



## Selection of water resources management options

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IN RECENT YEARS policy makers world-wide have become increasingly aware that water is a limited resource and that its scarcity is becoming a constraint to social and economic development. This is especially true in arid regions where scarcity and water quality deterioration have created tensions between user groups. Thus, a change should be observed in the scope of water resources management as water becomes increasingly scarce. Water resources management should start to address resources issues and the often-conflicting interests of the different beneficiaries. This means that new approaches and new concepts must be introduced (EPD 1996).

This paper will attempt to establish a multi-criterion water management technique for identifying and screening potentially applicable water resources management options to close the gap between supply and demand. Planning criteria will serve as a tool and set the framework for decision-making regarding the development and selection of different options.

There is a growing disparity between water supply and demand in arid and semi-arid areas; this disparity calls for a shift of emphasis in water management from supply to demand management. The options for closing the supply-demand gap should consider various means of matching supply and demand, and of satisfying environmental concerns. Demand management is one option, but other possible strategic options to be considered include (Le Moigne et.al. 1994):

- Broad technical arrangements to permit and improve physical development of water resources.
- Options for institutional and human resources arrangements, highlighting the potential of involving water users, non-government organisations, professionals, and local government in water resources management.
- Requirements, including possible new alternative methods, for capacity building in institutions and developing skills for water sector management.
- Environmental and health protection measures.

Demand and supply can be matched according to different scenarios and under different assumptions. A range of scenarios should be evaluated; not only using economic and financial criteria, but also considering environmental, ecological, institutional, political and other criteria. Such an exercise requires the involvement of all major stakeholders and is essential in order to formulate a national water

management strategy that is accepted and supported by the relevant actors.

In developing and analysing options, and in making recommendations, the water resources manager must strike a balance between the ideal and practical forms of water resources management for a country. The manager should in any event avoid producing a list of options and recommendations that is a "wish list" divorced from practical considerations of the resources available to implement a water resources strategy.

Options for reducing the water supply-demand gap differ in the amount and timing of the capital investment required, in their operating and maintenance costs, in the useful life of the capital investments, in the effectiveness of each option, and in their potential economic and environmental impacts on the area.

The assessment criteria used to rank the different potential options to meet the future national and regional water demand in terms of quantity and quality include several different considerations. These consist of technical aspects, economical aspects, environmental impacts, social implications, institutional aspects, and political implications.

Planning criteria will serve as a tool and set the framework for decision-making regarding the selection and development of different options. The planning criteria can be classified into the following categories:

- *Financial viability:*  
This category includes the following sub-criteria: fundability, unit cost of water production, tariff levels and affordability.
- *Technical viability*  
Criteria included in this category are: availability of technology, potential for implementation, feasibility, flexibility and reliability of technology
- *Source viability*  
Criteria included in this category are: availability and hydrologic certainty of the source, sustainability of quantity and quality, and flexibility of variable abstraction rates during development.
- *Political viability*  
Political implications encompass the following criteria: willingness of participants to co-operate with others, political stability of the source country, and compatibility with international laws and existing agreements.

- *Institutional viability*  
This aspect includes: existence, establishment, capacity and reliability of relevant institutions
- *Environmental viability*  
This aspect includes: impacts on the built environment and impacts on the physical and natural environment
- *Social viability*  
Public acceptance and fulfilment of development needs

## Screening and comparative evaluation procedures

The major objectives of this section are to outline and compare some recent developments in multiple objective decision-making that can be applied to evaluate and choose applicable water resource management options.

Multi-criterion decision-making (MCDM) modelling methods are designed for finding the most preferable solution to a problem in which discrete options are evaluated against criteria or factors ranging from cost (a quantitative criterion) to aesthetics (a qualitative criterion).

Table 1 depicts the basic layout of the discrete version of multi-criterion methods. In a sense, a multi-criterion tableau is like a spreadsheet on a computer for systematically organising and presenting information about a problem. The evaluations of the criteria ( $C_1, C_2, C_3, \dots, C_n$ ) for each option ( $A_1, A_2, A_3, \dots, A_n$ ) reflect the objectives or preferences of the decision-maker. For each option, one has a column of  $n$  entries for comparing this option to the others in order to determine the set of more preferred solutions. Most multi-criterion decision-making methods differ on the types of information required for evaluating the options as well as the definitions of the search procedures for finding the better solutions (Hiple 1992).

A wide variety of tools are currently employed for addressing challenging decision problems in water resources management. Many of these techniques originated from the field of operational research for addressing sys-

tems management problems such as those that often arise in water resources management. By being aware of the main characteristics of the problems being studied, one can select one or more decision-making methods that match the characteristics of the actual problem.

More than 70 Multi-criterion decision-making (MCDM) techniques and 49 different criteria upon which the choice of an appropriate MCDM technique can be based are identified in Tecle (1988). However, it would be very difficult if not possible for any one individual to possess the skills necessary to apply all the available techniques and evaluate them with respect to all criteria. Furthermore, experience in the use of a particular technique appears to be a pre-requisite for evaluating the technique with respect to a set of criteria (Duckstein et.al. 1982; Gershon and Duckstein 1984).

MCDM techniques for quantification of social and community goals range from simple visual procedures, rating and ranking methods, matrix and linear scoring methods, to multiple objective programming techniques. Accordingly, the choice of a suitable MCDM to be applied in this paper is based on the authors' familiarity with some of these techniques.

The most appropriate technique for application to the type of problem typified by watershed resources management is the rating technique which is based on the "direct weighting" approach. Each general category is assigned a weight (from 1 to 100) by each member of a Water Focus Group based on expert opinions (i.e. based on relevant experience and knowledge) which can be obtained by distributing a questionnaire to each member of the Focus Group. Then the simple average weight can be obtained for each category. (The Water Focus Group is comprised of individuals who are involved and interested in the various aspects of water resources development, planning, management, research, and utilisation.)

The procedure for screening of options involves the specification of a rating of each option with respect to its consistency or compatibility with each general category of criteria on an ascending scale of 1 to 10. After this qualitative rating an overall score will be determined for proposed options by multiplying the option rating for a given general criterion by the criterion weight, and then summing these products across all general planning criteria. Symbolically, if  $w_i$  is the weight assigned to the  $i^{\text{th}}$  planning criterion by members of the Focus Group, and if  $r_{ij}$  is the rating of the  $j^{\text{th}}$  option with respect to the  $i^{\text{th}}$  criterion, the overall score,  $S_j$ , for the  $j^{\text{th}}$  option is calculated as:

$$S_j = \sum (r_{ij} \cdot w_i)$$

The scores, which will be obtained by various members of the Focus Group, will be summed to obtain an overall score for each option. Options with higher scores are ranked higher, and considered more compatible with the planning criteria than those with lower scores.

**Table 1. Tableau used in multi-criterion decision-making**

	$A_1$	$A_2$	....	$A_n$
$C_1$				
$C_2$				
....				
$C_n$				

Source: Hiple (1992)

## Conclusions

As water resources become more scarce, management skills are needed to identify potential water resource management options. Various Multi-criterion decision-making techniques have been developed to enable the various options to be evaluated against identified criteria.

Use of a Focus Group, consisting of experts in the water resources field, to evaluate water resource management options reduces the likelihood of an option being favoured and chosen subjectively by an individual, and helps managers to reach an informed decision based on the consensus of experts.

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