sempor Dam and Irrigation (1971) considered alternatives and noted the project to be top priority in Indonesia's first five-year plan.

- All 4 water supply projects have been subjected to options assessment, with the projects studied as part of the least-cost expansion program.

- Two out of five multi-purpose projects considered alternatives (China's Zhejiang Shanxi Water Supply, 1997 and Korea's Andong Dam Multi-Purpose Development, 1971). The formulation of

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[6] See for example (a) Jenkins, G. 1997. *Project Analysis and the World Bank*. AEA Papers and Proceedings, Vol. 87 No. 2. May 1997. The World Bank; (b) Devarajan, S., Squire, L., and S. Suthiwart-Narueput. 1997. *Beyond Rate of Return: Reorienting Project Appraisal*. The World Bank Research Observer, Vol. 12 No. 1. February 1997; and (c) Belli, P. and L. Pritchett. 1995. *Does Good Economic Analysis Improve Project Success?* Mimeo, Operations Policy Division, World Bank.

[7] Least-cost analysis is used to compare alternative projects using either the equalizing discount rate or average incremental cost as indicators. For China's Zhejiang-Shanxi Water Supply (1997), the average incremental economic cost (AIEC) of water was compared between with and without-Project situations, at a 12% discount rate.

[8] Levelized cost analysis compares the unit economic costs (comprised of capital, fuel, and fixed and variable O&M costs) of the project with the alternative base load and peaking plants.

[9] The project was first studied in 1932 and work commenced at project site in the 1960s but lagged for lack of finance. Being ready for quick implementation, the project has become attractive again in the mid 1970s in view of the proposed system interconnections in the Central Java network and the acute power shortage. The project was the first hydroelectric plant in Indonesia and would complement future geothermal projects by providing the necessary peak power for matching the system load curve.

the three others were based on needs assessment (Myanmar's Sedawgyi Multi-Purpose Dam and Irrigation, 1976) or designed to fit the development strategy or national agricultural policy (Malaysia's Perlis Agricultural Development, 1985). For Indonesia's Wadaslintang Multi-Purpose (1981), the optimum dam size was decided after considering technical investigations and simulation studies on reservoir operations.

- Project preparation for Indonesia's Wadaslintang Multi-Purpose project (1981) was originally for 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.

Decision-Making Framework

Cost-benefit analysis (CBA) is the main decision-making framework and is supplemented by discounted cash flow (DCF) analysis (although some qualifications on methodology application will be made later on in the Economic Analysis section).

Table 5. Decision-Making Framework for Options Assessment and Project Feasibility Analysis

	1970s			1980s			1990s			1970s – 1990s			# of projects
	LCA	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	
HP	5	4	5	4	4	2	4	6	6	13	14	13	**16**
IR	1		2			2				1		4	**4**
WS	4	3	1							4	3	1	**4**
MP	1	2	2	1	1	2	1	1	1	3	4	5	**5**
All	11	9	10	5	5	6	5	7	7	21	21	23	**29**
#	**14**			**8**			**7**			**29**			

- Thirteen out of 16 hydropower projects used both CBA and DCF for decision-making. Indonesia's Garung Hydroelectric (1975) and Power XVIII (1983), and Malaysia's Batang Ai Hydropower (1981) relied only on DCF analysis as the financial internal rate of return (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 WTP estimates, the perceived marginal difference between the IRRs precluded efforts for a more rigorous analysis. The Philippines' Sixth Mindanao Power (1979) cited the difficulty in deriving conversion factors with a reasonable degree of accuracy.

- CBA was the norm for all 4 irrigation projects.

- Out of 4 water supply projects, all from the 1970s, 2 used DCF analysis, while another used both DCF and CBA. Another (Singapore's Water Supply, 1970) did not use any quantitative-based framework except LCA, but expounded on the capacity of the executing agency to implement the project successfully and on the general stability of the Singapore government.

- Both CBA and DCF analysis were performed for 4 out of 5 multi-purpose projects. For Indonesia's Wadaslintang Multi-Purpose (1981), only CBA was performed.

Impacts

- There was general recognition of environmental, health, and social impacts in addition to direct project impacts even from the 1970s. Some projects showed more efforts to list the impacts, especially for all 5 multi-purpose projects.

Identification of Impacts

- Indirect impacts such as environmental (e.g., protection of national biodiversity conservation area, decreased salinity, reduced pollution), health (reduction of waterborne diseases, productivity losses due to illness, and medical costs), social, employment generation, increased industrial/commercial

activity, improvement in farm incomes, enhanced recreation, foreign exchange savings, etc. were identified, and sometimes quantified.
- Only one project (Manila Water Supply, 1974) valued other impacts related to health, fire fighting, and property values.

Quantification of Impacts
- Where environmental impacts were identified, only 1 project (Lao PDR's Theun-Hinboun Hydropower, 1994) quantified SO_2, NO_x, and CO_2 avoided.
- Employment generation was identified in 17 projects, and quantified only in 7.
- Out of 6 projects where flood control benefits were identified, benefits were quantified in 1 (Indonesia's Wadaslintang Multi-Purpose, 1981) and valued in 2 others (China's Zhejiang-Shanxi Water Supply, 1997 and Korea's Andong Dam Multi-Purpose, 1971).

Valuation of Impacts
- All hydropower projects appraised in the 1970s and 1980s, except for two projects, valued power benefits based on average tariff. The Philippines' Sixth Mindanao Power (1979, which valued benefits at fuel cost savings and plant replacement costs displaced, while Korea's Samrangjin Pumped Storage Power (1980) valued benefits at tariff plus value-added tax.
- In the 1990s, benefit valuation for hydropower projects was based mainly on willingness to pay (WTP), estimates of which were based on avoided costs of alternative supply for firm energy, and on fuel and O&M savings for secondary energy. Exported power from Lao PDR's Nam Song Hydropower (1992) was valued at the current export tariff.
- For the Fujian Mianhuatan Hydropower (1995), the derivation of WTP estimates 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. The resulting weighted WTP of Yuan0.72/kWh was higher than the average tariff of Yuan0.55/kWh.
- The Lao PDR's Theun-Hinboun (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 practically a DCF analysis from the Government's perspective.

- Incremental benefits from irrigation projects were all valued at net value of production.

- Of the 4 water supply projects, three projects valued benefits based on the tariff. One of these (Manila Water Supply, 1974) presented an alternative valuation based on cost of alternative supply. One project did not value water benefits at all as no CBA was performed.
- For the Manila Water Supply project (1974), the value of health impacts was based on reduced labour time lost and avoided medical expenses. Benefits from reduced fire damages were also estimated, arising from the availability of water for fire fighting. In addition, improved water supply was estimated to enhance property values, with benefits valued at the increase in land values.

- For multi-purpose projects, flood control benefits were valued based on reduced or avoided flood damages. Incremental benefits from irrigation were based on net value of production. Water supply benefits were valued at alternative cost or tariff-based WTP. Power benefits were valued either at alternative cost of supply or tariff. Power benefits from Zhejiang-Shanxi Water Supply (1997) were valued at WTP based on the purchasers' price as reflected in the electricity purchase agreement. This tariff is higher than the long-run marginal cost of electricity.

Financial Analysis
- For all 16 hydropower projects, financial analysis was undertaken. Financial assessment from the point of view of the executing agencies was also conducted in 10 projects. However, one project (Second Mindanao Power, 1972) only had financial assessment and no project financial analysis, where the project was considered to contribute to the 8% return on rate base.
- Only in the 1990s hydropower projects (5 out of 6) was the weighted average cost of capital (WACC) calculated as the hurdle rate.
- Also, 5 out of 6 hydropower projects in the 1990s conducted sensitivity analysis 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 had sensitivity analysis. One of this was undertaken not on the FIRR but on the financial equalising discount rate.

- For all 4 irrigation projects, financial analysis was undertaken from the point of view of project beneficiaries through farm budget analysis.

- Financial analysis from the perspective of both owners and project was conducted for 3 out of 4 water supply projects, where the decision criterion was FIRR. Exception was Singapore's Water Supply project (1970) which was analysed only from the owner's perspective. The project was designed to earn 8% return on average net fixed assets. No sensitivity analysis for the FIRR was undertaken.

- For multi-purpose projects, those with irrigation components had farm budget analysis. Those with power components had project financial analysis performed, with FIRR as the decision criterion. Sensitivity analysis for the FIRR was performed only on 2 multi-purpose projects with the standard +/- change in costs and benefits and implementation delay. In addition, for the Zhejiang-Shanxi Water Supply (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 WACC as the hurdle rate for the FIRR.

- 21 out of 29 projects involved displacement of population and/or properties. Of these 21 projects, resettlement/land compensation costs for 17 (12 from the 1980s-1990s and 5 from the 1970s) were included in the project cost estimates; costs of the remaining 4 were borne by the executing agencies and not included in the project cost estimates and therefore, excluded in CBA.
- China's Zhejiang-Shanxi Water Supply (1997) has allocated the largest fund for resettlement/relocation at $117.52 million, representing 29% of total cost. If resettlement costs are excluded from project costs, the project's FIRR would increase from 8.5% to 11.7% Because of the large resettlement program, covering 37,000 people, a resettlement fund will be established and funded from a special tax on Project water and power sales to provide a safety net and credit source to affected people. An extensive monitoring program will be put in place for three years after relocation. The Reservoir Construction Fund of a minimum of Y10 million should be established by the Government by 31 December 1997 and replenished on a revolving basis while the Reservoir Maintenance Fund with minimum contributions of Y400,000 per annum should be established once power and water sales commence and be made available as required until the affected persons have fully restored their economic basis in the new locations.
- Second was China's Fujian Mianhuatan Hydropower (1995) which allocated $83.7M for both environmental mitigation and resettlement affecting 41,000 people.
- Of the 5 1970s projects whose resettlement costs were included in project cost estimates, Sri Lanka's Kirindi Oya Irrigation and Settlement (1977), settlement costs were not included for purposes of the EIRR calculation since no corresponding benefits were attributed to the settlement component. The project involved an extensive settlement component in addition to resettlement of dam-affected population.
- All water supply projects involved no resettlement.

- Of the 29 projects surveyed, 11 projects (only 2 from the 1970s) had internalised environmental mitigation costs. Some measures mentioned include partial lake regulation, extensive and accelerated logging prior to inundation, mandatory downstream releases, aquaculture and fishery monitoring program, installation of tubewells to improve domestic water supply quality, bottom outlet, reforestation, coastal embankment, tide regulation, etc.
- For Lao PDR's Nam Leuk Hydropower (1996), forest clearing prior to inundation will be done by a logging company through tendering. The funds collected from this company will be provided to the Department of Forestry to reforest or rehabilitate double the amount of hectarage lost to the siting of the reservoir.
- Nepal's Kali Gandaki "A" Hydroelectric project (1996) provided a listing of environmental and social mitigation measures with associated costs for each measure. Total planned mitigation costs amounted to $5.3 million, which were internalised in the total project cost. In addition, the National Electricity Authority was to provide $100,000 annually for assistance programs to project affected families.

- In 5 projects where mitigation costs were not explicitly stated, mention was made of incorporation of mitigation measures in project design.
- For Lao PDR's Nam Leuk Hydropower (1996), 1% of the annual revenue generated from electricity production will be used to fund for the protection and management of the national biodiversity conservation area (NBCA), and is added to O&M costs.

Economic Analysis

- Out of 6 hydropower projects appraised in the 1970s, only 1 did not conduct economic analysis as FIRR was considered to be a minimum estimate of the EIRR. The other projects however, only adjusted the financial costs for taxes and subsidies, and as benefits were valued at tariff, the EIRR was considered only as a minimum estimate.
- In the 1980s, the practice continued whereby 2 out of 4 hydropower projects did not calculate the EIRR, relying on the FIRR to provide a minimum estimate. For the Afulilo Hydroelectric project (1986) however, adjustments with respect to input distortions, output distortions, and wage rate were made. Equalising discount rate, in addition to EIRR, was also calculated in this project, with sensitivity analysis conducted on the economic EDR and not on EIRR This project also noted that since the opportunity cost of land and resettlement costs were small, they were ignored in economic analysis
- The practice further continued in the 1990s. Only 2 out of 6 hydropower projects made adjustments other than taxes. The EIRR was still the decision criterion, with NPV supplementing the EIRR in China's Fujian Mianhuatan (1995).
- For China's Hunan Lingjintan (1994), economic benefits were based on the capacity and energy balance of the Lingjintan and Wuqiangxi plants since the project will serve as a reregulating facility for Wuqiangxi.
- The discount rate was not generally specified for hydropower projects, except for Kali Gandaki "A" (1996) which cited 10% as the opportunity cost of capital in Nepal, for China's Hunan Lingjintan (1994) which mentioned the usual cut-off rate of 10%, and for Lao PDR's Nam Leuk Hydropower (1996) at 12%.

- For the irrigation projects, there was an explicit distinction between financial analysis and economic analysis, except for Indonesia's Sempor Dam and Irrigation (1971) where adjustments to financial costs were not described. The decision criterion used was the EIRR. Except for Sempor Dam, economic costs also included the value of crops and properties lost due to inundation. In addition, 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.

- Of the 4 water supply projects, only the Philippines' Manila Water Supply project (1974) was subjected to economic analysis, with EIRR as the decision criterion.

- For the multi-purpose projects, EIRR was the decision criterion. In allocating costs to the project components, the "priority of use", "separable costs – remaining benefits" or "design year usage" method was used, except for Korea's Andong Dam Multi-Purpose (1971) where cost allocation between irrigation and municipal and industrial water was based on equating EIRRs. No cost was allocated to the power component, being only a secondary objective. The project also provided that O&M costs of irrigation facilities would be borne by farmers.
- The economic costs for Wadaslintang Multi-Purpose (1981) included the value of production foregone and physical assets submerged, with land acquisition costs used as proxy.

Economic Discounting

- For hydropower projects, the discount rate was not generally specified, except for Kali Gandaki "A" Hydroelectric project (1996) which cited 10% as the opportunity cost of capital in Nepal, for China's Hunan Lingjintan Hydropower (1994) which mentioned the usual cut-off rate of 10%, and for Lao PDR's Nam Leuk Hydropower (1996) at 12%.
- For the irrigation projects, the method to obtain or calculate the discount rate was not specified, primarily because EIRR was the decision criterion and not net present value (NPV).
- Hurdle rates for the EIRR are not commonly specified in appraisal documents since the ADB guidelines specify a discount rate between 10% to12%, mainly used as a credit rationing mechanism

Sensitivity Analysis

- For hydropower projects even in the 1990s, sensitivity tests involved standard +/- changes in total costs and total benefits, and a few key variables for some like the effects of an initial 10-year drought, or benefits involving power export only. For all 6 projects, a sensitivity indicator was calculated and mitigating measures identified where significant risks were assessed.
- Half of the irrigation projects (both from the 1980s) used standard variations in costs and benefits and delay in implementation. The other half (both from the 1970s) tested the sensitivity of the EIRR to key variables such as price, crop yield, crop intensity, and foreign exchange rate.
- Two out of 5 multi-purpose projects tested key variables beyond standard changes in costs and benefits to include changes in wage rate, crop yield, crop intensity, prices, tariff, or life of power station.

Regional and Macroeconomic Analysis

- No macroeconomic models were used to evaluate the impact of the project on the whole economy. This is not to say however that there is no analysis of the country's macroeconomic situation.
- Fiscal affordability analysis was conducted for only one project, Nepal's Kali Gandaki "A" Hydroelectric (1996), pertaining to Nepal's Power Investment Program. At the macroeconomic level, the risk of the Project expenditures crowding out expenditures in the priority rural and social sectors was examined.
- In some cases, particularly for multi-purpose projects, macroeconomic and regional impacts were identified, such as optimal use of natural resources, improving income distribution in rural areas, increasing food self-sufficiency, balanced regional development, etc.

Distribution Analysis

- No quantitative distribution analysis was performed. For the Philippines' Manila Water Supply (1974), a more than usual qualitative discussion of benefit distribution was made, while focusing on low-income households.

Table 6. List of Asian Development Bank Project RRPs Reviewed

Project Title	Year	Dam	Country
Hydropower Projects			
Second Mindanao Power	1972	Agus 2	Philippines
Garung Hydroelectric	1975	Garung	Indonesia
Fourth Mindanao Power	1976	Agus 4	Philippines
Trengganu Hydropower	1978	Kenyir	Malaysia
Sixth Mindanao Power	1979	Pulangui	Philippines
Sedawgyi Hydropower	1979	Sedawgyi	Myanmar
Samrangjin Pumped Storage Power	1980	Samrangjin	Korea
Batang Ai Hydropower	1981	Batang Ai	Malaysia
Power XVIII	1983	Sengguruh	Indonesia
Afulilo Hydroelectric	1986	Afulilo	W. Samoa
Nam Song Hydropower Development	1992	Nam Song	Lao PDR
Hunan Lingjintan Hydropower	1994	Lingjintan	China
Theun-Hinboun Hydropower	1994	Theun-Hinboun	Lao PDR
Fujian Mianhuatan Hydropower	1995	Mianhuatan	China
Nam Leuk Hydropower	1996	Nam Leuk	Lao PDR
Kali Gandaki "A" Hydroelectric	1996	Kali Gandaki	Nepal
Irrigation Projects			
Sempor Dam and Irrigation	1971	Sempor	Indonesia
Kirindi Oya Irrigation and Settlement	1977	Lunugamwehera	Sri Lanka
Medium Scale Irrigation Package	1981	Huai Mae On	Thailand
Nusa Tenggara Agricultural Development	1988	Pengga	Indonesia
Water Supply Projects			
Water Supply	1970	Kranji	Singapore
Manila Water Supply	1974	Angat	Philippines
Second Water Supply	1976	Murai	Singapore
Second Manila Water Supply	1978	Angat	Philippines
Multipurpose Projects			
Andong Dam Multi-Purpose Development	1971	Andong	Korea
Sedawgyi Multi-Purpose Dam and Irrigation	1976	Sedawgyi	Myanmar
Wadaslintang Multipurpose	1981	Wadaslintang/Pejengkolan	Indonesia
Perlis Agricultural Development	1985	Timah Tasoh	Malaysia
Zhejiang Shanxi Water Supply (Phase I)	1997	Shanxi/Zhaoshandu	China

1.12 Notes on Survey of World Bank Practice

Options Assessment

- Quantitative options assessment through least-cost analysis (LCA) is generally practised for all projects (81%) even from the 1960s (75%). All hydropower and water supply projects are notably subjected to LCA. The project appraised is typically part of a least-cost power expansion program. For irrigation and multi-purpose projects on the other hand, the project appraised has been subject to various feasibility studies, which may have involved options assessment.
- Sophisticated optimisation models on least-cost expansion programs have been employed, with project selection based on the equalising discount rate. Ceyhan Aslantas project in Turkey (1973) also conducted a monthly operational study in assessing project alternatives.
- Sensitivity analysis in 8 cases is noted from the 1970s. Variables tested include load growth, capital cost, oil price, operating cost, shadow wage rate, or discount rate. For Pakistan's Ghazi Barotha (1995), sensitivity analysis complemented least cost analysis, by testing sensitivity of the alternatives to key variables, including discount rate, and in relation to new private projects, and other hydropower projects.
- Probability analysis supplemented sensitivity analysis in Nepal's Kulekhani (1975) where the decision-making framework was based on least-cost analysis (LCA), not cost-benefit analysis (CBA).

Decision-Making Framework

- In the 1960s, 3 out of 4 cases used LCA, although the Kainji Multipurpose project (1964) referred to LCA as present worth analysis.
- In the 1970s, half of the cases used CBA and 75% of the projects used LCA. For Nepal's Kulekhani Hydroelectric project (1975) and Kenya's Kamburu Hydroelectric project (1971), financial discounted cash flow analysis (in the absence of economic CBA) complemented the LCA in a decision-making framework.
- From the 1980s, the conduct of CBA has risen significantly, at 83% of projects in the 1980s and for all projects in the 1990s. LCA was used primarily for options assessment. In Chile's Pehuenche project (1987), which is part of the least-cost power expansion program, only financial discounted cash flow analysis was conducted. Kenya's water supply project (1989) used both LCA and CBA.
- Only 6 out of 26 projects were subjected to DCF analysis, 4 of which were for hydroelectric projects including only 1 in the 1990s (China's Tongbai Pumped Storage, 1999). DCF analysis was also conducted for 2 multi-purpose projects in the 1990s. The conduct of DCF analysis is not common among WB projects since emphasis is given more to the project owner's capability to sustain project operations through analysis of financial statements.

Table 7. Decision-Making Framework for Options Assessment and Project Feasibility Analysis

	1960s			1970s			1980s			1990s			1960s-1990s			# of projects
	LCA	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	**LCA**	**DCF**	**CBA**	
HP	2			5	2	1	4	1	3	4	1	4	15	4	8	**15**
IR						2	1		1				1		3	**3**
WS							1		1				1		1	**1**
MP	1		1	1		1				2	2	4	4	2	6	**7**
All	3	0	1	6	2	4	6	1	5	6	3	8	21	6	18	**26**
#	**4**			**8**			**6**			**8**			**26**			

Impacts

- Only in the 1990s was there general recognition of impacts other than direct project impacts (at least mentioned in the Staff Appraisal Reports (SARs)).

Identification of Impacts

- Direct project impacts were identified and valued, although 2 cases mentioned direct impacts in the future attributed to later stages of development, which were not incorporated in the analysis.
- Only 1 project (Xiaolangdi Multipurpose, 1995) provided a comprehensive list of impacts, although source/basis was not identified, but indicated who incurs/pays the cost or receives the benefit. The Daguangba Multipurpose project (1991) also noted several impacts, including improvements in environment, water quality, municipal and industrial waste disposal, fisheries, public health, employment and income, and women in development.

Quantification of Impacts

- Three projects in the 1990s (Ghazi-Barotha Hydroelectric, Ertan II Hydroelectric, Daguangba Multipurpose) quantified environmental impact (ash, CO_2, SO_2 emissions), employing detailed simulations of with and without-cases. Daguangba Multipurpose also quantified impact on employment (number) and income (dollars).

Valuation of Impacts

- Power benefits were generally valued using average tariffs and fuel cost savings from alternative plants.
- Berke Hydropower (1992) and Daguanba Multipurpose (1991) calculated WTP based on long run marginal cost while Nathpa Jhakri Power (1989) presented a detailed calculation of consumer surplus.

- There was no explicit distinction between non-incremental (defined as project outputs replacing existing supply) and incremental supply (project outputs meeting new or additional demands). EIRRs were therefore only minimum estimates.
- The exception is Ghazi Barotha (1995) where power benefits for residential consumers were estimated in terms of incremental demand (consumer surplus) and in terms of non-incremental demand (resource cost savings). For other consumer categories, benefits were valued in terms of avoided cost from diesel-based generators or tubewells. Meanwhile, Ertan II Hydroelectric (also in 1995) used an economic price equivalent to the price paid by the system at the consumer level for alternative supply (electricity purchased from joint investment and independent power producers) as a minimum proxy.
- Ghana's Kpong Hydroelectric project (1977) valued power benefits at average tariff plus cost of alternatives as well as tariff in neighbouring Liberia (but at 75% only).
- For China's Tongbai Pumped Storage project (1999), a dynamic benefits analysis was undertaken involving chronological simulation through the generation optimal dynamic simulation (GODS) model.

- Irrigation benefits were valued based on incremental net value of production.

- Water supply benefits (Third Nairobi Water Supply, 1989 and Ceara Urban Development and Water Resource Management, 1994) were valued at WTP based on average water tariff.

- Valuation of flood control benefits (5 projects) were based on damage avoided.
- Nigeria's Kainji Multipurpose project (1964) did not value power benefits explicitly. As decision criterion was present worth, secondary benefits from transportation, agriculture, and fishery were credited to the total cost of the project, and then compared with thermal alternative.

Financial Analysis

- Financial analysis from the perspective of the owner (i.e., evaluation of owners' financial statements) is common (20 of 26 cases), especially since the conduct of DCF analysis is not common. Where irrigation projects are involved, financial analysis from the perspective of project beneficiaries is given through an analysis of farm budgets.
- Financial analysis of two 1990s projects (China's Yangtze and Xiaoloangdi) were undertaken from the perspectives of the project, owner, and project beneficiaries.
- Only in 4 of the projects was the FIRR calculated and supplemented by NPV or payback period. Hurdle rates were not extensively discussed, but for power projects, return on rate base (RORB) or return on fixed assets was mentioned.
- Though there are cases where cash flows are presented in the SARs, expenditure and revenue flows are aggregated. Mention elsewhere in 7 documents however is made of social costs or environmental costs being incorporated in the project cost estimates.
- For Daguangba Multipurpose project (1991), an analysis of rent and cost recovery was presented.
- For China's Tongbai Pumped Storage project (1999), financial analysis was carried out to determine the tariff profiles required to generate a 12% rate of return. Sensitivity test was conducted on the following variables: tariff and operating hours.

Economic Analysis

- While there is explicit distinction between financial and economic analysis in general, some SARs do not specify adjustments made.
- Many cases particularly in the earlier years up to the 1980s (except for Turkey's Ceyhan Aslantas Multipurpose, 1973, Ghana's Kpong Hydroelectric, 1977 and India's Nathpa Jhakri Power, 1989) simply remove transfer payments and inflation effects from the project cost estimates. Some shadow pricing was done for wage rate but unclear in others. However, for Kpong's Hydroelectric project, no adjustment was made for wage rates even with the explicit recognition that the shadow wage rate could be 70-80% of the market wage.
- In the 1960s projects, no CBA was done. In the Kainji Multipurpose project (1964), present worth analysis (comparing the hydro scheme with the thermal alternative) was the basis for decision making.
- From the 1970s, CBA was done where EIRR was the main criterion. Only from the late 1980s was the IRR supplemented by NPV (4 cases) and BCR (2 cases).

- In the 1990s projects, financial flows were adjusted for input and output distortions, transfer payments, shadow exchange rate, and shadow wage rate.

Economic Discounting

- No SARs mentioned any method to obtain the discount rate. Six projects mentioned that the discount rate (ranging from 10-12%) is considered to be the opportunity cost of capital or social discount rate in that particular country (China, Ghana, Kenya, Mexico, Pakistan). None calculated the discount rate specifically for the study purposes.

Sensitivity Analysis

- Where CBA was conducted, sensitivity analysis was also undertaken. However, only in recent years was there testing of the impact of key variables on the decision criteria, as opposed to a standard +/- change in benefits or costs. Even then, however, there is no analysis of the likely magnitude of the changes in the key variables. Only in 5 cases were mitigating measures/actions identified to avoid any adverse impact on the project's viability.
- Only 2 projects (China's Xiaolangdi Multipurpose, 1995 and Pakistan's Ghazi Barotha, 1995) presented a systematic analysis of risk for changes in key variables, as identified in the Project Design Summary. Probabilities have been assigned to each scenario, so that a weighted average IRR and a probability distribution for the IRR can be obtained. In China's Tongbai Pumped Storage project (1999), there was an analysis of critical risks, indicating the risk rating (using a probabilistic method) and risk minimisation measures.

Regional and Macroeconomic Analysis

- In general, no affordability analysis from the perspective of the borrowing country was done, except for Pakistan's Ghazi-Barotha Hydropower Project where the impact of the project on the fiscal and balance-of-payments position of the country was analysed.
- There is generally no explicit linkage between the project and regional and macroeconomic objectives.

Distributional Analysis

- No quantitative distributional analysis was conducted.

Table 8. List of World Bank Staff Appraisal Reports (SARs) Reviewed

Project Title	Year	Dam	Country
Hydropower Projects			
El Chocon	1968	El Chocon	Argentina
Tachien Hydroelectric	1968	Tachien	Taiwan
Second Power Expansion	1970	Bayano	Panama
Kamburu Hydroelectric	1971	Kamburu	Kenya
Kulekhani Hydroelectric	1975	Kulekhani	Nepal
Fourth Power (Fortuna Hydroelectric)	1977	Fortuna	Panama
Kpong Hydroelectric	1977	Kpong	Ghana
Kiambere Hydroelectric Power	1983	Kiambere	Kenya
Perusahaan Umum Listrik Negara (Thirteenth Power)	1983	Cirata	Indonesia
Pehuenche Hydroelectric and Alto-Jahuel-Polpaico Transmission	1987	Pehuenche	Chile
Nathpa Jhakri Power	1989		India
Berke Hydropower	1992	Berke	Turkey
Ghazi-Barotha Hydropower	1995	Ghazi-Barotha	Pakistan
Ertan II Hydroelectric	1995	Ertan	China
Tongbai Pumped Storage	1999	Tongbai-Lower Reservoir	China
Irrigation Projects			
Rio Sinaloa Irrigation	1973	Bacurato	Mexico
Rio Fuerte/Rio Sinaloa Irrigation	1979	Bacurato	Mexico
Apatzingan Irrigation	1980	Chilatan	Mexico
Water Supply Project			
Third Nairobi Water Supply	1989	Ndakaini(?)	Kenya
Multipurpose Projects			
Kainji Multipurpose	1964	Kainji	Nigeria
Upper Pampanga River Irrigation	1968	Pantabangan	Philippines
Ceyhan Aslantas Multipurpose	1973	Aslantas	Turkey
Daguangba Multipurpose	1991	Daguangba	China
Ceara Urban Development and Water Resource Management	1994	Jerimum, Ubaldinho, Castro, Angicos	Brazil
Yangtze Basin Water Resources	1995	Jiangya	China
Xiaolangdi Multipurpose Project: Stage II	1995	Xiaolangdi	China

Table 9. World Bank Dam Projects Surveyed by Region and Decade

	1960s	1970s	1980s	1990s	1960s – 1990s
Asia	2	1	2	6	**11**
Africa	1	2	2		**5**
Europe		1		1	**2**
South America	1	4	2	1	**8**
All	**4**	**8**	**6**	**8**	**26**