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# Comprehensive River Basin Planning with Reference to The Okanagan Basin Study

CANADA-BRITISH COLUMBIA OKANAGAN BASIN STUDY

TASK 207(a)

# THE EVALUATION PROCESS

# IN

# COMPREHENSIVE RIVER BASIN PLANNING

# WITH REFERENCE TO THE OKANAGAN

# BASIN STUDY

by

J. O'Riordan

Planning Division
Water Planning and Operations Branch
Department of Fisheries and Forestry
Vancouver, B.C.

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ABSTRACT

This report discusses the criteria and methodology for evaluating water management plans according to the multiple goals of economic growth, environmental quality and social well-being. An evaluation matrix is devised whereby the impacts (positive and negative) of water management alternatives can be assessed in terms of the criteria associated with these multiple goals.

A conceptual analysis of the evaluation process is presented in the report (only) and it has been applied with some modifications to a selection of water quantity alternatives in the mainstem Okanagan (Okanagan Lake and Okanagan River) The report will form the basis for evaluating a number of comprehensive framework plans towards the end of the Study.

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## Summary

This paper is the first part of a two-part study of the evaluation process that will be used to evaluate alternative plans in the Okanagan Basin Study. The paper describes the main principles that affect the process of evaluation and indicates in theory how an evaluation matrix can be established to choose between alternative plans. The second paper, due in June 1971 will show how this evaluation matrix will operate in practice. The main findings of this first report are summarized below:

1. The Okanagan Basin Study represents a new strategy for river basin planning in Canada, based upon the concept of multiple objective - multiple means planning.
2. The multiple objectives of the study are not clearly and precisely stated in the Agreement, but appear to include economic development, environmental quality and social well-being objectives. More precise definitions of these objectives together with the measurement parameters required to assess them are presented.
3. The paper recognizes that water resource management is only one policy alternative for achieving the multiple objectives of the study. A number of proposed water resource targets or management means are defined which can contribute to all or part of the multiple objective function.
4. Benefits and costs of alternative plans are directly related to the defined multiple objectives. Therefore there may be economic, environmental and social benefits and costs related to each water management alternative.

5. When possible, all benefits and costs will be quantified, but only those directly related to the economic objective will be expressed in dollar values. However, social and environmental benefits and costs will be explicitly accounted in the evaluation matrix.
6. The spatial viewpoint from which the impacts of plan development can be evaluated is important and the implications of chosing the Okanagan region, British Columbia or Canada as a whole are discussed.
7. The distribution of benefits and costs of alternative plans between individuals and groups in the valley is discussed and a system of weighting the distribution of these gains and losses is emphasized.
8. A theoretical evaluation matrix which can account the economic, social and environmental benefits and costs of alternative water management plans is described and discussed. The paper emphasises that this tool is required to replace the traditional benefit-cost analysis if the multiple objectives of this study are all to be achieved.
9. The implications of the use of an evaluation matrix upon decision making are brought out, and the crucial importance of devising a rational weighting system with which to trade-off between the multiple objectives is emphasized.

## Preface

Because some of the terminology used throughout this paper is placed in a context which may differ from that which the reader is accustomed, it seems appropriate at the onset to present the definition of certain terms that appear frequently in the text.

### Objective

A major policy goal set by the highest decision-making body in government. An objective has instrumental value because it leads to a higher valued goal, that of improving social welfare. The statement of objectives should include measurement parameters to indicate the degree to which they are achieved and to ensure that the objectives do not overlap. Examples of objectives include increased economic growth (regionally and/or nationally), improved environmental quality and an equitable distribution of opportunity.

### Target

In this paper, the term target refers to a specific means of allocating resources to achieve one or more of the planned objectives. In the case of the Okanagan Study, targets will be expressed in terms of water management goals. For example the planning objective of achieving economic growth in the Okanagan basin might be achieved through the target of supplying water in the region for agricultural needs to 2020. Similarly, the planning objective of improving environmental quality might be partially met by the target of providing water quality standards consistent with body-contact recreational sports.

## Sub-Targets

Sub-targets relate targets to specified water resource demands in a study. For example, a sub-target related to the target of improving water quality might be to improve the water quality in a particular lake or reservoir to a specified water quality standard. Of course, the decision whether or not a sub-target should be achieved will depend upon a rigorous analysis of the benefits and costs associated with achieving this target.

## Benefits

Benefits are defined as positive contributions to achieving objectives through meeting specified targets or sub-targets. When possible, the benefits associated with each target will be categorized into the multiple objectives. Because of the inter-linkages between objectives, aggregated or joint benefits will arise, which will require special consideration to avoid double-counting. When possible, aggregated benefits will be distinguished from separable benefits, as the latter can be fully attributed to a particular objective.

In the case of the agricultural water supply target, direct benefits associated with the economic growth objective could include increased or more efficient production of agricultural outputs, while indirect or secondary benefits might involve the benefits stemming from the location of a new fruit processing plant. In terms of the environmental quality objective, such factors as aesthic appeal due to landscape diversity or the psychic enjoyment of picking fresh fruit may be positively valued by the society and therefore accounted as benefits.

Costs

Costs are defined as negative contributions to objectives through meeting specified targets or sub-targets. Not only are there economic costs associated with actual monetary expenditures, but there may be environmental costs such as the loss of recreational experience and social well-being costs such as an increase in flood risk for a certain community. Like benefits, joint costs may occur and must be treated with caution to avoid double-counting.

Project

A project refers to any alternative means for achieving a specified water resource target or sub-target. Thus, a project may refer to a structural alternative such as a new reservoir or canal or it may refer to a water management alternative such as metering and pricing water supplies or landuse zoning. Because of their nature, projects are usually associated directly with sub-targets.

Comprehensive Plan

An array of water quantity and water quality projects which combined, form a complete comprehensive water management plan. Thus, while projects are designed to achieve targets and sub-targets, a comprehensive plan is designed to achieve the multiple objectives of the study.

## Introduction

The Okanagan Basin Study represents a new strategy for river basin planning in Canada. Therefore the adequacy of the present planning approaches to water resource management in Canada to meet the challenge of this new strategy should be assessed at the onset of the study. In theory, the entire process at the policy, strategic and operational levels of planning should be scrutinized in this review, but because the Socio-Economic Task Force is mainly concerned with the evaluation process, only the the evaluation procedures will be considered in depth in this report. However, the implications of the required changes in the evaluation process upon other dimensions of the planning process are indicated throughout the paper.

One of the basic tenents in any planning study is that a choice will have to be made between a number of water resource management alternatives for achieving the objectives of the study. Decision on the choice of alternatives is based on those that best meet the objectives of the study. Thus the evaluation process which leads up to the point of decision-making is intimately connected to clear and precise definitions of the study objectives.

This paper reviews the basic principles for evaluating alternative plans and develops the concept of using an evaluation matrix in the evaluation process. The paper is the first part of a two-part description of the evaluation process that will be used in the Okanagan Basin Study and simply

outlines a number of important principles that will be taken into account by the Socio-Economic group when evaluating alternative plans. The second paper, now scheduled for completion in June, 1971 will indicate how these principles will be implemented during the study and specifically how the evaluation matrix will be used to enable rational decisions to be made.

Although this paper concentrates its attention on the evaluation process, it does attempt to review this evaluation process within the whole perspective of comprehensive basin planning. The paper begins by defining the scope of comprehensive basin planning through a review of the historical sequence of planning strategies. Then the complete planning process is briefly discussed to indicate the inter-relationships between its three major components - the evaluation process, basic planning activities and the institution structure. The main part of the paper examines in some detail each of the principle steps in the evaluation process, leading to a description of a conceptual model of the evaluation matrix. Finally, the implications of this evaluation matrix upon decision-making are discussed.

## The Concept of Comprehensive River Basin Planning

The concept of comprehensive river basin planning is perhaps best defined by reviewing the historical sequence of strategies in water resource development and planning. Four strategies have been identified (White, 1969). The first is single-purpose development and is exemplified by private schemes for irrigation water supply or the building of canals to improve inland navigable waterways. These projects were usually small in scale and localized in their impact upon the economic, social and physical environment.

The main purpose of this type of development was to promote economic growth. Scale economies were soon recognized by planners and led to larger scale projects which were multi-purpose in nature. Because of their size (and other reasons) such multi-purpose projects were undertaken at public expense and have their most notable example in the T.V.A. development, which produced water power, water supply and recreation benefits. Although this strategy is classified as multi-purpose, it had essentially a single objective, that of increasing national and in some cases regional income. Economic efficiency criteria based on the technique of benefit-cost analysis were developed to evaluate projects and aid decision-making.

As readily available water resources were utilized, and new engineering techniques developed, planners devised more ambitious projects including large-scale diversions from one watershed to another. Such schemes produced major impacts on the economic and physical environment giving rise to a growing public concern for protection of the natural environment, particularly the eco-systems that were threatened by such large-scale interventions. The increasing costs of water resource development in both financial and environmental terms ushered in a third strategy of multiple means - multipurpose river basin planning (National Academy of Sciences, 1966).

This strategy explicitly increased the range of alternatives to solve water supply problems, encouraging more efficient use of water through proper management as an alternative to large-scale diversion. For example, land use zoning or flood proofing of buildings were examined as alternatives to constructing dams or dykes; water metering was introduced to reduce demands, and waste treatment was encouraged instead of increasing water supplies to dilute wastes.

I would like to emphasize at this point that the main objective of all of these strategies I have mentioned so far is to develop and/or manage the water resource to stimulate economic growth. So essentially there was a single objective - economic development, which was realized by several purposes - supply for irrigation, industry, population growth, flood control, hydro power and navigation. But, people were also becoming aware that water is an important constituent of the environment - it is pleasing to look at, to swim in, to boat upon, to support valuable fish and wildlife resources. In addition, water can play a major role in community life and development as I think it does in the Okanagan Valley in British Columbia.

This awareness of the environmental role of water has required that the objectives of planning must be expanded to include environmental and social goals in addition to the traditional economic one. This has resulted in a fourth strategy, which I term <u>multiple objective</u> - <u>multiple means</u> or comprehensive planning and it is this strategy that we are developing in the Okanagan Study. Comprehensive planning represents a new strategy in water resource management in Canada, built upon the well tested strategies of the past, but because it is new, it requires fresh approaches to evaluation, to decision-making and to multi-agency co-operation.

This paper outlines a broader, and, I believe, a more appropriate approach to evaluation of comprehensive plans than has been used in the past.

The Okanagan Basin Study

With this historical review in mind, I think that it is now pertinent to examine the Okanagan Agreement and check how it matches up to the strategy of multiple-objective, multiple means planning. The Agreement explicitly states that there are at least two major objectives to the study:

"...The purpose of the Agreement is to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth of the Okanagan Basin..."

The Agreement also stresses that multiple means, i.e. a wide range of alternatives will be examined to meet these objectives, when it states that the study will:

"...focus on the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization..."

Further, social values as well as economic values must be taken into account for the Agreement declares that the public will be involved in the planning process:

"...to enable the comprehensive plan to be truly responsive to the wishes of the people for which it is designed..."

Clearly, then, the Agreement fits into the strategy of comprehensive planning. But, as a result, the broad scope of the study has its implications. Firstly, it costs more - up to $2 million can be spent for the planning phase of the study, which means that more money will be spent when we implement our plans. Secondly, the planning process is more complex - more disciplines are involved and more work is required to integrate the results of the various components of the study.

Whereas planning in British Columbia used to be undertaken by engineers, in this study we have biologists, ecologists, economists, sociologists as well as engineers working on the problem. Thirdly, the scope of the study may expand geographically. Should the planners indicate that water must be brought into the basin from another watershed, then we would be required to examine in detail all the economic, social and environmental repercussions of such a diversion before a decision could be made.

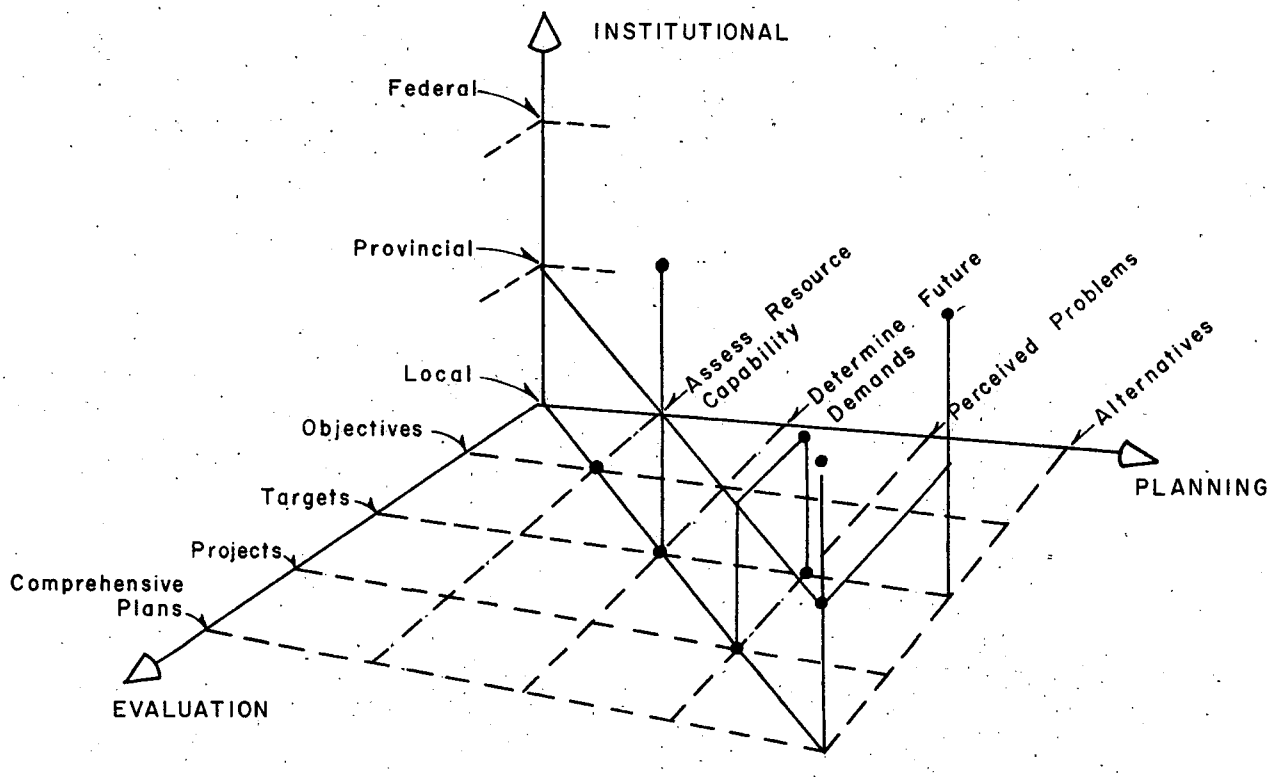
## The Planning Process

To understand the comprehensive approach to the evaluation process, I must first place it in context of the overall planning process. The description of planning presented here is based upon the concept that planning is a process of social change (Bishop, 1970). There are basically three components to the planning process:

1. The Evaluation Process - The evaluation process is based upon a hierachal structure of objectives from those of broad policy goals down to detailed water resource sub-targets.
2. Sequencial Structure of Planning Activities. The sequential structure of planning activities represents the main planning activities and decisions throughout the planning period.
3. The Institutional Structure - The Planning Participants - The institutional structure identifies all the interest groups both in the three levels of government and the general public and indicates how the decision-makers interact at any point in the planning process.

The interaction of these three components can perhaps best be visualized with the aid of a three dimensional diagram (Figure 1). This figure is presented to indicate that planning is a highly dynamic process, which passes through a series of logically related steps (often repeating the cycle several times), and that at each step in the planning process a number of hierachally related decisions must be made by the complex institutional structure.

FIGURE 1 A THREE DIMENSIONAL PLANNING SPACE
(after Bishop, 1970)




When discussing the evaluation process, I recommend that the reader refer to the above diagram so that he can understand how each step of the evaluation process interacts with the appropriate steps in the other two components of the planning process.

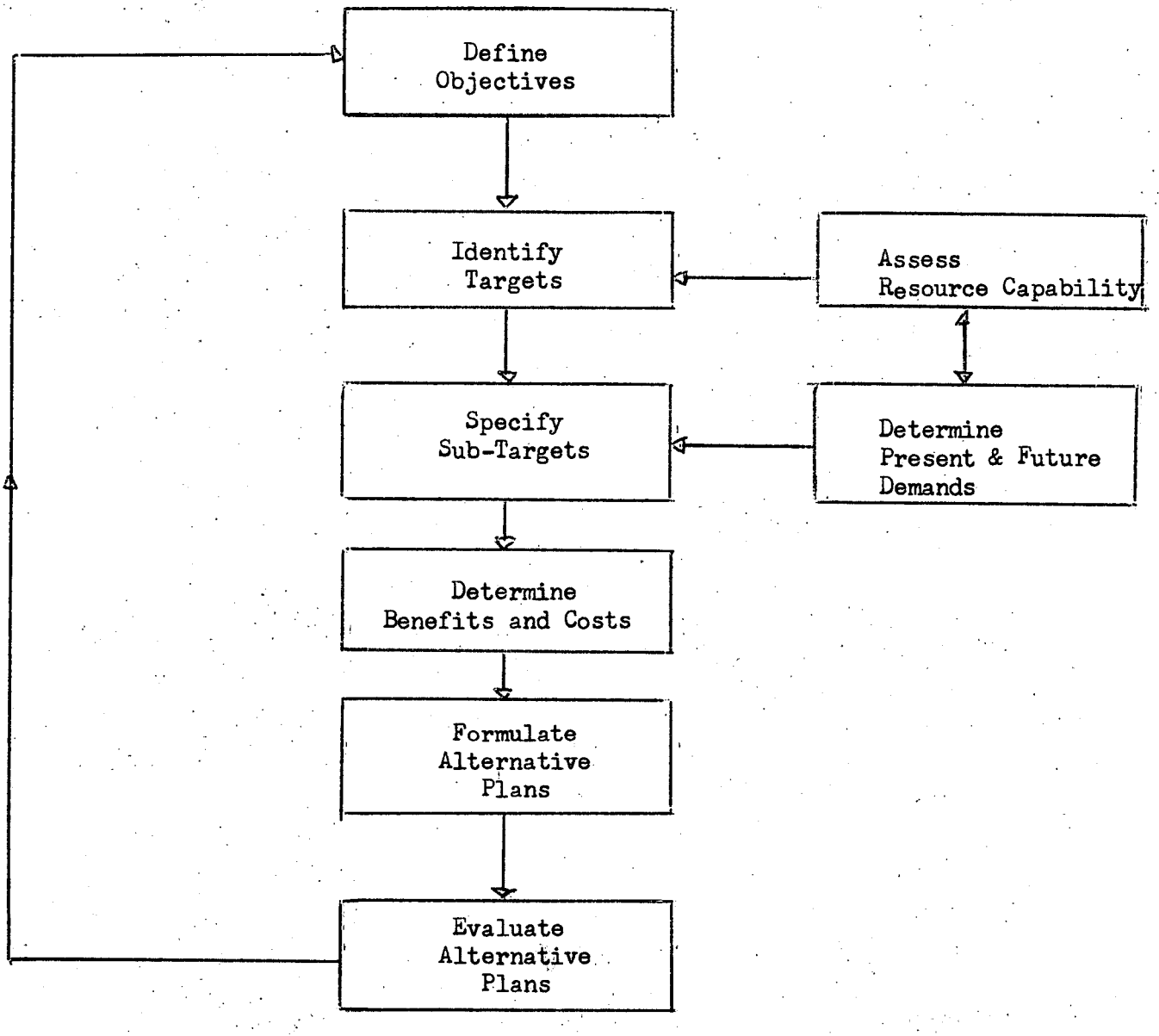
## The Evaluation Process

As is the case for all components of the planning process, the evaluation process can be stratified into a hierachy according to the level of detail required at any particular point of time in the planning process. Each element in the process can be decomposed into various subjects down to the smallest element in the evaluation process which is called the sub-target i.e. a specified water use for a particular location in the study region. A general heirachal structure of the evaluation process with key linkages to elements of the other components is indicated in Figure 2. The diagram shows that objectives are decomposed into targets and then sub-targets where particular problems are studied and then the sub-targets (and related projects) are aggragated into integrated planning alternatives. The whole process should be re-iterated for review and modification as time and money permits.

The remainder of this paper is devoted to a discussion of each of the hierachal sequence of steps in the evaluation process as shown in Figure 2. The reader is asked to review the definition of terms at the beginning of this paper as many terms are used in a rather special context.

FIGURE 2

Simplified Evaluation Process



## The Objectives of Comprehensive River Basin Planning

The commonly stated idealized goal in water resource planning is to maximize social welfare. Generally speaking, a person's welfare is increased if he is somehow better off as a result of some action that he was before. But the objective must be more precisely defined and include specific measurement criteria before the decision-maker can be certain he has achieved this ideal goal.

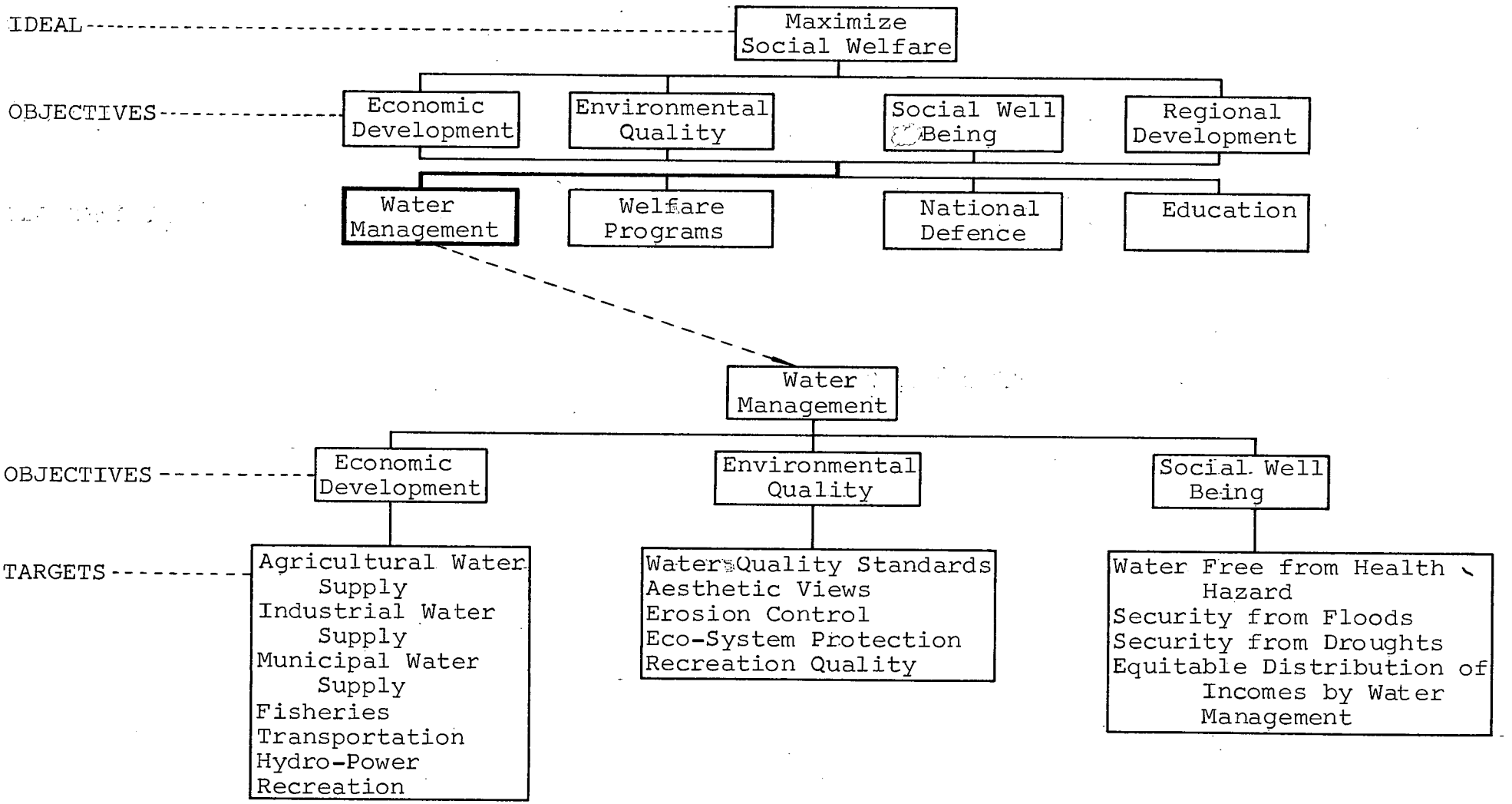
Until recently, welfare was usually measured in monetary terms and welfare was said to be increased if a person's net private consumption of goods and services was increased. Today, the values associated with welfare appear to have broadened to include 'the quality of life' as well as a more equitable distribution of opportunity. Therefore we must be more explicit in our definition of social welfare if we are to include all relevant human values.

I have produced a hierachal system of goals in Figure 3 to help define the relationship between the different levels of goals in comprehensive planning. The figure indicates that social welfare can be achieved by meeting a number of broad objectives. These objectives are major policy goals, set by the highest decision-making body in the government and are therefore instrumental for achieving the higher valued goal of improving social welfare. It is important, that these objectives are explicitly defined and shown to be non-overlapping (though they may conflict) and that their definition include measurement parameters to indicate how resource allocation decisions may achieve them.

The terms social betterment and economic growth used in the Okanagan Agreement are examples of broad objectives. However, they are

Figure 3

GOALS AND OBJECTIVES



ambiguously stated and although the decision-makers at the policy level of the Federal and Provincial governments [1] should ultimately be responsible for more precise definitions, it is perhaps the role of us planners to recommend such definitions to the Consultative Board. In this context, I have identified three objectives for the Okanagan Study and define them accordingly.

1. To increase economic development in the Okanagan and surrounding regions as measured by its net regional income i.e. the net value of incomes, goods and services. The geographic boundaries of the region will be drawn wide enough to encompass all significant project effects.
2. To enhance environmental quality by management, preservation and improvement of certain natural and cultural resources and ecological systems. A social preference index net of costs required to produce a specified level of environmental quality will be developed as a measurement parameter.
3. To enhance social well-being by creating a more equitable distribution of opportunity as measured by net per capita incomes, employment and population densities, and by contributing to security of life, health and property.

There are a large number of economic and social measures that can be chosen to achieve one or more of these broad objectives and thereby the ultimate goal of improving social welfare in the Okanagan, for example grants for industrial expansion, man-power retraining centres, subsidies for the agricultural industry. It is important to understand that water resource management is only one means of allocating resources to achieve these objectives. Ideally, comprehensive regional planning should examine a wide range of these social and economic means to achieve improved social welfare and allocate resources so that the marginal value of benefits (in terms of net social welfare) is the same for all social and economic programmes.

[1] In the Okanagan Study, the policy level is represented by the Canada-B.C. Consultative Board.

In fact only water resource management was specified in the Agreement and therefore all targets are specified in water resource management terms.

Identification of Water Resource Targets

The next step in the evaluation process is to specify how water resource management measures can achieve the previously stated multiple objectives. For this purpose water resource management means or targets must be defined and again the definitions should include measurement parameters that are compatible with those of the broad objectives so that the decision-maker can evaluate the degree to which these objectives have been achieved. Although each water resource management target is primarily conceived as a means of achieving one or other of the multiple objectives, any target could also contribute to other objectives. For example, the target of increasing water supply to increase the net value of agricultural production in the Okanagan obviously contributes to the economic development objective, but also may contribute to environmental quality through the preservation of green spaces (diversification of landscapes) and to the social well-being objective through maintaining employment and therefore incomes to family farmers.

It is important to understand at this time that the merit of achieving the water resource targets listed below should be evaluated in terms of all of the multiple objectives. Under the more traditional benefit-cost analysis, targets were evaluated simply in economic terms, i.e. whether they contributed to an increase in net regional (or national) income, and decisions were based upon the performance criterion of maximizing net benefits.

Under multiple-objective planning, each target should be evaluated in terms of economic growth, environmental quality and social well-being, and decisions will have to be based upon a complicated trade-off performance criteria which hopefully will maximize net social welfare (see section on decision-making).

Listed below is a preliminary statement of water resource management targets, all of which are explicitly or implicitly stated in the Okanagan Agreement.

1. To meet agricultural water supply needs in the Okanagan basin to the year 2020.
2. To meet domestic and municipal water supply needs in the Okanagan basin in the year 2020.
3. To meet industrial water supply needs in the Okanagan basin to the year 2020.
4. To provide adequate water quantity and water quality to satisfy water-orientated recreational demands for the Okanagan basin to the year 2020.
5. To provide all communities and individuals in the Okanagan basin with adequate protection from floods to the year 2020.
6. To provide adequate lake and river levels in the Okanagan basin to support water based transportation.
7. To preserve, protect, manage and enhance fishery and wildlife resources in the Okanagan basin to meet the commercial sport and aesthetic demands of the people in the basin.
8. To preserve, protect and enhance natural and cultural landscapes in the Okanagan to meet the aesthetic demands of the people in the basin.

9. To provide optimum water quality standards in the Okanagan basin to meet the needs and desires of the people in the basin.
10. To prevent and protect against water induced erosion in the Okanagan basin to the year 2020.

In effect then, water resource targets represent all relevant uses of water resources in the Okanagan basin which may ultimately contribute to the achievement of the multiple objectives. Thus, targets should not be identified until the Consultative Board has agreed to a set of precisely stated, non-overlapping multiple objectives. I see it as a function of the strategic level of decision making, represented by the Okanagan Study Committee to decide upon targets and for them to obtain feedback on these targets from the local agencies and organized groups in the Okanagan.

Specify Sub-Targets and Water Requirements

As defined at the beginning of this paper, sub-targets are specified elements of targets and are usually related to spatial components of the water resource system. Figure 2 indicates that an array of sub-targets can only be specified once economic growth studies and other demand studies have been completed and the capability of the existing resource base to meet these demands has been assessed. For example, there may well be a need to improve water quality in the Okanagan basin, but that need will likely vary from one lake to another and therefore specified water quality sub-targets may have to be established to look at each component of the water resource.

Each sub-target must contain specified water quantity and water quality criteria and an appropriate time dimension. Possible qualitative examples of the associated water quantity, water quality, time and space requirements are indicated in Table 1. In the case of many targets such as irrigation, recreation and fish and wildlife management, important related land requirements should also be specified. Of course, the physical criteria outlined in Table 1 only represent part of the evaluation process, for each sub-target would also be evaluated in terms of the multiple objectives to enable trade-offs to be determined when conflicts for scarce resources occur. The crucial step of evaluating sub-targets in terms of the multiple objectives leads me to a discussion of the concept of benefits and costs, delt with in the following section.

Identification of Benefits and Costs

Once the sub-targets have been specified in terms of water requirements, projects can be devised under the planning component wherever the existing water (and related land) resource cannot meet these requirements. As defined earlier, projects represent any water resource management means, either structural or non-structural to meet a sub-target.

Associated with each project are a number of benefits and costs each expressed in terms of one or more of the multiple objectives. The important concept of benefits and costs in comprehensive planning is that they only have meaning when they clearly relate to the multiple objectives. Benefits are defined as positive contributions to the attainment of objectives and costs are defined as negative contributions to specified objectives.

TABLE 1

EXAMPLES OF WATER QUANTITY, WATER QUALITY, SPACE AND TIME DIMENSIONS ASSOCIATED WITH WATER RESOURCE TARGETS

| Target | Water Quantity Requirements | Water Quality Requirements | Spatial Requirements | Time Requirements |
|---|---|---|---|---|
| Agricultural Water Supply | acre feet | appropriate water quality standard | Sub-basin | Monthly irrigation season |
| Industrial Water Supply | acre feet | appropriate water quality standard | Sub-basin | monthly all year |
| Domestic & Municipal Water Supply | acre feet | appropriate water quality standard | Sub-basin | all year |
| Recreation | lake levels, stream flows | appropriate water quality standard | major basins Sub-basin | monthly all year |
| Flood Control | lake levels, stream flows | N/A | Sub-basin | daily all year |
| Navigation | lake levels, stream flows | N/A | Sub-basin | daily all year |
| Fish & Wildlife | lake levels, stream flows | appropriate water quality standard | Sub-basin | daily all year |
| Erosion Control | lake levels, stream flows | Sediment loads | Sub-basin | monthly all year |
| Water Quality | lake levels, stream flows | appropriate for all uses. | Sub-basin | daily all year |
| Scenic Aesthetics | lake levels, stream flows, related land resource. | appropriate water quality for aesthetic demands. | Sub-basin | daily all year |

Thus there can be economic development benefits and costs, environmental quality benefits and costs and social well-being benefits and costs.

Using the example of an agricultural water supply target and its sub-target of supply X acre feet of Y water quality to the Mission Creek sub-basin in the Okanagan, several possible projects may be conceived to meet this demand. For each project, economic benefits may be identified as the net value of agricultural production returned to the additional water supply. In addition, the sub-target will create a number of acres of irrigated landscape, which might be valued by the local public as environmental benefits. On the other hand, if the water in Mission Creek was able to support a sport fishery should no diversion for irrigation take place, the loss of this fishery must be accounted as an environmental cost and as such weighed against the economic benefits (and other benefits) accruing to irrigation development. Examples of benefits and costs (expressed in qualitative terms at this stage) for possible targets are shown in Table 2.

From the example quoted above, it should be realized that not all of the consequences of alternative projects will be quantified in economic terms, but that there will be other consequences associated with the environmental and social well-being objectives that are often referred to as intangible, non-quantifiable, aesthetic or social impacts. To date these benefits and costs have rarely been explicitly included in decision making because they have not been quantified in monetary terms and therefore have not appeared in the benefit-cost analysis. Indeed, in many cases, it seems inappropriate to quantify such intangibles in monetary terms. Therefore, traditional benefit-cost analysis has not been able to weight all the pertinent information in decision-making and while it may maximize economic returns in resource investment decision, it does not necessarily maximize net social welfare.

TABLE 2

EXAMPLES OF BENEFITS AND COSTS ASSOCIATED WITH WATER RESOURCE TARGETS

| Target | Economic Growth | Environmental Quality | Social Well Being |
|---|---|---|---|
| Agricultural Water Supply | Increased or more efficient production of agricultural output; secondary benefits. | land scape diversity; fruit picking experience; eco-system management. | diversified economy; family farm income; rural development; stabilization of incomes. |
| Industrial Water Supply | Increased or more efficient industrual output; secondary benefits. | water quality deterioration; aesthetic benefits or costs. | benefits accruing to identified disadvantaged groups. |
| Municipal Water Supply | Service to increased population; land value enhancement. | lawn sprinkling; golf courses; open spaces; urban parks; water quality deterioration | urban crowding; health and sanitation costs. |
| Recreation | Expenditure impact on regional economy; land value enhancement. | aesthetics of recreation enjoyment; expansion of recreational choice; overcrowding of facilities. | increased opportunit; for identified disadvantaged groups |
| Flood Control and Management | Reduction of flood damage to existing and future facilities; land value enhancement; secondary benefits; economic opportunity costs. | erosion control; aesthetic value of land-zoning; impacts upon eco-systems. | increased feeling of security; stabilization of incomes and opportunity. |
| Navigation | More efficient transportation of goods. | Impact on eco-systems. | |
| Power | Market value of power supplies. | aesthetic impacts; impacts on eco-systems. | stabilization of incomes of certain groups. |
| Fishery and Wildlife Protection and/or Management | Expenditures of recreationists; commercial value of fishery and wildlife resource; more efficient resource productity; economic opportunity costs. | aesthetic value of hunting and fishing; wilderness values; land scape diversity. | increased recreation al opportunity for certain disadvantage groups; more diversified economy; optic values. |



continued.....

TABLE 2 (continued)

| Target | Economic Growth | Environmental Quality | Social Well Being |
|---|---|---|---|
| Erosion Control | Improved resource productivity; land enhancement. | water quality improvement; aesthetic impacts; land scape diversity. | |
| Preservation or Enhancement of Aesthetic Land scapes. | Economic opportunity costs forgone; recreational expenditures. | aesthetic enhancement; wilderness values; land-scape diversity. | 'option' values. |
| Water Quality Standards | Economic opportunity costs; increased resource productivity. | aesthetic impacts, increased choice of water uses. | health hazard contro increased opportunit for 'latent' recreational demand for certain groups. |

Depending upon the definition of the objective, benefits and costs may be expressed in one of the following categories:

1. benefits and costs that are ordinarily valued on the market and can be expressed in monetary terms.
2. benefits and costs that are not valued on the market but can be expressed in quantitative units eg. physical units (number of fish) or social units (employment opportunities).
3. benefits and costs that cannot easily be quantified and are expressed by qualitative description or a social preference index.

Obviously, in a comprehensive analysis of the effects of water resources development, some basis must be established for evaluating and communicating to the decision maker both the monetary and non-monetary consequences of alternative projects and ultimately of alternative comprehensive plans. To establish this, four important aspects of the problem should be considered. These are (a) the quantification and separation of monetary and non monetary consequences measured in terms of the multiple objectives; (b) the viewpoint of the decision-makers; (c) the inter-personal distribution of benefits and costs and (d) the time period of analysis.

(a) Quantification If alternatives are to be compared in a rational manner, their relative advantages and disadvantages must be quantified. As has been stated before, the units for quantification should be stated in the multiple objectives and impacts of each alternative should be measured and evaluated in these units wherever possible. This paper does not detail how the environmental and social well-being units should be defined, but Bishop (1970) has developed a scheme of 'factor profiles' which enable the monetary and non-monetary consequences to be weighted against each other and to allow trade-offs between alternatives.

(b) Viewpoint The spatial viewpoint from which project and comprehensive plan impacts are evaluated is of fundamental importance, especially as the comprehensive river basin agreements undertaken under the Canada Water Act* involve both federal and provincial governments. The viewpoint for evaluating the positive (benefits) and negative (costs) impacts of water resource plans may well differ between the regional, provincial and federal levels of government. For example, if, as the direct result of augmenting the supply of water into the Okanagan Valley, a pulp mill was to locate in the basin, then from a regional viewpoint, the economic and social benefits and costs to the regional economy stemming from the mill should be attributable to the increased water supply. If, however, the mill would have located elsewhere in British Columbia, then from a Provincial viewpoint no benefits or costs accrue to the Okanagan as the decision of the mill to locate in the Okanagan simply becomes a re-allocation of resources within the Province. Similarly, from a national viewpoint, if the alternative location of a mill would occur elsewhere in Canada, then again the decision to locate in British Columbia represents only a re-allocation of resources.

The problem of viewpoint may also be important at a regional level as the Okanagan Basin Agreement explicitly states that the evaluation of alternatives will be expanded to cover impacts on neighbouring areas. Thus, if improved water quality stimulates the recreation potential of the Okanagan basin and captures a demand that would otherwise have moved to the Shuswap watershed, then these recreational opportunities foregone in the Shuswap should be included as a cost in the evaluation matrix.

* The Okanagan Basin Agreement was signed in October 1969, prior to that of the Canada Water Act which came into effect in May 1970.

It is also likely that as the viewpoint adopted in the analysis broadens, some of the secondary effects tend to cancel each other out. For example, secondary benefits accruing to increased agricultural production such as an expansion in fruit processing industry may be a re-allocation of resources that may otherwise have located in the Niagra Peninsula in Ontario. Generally speaking, as the spatial scope of the analysis increases, evaluation of plans tends to rest more directly with primary benefits and costs and is less concerned with secondary effects.

(c) Inter-Personel Distribution of Benefits and Costs The distribution of benefits and costs from any project and the redistribution of opportunities are important considerations especially because the multiple objective function explicitly identifies these impacts in terms of per capita net income, employment and other opportunities. Not only should these re-distribution effects be identified and quantified, however, but the decision-makers must measure what value society places upon the distribution of gains and losses. This principle emphasizes the importance of a broadly based institutional structure interacting on decision-making. If the analysis were to be restricted only to the local level, Okanagan residents will obviously prefer any plan that increases their welfare at the expense of other regions. Thus, this approach will represent the weighting placed on redistribution of opportunity by Okanagan residents, but not by all British Columbians or by all Canadians. Obviously, provincial and federal decision-makers will have to provide their own weightings from their respective viewpoints before a decision can be made.

(d) The Time Period When analysing the alternatives the distribution of benefits and costs over time should also be taken into account (O'Riordan, 1970). An appropriate discount rate must be determined and applied to all benefits and costs, though changes in the relative value of outputs should be given special consideration. The time period of analysis should be carefully chosen to avoid biasing either short or long term effects unduly.

It is worth mentioning here that both the spatial viewpoint and time period or horizon will drastically affect the analysis in selecting and evaluating the benefits and costs of alternative plans. Both of these variables need to be clearly specified before the variables are quantified, and probably a complete evaluation will require sensitivity analysis in which a number of analyses are performed for each plan using different viewpoints and planning horizons.

## Evaluation of Alternative Plans

Once a number of projects have been identified and their impacts on the water resource and social system of the Okanagan assessed, the institutional agencies should aggregate a number of projects into a comprehensive plan that represents an integration of water management and development alternatives to achieve the multiple objectives. At this point, an evaluation matrix, based on the goals-achievement matrix developed by Hill (1967) is proposed as the necessary tool to implement comprehensive evaluation analysis of alternatives.

A conceptual model of an evaluation matrix for one alternative plan is now presented (Table 3). To develop the model, the following information is required:

1. A set of functional objectives $O_1$, $O_2$, $O_3$ .....$O_i$
2. An agreed system of weights for each objective $W_1$, $W_2$, $W_3$.....$W_i$ (see section on decision-making).
3. A set of targets and complimentary water resources needs to achieve the objectives $T_1, T_2, T_3$.....$T_n$
4. A set of sub-targets to achieve each target $T_{11}, T_{12}$.....$T_{ij}$; $T_{21}$, $T_{22}$....$T_{2m}$.....$T_{i1}, T_{i2}$.....$T_{in}$
5. A set of water resource projects to achieve one or more sub-targets. ($P_{111}, P_{112}$....$P_{ijk}$), etc.
6. A complete account of benefits and costs measured in terms of the achievement of a target for each objective ($B_{111}$, $B_{112}$...$B_{ijk}$); ($C_{111}$.....$C_{ijk}$)
7. In some cases, benefits and costs may be represented by expected values or a range of values to account for risk and uncertainty.
8. The incidence of benefits and costs on each relevant group in the community and the relative weight attached to each group.

In the table, a vector of targets ($T_n$) is established to achieve all of the multiple objectives to be attained by water resource management. For example, one such target, say $T_1$, might be to meet demand for agricultural water supply in the Okanagan basin to the year 2020.

TABLE 3

GENERAL EVALUATION MATRIX

PLAN A

| | Objective Rel. Wt. | $O_1$ $W_1$ | | | $O_2$ $W_2$ | | | | $O_i$ $W_i$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Target | Sub-Target | Project | Ben. | Costs | Sub-Target | Project | Ben. | Costs | Sub-Target | Project | Ben. | Costs |
| $T_1$ | $T_{11}$ | $P_{111}$ | $B_{111}$ | $C_{111}$ | | | $B_{2111}$ | $C_{2111}$ | | | - | $C_{i111}$ |
| | | $P_{112}$ | $B_{112}$ | $C_{112}$ | | | - | - | | | - | - |
| | $T_{12}$ | $P_{121}$ | $B_{121}$ | $C_{121}$ | | | - | - | | | $B_{i121}$ | - |
| | | P122 | B122 | C122 | | | $B_{2122}$ | - | | | - | - |
| | $T_{1j}$ | $P_{1j1}$ | $B_{1j1}$ | $C_{1j1}$ | | | - | $C_{21j1}$ | | | | |
| | | $P_{1j2}$ | $B_{1j2}$ | $C_{1j2}$ | | | - | - | | | - | - |
| | | $P_{1jk}$ | $B_{1jk}$ | $C_{1jk}$ | | | $B_{21jk}$ | - | | | - | $C_{i1jk}$ |
| $T_2$ | | | - | - | $T_{21}$ | $P_{211}$ | $B_{211}$ | $C_{211}$ | | | $B_{i211}$ | - |
| | | | $B_{1212}$ | - | | $P_{212}$ | $B_{212}$ | $C_{212}$ | | | - | $C_{i212}$ |
| | | | - | $C_{1221}$ | $T_{22}$ | $P_{221}$ | $B_{221}$ | $C_{221}$ | | | - | - |
| | | | - | $C_{1222}$ | | $P_{222}$ | $B_{222}$ | $C_{222}$ | | | $B_{i222}$ | - |
| | | | | | $T_{2m}$ | $P_{2m1}$ | $B_{2m1}$ | $C_{2m1}$ | | | - | - |
| | | | $B_{12m\ell}$ | | | $P_{2m\ell}$ | $B_{2m\ell}$ | $C_{2m\ell}$ | | | - | $C_{i2m\ell}$ |
| | | | | | | | | | | | | |
| i | | | - | $C_{1i11}$ | | | - | - | $T_{i1}$ | $P_{i11}$ | $B_{i11}$ | $C_{i11}$ |
| | | | - | $C_{1i12}$ | | | - | - | | $P_{i12}$ | $B_{i12}$ | $C_{i12}$ |
| | | | - | - | | | - | $C_{2in1}$ | $T_{in}$ | $P_{in1}$ | $B_{in1}$ | $C_{in1}$ |
| | | | $B_{1in2}$ | - | | | $B_{2in2}$ | - | | $P_{in2}$ | $B_{in2}$ | $C_{in2}$ |
| | | | - | $C_{1inp}$ | | | - | - | | $P_{inp}$ | $B_{inp}$ | |

There may be a number of sub-targets ($T_{ij}$) to meet sub-basin requirements for $T_1$, such as the development of agricultural water supply in the Mission Creek watershed to meet future agricultural water demands in that watershed.

For each sub-target, $T_{1j}$, there may be a number alternative methods of supplying the water, both structural solutions (reservoirs, groundwater wells) and for managerial solutions (pricing of water, water licence transfers). These alternative methods are represented by a vector of projects ($P_{11k}$) for target $T_{11}$ and vector ($P_{121}$) for target $T_{12}$ and so on. Associated with each project are benefits and costs, which may be defined in monetary, other quantitative units or in qualitative terms as appropriate. The vector ($B_{11k}$) represents the benefits associated with projects ($P_{11k}$) required to meet sub-target $T_{11}$ and the vector ($C_{11k}$) represents the costs associated with implementing these projects.

The external and/or joint benefits and costs associated with any project that directly or indirectly affect values associated with other objectives are also noted in the evaluation matrix. In the example described above, $T_{11}$ was defined as the need to supply agricultural water in the Mission Creek sub-basin; $P_{111}$, $P_{112}$ .....$P_{11k}$ are various storage reservoirs and groundwater wells that could be developed to supply the water; $B_{111}$,$B_{112}$....$B_{11k}$ are benefits due to increased or more efficient agricultural production, $C_{111}$, $C_{112}$.....$C_{11k}$ are the costs of constructing and operating the reservoirs or wells and $C_{2111}$ is the external cost resulting from the fact that project $P_{111}$ destroys a potential sports fishing resource.

All direct and indirect social costs and benefits are recorded according to the relevant objective. A dash in a cell implies that no cost or benefit is related to that objective if the associated project is implemented. The major advantage of this accounting system is that all effects --internal and external-- are explicitly shown according to their appropriate objective. Although for certain objectives all benefits and costs might be in the same units and therefore can be summed and compared, in most cases, the benefits and costs will be in different units which will make a grand benefit-cost summation impossible.

An evaluation matrix such as the one shown conceptually in Table 3 should be prepared for each alternative plan. Because the measurement units of benefits and costs in each cell will be similar, it should be possible to directly compare and therefore, rank these alternative plans.

Decision-Making in Multiple Objective Planning

The application of the evaluation matrix approach in comprehensive planning has a number of important implications on the institutional component of the planning process, the most important being the need to develop a new strategy for decision-making. In the past, under cost-effectiveness and benefit-cost analysis, decision-making was effected by the choice of the least costly alternative or by the largest benefit-cost ratio and few additional factors were taken into consideration. Even under the more elaborate economic analysis undertaken for multi-purpose planning, decision-makers were asked to compare and 'trade-off' between different outputs (irrigation, flood-control, etc.), all of which were expressed in the same unit, namely dollars.

This concept of multiple-objective planning complicates the decision making process because economic benefits expressed in monetary terms have to be compared and weighed against social and environmental benefits which are not necessarily expressed in monetary values. Thus the key to plan evaluation is to devise a rational weighting system so that all objectives can be compared simultaneously. In addition, the decision making strategy should also accomodate incremental analysis whereby the decision-maker can assess the impact of marginal adjustments in project size or resource use. In like manner, provision should be made in the evaluation of each major alternative plan to assess the contribution of each individual project to the achievement of objectives on a sequential or incremental basis. In this way, various contributions of projects could be examined to determine which combination will make the largest contribution to net social welfare.

Theoretical trade-off functions have been developed by some economists (Marglin 1967, Major, 1970), but in practice it is doubtful whether these can actually be established. Furthermore, because decision-making will involve both senior levels of government, the local levels of government and the public itself, it seems inappropriate to attempt to devise complex trade-off functions. A more practical strategy based on the theory of games appears to be more appropriate whereby, each participant in the decision-making process develops his own weighting system and then approaches the other participants with a bargaining position. In the likely event that the different levels of government will present different weighting functions, a process of bargaining should be initiated to resolve this initial conflict, based on the principle that all sides may have to give ground in order to gain ground.

Gains are made incrementally and realized only slowly with the objective of the game to achieve what is desirable by searching for consensus between all parties (Chevalier, 1969).

This approach to decision-making is relatively untried in basin planning and will require a great deal of commitment and understanding on the part of the decision-makers as well as a strong linkage with the public through a well-organized public participation programme before it will be effective.

## Conclusion

Social welfare is defined in this paper as a combination of economic, environmental and social objectives. The traditional concept of benefit-cost analysis based upon the superiority of the market place under competitive conditions as a dominant measure of value will not be a suitable performance criterion to achieve maximum social welfare. It is most likely to approximate the achievement of maximum economic welfare for those projects whose outputs have well-defined benefits and costs subject to monetary evaluation, but it appears likely to be an inefficient resource allocation tool for those projects where environmental and social well-being objectives are explicitly stated.

Because society has a definable welfare function when its values can be expressed according to the market mechanism (real or simulated), benefits and costs will be quantified in monetary terms wherever possible. But it is recognized that society does not have a clearly defined welfare function for certain environmental quality and other social values, as indicated by conflicts over local recreational and environmental issues.

The professional analyst has no right to dictate these values, but instead must attempt to determine more accurately society's well being and environmental preferences and values. Optimum social welfare can be achieved through successive trade-offs between the three broad objectives according to economic, social and political criteria.

The evaluation and decision-making process is complex, but that is in keeping with the concept of comprehensive planning. While the approach chosen in this paper does not result in a single number outcome, as in the case of the more traditional benefit-cost analysis,it is more responsible to the complexity of the consequences of comprehensive river basin planning.

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