A study of benefit-cost analysis in water resources development
by Bhochana Panyadhibya

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics
Montana State University

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Repayment is studied in terms of reimbursable and non-reimbursable projects. In the present single-purpose projects of Thailand all costs are treated as non-reimbursable, but with multiple-purpose projects developing it appears that Thailand will find a need for considering reimbursable costs. The basin account method is analyzed in terms of the Yanhee Project in which irrigation, flood control, and hydroelectric power are all important.

No attempt is made to apply all of the concepts studied to the problems of resource development in Thailand. Application of these concepts was limited to the Yanhee Project primarily because this is the only development having sufficient data to enable one to make even a cursory analysis.

A STUDY OF BENEFIT-COST ANALYSIS IN WATER RESOURCES DEVELOPMENT

by

BHOCHANA PANYADHIBYA

A THESIS

Submitted to the Graduate Faculty

in

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Any errors or omissions in this study are the responsibility of the author.

ABSTRACT

The purpose of this study is to describe and analyze the past and present benefit-cost procedures used in the United States. This study should be helpful in applying these procedures to multiple-purpose developments in Thailand.

The general concepts and principles of benefits and costs are studied in order to determine the benefit-cost ratio. This ratio is a general yardstick measuring economic feasibility.

Two methods of cost allocation -- the proportionate-use-of capacity method and the separable cost-remaining benefits method -- were studied. Here is an illustration of an economic and physical conflict. To base decisions purely and simply on physical relationships ofttimes leads to an uneconomic use of resources.

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CHAPTER I

INTRODUCTION

Problem Situation

The development of water resources in Thailand has increased rapidly during the past 60 years to meet the demand of population growth and rice export. Thailand has been almost exclusively an agricultural country as 65 percent of the population's earnings are from agriculture with the rice paddy farm being the most important type of farming.[1] It requires about six feet of water to mature the rice crop during the growing season.[2] The season runs from the first of June to the end of November. The average rainfall in the agricultural region of the country has been from 41 inches to 59 inches. Water shortages can be met by the river spilling over the bank in a good rainfall year, but in a drought year the river spillage is insufficient to provide for the rice crop. When this condition exists, rice production suffers severely and a national economic crisis develops.

The geographic area of Thailand falls into four natural zones, namely:

1. Central Plains -- consists of a large flat area forming the rice bowl of the country, and produces rice for export.

1/ Puay Ungbhakorn and Subhab Yotsoondhorn, "Rice Farming," Economics of Thailand, Pramuan Mit Co., Thailand, 1955, p. 14.

2/ Royal Irrigation Department, Administration Report of the Royal Irrigation Department of Siam, for the period of 1914 to 1926, Bangkok Times Press, Ltd., 1927, p. 1.

2. Southern Zone -- the coastal tail stretching to the China Sea; consists of low forest hills where the tin and wolfram mines are situated and where rubber is planted.

3. Northern Zone -- the land of mountain and valley. It is suitable for a small number of rice farms. There is a great amount of forest land, particularly teak, which ranks second among export products.

4. Northeastern Zones -- a barren plateau of about 500 to 1,000 feet elevation and is shaped like a huge shallow basin enclosed by high mountains.[1]

In 1896 the first system of water resources development was completed in the Central Plain by the Siam Canals, Lands and Irrigation Company. This company dug a series of canals in the concession areas obtained from His late Majesty King Rama V, and constructed a number of locks and sluices. This work was farm from adequate as these works were primarily inundating canals rather than controlled irrigation.

In 1902 the government negotiated with the Government of the Netherland East Indies for the services of Mr. J. Homan Van der Heide, an irrigation engineer, to investigate and construct some locks and sluices in the southern part of the Central Plain. This project had the same effect as those of the Siam Canals, Lands and Irrigation Company. The canal could not be used for irrigation when the water did not rise to the level that would inundate the rice farm.

In 1913, Sir Thomas Ward, an English irrigation expert of the Government of India, surveyed and proposed a water resources program throughout the Central Plain at the request of His Majesty King Rama VI.

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[1] W. D. Reeve, Public Administration in Siam, Oxford University Press, London, 1951, p. 2.

Since then, modern water development schemes have been constructed and expanded to all parts of the country. The Chao Phya Project, which is the biggest project in the Central Plain, was recently completed. This project is operated under the direction of M. L. Xujati Kambhu, the present Director General of the Royal Irrigation Department. Eighteen million United States dollars were borrowed from the World Bank in October, 1950 with interest at 4 percent and a premium of 3/4 percent annually.[1/]

The water developments in the past have been single-purpose projects. Today the projects have shifted to multiple-purpose because of the increased demands for hydroelectric power, flood control, drainage, recreation, communication and many other uses. The Yanhee Project in Tak Province, which will be the first hydroelectric power plant, is the first multiple-purpose project under construction. It is located somewhere between the Central Plain and the Northern Zone of the country. This multiple-purpose project when completed will provide 560,000 kilowatts of electric power for 35 provinces in the central part and some in the northern portion of the country. The government has borrowed 114 million dollars from the World Bank for construction costs.

Research Problem

This study will not be concerned with the specific procedures and techniques of water resources developments but will be concerned largely with the theories and principles used in American benefit-cost analysis

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1/ "Chao Phya Dam," Economic Year Book, Thailand, Rung Nakorn Publishing Co., Thailand, 1955, p. 257.

which may be applied to Thailand's problem. An analysis of benefit-cost procedures used in water resources development in the United States can serve as a guide to a successful, comprehensive water resources program for Thailand.

Many committees and subcommittees have been set up in the United States to develop mutually acceptable principles and procedures for determining benefits and costs of water resources projects.

In April 1946, the Federal Inter-Agency Committee set up a Subcommittee on benefits and costs. This Subcommittee issued a formal report in May 1950, entitled 'Proposed Practices for Economic Analysis of River Basin Projects. [1/]

In December, 1951, the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council held a meeting at Ogden, Utah, to discuss the general subject of measuring the economic benefits of irrigation development. In March, 1953, the same Committee had a meeting at Berkeley, California to discuss a paper submitted by Maurice M. Kelso, then Professor of Agricultural Economics at Montana State College on the topic, "Evaluation of Secondary Benefits of Water-use Projects."[2/] In December, 1954, benefit-cost analysis was again discussed by this Committee during the meeting at Berkeley, California.

1/ Reginald C. Price, Proposed Practices for Economic Analysis of River Basin Project., p. VII, Washington, D. C., May 1950.

2/ Western Agricultural Economics Research Council, Water Resources and Economic Development of the West, Report No. 1, Berkeley, California, March 1953.

In June, 1955, "Benefit-Cost Procedure for Small Water-Shed Programs" was one of the topics discussed at Pullman, Washington.[1/]

The many reports of groups and individuals concerned with the analysis of benefits and costs in water resources development point out a variety of procedures and criteria for such analysis.

Objective of this Study

To point out advantages and disadvantages of different criteria used to appraise benefits and costs of single and multiple purposes of water resources development.

To review, describe and select the past and current standards and practiced procedures in the analysis of benefits and costs of single and multiple purpose water resources development which will be suitable for application to various projects in Thailand.

Hypothesis

The procedures and criteria for appraising benefits and costs of water resources development in the United States can be used to evaluate water resources development in Thailand.

Procedure

There is a wealth of literature in the field of benefit-cost analysis in the United States. This literature will be used for this study. The study will consider various principles and standards of benefits and

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1/ Western Agricultural Economics Research Council, Water Resources and Economic Development of the West, Report No. 4., Pullman, Washington, 1955, p. 95.

costs of multiple-purpose projects which have been proposed or used in the United States. Some theories and procedures of cost allocation will be explained by using the methods appearing in the literature. Basin Accounting will also be studied in considering reimbursable and non-reimbursable projects. The purpose will be to show how to consider cost allocation and repayment.

CHAPTER II

THE OBJECTIVES, PRINCIPLES AND PROBLEMS OF BENEFIT-COST ANALYSIS

Purpose of Benefit-Cost Analysis

Benefit-cost analysis is one way to evaluate resource developments. However, it is not always the basic method used for approval or disapproval. Comprehensive benefit-cost study has been suggested by the Subcommittee on Benefits and Costs of the Federal Inter-Agency River Basin Committee;[1/] and the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council.[2/] Also many writers have devoted themselves to the problem of economic analysis in recent years.[3/] Economic analysis should serve the following purposes: (1) determine amount of benefits and costs; (2) determine feasible projects; and (3) array the various projects in the order of their relative efficiency in the use of economic resources.

1/ Subcommittee on Benefits and Costs, Proposed Practices for Economic Analysis of River Basin Projects, Washington, D. C., May 1950, pp. 1-85.

2/ Western Agricultural Economics Research Council, Water Resources and Economic Development of the West, Report No. 3, Berkeley, California, December 1954, pp. 1-35.

3/ H. S. Von Ciriacy Wantrup, Resource Conservation, Economics and Policies, University of California Press, Berkeley, 1952; Roy E. Huffman, Irrigation Development and Public Water Policy, Ronald Press Co., New York, 1953; and Mark M. Regan and John F. Timmons "Current Concepts and Practices in Benefit-Cost Analysis of Natural Resources Development," Water Resources and Economic Development of the West, Report No. 3, op. cit.

Definition of Benefits and Costs

The Subcommittee on Benefits and Costs suggests the following terminology for identifying benefits and costs:

Project costs are the value of goods and services (land, labor, and materials) used for the establishment, maintenance, and operation of the project including allowance for induced adverse effects whether or not compensated for. For example, in an irrigation project, the project costs would be the costs of making irrigation water available to the farmer.

Associated costs are the value of goods and services needed over and above those included in the cost of the project itself to make the immediate products or services of the project available for use or sale. The farmer's cost of producing wheat (other than any charge for the irrigation water) would be associated costs.

Secondary costs are the value of any goods and services (other than those covered by project and associated costs) which are used as a result of the project. These include the costs of further processing the immediate products or services of the project and any other costs over and above project and associated costs stemming from or induced by the project. In the irrigation projects example, the costs of transporting the wheat, elevator and milling costs, bakery costs, and the costs of distribution to the consumer would be secondary cost.

Primary benefits are the value of the immediate products or services resulting from the developments for which project costs and associated

costs were incurred. In the irrigation project illustration, the primary benefits are the value of the wheat produced by the farmer.

Secondary benefits are the values added over and above the value of the immediate products or services of the project as a result of activities stemming from or induced by the project. In the irrigation project example, the value of bread over and above the value of its wheat content would be a secondary benefit.[1/]

The Reclamation Manual classifies the types of benefits and costs as follows:

Types of costs

1. Project construction cost.
2. Project operation and maintenance cost.
3. Private or non-federal investment, operation, and maintenance cost.
4. Intangible costs and adverse effects upon the public welfare.

Types of benefits

1. Direct benefits.
2. Indirect benefits resulting from the direct benefits or from the project.
3. Public and intangible benefits.[2/]

The terms tangible and intangible are also used to distinguish between those benefits which can be measured in monetary terms and those which are measurable in non-monetary terms. Intangible benefits which are impossible

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1/ Subcommittee on Benefits and Costs, op.cit., pp. 8-9.

2/ United States Bureau of Reclamation, Manual, Volume XIII, 1951

to express in monetary terms should be carefully indicated in importance and influence on project formulation. The President's Water Resource Policy Commission stressed the importance of public benefits. The Commission wrote: "No aspect of multiple-purpose water resources development has been more productive of confusion and controversy than the treatment of social, or intangible values.[1/]

Concept and Approach

There are at least two benefit-cost concepts:

1. Concept of "net benefit to the people."

Generally, the net benefit concept is most widely known. It is concerned with the question of whether the people receive as great amount of net benefit from funds invested by the public as the net benefit from the same funds if invested privately or in other lines of public endeavor.

2. Concept of maximization or efficiency.

This concept considers the project in such a way that either the benefit-cost ratio is the largest number or the project has the greatest excess benefit over cost. Such a project is assumed to be the most efficient. It may be difficult to establish the project on the basis of efficiency, but for the economist acting as the policy-maker, the efficiency concept is most logical.

M. M. Kelso made a very fine statement on the purpose of an evaluation on the basis of "maximum benefit." His statement reads " . . . to

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1/ President's Water Resources Policy Commission, A Water Policy for the American People, Report No. 1., Government Printing Office, Washington 25, D. C., 1950, p. 56.

provide a basis for rational selection of public investment projects to insure, insofar as possible, that the liquid resources being sunk in them will yield a maximum of benefits over what might be realized from any other alternative use of such funds whether by public or private firms . . . ."[1/]

Multiple-purpose development complicates the problem of formulating alternative projects. Many complicated concepts have been used to consider such problems. These concepts deal with cost allocation and reimbursement to various purposes.

Need for uniformity.

The Subcommittee of the Federal Inter-Agency River Basin Committee has made a comprehensive study of benefit and cost problems with primary emphasis on developing uniform practices. The President's Water Resources Policy Commission also has recommended to " . . . evaluate the proposed programs and projects according to a uniform method which would result in a standard form of 'investment appraisal statement' for each project or program . . ."[2/]

In summary, if the alternative costs are considered a project is said to be properly formulated and economically justified if:

1. the project benefits exceed project costs;
2. each separable segment or purpose provides benefits at least equal to its costs;

1/ Maurice M. Kelso, "Evaluation of Secondary Benefits of Water-Use Projects," Water Resources and Economic Development of the West, Report No. 1, op.cit., p. 51.

2/ President's Water Resources Policy Commission, op.cit., p. 64.

3. the scale of development is such to provide the maximum net benefits; and

4. there is no more economical means of accomplishing the same purpose which would be precluded from development if the project were undertaken.[1]

Principle of Effects of Benefits and Costs

Principle of evaluation of benefit and cost.

The problem of evaluation varies from simplicity to complicity, depending on what kind of project or program is considered. These problems include technical, financial, economic and public aspects. The method used to consider how much the direct beneficiary will pay is concerned with financial feasibility. The public aspects are used to evaluate the program as a whole.

In considering financial feasibility all costs including the initial investment in land, labor, and materials and subsequent costs for replacement and for operation and maintenance must be accurately estimated.[2] In the same manner, the returns or receipts which might be received from the sale of electric power, payments for irrigation, municipal and industrial water supply, and tolls from waterways users must also be estimated. The comparison of these total costs and total returns would show the financial feasibility of that project or program. Financial feasibility alone cannot be used to consider the establishment of the project. Repayment on

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1/ Subcommittee on Benefits and Costs, op.cit., p. 37.

2/ For details of such costs, see President's Water Resources Policy Commission, op.cit., p. 59.

reclamation projects was extended from 10 years in 1902, to 20 years in 1914, to 40 years in 1926 and finally to 50 years in 1938. " . . . and since a number of these were, at that time of such recent origin that repayment obligations had not fallen due, the conclusion seems inescapable that the test of financial feasibility is not serving its purpose."[1/] This is one reason why the President's Water Policy Commission has suggested that Congress eliminate the requirement that irrigation projects show financial feasibility.

Most frequently in the past, formulation has been based largely on the judgments of those engineers designing the projects. Economics consideration often received little attention unless those responsible for design were familiar with the economic concepts involved. In determining the economic feasibility, the economic value of any particular project will have a relationship with other projects within the program. So a project should not be evaluated apart from a program, and a program itself should be evaluated from the standpoint of its contribution to the national development. This program evaluation would be concerned with economic feasibility. The procedure for program evaluation has been presented by the Subcommittee of the Federal Inter-Agency River Basin Committee.[2/] Primary emphasis was given to market values. The Subcommittee recognized benefits and costs which have extramarket value, but felt

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1/ Hurbert Marshall, "The Evaluation of River Basin Development," Law and Contemporary Problems, School of Law, Duke University, Vol. XXII, Spring 1957, p. 244.

2/ Subcommittee on Benefits and Costs, op.cit., pp. 1-84.

there is no suitable method for their evaluation as yet. Benefits having market value may be direct or indirect. For example, the farmer who produces farm products is said to have direct benefits. People in nearby business centers are said to have indirect benefits.

The evaluation of benefits and costs having market value can be made through the "benefit-cost ratio." A project having a benefit-cost ratio of 1 to 1, or greater, may be considered as economically feasible. The Engineer's Joint Council has recommended that projects having direct market benefit-cost ratios of less than one also be considered feasible when the intangible benefits are shown to be large and certain.[1/] Huffman has proposed " . . . the excess benefits over costs is maximized rather than that the largest possible benefit-cost ratio is achieved . . ."[2/]

The following illustration is presented for the purpose of securing a better understanding in selecting alternative multiple-purpose projects.

From this example, if the project has only one single purpose of irrigation, it will have the greatest benefit-cost ratio. If the project adds other purposes up to navigation use, the total net benefit will be greatest, the benefit-cost ratio being greater than one and the incremental benefit is also greater than the increment of cost. If the recreation, fish and wildlife purpose is considered to be important in that project, it can be added without changing the total net benefit. Pollution control,

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1/ Engineer Joint Council, "Principle of a Sound National Water Policy," Civil Engineer, May 1957, p. 52.

2/ Roy E. Huffman, op.cit., p. 197.

TABLE I. HYPOTHETICAL EXAMPLE OF THE BENEFIT-COST RATIO COMPARISON OF A MULTIPLE PURPOSE PROJECT.[a]

Number of purposes	Benefit		Cost		Total net benefit	Benefit-cost ratio
	Total	Increment	Total	Increment		
1. Irrigation	200	---	100	---	100	2 : 1
2. Power	500	300	300	200	200	1.66 : 1
3. Flood control	700	200	400	100	300	1.75 : 1
4. Drainage	850	150	450	50	400	1.89 : 1
5. Municipal and Industrial use	1,000	150	550	100	450	1.82 : 1
6. Navigation	1,150	150	600	50	550	1.91 : 1
7. Recreation, fish and wildlife	1,200	50	650	50	550	1.85 : 1
8. Pollution control	1,400	200	1,400	750	---	1 : 1
9. Domestic use	1,500	100	1,600	200	---	0.94 : 1

[a] Roy E. Huffman, op.cit., p. 198.

having a benefit-cost ratio of 1 to 1, is also justified if the intangible values in this purpose are large and important. The last purpose, domestic use, which is supposed to be very important for living, has been accepted by the Engineer Joint Council as feasible even when the direct market benefit-cost ratio is less than one. This condition may happen in some country where the water supply and ground water system are developed to provide enough facilities for the people. The idea of adding pollution control, which is beyond the point of equal increments of benefits and costs, i.e., 50 to 50, and domestic use where the benefit-cost ratio is 0.94 : 1, is that the negative net benefits of these two purposes can be subsidized by those purposes having benefit-cost ratios greater than 1 to 1.

Primary and secondary benefits attributable to the project

It is necessary to remark here that the preceding procedure should be the ratio of "the project benefits" to "the project costs." The project benefits consists of primary net benefits and secondary net benefits. The primary net benefits or the primary benefits attributable to the project are equal to the total primary benefits less associated costs. For example, the market value of rice that a farmer produced minus the costs incurred in producing the rice (other than any charge for irrigation water) would be primary benefits attributable to the project.

The secondary net benefits attributable to the project are those which are equal to secondary benefits less secondary costs. The secondary benefits have been defined as the values added over and above the value of the immediate products or services of the project as a result of activities stemming from or induced by the project. The values "stemming from" a project are those which come from the processing of products, such as milling and baking of wheat. Thus, the value of bread over and above the value of its wheat would be a secondary benefit. Values "induced by" a project are those which result from expenditures by the producers of the immediate products of a project, such as the increased income of local businessmen. Secondary costs include the costs of further processing the immediate products or services of the project and the costs spent by the local businessmen to meet the increased demand for goods and services in the project area.[1/]

1/ Hubert Marshall, op.cit., p. 242.

Project alternative and formulation

The concepts of benefit-cost described here are very valuable for considering alternative water resources development.

In formulating these principles and concepts, both regional and national alternatives would need to be considered. Regan and Timmons expressed their opinions that " . . . A project is considered properly formulated and economically justified if;

1. project benefits are in excess of project costs;
2. each separable segment or purpose produces benefits sufficient to cover the costs of its inclusion;
3. the scale of development produces greater net benefits than would either larger or smaller scale; and
4. more economical ways of accomplishing project purposes would not be precluded from development as a result of the project."[1/]

General Theory of Benefit-Cost Flow

Individual aspect

The possible economic effects of a specific project can be related to the private economy. It can be determined in terms of benefits and costs. The normal effect of most projects to the individual is in the form of services and facilities. The project will increase the real income or wealth, reduce costs of production, provide better paying jobs and lower costs of consumers' goods or services. These are direct and indirect benefits and costs expressed in terms of market value. The intangible

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1/ M. M. Regan and J. F. Timmons, Water Resources and Economic Development of the West, Report No. 3, op. cit., p. 5.

benefits expressed in terms of extramarket value flowing to individuals may be in the form of living convenience. For instance, expanding the span of life from the result of natural enjoyment, i.e., flowers, lawns and family gardens is an intangible benefit. Intangible costs are met in large part through taxes. How much and how long depends upon the cost-sharing and period justification of the project. Usually it ranges from 10 to 50 years.

Social economic aspect

General benefit and cost flows are concerned with increasing the productive power of the nation and the well-being of society. These would include power, transportation, national defense, recreational facilities and scenic values. According to a study of indirect benefits from irrigation published by the Montana Experiment Station there are at least five socio-economic complexes. These are:

1. Health-hospital-medical care service.
2. School functions and organization.
3. Livestock feeding and sale operations.
4. Business service activity.
5. Leadership functions.[1/]

These five groups are significant in the transition from dryland to irrigation as indirect benefits from irrigation.[2/]

1/ H. C. Holje, Roy E. Huffman, and C. F. Kraenzel, Indirect Benefits of Irrigation Development, Bulletin 517, Mont. Agr. Exp. Sta., Bozeman, Montana, March 1956, p. 38.

2/ Ibid., p. 38.

Public expenditures for these general social benefits can be evaluated in terms of budgets proposed by the government. In some projects the government has received returns from such public investments in excess of costs.

General Measurement Standard

Monetary basis for measuring diverse effects

It is necessary to have some common standards for the measurement of benefits and costs. The most widely accepted standard is the monetary unit. This monetary unit relates to price levels, interest rates, risk allowances, and period of analysis.[1/] At the present time, there is no specific standard for the measurement of extramarket values. For the purpose of benefit-cost analysis a non-monetary system has been used for such measurement.

Price level -- As project evaluation affects the society as a whole, the standard of measurement should be concerned with real costs and benefits which can be measured by the amount of goods and services at the time of exchange. The phrase "goods and services" in this writing refers to all objects and activities which satisfy human wants. Goods and services have economic value when they can fulfill human needs and have no economic value when there is no need or demand for them. The Subcommittee suggested that the most practical measure of such goods and services for meeting various needs and demands is the market price in currencies of the

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1/ Subcommittee on Benefits and Costs, op.cit., p. 15.

nation, e.g., in dollars.[1] This price must be that expected at the time when costs are incurred and benefits received. For costs expected to be incurred in the near future prevailing prices are used. The most practical construction costs are estimated on the basis of current prices.

For operation, maintenance and replacement costs and benefits the Subcommittee suggested that these be evaluated on the basis of prices estimated to prevail at the time of occurrence of such costs and benefits.[2] This concept requires forecasting for future development. For instance, population growth, technological changes, foreign trade and monetary and fiscal policy must be evaluated.

Regan and Greenshields recommended that such ideas are not essential. The real value of goods and services, as measured by their purchasing power can be used for comparison between goods and services invested and produced at the time of occurrence. Inflationary and deflationary prices should be of no significance in justification in a period when there is a high level of resource employment.[3]

Risk allowance and interest rates -- Risk allowances and interest rates are used as a means of adjusting benefits and costs for time differences. Risks can be classified as predictable risk and uncertain risk.

1/ Subcommittee on Benefits and Costs, op.cit., p. 7.

2/ Ibid., p. 18.

3/ M. M. Regan and E. L. Greenshields, "Benefit-Cost Analysis of Resources Development Programs," Journal of Farm Economics, November 1951, p. 872.

The former risk may be covered through insurance or appropriate allowance. For example, losses from fires, storms or flood damages would be of this type. Risk from uncertainties, consisting of errors in measurement of benefits and costs, technological change which affect the costs of projects, must be based upon judgment, since there is no method for determining these. The Subcommittee recommended an interest rate of 2 1/2 percent to 4 percent. A rate of 2 1/2 percent, approximately equivalent to long-term government bonds, is used either for federal or nonfederal public investment. A rate of not less than 4 percent is used for private investment and for converting deferred benefits to an average annual equivalent basis.

Period of analysis -- The amortization costs should be charged to cover the investment during the period of useful service. This period varies according to various agencies. The Corps of Engineers and the Federal Power Commission use 50 years, the Department of Interior 100 years. The Engineer's Joint Council recommended that " . . . amortization should be assumed to take place within the useful life of the project, or within a maximum of fifty years which ever is less . . ."[1/]

1/ Engineer Joint Council, op.cit., p. 52.

CHAPTER III

COST ALLOCATION

Purpose of Cost Allocation

"Cost allocation is the process of apportioning project costs among the various purposes served by the project."[1] Some purposes of the project may either be reimbursable or non-reimbursable. How much of the non-reimbursable part is to be carried by the Federal taxpayer or how much the direct beneficiaries should carry is determined by the method of cost allocation. So sound methods of cost allocation should be adopted in order to treat the taxpayer and beneficiaries equitably.[2] Private enterprise has two types of costs, i.e., direct and overhead costs in the same manner as the multiple-purpose project having separable cost and joint cost.[3]

Theories of Cost Allocation

There are various theories used for cost allocation, but two stand out in importance. They are:

1. Theory of allocation by basing costs on the proportion of the facilities used. This is called the proportionate-use-of capacity method.

1/ Subcommittee on Benefits and Costs, op.cit., p. 53.

2/ Ottar Nervik and others, Economics of Federal Irrigation Projects in the Missouri Basin, Circular 110, Agricultural Experiment Station, South Dakota State College, June 1954, p. 4.

3/ Roy E. Huffman, op.cit., p. 207.

2. Theory of allocation by basing costs on the basis of benefits accruing to each purpose. This is called the separable cost-remaining benefits method.

The Proportionate-use-of Capacity Method

According to this method, the cost of each purpose for one structure such as irrigation, flood control, or power is allocated in proportion to the capacity of water reserved, i.e., volume of water in the reservoir or cubic feet of water per second for each purpose.

Karl Gertell stated that the proportionate-use-of capacity method is uneconomic.[1] He illustrated the uneconomic nature of such a method in the following hypothetical table.

TABLE II. BENEFITS, COSTS, AND ALLOCATION COSTS OF HYPOTHETICAL MULTIPLE-PURPOSE PROJECT.[a/b/]

	Costs Dollars	Benefits Dollars	Benefit-cost ratio	Percentage of capacity required Percent	Allocation by proportionate-use-of capacity Dollars
Flood control alone	100,000	160,000	1.60 : 1.00	50	65,000
Additional reservoir capacity for irrigation	30,000	60,000	2.00 : 1.00	50	65,000
Total	130,000	220,000	1.69 : 1.00	100	130,000

a/ For purpose of clarity separable costs such as those for floodways and irrigation ditches are not shown; the same relationships are obtained if separable costs are included.

b/ Karl Gertel, op.cit., p. 132.

1/ Karl Gertel, "Recent Suggestions for Cost Allocation of Multiple-Purpose Projects in the Light of the Public Interest," Journal of Farm Economics, XXXIII, February 1951, p. 132.

His explanation is -- "This table gives benefit-cost relationships for a hypothetical reservoir considered for flood control and irrigation. If the dam were to serve its prime function of flood control alone, the ratio of benefits to costs would be 1.6 to 1.0, while a multiple-purpose structure gives a ratio of almost 1.7 to 1.0. A private concern would build the incremental capacity needed for irrigation, which has a benefit-cost ratio of 2 to 1, and create an additional $30,000 of net profit. However, under the proposed method of cost allocation the multiple purpose project would not be permissible as irrigation could not meet its allocation of $65,000, and a single-purpose flood control structure would have to be built."[1/]

Gertel wrote -- "The clasical example of a private enterprise that resembles a multiple-purpose project is the department store, which uses a given floor space for the joint sale of different products. Rather than pricing linens and cosmetics in direct proportion to the floor space taken up by the linen and cosmetic counters, the department store manager prices his products so as to maximize his profits."[2/]

The Separable Cost-Remaining Benefits Method

This method resulted from a joint agreement of three Federal agencies in March, 1954, as Karl Lee wrote: " . . . the Bureau of Reclamation joined with the Federal Power Commission and the Corps of Engineers

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1/ Ibid., p. 132.

2/ Ibid., p. 132.

announcing the adoption of a common allocation procedure designed to result in uniform treatment of functions and to result in uniform results regardless of which agency applied it. The procedure is essentially economic in nature and is identified as the 'separable-remaining benefit method.' Basically, the procedure is the same as the alternative, justifiable expenditure method except that separable costs are used instead of direct costs."[1]

The Separable Costs

There are two costs -- separable and joint costs -- important to this procedure. The separable cost is the difference between the multiple-purpose project costs and the costs of the project with one purpose omitted. In calculating this cost for irrigation, flood control, power and industrial water supply, it is necessary to compute any three purposes together, i.e., irrigation, flood control and power with the omission of the industrial use. Assuming total costs are $150,000 and the costs of power, flood control and irrigation $130,000, a separable cost of $20,000 would be assigned to the industrial use. The separable costs of the other purposes can be found in the same manner.

The Joint Costs

The joint cost is the difference between the cost of the multiple-purpose project as a whole and the total of the separable costs of all

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[1] J. Karl Lee, "Economic Implications of Recent Development in the Bureau of Reclamation," Water Resouces and Economic Development of the West, Report No. 2, Bozeman, Montana, June 1954, p. 84.