GUIDELINES

FOR THE ECONOMIC ANALYSIS OF WATER SUPPLY PROJECTS

Project Economic Evaluation Division
Economics and Development Resource Center

March 1998

These sector-specific guidelines present the main principles, concepts and procedures applied in the economic analysis of water supply projects. They are based on and consistent with the Bank's Guidelines for the Economic Analysis of Projects.

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Foreword

The Asian Development Bank has provided loans for the development and rehabilitation of water supply systems in several developing member countries. It has likewise provided loans for urban development projects where water supply was a significant component. In the past, water supply projects were usually appraised on the basis of technical criteria and financial analysis; the total economic benefits of investment in water supply operations were not valued.

The application of economic analysis at an early stage in the project cycle is crucial to enhance project quality. The Project Economic Evaluation Division (EDEV) of the Economics and Development Resource Center, in close cooperation with the operational divisions, prepared Interim Guidelines for the Economic Analysis of Water Supply Projects. These interim guidelines were approved by Management in June 1995 and field-tested through a regional technical assistance.

The interim guidelines were revised to reflect field experiences from in-country case studies of Bank-assisted water supply projects. The revised guidelines were reviewed by an interdepartmental consultative group and comments were incorporated. The revised guidelines replacing the earlier approved interim guidelines, were approved by Management in March 1998.

These sector-specific guidelines provide the basic concepts, principles and procedures for identifying, quantifying and valuing the economic benefits and costs of water supply projects. They are consistent with the Bank's general guidelines for the Economic Analysis of Projects.

These sector-specific guidelines are for use by Bank staff, consultants and officials from developing member countries who are involved in the water supply sector.

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March 1998

ABBREVIATIONS

AIC	–	Average incremental cost
AIEC	-	Average incremental economic cost
AIFC	–	Average incremental financial cost
EIRR	–	Economic internal rate of return
ENPV	–	Economic net present value
EOCC	–	Economic opportunity cost of capital
FIRR	–	Financial internal rate of return
m^3	–	Cubic meter
NEB	–	Net economic benefits
SCF	–	Standard conversion factor
SERF	–	Shadow exchange rate factor
SWRF	–	Shadow wage rate factor
UFW	–	Unaccounted for water
WTP	–	Willingness to pay

Contents

I. INTRODUCTION

1. These sector guidelines present the main principles, concepts, and procedures applied in the economic analysis of water supply projects.[1] They are based on and consistent with the Bank's *Guidelines for the Economic Analysis of Projects*.[2] The guidelines provide a general methodological framework and are prepared for

- mission leaders who need to understand the basic concepts and major methodological steps in the economic analysis of water supply projects;
- project economists, financial analysts, and staff consultants who are mission members and who need to conduct sound economic analysis, and demonstrate the financial sustainability and economic viability of water supply projects; and
- consultants working on project preparatory technical assistance who are responsible for carrying out the economic analysis at the feasibility stage.

2. Economic analysis generally aims to improve the social well being of society in terms of income or consumption by encouraging the efficient use of resources. Financial viability and project risks are also assessed to test the sustainability of service delivery and economic benefits. These analyses are carried out in conjunction with social, technical, institutional, and environmental analyses prior to project appraisal and when necessary throughout the project cycle.

II. METHODOLOGY

A. Basic Procedures and Characteristics of Water Supply Projects

3. The basic analytical procedures are in accordance with the *Guidelines for the Economic Analysis of Projects* and include

- defining project rationale, objectives, scope, and geographical coverage, i.e., the proposed service area;
- analyzing and forecasting effective demand for project outputs;

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1 The Bank's Handbook for the Economic Analysis of Water Supply Projects provides detailed illustrations on how to apply the concepts, principles, and methods presented in these guidelines in actual projects.

2 Asian Development Bank. 1997. *Guidelines for the Economic Analysis of Projects*. Manila.

- choosing the least-cost design to meet demand, in economic terms, or selecting the most cost-effective way to attain the project objectives;
- identifying the differences between economic and financial analyses;
- identifying quantifiable economic benefits and costs;
- identifying the nonquantifiable effects of the project that may influence project design and the investment decision;
- determining whether economic benefits exceed economic costs;
- calculating the economic internal rate of return (EIRR) and assessing the viability of the project;
- testing for sustainability and risks associated with the project;
- assessing whether the project's net benefits will be sustainable throughout the life of the project; and
- identifying the distribution of the effects and the poverty reduction impact of the project.

Economic analysis provides a measure, i.e., the EIRR, that will be compared with the economic opportunity cost of capital (EOCC). In practice, the extent of the economic analysis of projects varies according to the feasibility of quantifying and valuing project benefits and costs. The diagram in Appendix 1 shows a flowchart of these steps.

4. Water supply projects generate significant economic benefits. Their characteristic features include

- investments occur in medium-term phases, typically ten years;
- levels of sunk costs are typically higher in urban, rather than rural, areas;
- large economies of scale typically occur in production and transport mains rather than in distribution;
- water is usually a nontradable output;

- domestic consumers are end users, while nondomestic users are intermediate and end-use consumers;

- a medium to high proportion of water use is for construction works and other public places like hospitals, hotels, and commercial undertakings; and

- they have a relatively long investment life.

While water is vital for human life and therefore a precious commodity, in comparison with other resources it is wasted on a large scale. The pricing of water in developing countries is rarely efficient: tariffs are often below cost and governments are required to finance construction and operational deficits.

5. The rationale for a project should be identified early in the project cycle, enabling the analyst to determine whether the proposed investment option is the appropriate intervention or whether a policy or institutional change is preferable and more sustainable in terms of achieving the project objectives. Policy reforms and/or capacity building are an important part of project design.

6. Reliable water demand projections are important for determining the best size and timing of investments. The potential for economies of scale; the lumpiness of larger water supply project investments; the relationship of demand to price; and the differences in the determinants of demand and consumption patterns, e.g., peak and nonpeak demand cycles in urban areas, make the analysis of effective demand in urban and rural areas a critical element in the economic and financial analyses of water supply projects. However, demand forecasting remains a challenging empirical exercise often constrained by the availability of sufficient and reliable data.

7. To the extent feasible, estimates of the relationship between quantity demanded and price, i.e., price elasticity, should be made, and tariffs should be based on the economic cost of water supply provision. Where tariffs are lower than the economic cost of provision, overconsumption and wastage may occur, thus contributing to operational deficits. However, where tariffs are higher than the economic cost of provision, underconsumption, especially by the poor, may result in a consequent loss of welfare to the community.

8. Different sources of water entail varying processing costs. The efficient provision of water should start with the least-cost option. As the demand for traditional sources of water supply increases, the sustainability of these resources is increasingly exceeded resulting in the need to develop higher cost sources of supply.

9. The key differences between the economic and financial analyses of a project are the way the costs and benefits are valued. For example, the marginal cost of raw water comprises not only the investment and operation and maintenance costs calculated as average incremental cost, but also the opportunity cost of water. The opportunity cost of water is the benefit foregone in the next best alternative use of water, e.g., irrigation of agricultural crops. On the benefit side, financial benefits are based on the revenues generated from the project. Economic benefits may include both quantifiable and nonquantifiable benefits associated with water from alternative sources being displaced by the project, and new and additional sources of supply becoming available.

10. Economies of scale differ for various components of a water supply project; typically, economies of scale are larger in production and bulk transport than in distribution. Failures that are associated with mismanagement and inefficient use of water resources can be traced to two major causes: (i) nonexistent or malfunctioning water markets that cause market failure and (ii) government interventions that cause policy and institutional failures.

11. In the case of water supply projects and associated sanitation components, in particular, benefits cannot always be reliably quantified and fully valued in monetary terms. Whether comprehensive benefit-cost analysis can be carried out or not, depends on the availability and reliability of empirical data to value the project benefits. The cost-effectiveness of data collection and analysis must also be taken into account in the appraisal of projects, particularly for small rural projects. In some cases, it may be possible to approximate the monetary value of project benefits based on postevaluation findings or on research data from a similar project in a different location. Such approximation, however, results from a careful assessment of the relevance of assumptions used in the economic valuation procedure for the similar project, e.g., conditions with regard to rainfall/climate, and availability and accessibility of existing water sources. If those assumptions are not, or are less, plausible in the proposed project context, benefit-cost analysis may have to be replaced with a qualitative assessment of project benefits.

12. The guidelines cover the economic analysis of both urban and rural water supply projects. Rural water supply typically comprises regional time slices of water supply sector development plans, and economic analysis at the feasibility stage is limited to a representative sample of subprojects. Where the water supply projects are confined to areas where the services are targeted at project beneficiaries who are poor, disadvantaged, and vulnerable, water services are to be considered as a public good to meet a basic need and reduce poverty. On the other hand, even in rural communities there may already be a sufficient number of people who can afford and are willing to pay the full cost of water services. For them, water should be provided at the full economic cost for the preferred level of service. As incomes of poor households and thereby ability to pay increase gradually over time, their contribution to cost recovery should also increase.

B. Project Objectives

13. The project framework is a project design tool that integrates the evaluation of the economic and social effects of projects and provides a common basis to directly and indirectly evaluate productive projects within the context of the project objectives. For economic analysis, it encourages clarification of the economic logic underpinning project design and the development of a clear statement of the overall sector goal and immediate project objectives, i.e., why the project is being undertaken. The integrated approach ensures transparency and accountability, and promotes the efficient use of resources. In the project framework, the relationships between input-output, project purpose, and sector goal are made explicit. Objectively verifiable indicators are provided for each of these. The indicators constitute the basis for monitoring project performance at the implementation stage and during the operational life of the project. Benefit monitoring will also be useful for postevaluation. Key assumptions concerning project-related activities, management capacity, and sector policies beyond the control and management of the project authority are also made explicit in the framework.

C. Demand Analysis

14. Urban, rural, domestic, and nondomestic consumers have different consumption patterns determined by different factors. Thus approaches for demand estimation also often differ. In urban areas, existing users are normally charged for their water supply, whereas in rural areas, formal water supply systems may not exist and rural households generally do not pay for water use. In urban areas attempts can be made to derive an estimate of price elasticity and, probably, of income elasticity of demand. This is more difficult for rural water supply.

15. The domestic water demand in urban areas depends on several factors:

- category and number of households;
- household size and its composition;
- present water use in both peak and nonpeak periods;
- household income;
- present prices paid or incurred by households;
- present quality of service;

- weather elements, e.g., rainfall and temperature; and
- unaccounted-for-water (UFW).

Where feasible, statistical methods may be used for demand forecasting by incorporating these factors and their past trends. But such methods can only be used if reliable data is available.

16. It may, however, be possible to arrive at a relationship between the quantity of water demanded and prices to be paid or incurred by the households and between the quantity of demand and household income. This can be done by estimating the price and income elasticity of demand. Of these two, the response of demand to tariffs can be used to manage demand and influence the financial management of water utilities. Price elasticities vary widely from a very inelastic value -0.02 to an elastic -1.57, due to differences in availability of alternative sources from region to region, from season to season, from rural to urban, and by type of use, e.g., indoor and outdoor use. Typical elasticities range from -0.2 to -0.5, a range large enough to require further local data collection and research. The price elasticity of demand is used to arrive at the demand curve, which can then be used to measure the gross (economic) benefits of a water supply project. The income elasticity of demand, on the other hand, helps the designer to arrive at the composite final demand of water depending on the interplay of the price paid and the income of households.

17. Economic simulation models can also be used to support experienced judgment. Subject to adequate data availability, such models should be used to stimulate a creative interaction between the economist and the engineer, based on preliminary benefit, cost, and demand assumptions. Such forecasts should be attempted early in the project cycle.

18. The demand forecast should also identify the extent to which new supplies are expected to be *nonincremental,* i.e., replacing existing water supplies, or *incremental,* i.e., adding to existing supplies. This distinction is important for the way in which benefits are valued.

19. For rural water supply projects , simpler techniques, e.g., the requirement approach, will be more appropriate as a first step. The requirement approach should, however, be used in consultation with the community to arrive at the users' present consumption level and their expected future water use. For areas with higher incomes, the factors to be considered for demand forecasting include (i) size and number of households, (ii) household income, (iii) present price paid or incurred for water, (iv) quality of the supply, and (v) weather elements. Using contingent valuation methods and/or through related market behavior, surrogate demand curves may be derived.

20. The characteristics of demand in rural areas are different for different categories of households in the rural community:

- Where the targeted project beneficiaries are poor with very low incomes and living below the country-specific poverty line, and where there is a high incidence of water-borne and water-related diseases because of the lack or unavailability of safe water, the demand for this group is likely to be categorized as a basic need.

- However, where there is already existing economic activity and consequently the community has enough income to pay, and in most cases is willing to pay, the demand analysis can be done in a manner similar to that in urban areas.

21. In rural areas where poverty is endemic, the demand for the first 10 to 20 liters of water per capita, necessary for subsistence, has a high economic value. This minimum quantity satisfies a basic need of the population. Additional volumes of water demanded beyond this basic need level, which will be provided by a new water supply project, constitute incremental economic benefits that need to be analyzed in a manner similar to that of urban water supply. The analysis should reflect the actual or effective demand of the rural population which also depends on the availability of alternative sources. If rural communities are made up of different income groups, each income group may have a different demand for water supply services. The design of a rural water supply project based on economic analysis aims at improving the level of service to all water users by ensuring an acceptable level of cross-subsidization within the community. One should be cautious, however, about generalizations and cross-subsidization may not always be a feasible option in all rural communities.

22. The factors that are important for nondomestic urban water demand include commercial and industry sector growth trends, and projected government/social sector growth based on projected population growth. Nondomestic demand can often be estimated as a percentage of domestic demand based on past trends. If assumptions regarding urban industrial growth are plausible, industrial water demand can be more accurately ascertained based on water consumption rates for each industry subsector.

23. Another determinant of water demand is a realistic assessment of UFW based on trends and expectations of the efficiency of the water supply organization. Finally, the daily and seasonal peak demands should be estimated. An assessment of past records and projected demand and consumption patterns are one basis for this analysis.

24. Socioeconomic research and user surveys are undertaken to (i) identify user preference by level of water service, e.g., house or yard connection or public tap; (ii) evaluate willingness to pay (WTP) for the preferred level of water service; (iii) increase the reliability of demand forecasts and benefit estimates; and (iv) assess the demand response to changes in

water prices, household incomes, and industrial growth. Where the market for an improved water service does not exist, i.e., in most of the rural areas, the application of contingent valuation and related methodology can be relevant to estimate demand and value benefits. All procedures should be explained to ensure transparency and replicability.

25. Basinwide impacts of projects on water demand and supply are also examined. Competition for water is growing in many water basins throughout the world, often as a result of rapid urban and industrial expansion. Project planning and operation are aimed at managing demand efficiently to maximize the economic value of water use. To ensure the efficient allocation of scarce water resources, resource management studies should be undertaken and projects designed and appraised as part of a basinwide resource management program.

D. Least-cost Analysis

26. Having defined project objectives and prepared a preliminary forecast of effective water demand, the next step is to identify the least-cost alternative to achieve the stated project objectives. Economic costs are used to examine the scale, location, technology, and timing of alternative project designs. The analysis aims to identify the least-cost project option for supplying (or conserving) water to meet forecast demand. If the benefits are the same, least-cost analysis compares the economic costs of mutually exclusive, technically feasible project options, and identifies the one with the lowest present value of economic costs. If the economic benefits of the project alternatives are not the same, a net present value analysis is carried out. The economic costs of project alternatives are discounted at the EOCC, taken as 12 percent in real terms. If the EIRR is to be calculated, it should be worked out for the incremental cash flow of the mutually exclusive alternatives.

27. A least-cost analysis of water supply projects producing the same benefits can be approximated by estimating the average incremental economic cost (AIEC) of water for each project (or long-term expansion plan) alternative, selecting the one with the lowest AIEC. If the least-cost option for increasing supplies is through more efficient management and rehabilitation of the existing system rather than through augmenting supply capacity, then this option should be a priority project component. Supply capacity augmentation is the next step and should be considered in the project design if clearly indicated by the demand forecasts.

28. Because water demand, supply cost, and price charged for water tend to be closely interrelated, the least-cost analysis should account for the effect of uncertain demand. Lower than forecast demand results in higher average costs that can push up water prices and depress demand further. Sensitivity analysis can be used to show whether the project option remains the least-cost alternative under adverse changes in key variables. The scale of the

project may vary in relation to prices charged to consumers, and the size may influence the least-cost alternative. This is explained further in Appendix 2.

E. Economic and Financial Analyses

29. Economic and financial analyses represent complementary yet distinct ways to estimate the net benefits of an investment project. Both are based on the difference between the with-project and the without-project situations. The concept of net financial benefit, however, is different from that of net economic benefit. Whereas financial analysis estimates the financial impact of the project on the project-operating entity, economic analysis estimates the economic impact on the country's economy. They are complementary because for a project to benefit the economy, it must be financially sustainable. If a project is not financially sustainable, there will be inadequate funds to properly operate, maintain, and replace assets, and the quality of the water service will deteriorate, eventually affecting demand and the realization of financial revenues and economic benefits.

30. Financial benefit-cost analysis of the project involves estimating the financial internal rate of return (FIRR) in *constant* prices. The FIRR is the rate of return at which the present value of the stream of incremental net flows in financial prices is zero. If the FIRR is equal to or greater than the financial opportunity cost of capital, the project is considered financially viable. Thus, financial benefit-cost analysis covers the profitability aspect of the project at the enterprise level.

31. The basic difference between the financial and economic benefit-cost analyses (profitability aspect) of a project is that the former compares benefits and costs to the enterprise in *constant financial* prices, while the latter compares the benefits and costs to the whole economy measured in *constant economic* prices. Financial prices are market prices of goods and services that include the effects of government intervention and distortions in the market structure. Economic prices reflect the true cost and value to the economy of goods and services after adjustment for the effects of government intervention and distortions in the market structure through shadow pricing of the financial prices. Therefore, in such profitability analyses (financial and economic analyses), depreciation charges, sunk costs, and expected changes in the general price level should not be included. Depreciation charges should not be treated as costs as the investments already figure in the cash flows; sunk costs constitute expenditure for fixed assets in place prior to the investment decision; and in the profitability analyses, the benefits and costs are to be valued at constant prices (of the appraisal year). The expected changes in relative prices (as distinct from the changes in the general price level), however, should be incorporated.

32. The taxes and subsidies included in the price of goods and services are integral parts of financial prices, but they are treated differently in economic prices. If the supply of a project input is incremental, i.e., the total input supply with the project exceeds the total input supply without the project, and there is a production tax on its price, the net-of-tax price will represent the amount that sellers are willing to accept as compensation. This price, the *supply* price, will therefore form the basis of the economic cost per unit of project input. On the contrary, if the demand for project output is incremental, i.e., total output demand with the project exceeds total demand without the project, and there is a sales tax on its price, the gross of tax price will represent the amount that buyers have to pay. This price, the *demand* price, will therefore form the basis of the gross economic benefit of incremental output.

33. Financial and economic benefit-cost analyses also differ in relation to the external effects (benefits and costs) of a project. There are many examples of such externalities that are not accounted for in market transactions and that are, therefore, not directly reflected in the financial cash flow of a project. The environmental impact of a project is a typical example of such an externality. Other examples in the case of water supply projects are depletable water resources, especially in the case of projects using groundwater, and water supply projects using scarce raw water resources in the case of competition between the users of raw water. Economic analysis attempts to value such externalities and internalize them into project benefits and costs to improve the efficiency of the use of the limited resource and to contribute to the enhancement of environmental sustainability.

34. In the case of depletable water resources, the external costs may be internalized into economic cost calculations. In the case of groundwater, the finite capacity of aquifers means that when withdrawal rates exceed the rate of recharge, an alternative water source must eventually be found. The higher future cost of obtaining water implies a scarcity rent or *depletion premium*. If a natural resource is depletable, its economic cost will comprise the opportunity cost in terms of benefits foregone from the water's best alternative use and from scarcity rent. Even when costing surface water, scarcity rent may be relevant. When a water utility approaches the limits of its legal entitlement from a river source, it has to find an additional, usually more expensive, source to meet growing demand. If, on the other hand, the water utility is able to purchase new water rights in the open market, then the scarcity rent will be an explicit part of the price paid, and the market price of raw water will provide the basis of its economic price.

35. If there is competition between the end users for raw water, then water use imposes a cost on the economy. The cost concept applied to the value of raw water in the economic analysis of a water supply project is that of opportunity cost: the maximum benefit foregone. For example, if a project's intake of river water reduces the quantity of water available for downstream irrigation during the dry season, then the cost of raw water is measured by its value to downstream irrigators, i.e., what they would lose in net income from being unable

to produce a dry season crop. The economic cost of raw water should be estimated in the context of a comprehensive water resources management study of a river basin. Where the supply of raw water is expected to continue to exceed the demand for all uses, the opportunity cost of raw water (at the intake) would be zero.

36. How the treatment of sanitation is handled in the economic analysis depends on whether the scope of the water supply project does or does not include a substantial sanitation component. Three cases can be identified for which the following approach to economic analysis is recommended:

Case 1. Investment in the sanitation component is very small compared with that in the water supply component. The economic cost of the sanitation component can be included as part of the overall project costs and the economic analysis conducted accordingly. If the size of the sanitation component is too small to warrant additional investment, the external costs should be incorporated in the economic analysis of the project to the extent possible.

Case 2. Investment in sanitation is in the medium-size category and the economic benefits and costs of sanitation are identifiable. However, the investment in sanitation is not large enough to warrant consideration as a separate project. In this case, an integrated economic analysis, i.e., combined water supply and sanitation, is suggested, including the economic impact of incremental wastewater pollution on human health, agriculture and marine sources, and environmental values. Effluent charges can be determined from the costs of collecting, transferring, treating, and disposing of wastewater.

Case 3. Investment in sanitation is very large compared with that in water supply. Sanitation should be treated as an independent project for which economic analysis is carried out.

37. An important objective of a water supply project is the improvement of health due to the reduction and ultimate elimination of water-related diseases. Although there are some techniques being advocated by environmental and health economists for the monetization of health benefits from safe water, it remains difficult in the appraisal of water supply projects. For example, consider the case of financial revenues collected from the users as a measure of WTP being used to determine the monetary benefits from the project. The financial revenues do not capture all the external effects of better community health stemming from the consumption and use of clean water. The magnitude of health benefits from water supply projects, however, depends on the efficient maintenance of a potable water supply through

institutional changes like privatization in urban areas and community participation and community management in rural areas, and the provision of complementary sanitation and health and hygiene education. All of these measures entail costs. When public health benefits are expected to be significant and sustainable, health benefits can be estimated either in terms of avoided private and public medical expenses or in terms of productivity and income gains due to reduced morbidity or by calculating the alternative cost of achieving those health benefits, e.g., boiling and filtering water plus public awareness campaigns.

38. UFW represents another source of economic benefits and is treated differently in economic and financial analyses. UFW is water that is produced but not sold. It is either lost through leakages, known as technical losses, or unaccounted consumption, known as nontechnical losses. The distinction between technical and nontechnical losses is important for the economic analysis of water supply projects. Whereas both technical and nontechnical losses increase the cost of supply, nontechnical losses benefit consumers who do not pay. The value of these benefits should therefore be included as part of the project's overall benefits. Water sold but not paid for, as represented by bad debts, is treated in the same way as nontechnical losses in economic benefit-cost analysis. UFW is often difficult to estimate. Estimating technical and nontechnical losses separately is even harder. Project design should aim to reduce UFW and eliminate nontechnical losses. To improve the estimates, consultants should be required, from the start of a feasibility study, to install measuring devices in key places in the network.

39. Economic benefits and costs can be expressed using different units of accounts (numeraires), either domestic price level or world price level numeraire. If the domestic price level numeraire is selected, the analyst should apply the shadow exchange rate factor (SERF) to tradable components. The SERF is the ratio of the economic price for foreign currency to its market price and may be calculated as the shadow exchange rate divided by the official exchange rate. The shadow exchange rate is the weighted average of imports and exports in domestic prices to the border price equivalent value of the same goods, which means that the SERF is the reciprocal of the standard conversion factor (SCF). The SCF is the ratio of the border price equivalent value of traded goods to their value in domestic prices. If the world price level numeraire is chosen, the nontradable items are expressed at the world price level by applying a specific conversion factor or the SCF.

40. As water supply projects, especially in the rural areas, may have a considerable impact on poverty, it is important to calculate the distribution of project effects on different project participants, especially the poor. To assess the impact of the project on poverty reduction, it is more convenient to use the domestic price level numeraire as it allows a direct comparison of economic and financial values.

F. Identification and Valuation of Project Economic Benefits and Costs

Identification

41. Benefit-cost analysis compares the with-project economic benefits and costs with those for the without-project scenario. However, the without-project case is rarely a simple continuation of the existing situation. For example, if a rehabilitation component prevents future costs or safeguards existing benefits, then these effects are included in the without-project benefit and cost streams. External effects are included in both the with-project and without-project situations.

Quantification and Valuation

42. The project output is made up of two parts: incremental and nonincremental water. Incremental output adds to the quantity of water consumed without the project, but nonincremental output does not. Nonincremental output, i.e., the existing demand, displaces consumption supplied by other public or private water sources.

43. The first step in the benefit-cost analysis of a water supply project is to forecast the incremental and nonincremental demand resulting from the project. The nonincremental demand is equivalent to the amount of water demanded from alternative sources that will be displaced by the project. Incremental demand is the amount of new and additional demand induced or generated by the project.

44. The gross economic benefit from a new water supply is made up of two parts:

- resource cost savings on the nonincremental water consumed in switching from alternative supplies to the new water supply system resulting from the project, and
- the WTP estimated on the basis of average demand price, for incremental water consumed.

45. Resource cost savings are estimated by multiplying the quantity of water consumed without the project, i.e., nonincremental quantity, by the average economic supply price in the without-project situation. For simplicity, it is assumed that the quantity of water consumed without the project is the same as the quantity of water consumed before the project. In cases where the before-project water is not paid for in cash, the implied price can be estimated in terms of the opportunity cost of resources, e.g., labor, expended to obtain supplies of water.

46. The WTP for incremental supplies can be estimated through a demand curve indicating the different quantities of water demand that could be consumed at different price levels. The economic value of incremental consumption is the average price value derived from the curve times the quantity of incremental water. If there is inadequate data to estimate a demand curve, a contingent valuation methodology can be applied to obtain an estimate of the WTP for incremental output.

47. The gross economic benefit stream should be adjusted for the economic value of water that is consumed but not paid for. It can be assumed that, on average, this group of consumers derives the same benefit from the water as those who pay. For example, if 70 percent of water is sold and paid for, 10 percent sold but not paid for (bad debts), and 10 percent consumed but not sold (nontechnical losses), the economic value of water supplied by the project is equal to the ratio of water consumed (90 percent) to water paid (70 percent) or 1.29 (= 0.9/0.7) times the average economic value of revenue water that is paid for.

48. After estimating gross economic benefits, the next step in the economic analysis is to calculate the capital and operating costs of the project, including connection costs. The procedure is as follows: (i) select either the domestic price or world price numeraire; (ii) apportion costs into their tradable and nontradable components; and (iii) using the official exchange rate, value the tradable components at their border price, adjusted to the project location. Then, do either of the following:

- In case of use of the domestic price numeraire, revalue the tradable components from the border price level to the domestic price level by multiplying by the SERF and value nontradable components at their supply price.

or

- In case of use of the world price numeraire, value the tradable component at the border price equivalent value and revalue the nontradable components to the border price by multiplying by the SCF.

Appendix 3 shows an illustrative calculation of the economic value of output from a water supply project.

Economic Viability Analysis

49. Once the economic benefit and cost streams are derived, a project resource statement can be developed and the EIRR for the project calculated. Bank practice is to use 12 percent as the minimum rate of return for projects for which an EIRR can be calculated, although for projects with considerable nonquantifiable benefits, 10 percent may be accept-

able. For water supply projects located in rural areas, there may be limitations to value the economic benefits, thus making it difficult to calculate a reliable EIRR. However, the economic analysis may be undertaken on the basis of the least-cost or cost effectiveness analysis using the economic price of water.

50. Economic criteria for project acceptability stem from the analytical steps set out in para. 3. A project is acceptable if it is shown to be (i) consistent with government objectives and policies; (ii) providing a service at a price for which there is an effective demand; (iii) the least-cost project alternative for meeting demand; and (iv) economically worthwhile.

51. In the case of projects for which economic benefits can be reliably estimated, economic criteria include the EIRR. For such projects to be acceptable, the EIRR should equal or exceed the EOCC. In Bank practice, given the complexity of estimating country-specific EOCCs, a cut-off rate of 12 percent is set regardless of the country concerned.

52. Benefits and costs that can not be expressed in monetary terms may be important in water supply projects and should therefore be identified and quantified to the extent feasible. The importance of unquantifiable net beneficial or adverse project effects should be assessed along with the EIRR analysis.

G. Sensitivity Analysis

53. Any economic analysis is based on uncertain future events and inexact data. Sensitivity analysis is therefore undertaken to identify those benefit and cost parameters that are both uncertain and to which the EIRR and FIRR are sensitive. Switching values showing the change in a variable required for the project decision to switch from acceptance to rejection are presented for key variables and compared with postevaluation results for similar projects, whenever such results are available. For large projects and those close to the cut-off rate, a quantitative risk analysis incorporating different ranges for key variables is recommended. Measures mitigating against major sources of uncertainty are incorporated into the project design, thus improving it.

H. Sustainability and Pricing

54. For a project to be sustainable, it must be both financially and economically viable. A financially viable project will continue to produce economic benefits that are sustained throughout its life. Assessing sustainability includes evaluating the project's fiscal impact, i.e., whether the government can afford to pay the level of financial subsidies that may be necessary for the project to survive. In some cases, the financial situation of the water enter-

prise may be such that incremental analysis at the project level alone may not provide a reliable indication of the project's financial sustainability. In such cases, financial analysis at the enterprise level will be of key importance.

55. To demonstrate financial sustainability of the project, financial analysis should be undertaken at the water enterprise and project levels. Financial analysis at the water enterprise level involves preparation of balance sheets, income statements, and sources and uses of funds statements, all at *current* prices. Financial analysis covers the financial liquidity aspect of the project at both levels.

56. Assessing sustainability includes examining the role of cost recovery through water pricing, estimating the direct effect on public finances of the project's net cash flows, and making an assessment of the government's capacity to finance subsidies. This is done by calculating the average incremental cost of water for comparison with the average price charged for system connection and water use. Based on the planned long-term expansion path of the water enterprise, the average incremental cost of water can be defined in terms of financial or economic values. The average incremental financial cost (AIFC) of water is equal to the present value of the stream of future capital and operating costs at financial prices divided by the present value of the future quantity of water sold. The AIEC of water is equal to the present value of the stream of future capital and operating costs (including depletion premium and opportunity cost of water) at economic prices divided by the present value of the future quantity of water consumed. When the domestic price numeraire is used in the analysis, the AIEC can be directly compared with the average water tariff. If the world price numeraire is used, the average tariff must be multiplied by the SCF. Even in the case of rural water supply projects categorized as basic need, cost recovery of at least a part of the operation and maintenance costs based on the AIFC must be considered.

57. Tariffs should be based on cost, social objectives, and the ability of the government to subsidize water. If wealthier beneficiaries pay a tariff higher than the full cost of water, there may be no need for the government to subsidize the water utility. Tariff structures sometimes aim at cross-subsidization. As long as the net economic benefits are positive, financial subsidies may be justified to meet a basic level of demand for water. Unless subsidy regulations are clear at the outset, FIRR calculations for water supply and sanitation projects should first be done excluding government subsidies, followed by the calculation of the required financial subsidies, e.g., the AIFC per cubic meter (m^3) minus the average tariff per m^3 (including connection fee) multiplied by the volume of water sold.

58. To minimize financial subsidies, projects are designed to supply services that people want and are willing to pay for. Research by the World Bank found that in many urban communities households are willing to pay the full cost of water service and often the full cost of sanitation services. WTP for water may be high in rural areas as well, especially for the

wealthier segment of the community. Nevertheless, a society may choose to provide cheap water or other services to the poor, as one of many alternative means of improving their welfare, but public intervention is rarely neutral. Cross-subsidies should generally be discouraged because they also distort prices.

59. Postevaluation experience shows that subsidies aimed at helping the poor may not always benefit them in a sustained manner. Underpricing can lead to wasting of water, in particular by the nonpoor; deterioration of the water system and services; and ultimately to higher prices for all. To minimize economic costs and maximize the socioeconomic development impact, subsidies should be carefully targeted to lower the price charged for water to poor and low-income households. Because it is difficult to raise funds through general taxes, self-financing of public water enterprises becomes a desirable policy.

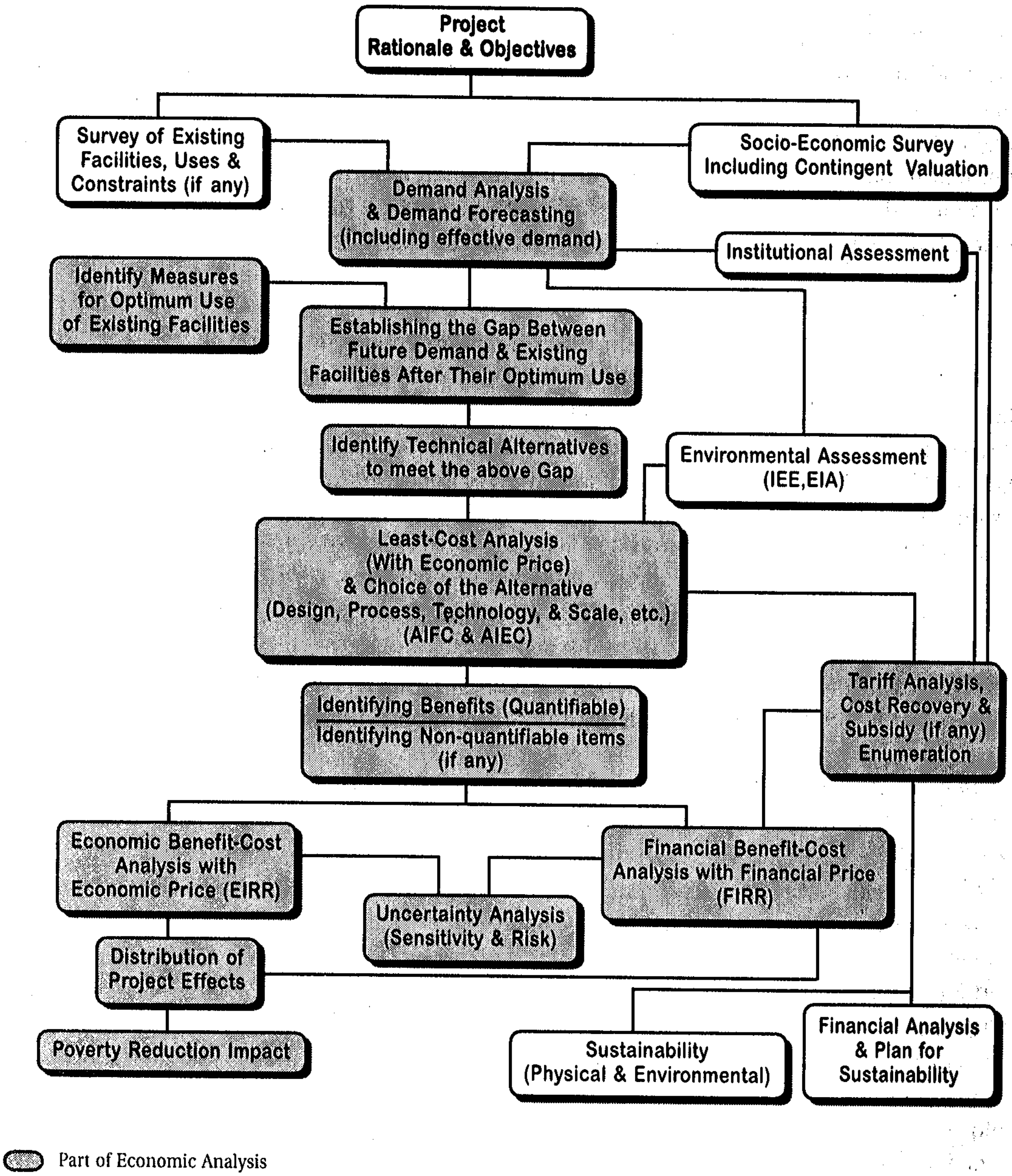
I. Distribution of Project Effects and Impact on Poverty Reduction

60. Water supply provision, especially in rural areas and shantytowns in urban areas, is considered to be important for poverty reduction. The poverty-reducing impact of a project is traced by evaluating the expected distribution of net economic benefits (NEB) to different groups, namely, consumers, suppliers including labor, and the government. The steps to be followed are

- estimate the present value of net financial benefits by participating group,
- determine the distribution of the NEB by group by adding the difference between net benefits by group at economic and financial prices,
- determine the NEB accruing to poor households (below the poverty line) according to the proportion of each group that is poor, and
- calculate a poverty impact ratio by comparing the NEB to the poor with the NEB to the project as a whole.

APPENDIX 1

FLOW CHART FOR ECONOMIC ANALYSIS OF WATER SUPPLY AND SANITATION PROJECTS



AIFC – average incremental financial cost; AIEC – average incremental economic cost; EIRR – economic internal rate of return; EIA – environmental impact assessment; FIRR – financial internal rate of return; IEE – initial environmental examination

LEAST-COST ANALYSIS, TARIFFS, AND THE CONSERVATION OF WATER RESOURCES

1. In general, there are two water conservation measures. The first is a reduction of technical losses, the second a reduction of water demand. This Appendix focuses on the second: reducing demand by raising tariffs, and its implications for the least-cost analysis.

2. The usual sources of water are groundwater and surface water. Alternatives are analyzed, with regard to capacity to supply water, the distance to the city, the investment costs to satisfy demand, and the operation and maintenance costs. The comparison of the alternatives is usually based on the discounted economic flows of the alternatives. The AIEC per m^3 is calculated by dividing the discounted economic cost flow by the discounted quantities of water consumed.

3. However, the AIEC only indicates the least-cost alternative if the quantity of water consumed in all options is the same. The challenge of least-cost analysis can be extended by choosing between project alternatives with different sizes, as a result of increased cost-recovery (demand management). In general, a downsized project will have a higher AIEC per m^3 but can yield a higher EIRR and economic net present value (ENPV). Increased cost-recovery also means a higher potential for financial sustainability. A downsized project needs consideration in project design.

4. Note that it is also possible that at higher user charges, only alternative sources with higher costs (water vendors) are replaced by the project, while cheap alternative sources (existing hand pump) are maintained. This increases the without-project cost of water replaced by the project, resulting in higher economic benefits. This argument introduces a complication for the analysis because it needs estimates of the without-project cost of water for all (major) alternative sources.

5. A reduction of demand could imply that, if the capacity of the cheapest source is limited, investments in more expensive sources can be postponed. For example, a high demand estimate at low tariffs could predict that groundwater sources (generally cheaper) are sufficient until year ten only, so that from year 11 and onward, more expensive surface water sources have to be exploited to meet demand. A low demand estimate at higher tariffs could extend the groundwater supply until year 15, and postpone the use of surface water. This may considerably reduce the investments of the first phase of a long-term water supply master plan.

6. Even when the reduced demand projections would lead to losses of economies of scale, the average investment cost of groundwater only, or of the combination of the two

sources per m^3 capacity, may decrease. This results in lower investments, in a lower unit cost of water (average incremental cost, AIC), a higher internal rate of return, and a higher net present value.

7. In this way, higher tariffs leading to a reduced demand projection can improve project design, switch the choice to the least-cost alternative, and might even, by postponing exploitation of more expensive water sources, lead to the successful appraisal of projects that previously were evaluated as unfeasible.

ECONOMIC VALUATION OF OUTPUT FROM A WATER SUPPLY PROJECT

I. Project Description

A. Proposed Project

1. A piped water supply project is proposed to meet a growing demand for a township from its existing level of 120,000 m³ to 180,000 m³ per year.

B. Existing Supply (120,000 m³ per year)

2. The existing yearly demand is met partly (20 percent) by the supply from private vendors and partly (80 percent) from the operation of household wells at the following financial prices, which include the costs of home processing of water to a quality close to that of piped supplies:

Sources	Proportion	Yearly Quantity (m³)	Cost/m³
Private Vendors	20%	24,000 m³	P 40.00
Household Wells	80%	96,000 m³	P 10.00
Total	100%	**120,000 m³**	

3. The price of piped water supplies from the public system is only P5.00 per m³, which may be lower than its cost of supply. The pricing and the higher quality and reliability of the piped supplies ensure that the existing sources from household wells and private vendors will be fully displaced.

C. Future Extended Supply

4. The demand of the township is expected to increase to 180,000 m³ per year, an increase of 60,000 m³ especially with the tariff level for newly proposed piped supply at only P5.00 per m³.

D. Data for economic pricing

(1) The private vendors' supply price of P40.00 per m^3 reflects labor costs of 50 percent and nontraded costs of 50 percent.

(2) The household wells price of P10.00 per m^3 reflects a traded component of 80 percent and nontraded component of 20 percent.

II. Calculation for Economic Valuation of Output (Using domestic price numeraire)

Shadow wage rate factor (SWRF) = 0.85
Shadow exchange rate factor (SERF) = 1.25

A. Economic Value of Nonincremental Water

(For existing use of water to be replaced based on average existing supply price)

Sources		Component	Amount (P)	Conversion Factor	Economic Price (P)
(1)	Private Vendors	Labor	20.00	0.85	17.00
		Nontraded	20.00	1.00	20.00
	Total		40.00		37.00
(2)	Household Wells	Traded	8.00	1.25	10.00
		Nontraded	2.00	1.00	2.00
	Total		10.00		12.00

Financial price of nonincremental water
(weighted average with 20% of vendors' supply and 80% of household wells)
= 0.2 x 40.00 + 0.8 x 10.00 = P16.00 / m^3

Economic price of nonincremental water (weighted average)
= 0.2 x 37.00 + 0.8 x 12.00 = P17.00 / m^3

B. Economic Value of Incremental Water
(For future increase of water use based on average demand or WTP price)

Average price of water without the project	=	P16 / m³
Price of water with the project	=	P5 / m³
Average demand price without and with the project	=	(16 + 5)/2
	=	P10.5 / m³

C. Economic Value of the Water Supply Project
(in domestic price numeraire) in a year

Gross economic benefit of the water supply project
= (Economic value of nonincremental water) +
(Economic value of incremental water)
= (120,000 m³) x (P17.00) + (60,000 m³) x (P10.50)
= P2,670,000.00

III. Calculation for Economic Valuation of Output (Using world price numeraire)

Standard conversion factor (SCF)	=	1 / SERF
	=	1 / 1.25
	=	0.80
Shadow wage rate factor (SWRF)	=	0.85 x SCF
	=	0.85 x 0.80
	=	0.68

A. Economic Value of Nonincremental Water
(For existing use of water to be replaced based on average existing supply price)

Sources	Component	Amount (P)	Conversion Factor	Economic Price (P)
(1) Private Vendors	Labor	20.00	0.68	13.60
Nontraded	20.00	0.80	16.00	
Total		40.00		29.60
(2) Household Wells	Traded	8.00	1.00	8.00
Nontraded	2.00	0.80	1.60	
Total		10.00		9.60

Financial price of nonincremental water.
(weighted average with 20% of vendors' supply and 80% of household wells)
= 0.2 x 40.00 + 0.8 x 10.00 = P16.00 / m^3

Economic price of nonincremental water (weighted average)
= 0.2 x 29.60 + 0.8 x 9.60 = P13.60 / m^3

B. Economic Value of Incremental Water

(For future increase of water use based on average demand or WTP price)

Average price of water without the Project	=	P16 / m^3
Price of water with the Project	=	P 5 / m^3
Average demand price without & with the Project	=	(16 + 5)/2
	=	P10.5 / m^3
The world price equivalent of the average demand price	=	10.5 x (SCF)
	=	10.5 x 0.8
	=	P8.4 / m^3

C. Economic Value of the Water Supply Project

Gross Economic Benefit of the Water Supply Project
= (Economic value of nonincremental water) +
(Economic value of incremental water)
= (120,000 m^3) x (P13.60) + (60,000 m^3) x (P8.40)
= P2,136,000.00