Strategies for Catchment Development Master Plan and Economic Aspects of Water Resource Planning

Sivakumar SS

Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Sri Lanka

Abstract- The economic aspects of water resource planning involve the evaluation so far, as practicable in monetary terms of the physical potentialities of the catchment for alternate courses of action involving types of uses, different configurations and sequences of development in time. Interpretation in terms of monetary values of the consequences of alternate courses of action, though most convenient way for comparison, is not always possible since extra market consequences, indirect benefits also become important influences in deciding the project acceptability. This is so because in a welfare economy, economic efficiency measured in terms of market value of what the economy produces is an imperfect measure of economic welfare. The measurement of benefits and costs of development programmes should extend beyond mere market values. This article deals with how these are to be addressed in terms of economic point of view and give some thoughtful contents as guidelines for the preparation of water resource catchment development master plan taking into account the needs of not only irrigated agriculture, but also the various other water uses so that the available water can be put to optimum use.

Index Terms- Catchment development, Economic rate of return, Irrigated agriculture, Master plan, Present value, Water resource development,

I. INTRODUCTION

Unlike other natural resources, water is a unique resource, which renews itself. It is due to its constant circulation in the ocean-atmosphere-earth-ocean system. No matter how much water is consumed in daily life, its amount seldom dwindles. With time and under certain conditions water regains its properties and becomes fit for reuse. This is probably the reason why water resources appear to be unlimited for a long time. The key consumer of fresh water is agriculture rather than industry. Irrigation of fields, orchards and estates claim almost 80% of the water consumed the world over. Unfortunately, 97.5% of all water resources on earth are salty. Consequently, fresh water including the one in glaciers accounts for only 2.5%. Even here the most accessible one is as little as 0.3%. More over the natural distribution is extremely uneven.

The demand for water is continuously on the increase with the growth of population, industry and agriculture. However, the total amount of available water remains more or less constant. This is bound to lead to scarcity of water, if not today, in the foreseeable future. In order that such a scarcity does not occur and hamper the development of the country, it is very important to improve the efficiency of planning and management of our water resources economically.

In other words, a water resources plan, consistent with the overall economic, social and environmental policies of the country, is an important element to ensure that water resources contribute to the country's development objectives. Most development decisions today are multi-objective in nature, involving economic, social and environmental dimensions and values. However, until relatively recently, this fact was not seriously taken into consideration in planning for water resources development. Instead, economic development was considered to be a desirable end in itself, often with little regard to adverse effects on social or cultural systems and the natural environment. As the pace of economic development increases these effects can no longer be ignored.

In water resource planning, the normal questions that the planner is asked to answer through economic analysis are

- Which are the projects to be taken up?
- What are their scales of development?
- When are they to be commissioned?

The study involves the analysis of individual projects as well as the sub-catchment or system as a whole. In normal commercial practice, a rigorous financial analysis provides the answer. But, in the case of water resource which is a public good, the question of equity and other considerations makes the financial analysis an insufficient procedure. A broader economic benefit-cost analysis serves as more suitable criteria.

Without any doubt, conditions in the basin will change even if no planned development programmes are implemented. Therefore, the economic evaluation requires that the comparison be made between events predicted to occur if the development programmes are implemented and those predicted to occur if the planned programmes are not implemented. This is the with-and-without principle which should be preferred for adoption for project/catchment evaluation.

II. ECONOMIC PERFORMANCE INDICES

The following four methods or indices that are considered conceptually correct for comparing alternatives.

- The present worth method
- The rate of return method

- The benefit-cost ratio method
- The annual cost method.

However each method is having its own merits and demerits. Every method are very briefly and simply defined below

- The present worth method selects the project or alternative with the largest present worth of the discounted algebraic sum of benefits minus costs over its life.
- The rate of return is the rate of discount at which the algebraic sum of present worth of benefits minus costs equals zero. Alternatives having a rate of return exceeding the minimum acceptable value may be chosen.
- Benefit-cost ratio is the ratio of present worth of benefits to present worth of costs and the ratio should exceed unity.
- In annual cost method, benefits and costs are converted into a uniform annual figures and the alternative with the greatest annual net benefit is chosen.

Various study groups time to time used various methods for their studies. During 1960s benefit-cost ratio method was popularly used for assessing the feasibility of new projects. For simplicity they had also recommended that indirect or secondary benefits need not be considered. Later in 1964, some economists suggested that the economic benefit criteria should be adopted for approving irrigation projects and since then benefit-cost ratio criterion is being adopted for project appraisal. But the continued use of benefit-cost ratio is also in practices now a day. The World Bank uses internal rate of return criteria which is considered more suitable as a basis for making a choice between two investments and where financial return is the dominant consideration. The criteria that is followed at present is that the benefit cost ratio should equal or exceed 1.5 in normal case and should equal or exceed 1.0 in case of chronically drought prone areas.

III. BENEFITS AND COSTS

In the most general sense, benefits are the measure of effectiveness of a set of actions in achieving the set goals. The most convenient way to measure the benefits is in terms of market value of goods and services produced, but there are benefits which are not amenable to such measurements. Some benefits are correctly registered in markets such as the income from freely marketable crops. Some benefits are incorrectly registered by market prices as in the case of some food grains whose prices are controlled by Government. .Some benefits are not registered in markets, but simulated market values can be obtained and for some others it is nearly impossible to think of any kind of market valuation. Examples of these two types are benefits from recreation in public parks and the value of beneficial landscape respectively. Thus benefits are not synonymous with monetary revenues.

Benefits should be measured without regard to whom these accrue. Thus, primary or direct as well as secondary or indirect benefits are important. For simplicity, only primary benefits are usually evaluated, even though a study of secondary benefits is desirable to see whether they are significant and worth evaluating.

The most convenient way of assigning numerical benefits is to determine the market value of the output it produces. To have uniformity, the transportation costs should be deducted from the ultimate market prices to get the price at the point of production. If the production is expected to be very large relative to the current production, probably it may affect market prices. This should be considered in the analysis of benefits. The only way to do this is to evaluate the demand function for commodities in question considering pre-project and post-project conditions. Where market prices are distorted through Government subsidies, this should also be taken into account.

In cases where markets in the usual sense do not exist and therefore, the willingness to pay as a measure of social value or benefit cannot be evaluated, simulation of market prices can be resorted to. Examples are recreation, flood protection etc. Flood control benefits are calculated as the value of damage prevented on the assumption that the occupants of the flood plain may be willing to pay any price up to their potential damage in the absence of the scheme. In the case of recreation various methods are suggested to simulate the situation.

Alternate cost approach is another method of evaluating benefits where market prices are not true reflection of willingness to pay. A common case is the evaluation of benefits of hydropower projects. The alternative chosen should be the most economical and likely choice that would be adopted in the absence of the project under study. However, this method should be cautiously used as this presumes that a decision has already been made to achieve the objective by some means regardless of cost. Cost of a single purpose project when compared with the benefit from a component of a multipurpose project may distort the reality due to economy of scale and should be guarded against such mistakes.

In the most general sense, the cost of some particular commitment of resource may be defined as the benefits given up in the most productive alternate use of those resources. Thus costs are not to be equated to cash outflows alone. A very cheap development in terms of cash investment may cause very deleterious conditions at a downstream point. Therefore, in cost analysis, apart from monitory costs which are primary project costs, indirect or secondary costs as well as intangible costs should be taken into account. As in the case of benefits, only the direct project costs are considered for simplicity. However, a study of those secondary effects of projects which may reflect as a project cost ultimately should be analyzed and provided for.

The benefits and costs of projects occur over a period of time. Clearly, the value of a unit output accruing after ten years is not the same as that occurring at present. This necessitates the consideration of time value of benefits and costs. They must first be put on a common time base and discounted using suitable interest rate to a point in time, usually the present time or the time at which decision is taken. The rate of interest should reflect the degree of preferences for an early realization of benefit from

the project from the point of view of society. The selection of a proper interest rate is a tricky issue in planning. Many simplified solutions are usually adopted such as the interest on long-term borrowings by the Government, In Sri Lanka, an interest rate of 10% for benefit-cost ratio calculations of water resource development projects is presently followed.

Another factor to be considered in the analysis of benefits and costs is the uncertainty associated with the future prediction of benefits and costs. The uncertainty increases with the length of planning period. Yet, when decisions have to be taken which commit resources to long periods, it is not possible to predict values with complete accuracy. This situation can be taken care of by 'making an allowance for the uncertainty. One method would be to adjust the benefit and costs by a "correction factor" before discounting. Another method would be to add a risk factor to the discount rate. Sometimes the life expectancy estimates are adjusted downwards.

IV. Measurement of Benefits and Costs

The direct benefits of new irrigation or supplementary irrigation project are the difference between the annual net income from farm produce with irrigation and annual net income without irrigation. The increase in the value of land as a result of the introduction of irrigation is also considered as a direct benefit. The indirect or secondary benefits include increased activities in business and trade and agro based processing and manufacturing activities. There are also intangible benefits such as greater stability and welfare to community, better health and new employment opportunities. Guidelines of Irrigation department for the preparation of Detailed Project Report for Irrigation and Multipurpose projects suggests that the annual benefits for computing benefit cost ratio should be taken as under

A. Agricultural production in the area to be irrigated under pre-project conditions.
B. Agricultural production in the area after completion of the project.
C. Difference between (A) and (B)

The yield under pre-project and post-project conditions and the prices to be used for the crops may be obtained from the respective provincial Agricultural Department. The net income from farm produce should exclude the farming expenses such as fertilizers, seeds, labors etc. The cost shall consist of the following:

- Interest at the rate of 10% on the estimated cost of the project including cost of land development
- Operation and maintenance cost including that for head works
- Depreciation of the project based on assumed life of the project
- In the case of lift canals, charges for power and depreciation of pumping system
- The benefit-cost ratio is worked out 'as the ratio of annual benefits to annual costs.

Generally, a new hydropower project supplements an already existing network. The monetary benefits by satisfying the power demand projected through a power market survey will be equal to the prevailing regional price per unit. The expectation of an increase in power use, if current prices continue is based on the assumption that the value in use will exceed the price. If the power project is to serve an isolated area, then the benefits will equal to the area under the demand curve between amount of power available with and that available without the project.

Often, evaluation of power projects are done in terms of the cost of the most economical and likely alternative source that would be used to meet the power requirement in the absence of the hydroelectric project under study. The cost of generation by alternative methods must be determined as a part of the study to justify hydroelectric power.

Indirect benefits from power generation may arise due to factors like increased industrial activity as a result of the availability of cheap and reliable power supply. Intangible benefits include increased comforts and conveniences and improved living condition of people and also conservation of non- renewable fuels. The costs of hydropower generation shall consist of the following

- Incremental project construction costs attributable to power generation
- Costs of power components such as power house, generators, penstocks, transmission and distribution system etc
- Operation, maintenance and replacement costs of power components
- Depreciation costs.

The benefits from providing domestic water supply accrue to a larger spectrum of people in the society compared to other water uses. The benefits from municipal and industrial water supply projects can be measured by

- The customers willingness to pay for delivered water when such a measure can be deduced from market information
- The cost of the next best alternate source of supply for those customers who would clearly be supplied by that alternative in the absence of the present project.

The first method will be a more reasonable approach if sufficient data to develop the demand curve can be obtained. The costs attributable to domestic and industrial water supply will include

- The cost of source development. This may include the intake structures and/or the allocated part of a storage project
- Transmission, treatment and distribution costs including cost of local storages
- Operation, maintenance and replacement costs
- Depreciation costs.

Flood control benefits generally consist of two components as given below

- The damage prevented to the existing and future flood plain property that would exist in-the absence of the flood control project
- The enhanced productivity of the flood plain. The damage prevented should be computed based on the present status and anticipated conditions after the completion of the project.

The average annual damage should be based on at least 10 years data. If sufficient data is available, it will be advisable to construct a damage-frequency curve and determine the average annual damage corresponding to different frequency floods. Thus the level of protection provided by a given structure and the damage prevented can be correlated.

The damage due to floods may be to agricultural crops, structures and monuments and/or human lives. Some of the damages may be permanent losses, others may be capable of restoration through repairs, rehabilitation etc. A distinction should also be made between preventable and non-preventable damages as also between recurrent and non-recurrent losses. Care must be taken to avoid duplication of benefits. The costs of flood control projects will usually consist of

- Incremental project construction costs attributable to flood control including exclusive provisions like embankments, channel improvements etc.,
- Value of water and power foregone by virtue of reserving some of the storage for flood moderation
- Operation, maintenance and replacement costs.

Improved inland navigational facilities benefit the economy since it is a cheap mode of transport and effect saving of fuel. The benefits may accrue by way of

- The amount of cost saved by diverting the present traffic from higher cost modes of transportation to inland or coastal waterways
- The new traffic generated by the added navigational facilities. This is measured as the willingness to pay by the new water carrier customers
- The income of new business establishments stimulated by the added water transport facilities and savings to existing business which may shift to riverside locations
- Value of recreation provided by the improved waterway.

The following costs may be expected to accrue for any in land navigation project

- The construction of navigation features including channel, lock, navigational aids and other facilities
- Operation, maintenance and replacement costs
- Value of other benefits foregone as a result of operating the system to cater for irrigation
- Construction of recreation facilities, if such benefits are included.

The benefits from recreation are by way of a quality added to life whose value is beyond monetary measurement. But, the planner has to assign a value to this benefit in order to commensurate with other project purposes.

There are various methods of recreation benefit evaluation that have been proposed and used. The oldest practice is to select a value per visitor-day based on a judgment evaluation of the quality of the available recreation experience. Other methods are that using alternative-cost approach, user-assigned values evaluated through a questionnaire, correlating admission fee charged with the number of users who may pay for it etc.

The most successful method seems to be based on demand curve imputed from expenditures incurred to enjoy outdoor recreation. The recreational cost incurred by the user such as travel, food, lodging etc. reflect the value placed by the user on the particular recreational experience. The costs of recreation include

- Cost of construction of recreational facilities;
- Value of other benefits foregone as a result of creating these facilities such as maintenance of a certain reservoir level
- Operation, maintenance and replacement costs.

The benefits from water quality management measures are difficult to locate and quantify. These measures modify the damages inflicted by a given pollution concentration on the water users. The benefits would fall into one or more of the following classes

- Health improvement to people who use the water in untreated or inadequately treated form in the absence of the measures
- Reduced water treatment costs by downstream municipalities
- Reduced treatment costs by industries who draw water from downstream points
- Value of increased recreation stemming from better quality water
- Increased aesthetic value.

The cost of water quality management may include

- Construction of structures such as dams, treatment plants etc.,
- Operation, maintenance and replacement costs,
- Cost of solid waste disposal
- Increased air pollution by treatment of waste.

Benefits from development of fishery mainly come under two classes

- The commercial value ft the fish catch
- The recreational value of fishing.

The commercial value of increased fish catch is evaluated in terms of the expected market prices whereas the benefits from recreation are evaluated as described in previous paragraph.

The costs may include costs of facilities such as fish ladders, value of benefits foregone, if any and the appropriate operation, maintenance and replacement costs.

The benefits from environmental conservation such as the preservation of rare species of flora and fauna or unique habitats come under intangible benefits since their monetary values are difficult to assess. The best practice may be to determine the incremental cost of preservation as a function of some quantitative measure of the amount of resource conserved such as the number of rare species of wild life or number of acres of rare flora conserved and make sure that they are compatible. The total cost of conservation should include the direct cost of conservation and the benefits foregone by reducing other project outputs.

V. Financial Feasibility

In economic analysis, the question is not usually raised as to who will ultimately pay for the costs of the scheme. To say that a project's benefits to the nation will offset its costs is one thing, to decide on whether or not costs are to be recovered and if so the method of recovery is another. Thus financial feasibility of projects is a factor to be looked into.

Financial return through sale of production is not always possible in the case of water resources development which is by and large a collective good. For example, the flood control benefits are enjoyed by the general public especially those in the protected area, whether they choose to "buy" the benefits or not. Moreover, in our country, the majority affected in flooding is the economically weaker sections and charging them goes against the principle of income redistribution through development. Such social considerations, apart from technical difficulties of charging, provide reason for subsidizing or even making the service free.

At present, financial feasibility is not a criterion for approving irrigation projects in Sri Lanka. For multipurpose projects involving power generation, a financial return statement is prepared for the power component. The National Water Policy document recommends that the water rates charged should be adequate to cover the annual maintenance and operation charges and a part of the fixed costs of projects. For hydropower, urban and industrial water supply and navigation projects or these components in a multipurpose project, which have a ready market, it should generally be possible to attain financial viability.

VI. Costs Allocation of Water Resource Project

In the case of multi-purpose projects, it becomes necessary to apportion costs among the various project purposes. There is no universal agreement on this issue. The basic principle underlying the allocation is that the savings derived through the use of the combined structure for numerous purposes should be shared equitably by all these purposes. The cost includes separable costs and joint costs. Separable costs are directly attributable to specific purposes and joint costs are shared among the different purposes. Allocated cost should be

- Not more than the benefits to be achieved by that purpose
- Not more than the cost of an alternate project built for that purpose
- Not less than the cost of items meant for the specific use of that purpose.

VII. Conclusion

Country like Sri Lanka, because of its small size does not have very large catchments, is not having guidelines for preparation of water resource development master plan. But the Indian standard 7560-1974 gives the guidelines for allocation of cost among different purposes of river valley projects. This describes various methods of allocating costs such as alternate cost method, benefit method, equal apportionment method etc. and their advantages, disadvantages and limitations. This can be used as guidelines for Sri Lanka also.

In conclusion none of the methods is suitable for all conditions and the choice of a particular method will be governed by its suitability in specific conditions.

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Authors

Dr. (Eng.) S.S.Sivakumar PhD, MSc.(WRD), BSc.(Eng)
C.Eng, MIE(SL), FIE(SL) , BMI&PSI, LMSLAAS, LMIWRS, LMICOLD, APGBC.(SL)
Head - Civil Engineering,
Faculty of Engineering, University of Jaffna
Kilinochchi, Sri Lanka.
TP: Rec: (94) 024 222 063 2 ; Mobile: (94) 077 250 873 0
Mail: sssivakumar@jfn.ac.lk, sssiva100@gmail.com

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