CHAPTER 6

ECONOMIC BENEFIT-COST ANALYSIS

CONTENTS

Figures

Boxes

Tables

6.1 Identification of Economic Benefits and Costs

6.1.1 Basic Principles

1. After choosing the best among project alternatives and verifying the financial viability of the selected option, the next step is to test the economic viability of that option. The initial step in testing the economic viability of a project is to identify, quantify and value the economic costs and benefits. Two important principles to be followed are:

(i) Comparison between with- and without-project situations; and

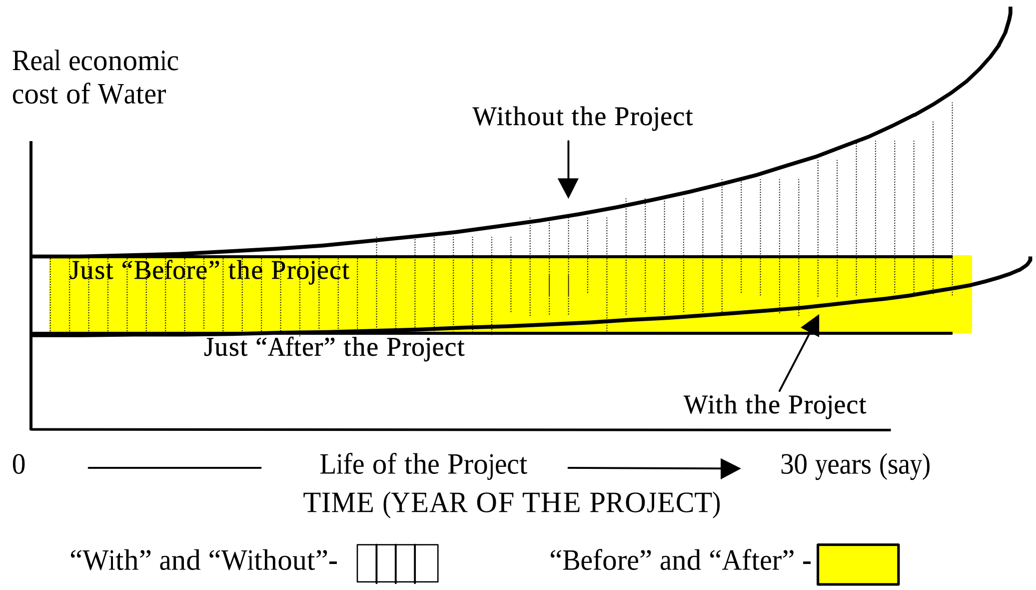
(ii) Distinction between nonincremental and incremental inputs (costs) and outputs (benefits).

6.1.2 With- and Without-cases: Comparison

2. The comparison between "with" and "without" the project is often different from the comparison between "before" and "after" the project. The without-project situation is that which would prevail if the project is not undertaken. For example, population in the project area will grow leading to an increase in the use of water; and water sources will become increasingly scarce and remote, contributing to a higher cost of water to the consumers. The situation, therefore, will not remain static at the level just "before" the project.

3. The project inputs and outputs should be identified, quantified and valued by comparing the without-project situation with that of the with-project to cover the relevant project benefits and costs. Figure 6.1 shows the differences of the real economic cost of water in the with- and without-project and the before- and after-project situations. A similar diagram could also be used to show the differences in the benefits between the various project situations.

Figure 6.1 "With" and "Without" Project vs. "Before" and "After" Project



6.1.3 Nonincremental and Incremental Inputs and Outputs

6.1.3.1 Introduction

4. In identifying project benefits and costs, a distinction is to be made between nonincremental and incremental inputs (costs), and between nonincremental and incremental outputs (benefits). This distinction is important because nonincremental and incremental effects are valued in different ways. Nonincremental inputs are project demands that are met by existing supplies while incremental inputs are project demands that are met by an increase in the total supply of the input. Nonincremental outputs are project outputs that replace existing outputs while incremental outputs expand supply to meet new or additional demands.

5. Inputs (either nonincremental or incremental) to a water supply project (WSP) may include expenditure categories such as water, electricity, labor, equipment and materials, etc., while outputs (either nonincremental or incremental) may include water supply and/or sanitation services.

6.1.3.2 Nonincremental Inputs

6. In some cases, water supply to a user of water, say an industrial plant, is to be met (partly or fully) by an existing stock of available water without expansion of overall supply. For example, such supply is met by withdrawing water from existing users in, say, agriculture. Such water is defined as nonincremental water input.

6.1.3.3 Incremental Inputs

7. If a water demand is to be met by an expansion of the water supply system, the water supply input should be considered as incremental supply of water.

6.1.3.4 Nonincremental Output

8. If the output of a WSP replaces the existing supply to the users, that output is defined as nonincremental output. For example, if the present source of water to the consumers is from vendors or from wells, a canal and or a river (with time and effort spent on such use of water), the supply of water from the project which replaces this is to be considered nonincremental.

6.1.3.5 Incremental Output

9. The supply of water from a project that meets additional or induced demand (possibly as a result of availability of higher quality of water at lower cost) is to be considered as incremental output.

6.1.4 Demand and Supply Prices

10. In economic analysis, the market prices of inputs and outputs are adjusted to consider the effects of government intervention and market failures. Shadow prices based either on the supply price or the demand price, or a weighted average of the two, are used. Different shadow prices are used for incremental output, nonincremental output, incremental input and nonincremental input. Incremental outputs and nonincremental inputs are valued in the same manner, i.e., in terms of their adjusted demand price or willingness to pay. Nonincremental outputs and incremental inputs are valued in terms of their adjusted supply price or opportunity costs. This is shown in Table 6.1.

Table 6.1 Shadow Prices of Project Outputs and Inputs

	Incremental	Nonincremental
Outputs	Adjusted demand price or willingness to pay	Adjusted supply price or opportunity cost
Inputs	Adjusted supply price or opportunity cost	Adjusted demand price or willingness to pay

6.2 Quantification of Economic Costs

11. In estimating the economic costs, some items of the financial costs are to be excluded while some items not considered in the financial costs are to be included. This is to reflect costs from the viewpoint of the economy as a whole rather than from the viewpoint of the individual entity. They are summarized below:

6.2.1 Taxes, Duties, and Subsidies

12. Taxes, duties, and subsidies are called transfer payments because they transfer command over resources from one party (taxpayers and subsidy receivers) to another (government, the tax receivers and subsidy givers) without reducing or increasing the amount of real resources available to the economy as a whole. Hence, such transfer payments are not economic costs.

13. However, these transfer payments are to be included in the economic costs in certain circumstances, including:

(i) if the government is correcting environmental costs through a tax or a pollution charge;

(ii) if the water supply input is nonincremental (refer to para. 6.1.3 above). For example, the volume of water withdrawn from existing agricultural use which is supplied to a newly established industrial plant is to be considered as water. Its economic cost is based on the demand price of agricultural water and as such, the transfer element (tax or subsidy) is a part of the demand price.

6.2.2 External Effects

14. These refer to such effects of a WSP on the activities of individuals/entities outside the project that affect their costs and benefits but which are not directly reflected in the financial cash flow of the project. For example, environmental effects of a WSP, such as river water pollution due to discharge of untreated wastewater effluent, affect activities like fishing and washing downstream.

15. Other examples include the following:

(i) a WSP uses ground water from an aquifer and the natural rate of recharge of that aquifer is less than the withdrawal rate of water. This results in a “depletion” of the resource for which a premium is to be imposed as an economic cost to the project.

(ii) a WSP uses scarce or limited water resources and there is competition among the users of raw water. This may lead to withdrawing water from existing users (e.g., irrigation) to provide water to a new industrial estate, thus imposing a disbenefit to the existing agriculture users. This case is referred to as (nonincremental) water inputs in paragraph 6.1.3 above.

6.2.3 Working Capital

16. A certain amount of working capital is normally required to run a WSP. This working capital includes inventories and spare parts which must be available to facilitate smooth day-to-day operations. Items of working capital reflect not only inventories but also loan receipts, repayment flows, etc. However, for the purpose of economic analysis, only inventories that constitute real claims on a nation’s resources should be included.

6.3 Quantification of Economic Benefits

6.3.1 Benefits from a Water Supply Project

17. Gross benefits from a WSP can be estimated conveniently by apportioning the supply of water into nonincremental output and incremental output.

These were explained in para. 6.1.3.

18. The following example, with calculation and diagram, explains the concepts of valuing incremental and nonincremental demand.

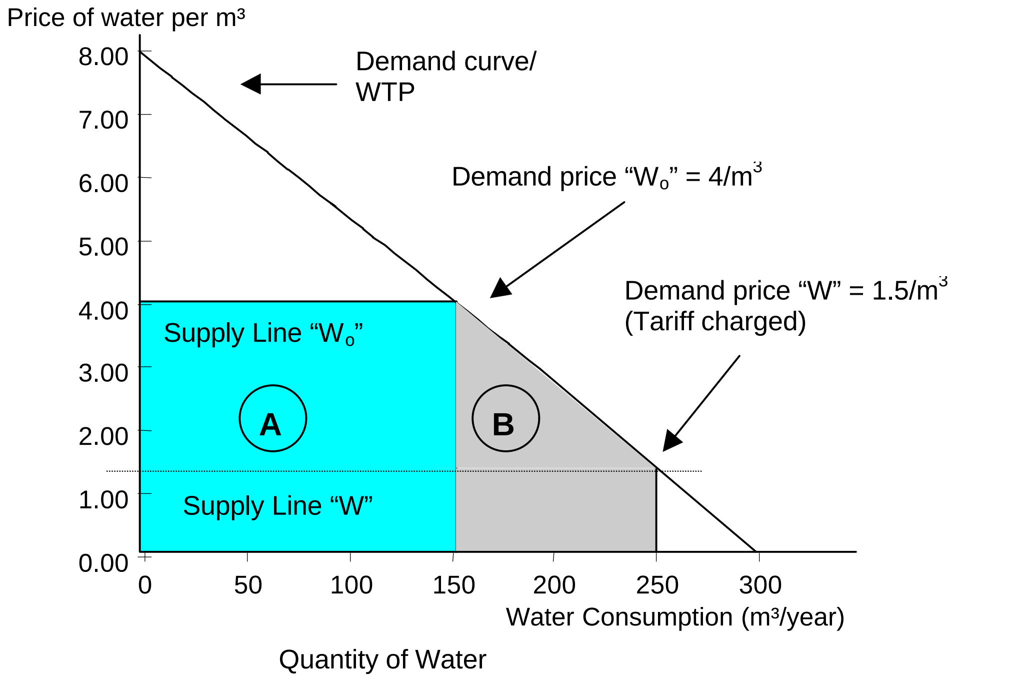
Data:

A piped WSP is proposed to meet a growing demand for an area from its existing level of 150 m^3 per year to 250 m^3 per year. The present supply of 150 m^3 per year is met as follows: 25 percent from vendors and 75 percent from household wells, at the following financial prices which include the cost of home processing of water to a quality closer to that of piped supply.

Sources	Proportion	Annual Quantity	Cost/m^3
Private vendors	25%	37.5 m^3	5L
Household wells	75%	112.5 m^3	3L
Average of supply price			4L/m^3

This is a public water supply scheme and the price of piped water supply is only 1.5 liters per m^3, which is lower than the present cost of supply. Due to the higher quality and lower price of piped supplies, the existing supply of water by vendors and household wells will be fully replaced. The concept of gross benefits is illustrated in Figure 6.2.

Figure 6.2 Concept of Gross Benefits



Quantity consumed:

Q_{wo}	$=150\ m^3/yr$	=	water from vendors and wells
Q_w	$=250\ m^3/yr$	=	water from the project

Prices:

P_{wo}	$=4L/m^3$	=	cost of water (existing)without-project
P_w	$=1.5L/m^3$	=	tariff with-project

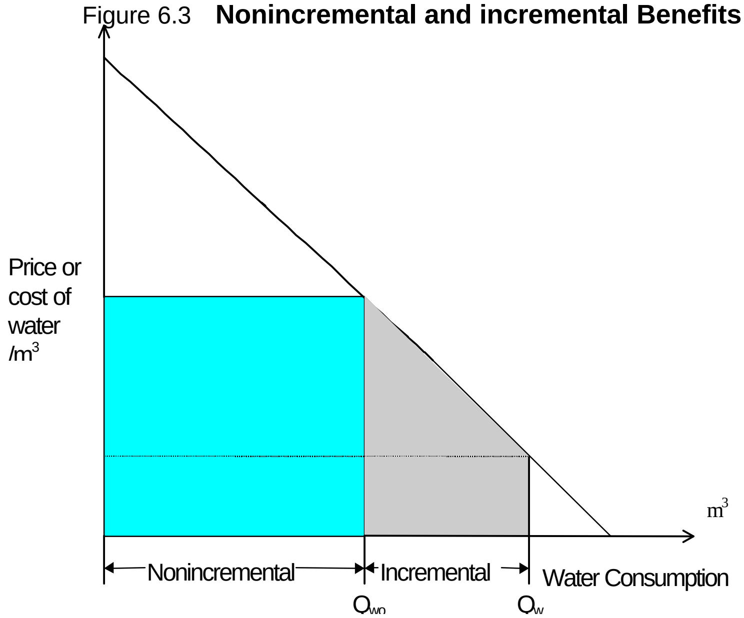
Non-incremental benefit due to full replacement of existing supply
(based on average supply price) = AREA A
= (Qwo) x (Pwo)
= 150 x 4
= 600 L

Incremental benefit due to future increase of water use		
(based on average demand price)	=	AREA B
	=	1/2 (Pwo + Pw) x (Qw - Qwo)
	=	1/2 (4 + 1.5) x (250 - 150)
	=	275 L
Total gross benefit	=	Area A + Area B
	=	600 + 275
	=	875 L

The prices used in this example are in financial terms. They are to be expressed in economic terms by applying economic valuation methodology described in Section 6.4.

19. From the example, it can be seen that the nonincremental part of the gross benefit is based on the average supply price of water in the without-project situation whereas the incremental part is based on the average demand price of water. In the example, the demand curve is taken to be a straight line. But if the demand curve is arrived at by some other method including the contingency valuation method, the actual demand curve (which may not be a straight line) can be used to arrive at the gross benefit of incremental water by calculating the area below the demand curve, as shown in Figure 6.3.

Figure 6.3 **Nonincremental and incremental Benefits**



6.3.2 Measuring Other Benefits of a Water Supply Project

6.3.2.1 Health Benefits

20. WSPs have been justified on the basis of expected public and private health benefits, which are likely to occur with the project due to the overall improvement in the quality of drinking water. Such benefits are likely to occur provided the adverse health impacts of an increased volume of wastewater can be eliminated or minimized.

21. Drinking unsafe water may cause water-related diseases, such as Diarrhoea, Roundworm, Guinea Worm and Schistosomiasis. People affected by these diseases may have to purchase medicines, consult a doctor or lose a day's wage. Accordingly, health benefits due to the provision of safe water have two dimensions: avoided private/public health expenditures; and economic value of days of sickness saved.

22. Whether for the existing use of water (nonincremental) or its future extended use (incremental), it is often difficult to estimate the health benefits in monetary terms. The reasons include:

(i) improved health due to safe water and sanitation alone is difficult to arrive at. For example, public health programs may promote boiling or chemical treatment of water and improve the overall health conditions. Such improvement could not be attributed to the provision of safe water.

(ii) the supply of safe water alone may not improve health unless complementary actions are taken, such as hygienic use of water through hygiene education, nutritional measures, etc.

(iii) The ultimate effect of health benefit is the increased labor productivity due to the "healthy life days" (HLDs) saved, which may possibly be estimated in quantitative terms; but to arrive at the value of increased productivity in monetary terms is difficult and complicated as appropriate data is rarely available.

23. Because of these reasons, it is customary to confine the health benefit-related analysis to cost effectiveness analysis and arrive at HLDs saved per unit of money spent. In the case of projects with a low EIRR or where the EIRR cannot be calculated, the alternative with the highest HLDs per unit of money spent should be selected.

24. In practice, health benefits are often not valued but treated as non-quantifiable benefits. If health benefits are expected to be significant, the EIRR analysis should then be supplemented with a qualitative, if possible quantitative, assessment of the importance of such benefits. There may be cases where a valuation of health benefits can be done.

6.3.2.2 Time Cost Saving Benefit

25. In the without-project situation, time spent in collecting water from the nearest source of water supply (e.g., wells, tank, river, standposts on the road) may be considerable, especially during the dry season. An important benefit from a piped water supply and provision of public taps is that it brings the source of water very near to the households. Time saved in with- and without-project situations can be estimated. What is difficult, however, is how to value time in monetary terms. Different approaches have been used by different agencies and authorities. Box 6.1 shows three such examples.

Box 6.1 Value of Time Spent on Water Collection

There are different approaches to value time savings:

- The Inter-American Development Bank assumes that time savings should be valued at 50 percent of the market wage rate for unskilled labor;
- Whittington, et al (1990) conclude that the value of time might be near- or even above-the-market wage rate for unskilled labor;
- A 1996 WB SAR on the Rural Water Supply and Sanitation Project in Nepal, has taken (i) 30 percent of time saved, devoted to economic activities, at the full rural market wage; (ii) 16 percent of time saved, devoted to household activities, at 50 percent of the rural market wage; and the remainder 54 percent at 25 percent of the rural market wage. This comes to a weighted average of 51.5 percent of the rural market wage.

26. It is, however, difficult to find out the precise value of time without a considerable amount of research and data. As an approximation, it is suggested that the value of time saved is calculated on the basis of the local minimum wage rate for casual unskilled labor.

6.3.2.3 Demand Curve Analysis and Other Benefits

27. It is suggested in para. 6.3.1 that a demand curve be estimated by establishing the user's behavior in the without-project situation (such as vendor's charges paid or costs of well's operation) as one point on the demand curve and the water charges levied by the government or water authorities as a second point on the demand curve. Water charges for piped water are the basis for the future water use with-project.

Alternatively, a surrogate demand curve may be derived using the contingency valuation method to derive gross economic benefits. If such demand curves are well established and reflect the user's marginal willingness to pay, then again bringing in health benefits and time saving benefits separately will lead to double counting.

28. Costs due to ill-health (arising out of unsafe water) and costs of time spent in collecting water in the existing without-project situation (if at all it can be valued in monetary terms) may, however, be used to arrive at the point in the demand curve in the without-project situation.

6.4 Valuation of Economic Benefits and Costs

6.4.1 General

29. Once the costs and benefits, including external effects, have been identified and quantified, they should be valued. Decisions by the producers and users of project output are based on financial prices. To appraise the consequences of their decisions on the national economy, benefits and costs are to be valued at economic prices. Therefore, the (financial) market prices are to be adjusted to account for the effects of government interventions and market structures.

(i) transfer payments - taxes, duties and subsidies incorporated in market prices of goods and services;

(ii) official price of foreign exchange where government controls foreign exchange markets;

(iii) wage rates of labor where minimum wage legislation affects wage rates; and,

(iv) commercial cost of capital where government controls the capital market.

30. Hence, as market rates in those cases are poor indicators of the economic worth of resources concerned, they need to be converted into their shadow prices for economic analysis.

6.4.2 Principle of Shadow Pricing (Economic Pricing)

6.4.2.1 Opportunity Cost

31. Opportunity cost is the benefit foregone from not using a good or a resource in its next best alternative use. To value the benefits (outputs) and costs, the opportunity cost measured in economic prices is the appropriate value to be used in project economic analyses.

32. Opportunity Cost of Labor. Assuming that surplus labor is available in the project area, the economic cost of labor employed in a new project will approximate the economic value of net output lost elsewhere, which is reflected in the rural labor wage of casual labor (say 40 taka per day). The labor rate used in the financial analysis of the project is the government controlled minimum wage rate of 60 taka per day. The ratio of the economic opportunity cost of labor to the project wage rate will be 40/60 = 0.67. This means that the true economic cost of labor is two-thirds of the wages paid in financial prices.

33. Opportunity Cost of Land. The economic value of land in a project is best determined through its opportunity cost. For example, for new projects in a rural area, the opportunity cost of land will typically be the net agricultural output foregone, measured at economic prices.

34. Opportunity Cost of Water. Depending on the source of water, the opportunity cost of water may vary from zero to a very high figure. If the water in the area is abundant, the opportunity cost of using such water is zero; but if, on the contrary, the water is scarce and an urban water supply scheme has to use some water by taking it away from existing agriculture or industrial use, the opportunity cost of water will be equal to the value of net agricultural or industrial production lost by diverting water from these alternative uses. Box 6.2 shows a typical calculation.

Box 6.2 **Calculating Opportunity Cost of Water**

Water for drinking purposes is required to be diverted from present agricultural use.

(1)	Annual net income from 1 ha. of paddy is		
	from (existing) irrigated land	=	Tk11,600
	annual net income from rainfed land	=	Tk7,100
	(in future when irrigation water is not available)		-----------------
	Benefit from irrigation	=	Tk4,500
(2)	Farmers' need of water for irrigation at present	=	8,000m^3 per ha.
(3)	Incremental net benefit from irrigation	=	Tk4,500/8,000m^3
		=	Tk0.56 / m^3
(4)	Opportunity cost of diverted water	=	Tk0.56 / m^3

Note: Net income = total production output (sales) - total production costs

6.4.3 Conversion Factors and Numeraire

6.4.3.1 Numeraire

35. Economic pricing can be done in two different currencies and at two different price levels. The choice of currency and the price level specifies the numeraire or unit in which the project effects are measured, such as:

(i) Domestic price level numeraire, when all economic prices are expressed in their equivalent domestic price level values; and

(ii) World Price level numeraire, when all economic prices are expressed in their equivalent world price levels.

Table 6.2 **Unit of Account**

Price Level	Currency	
	National	Foreign
Domestic Prices	Domestic, taka	Domestic, dollars
World Prices	World, taka	World, dollars

36. As the *Guidelines for the Economic Analysis of Projects* makes clear, provided equivalent assumptions are made in the analyses, the choice of the numeraire (whether the world price or the domestic price level numeraire) will not alter the decision on a project. However, in some special cases, especially in WSPs, it is convenient to conduct the economic analysis of a project in units of domestic prices. These cases relate to projects where distributional effects and the question of a subsidy to users below the poverty line are important policy issues.

37. The example in section 6.5 shows the relevant calculation using both numeraires.

6.4.3.2 Border Price

38. The world price mentioned in Table 6.2 is represented by the country's price of imported or exported goods at the border.

(i) for imported items, the border price is the c.i.f. value (cost, insurance and freight) expressed in domestic currency by using the official exchange rate (OER).

Example: The c.i.f. value of an imported water supply pump is $20,000.00 and the OER is P40 = $1. The economic border price of the pump expressed in domestic currency is 20,000 X 40 = P800,000.

(ii) for exported items the border price is the f.o.b. value (free on board) expressed in domestic currency using the OER.

6.4.3.3 Traded and Nontraded Goods and Services

39. Goods and services which are imported or exported are known as traded items and their production and consumption affect a country's level of exports or imports. Using the world price numeraire in economic valuation (c.i.f. for imports and f.o.b. for exports expressed in domestic currency by using OER), there is no need for any further conversion. If, however, the domestic price level numeraire is used in economic valuation, the c.i.f. and f.o.b. values are to be converted to their domestic price equivalent by using the relevant conversion factor (e.g., shadow exchange rate factor, SERF) which is the reciprocal value of the standard conversion factor (SCF).

40. The link between the domestic and world price numeraire is provided by a parameter reflecting the average ratio of world to domestic prices for an economy. If

the analysis is done in world price or border price equivalent, this parameter is the standard conversion factor (SCF) which compares world prices with domestic prices. In a domestic price system, its reciprocal – the ratio of the shadow to the official exchange rate (SER/OER), sometimes termed the foreign exchange conversion factor – is used. In either system, the relative valuation of traded to nontraded goods is provided by the average ratio of world to domestic prices.

41. Box 6.3 shows the commonly used equation for calculating the SCF.

Box 6.3 SCF and SERF

$$SCF = \frac{\text{Border price}}{\text{Domestic price}} \approx \frac{\text{Official exchange rate (OER)}}{\text{Shadow exchange rate (SER)}}$$

$$= \frac{M + X}{\{ M (1 + t_m - s_m)\} + \{X (1 - t_x + s_x)\}}$$

Where:

M & X - are total imports and exports, respectively, in a particular year at world prices and converted into local currency at the OER.

t_m & t_x - are the average rate of taxes on imports and exports, respectively, calculated as the ratio of tax collected to M and X.

s_m & s_x - are the average rate of subsidy on imports and exports, respectively, calculated as the ratio of subsidy paid to M and X.

Illustration: Philippines 1994

M = 495,134 million pesos

X = 202,698 million pesos

Tax on imports	= 88,278 m pesos	$t_m = 88{,}278 / 495{,}134 = 0.178$
Subsidy on imports	= 0	$s_m = 0$
Tax on exports	= 17 million peso	$t_x = 17 / 202{,}698 = 0.00008$
Subsidy on exports	= 0	$s_x = 0$

$$\text{Hence, } SCF = \frac{(495{,}134) + (202{,}698)}{\{495{,}134 \times (1 + 0.178)\} + \{202{,}698 \times (1 - .00008)\}}$$

$$= 0.888$$

Also, SERF = SER/OER = 1/SCF = 1 / 0.888 = 1.126 – 1.13 (Rounded).

In other words a SCF = .888 results in a 13 percent premium on foreign exchange.

6.4.3.4 Conversion Factors

42. To remove the market distortions in financial prices of goods and services and to arrive at the economic prices, a set of ratios between the economic price value and the financial price value for project inputs and outputs is used to convert the constant price financial values of project benefits and costs into their corresponding economic values. The general equation is as follows:

$$CF_i = EP_i / FP_i$$

where CF_i = conversion factor for i
EP_i = economic value of i
FP_i = financial value of i

43. Conversion factors can be used for groups of similar items like engineering, construction, transport, energy and water resources used in a particular project, or for the economy as a whole as in the SCF or SERF. The former are referred to as project specific conversion factors for inputs while the latter refer to national parameters. These are briefly discussed hereafter.

National parameters:

44. Several nontraded inputs occur in nearly all projects. These include construction, transport, water, power and distribution. It is useful to calculate specific conversion factors for these commonly occurring inputs on a country basis so that consistent values are used across different projects in a country. These are known as national parameters. Their determination is normally the work of national institutions, such as the Ministry of Finance and/or an Economic Development Unit or Central Planning Organization, if any. In countries where national parameters are not available, international financial institutions (World Bank, regional development banks like ADB) attempt to use conversion factors (e.g., SWR, SER and SCF) derived from recent consultant reports or research studies available in the country concerned and try to update them periodically.

Project specific conversion factors for inputs:

45. Where the supply of nontraded inputs is being expanded, specific conversion factors can be calculated through a cost breakdown at financial prices. The following calculations show an illustration of electricity charges in a WSP.

National conversion factors:

SCF	=	0.885
SERF	=	1.13
Labor (unskilled)	=	0.7 in domestic price(=SWR)
Labor (skilled)	=	1.0 in domestic price

Cost breakdown of electricity supply per kWh:

Fuel (traded)	=	P 0.900
Skilled labor	=	P 0.015
Unskilled labor	=	P 0.025
Capital charges		
Traded element	=	P 0.300
Nontraded element	=	P 0.340
Domestic materials (nontraded)	=	P 0.120

Subtotal	=	P1.700
Government tax	=	P0.170

Total	=	P1.870

Table 6.3 Economic Price of Electricity (per kWh)

		World Price Numeraire		Domestic Price Numeraire	
	Financial Cost	Conversion Factor	Economic Value (P)	Conversion Factor	Economic Value (P)
Fuel (traded)	0.900	1.0	0.900	1.13	1.017
Skilled labor	0.015	1.0 x 0.885	0.013	1.00	0.015
Unskilled labor	0.025	0.7 x 0.885	0.015	0.70	0.018
Capital charge					
Traded	0.300	1.0	0.300	1.13	0.339
Nontraded	0.340	0.885	0.301	1.00	0.340
Domestic Materials (nontraded)	0.120	0.885	0.106	1.00	0.120
Government tax	0.170	0	0.000	0.00	0.000
	1.870		1.635		1.849

C.F. in world price numeraire = 1.635 / 1.87 = 0.874

C.F. in domestic price numeraire = 1.849 / 1.87 = 0.989

The financial price of electricity has to be adjusted to its economic price by multiplying with this project specific conversion factor.

6.5 Valuation of Economic Benefits and Costs *of Water Supply Projects*

6.5.1 Economic Benefits of Water Supply Projects

46. This can be best explained by an illustration. The benefit evaluation in financial terms of the nonincremental and incremental components of demand discussed in Section 6.3.1 will be used for this purpose.

47. The data are again shown below:

Q_{wo}	=	quantity without-project	=	150 m^3/yr
Q_w	=	quantity with-project	=	250 m^3/yr
P_{wo}	=	financial cost/price of existing water supply	=	4 P/m^3
P_w	=	(financial) tariff with project	=	1.5 P/m^3

Nonincremental benefit based on average supply price	=	600 P
Incremental benefit based on average demand price	=	275 P

Total gross benefit per year in financial terms	=	875 P

Letter P may refer to any other local currency unit.

For economic valuation purposes, the breakdown of the items into traded, nontraded, labor and transfer payments (if any) is needed. The numerical values of the national parameters, i.e.: SCF/SERF, SWRF, etc. should also be known.

Demand and supply:

48. The existing annual demand is met partly (25 percent) by the supply from private vendors and partly (75 percent) by 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	Cost(P)/m^3
Private vendors	25%	37.5 m^3	8.61
Household wells	75%	112.5 m^3	2.46
Total	100%	150.0 m^3	4.00 (weighted average)

Breakdown of costs

1. Private vendors' supply price (8.61 P/m^3)

Unskilled labor	=	4.31 P/m^3	=	50%
Nontraded materials	=	3.44 P/m^3	=	40%
Traded element	=	0.86 P/m^3	=	10%
Total	=	8.61 P/m^3	=	100%

2. Household wells' price (2.46L/m^3)

Traded element	=	1.72 P/m^3	=	70%
Unskilled Labor	=	0.37 P/m^3	=	15%
Nontraded materials	=	0.37 P/m^3	=	15%
Total	=	2.46 P/m^3	=	100%

The steps followed in calculating the economic benefit are shown in Box 6.4 (using domestic price numeraire) and in Box 6.5 (using world price numeraire).

Box 6.4 **Calculation of Economic Benefits**
(Using Domestic Price Numeraire)

SWRF = 0.7
SERF = 1.2
Premium = .2

A. Economic Valuation of Nonincremental Benefits

Source of Water	Cost Components	Amount	Conversion Factor	Economic Price (P)
Private Vendors	Traded	0.86	1.20	1.03
	Unskilled labor	4.31	0.70	3.02
	Nontraded materials	3.44	1.00	3.44
	Total	8.61		7.49
Household wells	Traded	1.72	1.20	2.06
	Unskilled labor	0.37	0.70	0.26
	Nontraded materials	0.37	1.00	0.37
	Total	2.46		2.69

Weighted average economic value of nonincremental water
= (0.25 x 7.49) + (0.75 x 2.69)
= 1.87 + 2.02 = 3.89 P/m^3

B. Economic Valuation of Incremental Benefits

Average cost/price of water without-project = 4 P/m^3
Tariff of water with-project = 1.5 P/m^3

Average demand price with- and without-project (using domestic price numeraire) = (4 + 1.5) / 2
= 2.75 P/m^3

C. Economic Value of Water Supply Project (using domestic price numeraire)

Gross economic benefits of water supply project
= (Economic value of nonincremental water) + (Economic value of incremental water)
= (150 x 3.89) + (250 – 150) x 2.75
= 858.5 P

Box 6.5 **Calculation of Economic Benefits**
(Using World Price Numeraire)

SCF = 1/SERF = 1/1.2 = 0.83
SWRF = 0.7 x SCF = 0.58

A. Economic Value of Nonincremental Benefits

Source of Water	Cost Components	Amount	Conversion Factor	Economic Price (P)
Private Vendors	Traded	0.86	1.00	0.86
	Unskilled labor	4.31	0.58	2.50
	Nontraded materials	3.44	0.83	2.86
	Total	8.61		6.22
Household wells	Traded	1.72	1.00	1.72
	Unskilled labor	0.37	0.58	0.21
	Nontraded materials	0.37	0.83	0.31
	Total	2.46		2.24

Weighted average economic value of nonincremental water
= (0.25 x 6.22) + (0.75 x 2.24)
= 3.235 P/m^3 = 3.24 P/m^3 (rounded)

B. Economic Valuation of Incremental Benefits
Average cost/price of water without-project = 4 P/m^3
Tariff of water with-project = 1.5 P/m^3

Average demand price with and without the
Project (in financial prices) = (4 + 1.5)/2
= 2.75 P/m^3

World price equivalent of average demand price = 2.75 x SCF
= 2.75 x 0.83
= 2.28 P/m^3

C. Economic Value of Water Supply Project (in world price numeraire)
Gross economic benefits of water supply project
= (Economic value of nonincremental water) + (Economic value of incremental water)
= (150 x 3.24) + (250 – 150) x 2.28
= 714.00 P

6.5.2 Economic Value of Water Supply Input

49. This can best be illustrated by an example. A newly established industrial plant needs a large quantity of water from the public water supply. Two thirds of the total requirement of the industrial plant (180,000 m^3 per year) will be met from an expansion of the existing water supply. To meet the remaining one third of the supply to the industrial plant, it will be necessary for the public water supply organization to withdraw this water from existing agricultural use as there is a strict limitation to the water resource. Hence, the water supply to the industrial plant will be as follows:

Nonincremental water input	=	1/3 of 180,000
(diverted from agricultural use)	=	60,000 m^3
Incremental water input	=	2/3 of 180,000
(to be met from expansion)	=	120,000 m^3

Data:

The financial cost breakdown of the incremental water input is as follows:

		Taka/10m^3
Tradable inputs	=	37.5
Power	=	90.0
Capital charges		
Construction (nontraded)	=	31.3
Equipment (traded)	=	8.7
Unskilled labor	=	92.5
Nontraded domestic materials	=	16.3
Subtotal	=	276.3
Taxes and duties	=	27.6
Total	=	303.9 per 10 m^3

Therefore, the financial cost per cubic meter is 30.39 taka.

The economic valuation of water supply input is illustrated in Box 6.6.

Box 6.6 **Economic Valuation of Inputs** (Using Domestic Price Numeraire)

Conversion factors (national parameters):
SERF = 1.25
SWRF = 0.68

A. Economic Price of Incremental Water input (120,000 m^3) in domestic price numeraire

Items	Financial Cost Breakdown (Taka/10 m^3)	Conversion Factor	Breakdown of Economic Price (Taka/10m^3)
Tradable inputs	37.5	1.25	46.88
Power	90.0	0.989 */	89.01
Capital Charges			
Construction (nontraded)	31.3	1.00	31.30
Equipment (traded)	8.70	1.25	10.88
Labor	92.5	0.68	62.90
Nontraded domestic materials	16.3	1.00	16.30
Taxes and duties	27.6	0	-
Total	303.9		257.27

*/ - worked out separately. This shows there is a heavy subsidy in power supply.
The economic price per cubic meter is 25.73 taka.

B. Economic Price of nonincremental water input (60,000m^3)

Water diverted from agricultural use to meet the industrial demand is estimated through the marginal loss of net agricultural output, at shadow prices per unit of water diverted to the new users.

Opportunity cost of water in financial price diverted from agricultural use is 0.56 taka per m^3 of water. The data used here is taken from paragraph 6.4.2.1 in Box 6.2.

C. Conversion factor for the agricultural product lost by withdrawing water from agriculture

Agricultural prices for the crops grown in the area are regulated and some of the inputs like 'energy' and 'water' are subsidized. The net effect is expressed in a conversion factor relative to the financial cost of a unit of water. The conversion factor is calculated as 2.55 in domestic price numeraire.

Economic price of nonincremental water input for industrial use (diverting from agricultural use) can now be worked out: 0.56 x 2.55 = 1.428 Taka per m^3.

Total value of the water input for industrial use
= (Economic price of incremental water) + (Economic price of nonincremental water)
= (120,000 x 3.03) + (60,000 x 1.428)
= 363,600 + 65,520
= 429,120.00 Taka

6.5.3 Summary of Basic Criteria Used In Economic Valuation of the Project Outputs and Inputs

50. The basic criteria used in the economic valuation of incremental and nonincremental outputs and inputs are summarized in Table 6.4.

Table 6.4 Economic Valuation of Project Outputs and Inputs

	Incremental		Nonincremental	
	Basic Criteria	Illustration (refer to..)	Basic Criteria	Illustration (refer to..)
Outputs	Adjusted demand price or WTP	Example in para. 6.5.1.1 (B)	Adjusted supply price or opportunity cost	Example in para 6.5.1.1 (A)
Inputs	Adjusted supply price or opportunity cost	Example in para. 6.5.2 (A)	Adjusted demand price or WTP	Example in para. 6.5 (B)

6.6 Economic Benefit-Cost Analysis: *An Illustration*

51. This section shows a simple illustration of an economic benefit cost analysis. The example starts with the financial benefit-cost analysis, so that the links and differences between both analyses can be brought out.

6.6.1 Financial and Economic Statement of a WSP

52. Table 6.5 shows the financial statement of a WSP providing 1.00 Mm^3 of water per year. The quantity of water sold is assumed to build up annually by batches of 200,000 m^3, from year 1998 to reach full project supply by 2002. At an average tariff of Rs2.00 per m^3, the financial revenues of this project will eventually reach Rs2 mn per year.

Table 6.5 Financial statement

Year	Water	Financial	Financial costs			Net
	Sold	revenues	Investment	O&M	Total	Financial Benefit
	'000 m³	Rs '000	Rs '000	Rs '000	Rs '000	Rs '000
A	B	D	E	F	G=E+F	H=D-G
1997	0	0	11,000	0	11,000	-11,000
1998	200	400		440	440	-40
1999	400	800		440	440	360
2000	600	1,200		440	440	760
2001	800	1,600		440	440	1,160
2002	1,000	2,000		440	440	1,560
2003	1,000	2,000		440	440	1,560
2004	1,000	2,000		440	440	1,560
2005	1,000	2,000		440	440	1,560
2006	1,000	2,000		440	440	1,560
2007	1,000	2,000		440	440	1,560
2008	1,000	2,000		440	440	1,560
2009	1,000	2,000		440	440	1,560
2010	1,000	2,000		440	440	1,560
2011	1,000	2,000		440	440	1,560
2012	1,000	2,000		440	440	1,560
NPV @7%	6,876	13,752	10,280	3,745	14,026	-274
Per m³ sold		2.00	1.50	0.54	2.04	-0.04
					AIFC	FIRR = 6.5%

53. The investment cost of the project amounts to Rs11.00 million and the annual operation and maintenance cost is estimated to be 4 percent of the investment. The weighted average cost of capital (WACC) is 7 percent. The calculation of the WACC is not shown in this example. The financial net present value of the project, discounted at 7 percent, is negative (Rs274,000). The FIRR is 6.5 percent, which is below the WACC of 7 percent. The AIFC at 7 percent is Rs2.04 per m³.

54. The economic benefit-cost analysis of the project involves the conversion of financial into economic values and introduces a new cost element: the opportunity cost of water. In this example, the domestic price numeraire is used. The economic statement is given in Table 6.6.

Table 6.6 Economic Project Resource Statement

Year	Water sold			UFW[a/]			Total water prod.	Total water cons.	Gross benefits				Resource costs				Net economic benefit
	Non-incr.	Incr.	Total	NTL[b/]	TL[c/]	Total			Non-incr.	Incr.	NTL	Total Benefit	Investment	O&M	OCW	Total cost	
	'000m^3	'000m^3	'000m^3	'000m^3	'000m^3	'000m^3	'000m^3	'000m^3	Rs'000	Rs'000	Rs'000	Rs'000	Rs'000	Rs'000	Rs'000	Rs'000	Rs'000
A	B	C	D=B+C	E	F	G=E+F	H=D+G	I=D+E	J	K	L	M=J+K+L	N	O	P	Q=N+O+P	R=M-Q
1997	0	0	0	0	0	0	0	0	0	0	0	0	12,100	0	0	12,100	-12,100
1998	80	120	200	29	57	86	286	229	400	360	109	869		447	57	504	365
1999	160	240	400	57	114	171	571	457	800	720	217	1,737		447	114	561	1,176
2000	240	360	600	86	171	257	857	686	1,200	1,080	326	2,606		447	171	618	1,988
2001	320	480	800	114	229	343	1,143	914	1,600	1,440	434	3,474		447	229	675	2,799
2002	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2003	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2004	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2005	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2006	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2007	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2008	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2009	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2010	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2011	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
2012	400	600	1,000	143	286	429	1,429	1,143	2,000	1,800	543	4,343		447	286	732	3,611
NPV @ 12%	1,859	2,789	4,649	664	1,328	1,992	6,641	5,313	9,297	8,368	2,524	20,188	10,804	2,716	1,328	14,848	5,341
Per m³ consumed									1.75	1.58	0.48	3.80	2.03	0.51	0.25	AIEC= 2.79	1.01

[a/] Unaccounted for water
[b/] Non-technical losses
[c/] Technical losses

EIRR
19.0%

6.6.2 Economic Benefits

6.6.2.1 Water Sold

55. The economic benefit-cost analysis distinguishes between nonincremental and incremental water. Forty percent of the total annual volume of water sold (column D) displaces water previously obtained from other sources (i.e. nonincremental water, column B). The remaining 60 percent is an addition to total water demand (i.e. incremental water, column C).

56. The methodology for valuing nonincremental and incremental water is different. Nonincremental water is valued on the basis of resource cost savings. This proxy for the economic supply price of water without the project is estimated to be Rs5.00 per m^3. Incremental water is valued on the basis of willingness to pay as proxy for the average demand price with (Rs2.00/m^3) and without (assumed at Rs4.00/m^3) the project. It is estimated to be Rs3.00 per m^3. All these prices are in economic terms. Columns J and K give the total economic values of nonincremental and incremental water sold, derived by multiplying the quantity of non-incremental and incremental water by their respective values.

6.6.2.2 Unaccounted-for-Water

57. Thirty percent of the volume of water produced will not generate any financial revenue; this unaccounted-for-water (column G) is lost during the distribution process. The concept of unaccounted-for-water (UFW) is used by the engineer to estimate the required volume of water production (column H) and production capacity.

58. A portion of UFW may, in practice, be consumed. The reason why it is administratively lost is that it is either consumed illegally or that its consumption has not been metered. This portion of UFW is called nontechnical losses. In the example, it has been estimated to be 10 percent (column E) of the total water production. The remaining 20 percent of UFW is leakage, known as technical losses (column F).

59. The economic benefit-cost analysis is concerned with all participants in the economy and the benefits are the benefits to the entire society. As such, the focus is on water consumed instead of water sold; this is why the value of nontechnical losses should be taken into account. In the example, it is assumed that nontechnical losses occur for both nonincremental and incremental water. Therefore, the value of nontechnical losses per m^3 is determined as the weighted average of the economic value of incremental and nonincremental water per m^3; in the example this would be Rs3.80 per m^3 (40% x Rs5.00 + 60% x Rs3.00). Such weighing is not necessary if nontechnical

losses would only occur for nonincremental water. The economic value of NTL would then be Rs5/m[3].

6.6.3 Economic Costs

60. In this example, the domestic price numeraire is used. The SERF is 1.25 and the SWRF 0.80. Nontraded inputs have been valued at the domestic price, using a conversion factor equivalent to 1.0. The breakdown of the investment cost into different components and the conversion to economic cost are shown in Table 6.7.

Table 6.7 Conversion of Financial into Economic Costs

	Financial Rs'000	CF	Economic Rs'000
Traded	6,000	1.25	7,500
Non-traded			
Unskilled labor	2,000	0.80	1,600
Local Materials	3,000	1.00	3,000
Total	11,000		12,100

61. The economic cost of the investment is Rs12.1 million. The financial annual operation and maintenance cost of the project (i.e., 4 percent of the investment) has been shadow-priced in Table 6.8. The conversion factor for electricity is 1.10 which indicates that electricity is a subsidized input.

Table 6.8 Conversion of financial operation and maintenance cost

	Financial %	CF	Economic %
Traded	30.0%	1.25	37.5%
Non-traded			
Unskilled labor	40.0%	0.80	32.0%
Electricity	20.0%	1.10	22.0%
Local Materials	10.0%	1.00	10.0%
Total	100%		101.5%
CF = (101.5/100) =		1.015	

62. The average weighing of conversion factors for the O&M costs results in a CF of 1.015. The annual O&M cost is calculated as 11,000 x 4% x 1.015 = 447. The third cost component considered in this example is the opportunity cost of water,estimated as Rs0.20 per m³ of water produced. This estimate is arrived at as a separate exercise not shown in this example. In year 2001, the OCW is equal to 1,143 x .2 = 229.

6.6.4 Results

63. Table 6.6 shows that project is viable from the economic viewpoint: the ENPV at 12 percent discount rate is positive Rs5.3 million and the EIRR 19.0 percent. The AIEC at 12 percent is Rs2.79 per m³ while the economic benefit per m³ is Rs3.80. The net economic benefit per m³ is Rs1.01.

6.6.5 Basic Differences between Financial and Economic Benefit-cost Analyses

64. The examples show the basic differences between financial benefit cost analysis and economic benefit-cost analysis:

(i) the financial benefit-cost analysis is concerned with the project entity whereas the economic benefit-cost analysis is concerned with the entire economy;

(ii) in financial benefit-cost analysis, discounting is done at the FOCC (approximated by the WACC) whereas in economic benefit-cost analysis, discounting is done at the EOCC of 12 percent. The Bank's *Guidelines for the Economic Analysis of Projects* provide an explanation of the chosen discount rate.

(iii) in financial benefit-cost analysis, benefits are valued on the basis of water sold whereas the economic benefit-cost analysis values its benefits on the basis of water consumed. The difference is the nontechnical loss;

(iv) the average incremental financial cost (AIFC) is based on the present value (at the FOCC) of water sold (6.876 Mm³ in Table 6.5) and the average incremental economic cost of water (AIEC) on the present value (at the EOCC) of water consumed (5.313 Mm³);

(v) the valuation of economic benefits differentiates between incremental and nonincremental demand for water in the calculation of financial revenues. This distinction is not necessary;

(vi) in economic analysis, project inputs are shadow-priced to show their true value to the society. Some inputs may not have a financial cost and are not shown in the financial benefit-cost analysis (e.g., if raw water at the intake is available to the water supply utility for free). However, they should be shown in the economic benefit-cost analysis if the input has a scarcity value (e.g., if raw water is diverted from another alternative use such as irrigation or hydropower);

(vii) in financial benefit-cost analysis, the FIRR should be compared with the FOCC, and in economic benefit-cost analysis, the EIRR should be compared with the EOCC, to assess the project's viability in financial or economic terms, respectively.