MULTIPLE-PURPOSE DEVELOPMENT OF WATER RESOURCES

by

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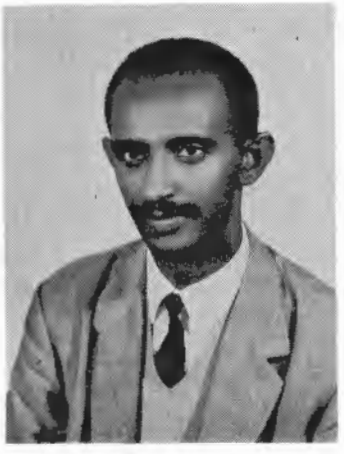


ABSTRACT

Full and complete utilization of water resources is an economic and social advantage to all members of a society. The water resources potential of Ethiopia is practically untouched, and their systematic and wise development is of paramount importance for enjoying the maximum possible benefits.

This paper indicates that, although a multiple-purpose development may not give the maximum benefit for one purpose, by including other purposes, it provides an optimum use of water thereby achieving a better over-all economy. It also points out the conflicting requirements of various functions and the difficulties they pose in the design of multiple-purpose projects.

The paper summarizes some of the current practices of cost allocations to various functions of the multiple-purpose development and calls for giving more weight for multiple-purpose projects in this country than that they are given at present.

INTRODUCTION

Water is one of the most basic resources in a country. Some resources, like minerals, can be preserved in their natural form and can be saved until required. If a mineral resources is little exploited by present generation, it can wait undiminished for the next generation. Water is a flowing resource and like time it waits for no man. Unlike the mineral resource, it can not be preserved for the coming generations. Any water unused today is lost for ever. Each year the development of water resources is delayed, the potential value of water diminishes. Delay means waste and loss of potential wealth. Ethiopia is rich in water resources. The waste of these resources is inexcusable in this country where agriculture for balanced food supplies and power for industries are needed; and where the future of this country is often talked about to depend on agricultural development.

Water resources development is concerned with the use of water and related resources for better living. Planning must be directed toward the present and future needs of the society to be served. An appraisal of water resource must consider surface as well as ground water supplies in terms of location, quantity and quality. It should include all main elements in water resources development such as domestic, municipal and industrial uses, irrigation, hydropower, flood control, navigation, pollution abatement, watershed management, fish and wild life conservation and recreation. In plan formulation, emphasis must be made on a project objective. The basic objective should be to provide the best use, or combination of uses, of water and related land resources to meet all foreseable short-term and long-term needs. All purposes of development should be given full consideration. Many water resources projects are potentially useful for more than one of the above basic purposes. By designing and building them to serve more than one purpose, greater over-all economy can be achieved.

MEANING OF MULTI-PURPOSE PROJECT

There is difference of opinion among engineers as to the meaning of multi-purpose project. There are engineers who consider any reservoir used or capable of being used for more than one purpose as multiple-purpose reservoir.

An irrigation project, solely designed for irrigation as an objective, may provide other incidental

benefits. An irrigation project producing power for pumping irrigation water is a good example of this type, and some engineers take this as a multi-purpose project.

This paper follows the definition given by the committee of the American Society of Civil Engineers on multiple-purpose development. The committee defines multi-purpose projects as "projects designed and operated to serve more than one function and should exclude those projects whose design and operation are controlled by one function, eventhough other benefits accur as by-products."

EVOLUTION OF MULTIPLE-PURPOSE DEVELOPMENTS

In many countries, especially developing ones, the control of a river subject to disasterous floods, the exploitation of a river for power generation, the improvement of river channel for navigation, the regulation of surface water and the exploitation of the ground water for irrigation, domestic, municipal and industrial use, the disposal of sewage and industrial waste or any other use or control of water has been treated until very recently as isolated problems. This disorderly and unintegrated development of water resources has neglected the maximum utilization of the available water. Single-purpose development has created and is still creating a lot of waste of flowing wealth. Many already constructed single-purpose projects have occupied sites that could have been used for multi-purpose projects and thereby providing optimum benefits from the available water.

The rapid growth in multiple-purpose development stems mainly from a realization to make maximum use of existing water resources. The start of the evolution of multiple-purpose development of water resources is the recognition of the multi-purpose concept itself. This began in the U.S. with the intimation of the relationship between navigation and flood control first; between irrigation and flood control second; between watershed management and flood control, navigation and irrigation third. This led to laying down the broad fundamentals of the multiple-purpose concept.

River basins are the natural sub-divisions of water resources. The river-basin concept is another factor that evolutioned multi-purpose development. This recognizes the interrelation of resource elements. A drainage basin is to be considered as an economic unit and a dynamic and organic system. Multi-purpose development can, in river-basin concept, make the maximum utilization of the water of the basin in an integrated development of the entire basin.

The new idea of a comprehensive programme of development; the new concept of social benefits and costs as applied to region; and the new concept of a unified control (TVA in U.S.; Damodar V.P. in India, AVA in Ethiopia etc.) have made the multi-purpose approach of water resources development the most attractive and benefitial one.

FUNCTIONAL REQUIREMENTS IN MULTI-PURPOSE PROJECTS

In multi-purpose projects, the success of using a storage space for different functions depends on the extent of compatability of these functions. Reviewing their requirements indicates the existence of conflicts among them. Analysing these confilicts calls for coordination and reconciliation among various uses. That the requirements of reservoir operation in multi-purpose projects are fundamentally conflicting, are indicated below:

1. Regulation for flood control is best accomplished when reservoirs are kept empty to reduce the flood peaks and to store the flood waters for releasing according to the capacity of the channel downstream.
2. Conservation for domestic, municipal, industrial or irrigation use requires that flood waters be held in storage during the flood season, sometimes over a period of years in the arid and semi-arid regions, and that the release of water be in conformity with seasonal demands.
3. Regulation of stream flows for the generation of hydro-electric power requires that reservoirs be kept as nearly full as practicable, that they never be emptied, and that the release of water be made in accordance with demands for power and energy.
4. Reservoirs for slackwater improvement of streams for navigation must be limited in height because of the need for locks, and hence cannot have large storage allocations for other purposes.
5. Conservation of fish and wildlife may require maintaining a stable reservior level and in no event may such a reservoir be emptied.
6. Recreational use preferably requires the reservoir to remain nearly full during the recreation season.

Flood control with its requirements for empty storage space is the least compatible of all uses. Because of conservation of floods and regulation of releases are essential over extended period of time to both irrigation and power, there is less conflict between them than between either of them and flood control. Coordination of the requirements for fish and wildlife conservation and for recreational uses of reservoirs with the requirements for either flood control or irrigation is almost impracticable; this is because flood control reservoirs are subject to rapid changes in level, and irrigation reservoirs must be emptied of all water whenever it is needed. Without compromise it is only superimposition of capacities that would avoid the conflicting requirements of flood control and irrigation, or of flood control and power generation. If pyramiding is made the component parts could be operated in effect as separate reservoirs.

DESIGN OF MULTI-PURPOSE PROJECTS

The design of any multi-purpose project is basically an economic problem. The basic factor in multi-purpose design is compromise. The structural features (dams, spillways, sluiceways, gates, water conductors, powerplants etc.) are more or less the same for single purpose as well as for multi-purpose projects. The most important point in multi-purpose design is the selection of the physical works and an operation plan to provide an effective coordination and reconciliation among the various uses.

If a reservoir of a given capacity is to serve several purposes, its value for anyone purpose cannot be the maximum possible for that purpose. The reservoir operation must be planned in such a way that operation for all purposes are included. This would probably reduce the maximum possible benefits from one purpose inorder to include other purposes. The sum of all the benefits from the services should be the optimum and this should exceed the maximum benefit from anyone function. Detail and systematic studies of benefits and costs for different capacities of reservoirs, different types of dams, and the inclusion or exclusion of each of the several purposes must be made in order to obtain this optimum economic and physical balance.

ECONOMICS OF MULTI-PURPOSE PROJECTS

Economics in river development are frequently possible by formulation of a balanced and comprehensive plan involving a combination of purposes and a combination of facilities and measures. Multiple-purpose projects permit more complete use of the physical potentialities of individual reservoir sites and fuller utilization of project facilities than single-purpose projects. Multiple-purpose programmes would further the realization of optimum beneficial values from the available water resources.

In the design of any project intended to serve more than one purpose, the conflicting requirements of these purposes must be compromised unless there is to be pyramiding of capacities and costs. There is a need of consideration of the relative values involved before any compromise of conflicting requirements can be made intelligently. Compromise of such conflicting requirements will depend on evaluation of each direct and indirect benefit that will actually be realized in the operation of the project. The sum of all such benefits must be substantially more than the costs of construction and operation.

Benefits arising from the construction of any multi-purpose project approach an upper limit as the capacity provided in the reservoir is increased. Costs of construction become tremendous whenever the size of the reservoir exceeds the limitations of the site. If typical curves are plotted showing the relations between benefits and reservoir capacity, and between costs and reservoir capacity, these curves intersect at two points. Below some small capacity the costs will exceed the benefits, and beyond some much greater capacity the benefits again become less than the costs. (Please, see the attached figure.)

For any reservoir capacity between 0.3 unit and 8.3 units, the benefits (1) exceed the cost (2) The maximum difference between benefits and costs occurs for a reservoir of 3.3 units in size. This is 40% of the upper limit where the costs become as great at the benefits. The maximum ratio of benefits. The maximum ratio of benefits to costs (3) occurs for a reservoir of 1.9 units capacity, which is only 23% of the same upper limit. With available water, the reservoir capacities corresponding to the last three values determined in this illustration must be given consideration in the design of any multi-purpose reservoir. In any such comparision of costs and benefits of multi-purpose reservoirs, the benefits deemed to arise out of the reservoir must be a tangible as the cost themselves.

COST ALLOCATIONS FOR MULTI-PURPOSE PROJECTS

Cost allocation is the process of assigning to each purpose of a multi-purpose project an appropriate share of the total multiple-purpose cost. There is no as such a very satisfactory method of cost allocation that would be equally applicable to all projects and that would yield allocations which are equitably correct. There is usually no difficulty in identifying the costs of facilities used for one specific purpose; the problem is to apportion costs of joint-use facilities. Generally any method of allocation must first set aside the separate costs which are clearly chargeable to a single project function, such as the cost of powerhouse, navigation locks, irrigation canals, or fish ladders. Many methods have been used, usually to favour some particular use over others. Some consideration to basic philosophies rather than exhaustive treatment is presented here.

Use of facilities:

Purposes making the same type of use share in proportion to their use.

Priority of Use:

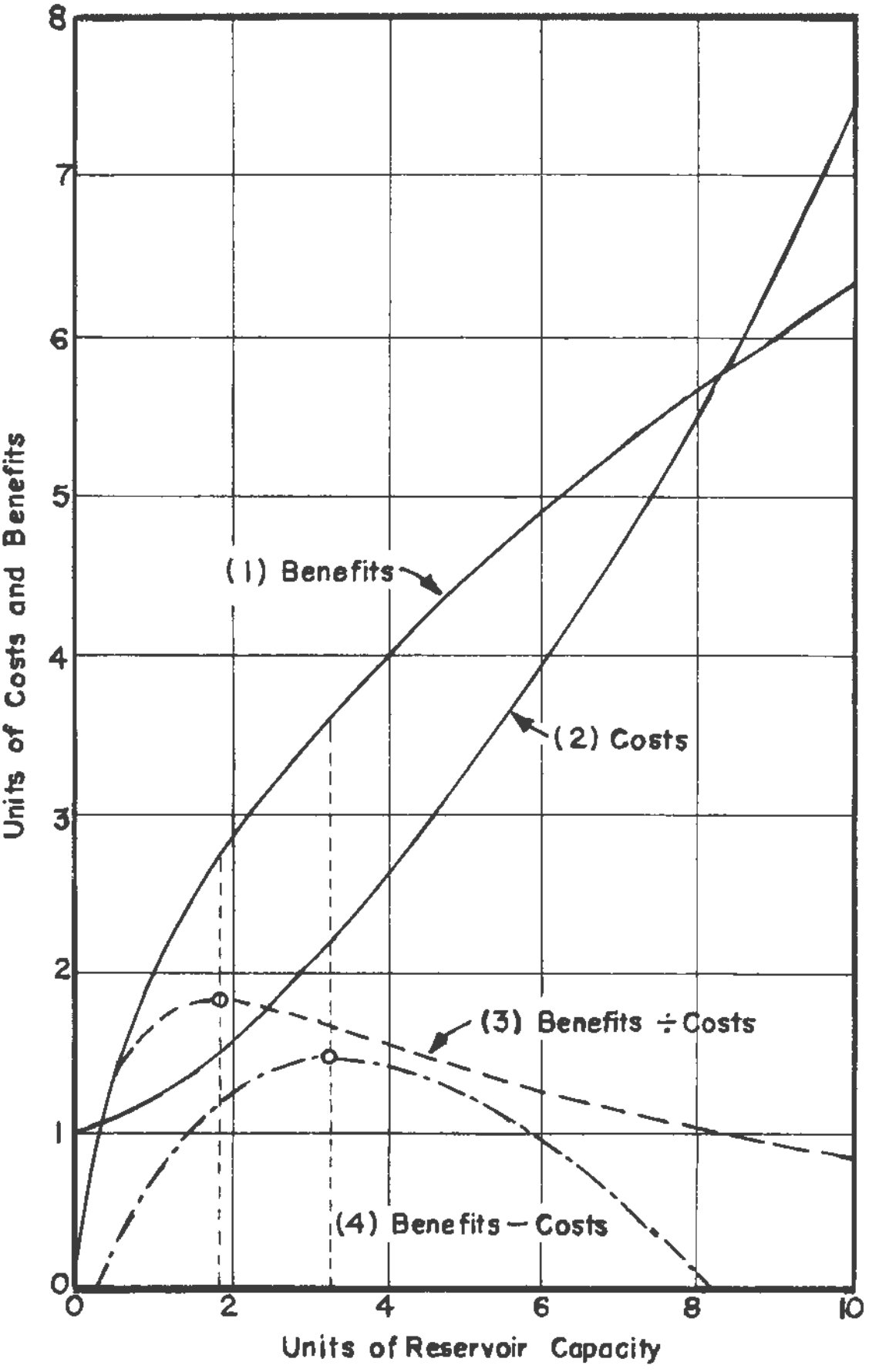
If there is favoured principal user compared to other uses of projects, the priority user may be considered to pay the basic costs and incidental costs; or adjustment can be made for differences in use arising from the application of priority treatment over equal treatment.

Benefits:

If one beneficiary derives a greater benefit than another for the same use, that user may be expected to pay a greater amount.

Alternative Justifiable-expenditure Method:

This approach is an indirect method based on the assumption that no beneficiary should be required to



RELATION BETWEEN BENEFITS AND COSTS OF MULTIPLE-PURPOSE RESERVOIRS

pay more than he would be required to pay for equal service from the cheapest alternative providing equal benefit.

Separable Costs-Remaining Benefits Method:

This method calls for allocation to each purpose the separable costs of including that purpose in a project plus a share of the "joint cost" which are the difference between the total project costs and the sum of the separable costs for each purpose. The joint costs are allocated to each purpose in proportion to their "remaining benefits" which are the difference between separable cost of a purpose and the benefits to that purpose or the alternative costs of obtaining those benefits which ever is less. This method has been widely used and generally found adaptable and acceptable in most situations.

MULTIPLE-PURPOSE PROJECS IN DEVELOPING COUNTRIES

In developing countries like Ethiopia, the concept of multi-purpose development does not seem to be given the right attention it should have. There are many water resources projects being undertaken for single-purpose development without possible consideration for other uses. Immediate demands, without little forethought for future consequences, may press on piecemeal developments. Usually, major water control structures, once built, can be altered either not at all or only with difficulty and substantial expense. If the suitable dam sites are already appropriated for single-purpose projects, the opportunities for economic multi-purpose developments are considerably reduced or even eliminated. This type of undertaking, eventhough it gives a temporary solution to the problem then prevailing, would not only undermine the optimum use of water but also create a waste of avaliable resources.

Therefore, plan formulation should be directed towards full development and complete utilization of the available water resources. This, from the national point of view, will lead to comprehensive river-basin or regional development as an essential means to optimum use of water. Comprehensive river-basin study would help identify water resources projects and put them in priority orders of development in consideration of relative economic and social attractiveness without favouring any particular use of water. Thus comprehensive river-basin study gives impetus to multi-purpose development schemes.

SUMMARY

Water is a very precious natural resource. The method of exploitation of this resource, until very recently, does not make use of the maximum utilization of available water. Mul.iple-purpose development of water resources makes an optimum use of water in the basin thereby achieving greater over-all economy.

Different uses of multiple-purpose development have conflicting interests. Because of conflicting requirements, the design of multiple-purpose projects is mainly a compromise among the various uses and is basically an economic problem.

The cost allocation procedures for various functions of the multiple-purpose projects appear to be sound in principle but subject to questions when applied. The main opjective for cost allocation among purposes is to achieve mutually agreeable division of costs. The existing procedures, eventhough used in the absence of better ones, are not found to be that much equitable.

In developing countries like Ethiopia, multiple-purpose development should be given more weight than it is getting now, and planning for water resources should be directed towards optimum use of water. Therefore, great care must be exercised to use promising sites to their best advantage from the stand point of all requirements that can be served.

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