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Identification and Estimation of Priority Weights of Irrigation System Management Objectives for Irrigation System Performance Assessment

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ABSTRACT: Most studies to assess performance of irrigation systems have acknowledged the existence of conflicting multiple irrigation systems management objectives but have not been able to empirically identify these objectives and assign weights of trade-offs. Hence these studies have not been accurate for policy decision making on irrigation investment and management. This study proposes a methodology, namely multidimensional scaling, to identify irrigation system management objectives and estimate weights of trade-off among them. The results suggest the need for a multi-disciplinary approach, that recognizes technical, social, economic and political objectives in assessing performance of irrigation systems.

INTRODUCTION

Investment in irrigation development has been a main strategy to alleviate poverty of the rural poor in Sri Lanka. With the development of most of the easily irrigable land, the cost of irrigation construction has increased tremendously. There is also a belief that existing irrigation systems in Sri Lanka are substantially under-performing. Attributing to the above factors, public investments are being diverted to improve performance of existing irrigation systems (Aluwihare and Kikuchi, 1991).

The ability to accurately assess performance of irrigation systems is necessary at different levels of economic decision making *i.e.*, at the national level, to decide whether investments need to be diverted to the irrigation sector or other sectors of the economy; if investments are to be diverted to the irrigation sector to priorities investments among several

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irrigation systems, management activities *etc.* At the irrigation system level to make effective day-to-day management decisions to improve performance is also necessary. Despite the importance of ISPA there are few if any valid measures and empirical studies on ISPA (Carruthers, 1987). This limits rational decision making on the above policy issues.

THE PROBLEM

Irrigation System Performance Assessment (ISPA) refers to the measurement of efficiency of an irrigation system. Efficiency in turn refers to the degree of achievement of irrigation management objectives under given constraints. Thus identifying irrigation system management objectives is an essential first step for ISPA (Smith, 1990; Svendsen and Small, 1990). Studies that have empirically examined and validated the use of specific objectives of irrigation system management for ISPA are not found (Kotagama 1992).

Identification of irrigation system management objectives is conceptually and practically difficult. Irrigation system management involves satisfying different persons, each person having multiple objectives. Different weights of importance or trade-offs are assigned to those objectives by people. The assigned weights too could change over time and under different economic-social-political and technological circumstances at a given time. Thus, the difficulty of identifying irrigation management objectives that constitutes an irrigation systems performance function is equivalent to the difficulty of identification of a social welfare function.

Most ISPA studies have acknowledged the existence of multiple objectives of irrigation management but have used a single externally specified (identified by researcher or policy maker rather than farmers or system managers of the concerned system) technical objective (such as supplying technically optimal crop water requirements) for ISPA (Kotagama, 1992). First, conclusions of these past ISPA studies are subjective by depending on the values of the analyst in choosing objectives of irrigation management. Secondly, ISPA on technical objectives is based on the erroneous presumption that supplying technically optimal crop water requirements directly results in the welfare of the farmers (Levine and Coward, 1989; Chambers, 1984). Thirdly, ISPA on a single technical objective would be misleading due to conflicts of multiple irrigation management objectives. Basic economic theory explains, if water is distributed on the technical objective of supplying crop water requirement that maximizes crop yield, it does not achieve the economic objective of maximizing income, if water is scarce.

Where irrigation systems management objectives are in conflict, trade-offs among objectives are pursued. No one objective is maximized (or minimized) in reality. For example Vedula and Rogers (1981) in examining the optimum cropping pattern to be adopted in an irrigation area in Karnataka, India on the objectives of maximizing net income and maximizing irrigated area have found that increasing irrigated area by 43% reduced system net income by 20%. Thus the weakness in considering a single objective in ISPA is that the standards of expectation (*i.e.* potential performance) are set at higher (or lower) levels than realistically possible. This leads to the error of overestimating the degree of under-performance of irrigation systems when assessed on a single irrigation system management objective.

Hence the identification of irrigation systems management objectives and the weighted trade-offs between them are necessary for realistic and accurate assessments of irrigation system performance.

OBJECTIVE OF THE STUDY

The objective of this study is to identify the irrigation management objectives and estimate the relative weights of trade-offs assigned to them.

METHODS

Theoretical justification of methodology

In private resource systems the management objectives are often clear. Even if not clear, elicitation of objectives is not difficult because it involves only the private resource user. In public resource systems such as public irrigation the objective is often mentioned as improving welfare. Welfare is an ambiguous concept that corresponds to multiple objectives of multiple persons in society. Specification of a welfare function is known to be difficult. Similarly identifying a multiple objective performance function of public irrigation system management is also difficult.

The composition of individual preferences into a social welfare function has been much of the efforts of welfare economists. Three basic approaches have been taken with different assumptions (Cohon, 1978). These approaches are; [1] aggregation of individual preferences, [2] counselling of a public policy maker and [3] prediction of political outcomes. Kotagama (1992) has reviewed the strengths and weaknesses of these approaches in relation to the applicability of identifying the multiple objective irrigation performance function. It has been concluded that no one method is best and pragmatic. Whilst acknowledging the weakness of the approach (Kotagama, 1992) this study is based on the counselling approach of eliciting the objectives of irrigation management from the irrigation manager and 10 elected farmer leaders of the irrigation system studied. The assumption is that they represent the public interest on irrigation management.

The method of analysis

The study was done in the Nagadeepa irrigation system in Sri Lanka. It is a public, medium scale, reservoir based irrigation system located in the dry zone. Data were collected from the irrigation system manager and 10 farmer organization leaders. The following procedure which is closely similar to previous studies on identifying and weighing small farmer's objectives (Barnett *et al.,* 1982; Akatugba, 1991) was adopted.

1) The respondents were presented with 36 irrigation management objectives on a set of cards, each card containing a single objective and were requested to select the most important ten objectives. The objectives were identified based on a review of literature on irrigation development and management in Sri Lanka and participant observations in the Nagadeepa irrigation system in *Yala* 1990. The list of objectives are given in Table 1.

2) The ten selected objectives were presented in pairs and the respondents were requested to express the degree of importance of one objective in relation to the other on a scale of 1 to 5, where

Table 1. Estimates of relative weights and ranking of irrigation management objectives.

Objectives	Coordinate Distances	Standardizes Distances	Weights of Importance	Relative Weights	Rank of Import.
Supply crop water requirement	- 1.6042	1.00	1.00	.2252	1
Minimize risk of crop failure	- 0.9597	1.64	0.61	.1374	2
Improve standard of living of farmers	- 0.7842	1.82	0.55	.1238	3
Fair distribution of water among farmers	- 0.4629	2.14	0.46	.1036	4
Maximize systems income	- 0.1954	2.40	0.41	.0923	5
Minimize farmer conflicts	- 0.0943	2.50	0.40	.0900	6
Distribute water to maximum number of farmers/land	0.3533	2.95	0.34	.0766	7
Promote crop diversification	0.8331	3.43	0.29	.0653	8
Minimize water conveyance losses	0.9266	3.53	0.28	.0630	9
Promote farmer organizations	1.9878	4.59	0.21	.0473	10

Notes: The standardized distance is obtained by adding a constant positive (- 1.6042) to all values such that the largest negative value is positive 1. The smaller the distance the more important is the objective (Barnett et al., 1982). i.e. closer to the 'ideal'. There fore the reciprocal of the distance is taken as the estimate of the weight of importance. Relative weights of importance are estimated by summing individual weights of importance of all objectives and taking the proportion between the weight of importance of each objective over the sum of weights of importance. Ranking of objectives is based on the relative weights of importance.

larger the number more important was the objective in relation to the other. This process is referred to as `paired comparison'.

3) The data obtained on paired comparison of objectives were analyzed with the use of Multidimensional Scaling (MDS) Technique to derive weights of relative importance of objectives. A comprehensive explanation of the philosophy of MDS and the technique of application is given in Kruskal and Wish (1978). Briefly, multidimensional scaling refers to a class of techniques that infer multidimensional structure from one dimensional ranking among objects or perceptions. In the present study the perceptions are objectives of irrigation management. In the process of ranking objectives there is an underlying attribute space of some dimension in which each objective is assessed on it's importance in relation to others. That is, there is a metric of distances among objectives in the attribute space. In the present study the attribute space is assumed to be composed of two dimensions of private and public benefits of irrigation system management. MDS techniques convert the ordinal ranking data into cardinal estimates of distances among objectives (which are converted to weights) by estimating the best fit among distance between objectives in the attribute space. Several computer programmes have been developed for this purpose and are available as commercial software. This study used the ANTHROPAC software developed by Borgastti (1989).

MDS has been used mostly in marketing research to examine consumer's relative preferences on different products (Moore, *et al.*, 1979; Wierenga, 1980). It has also been used to derive relative weights of importance among farming objectives of Singhalese Subsistence farmers (Barnett *et al.*, 1982).

RESULTS AND DISCUSSION

The results are discussed with reference to implications of the analytical method on ISPA methodology and on policy decision making in irrigation.

During data collection it was found that the response from farmers was poor and unreliable. This could have been due to several reasons. The questionnaire may have been poorly designed (*i.e.* the number of objectives presented were too many and wording was not understood). The explanation of the meaning of each objective took considerable time and often lead to discussions that digressed from data collection. The repetitive nature of paired comparison bored the farmers and they showed less interest as the interview progressed. The 'game – like' or the seemingly lack of seriousness of the nature of questioning procedure was perhaps disliked by farmers. Hence data from farmers were not analyzed.

It is suggested that paired comparison data collection with farmers should be limited to five to ten objectives the most and must be very clearly worded. Important objectives must be identified apriori through the participant observation method. The data collection method adopted by Akutugba *et al.,* (1991) to order multiple objectives of small farmers in Nigeria could be better than the method adopted by the author. Akutugba *et al.,* (1991) did not require the farmers to respond on a scale of importance of one objective to another; instead farmers were requested only to respond to which objective was more important. The frequency of choice of objective among 150 farmers were used as data for multi dimensional scaling. The procedure is apparently simple, easily understood by farmers and less time consuming in data collection.

The response from the irrigation manager to paired comparison of objectives was satisfactory. Table 1 gives the ranking of objectives and relative weights of objectives. The reliability of estimates of multidimensional scaling is evaluated based on the 'stress factor'. The stress factor varies between 0 and 1, and the smaller it is more reliable are the estimates. In this analysis the stress factor was 0.31.

Based on the ranking of objectives of the irrigation manager (Table 2) it is found that irrigation management's primary objective is to supply crop water requirements (for maximum yield). This justifies the use of technical objectives to assess irrigation systems performance as done by most past ISPA studies. However, basic economic theory suggests that the problem in using the supply of crop water requirements as the main objective for assessing performance of irrigation projects is that this agronomically determined objective when used for policy decisions, will lead to mis – allocation of investments. When water is scarce it is not the supply of crop water requirement to achieve maximum yield that maximizes the welfare of society, but a lower water application, where the marginal value product of water is equal to the scarcity value of water. Hence a question arises as to whether irrigation system manager is to be blamed for pursuing an inappropriate objective.

Irrigation management objectives could be internal to the irrigation system such as of managers and farmers and external to the system such as national policy makers (Svendsen and Small, 1990). This study identified the internal objectives of the irrigation system manager. The approach taken in the identification of objectives determines the nature of usefulness of results of ISPA studies. There is a view (Seckler *et al.*, u.d) that irrigation systems performance should be assessed on `internal objectives' rather than on `external objectives'. Such an approach is most appropriate to system level decision making and particularly to identify the causes of under-performance of an irrigation system. [ISPA on internal objectives would not be directly useful for national policy decision making: Firstly, if internal and national policy objectives are different, secondly, if internal objectives of different irrigation systems are different such that results of ISPA studies are not comparable (Svendsen and Small, 1990)]. Nevertheless, the contention is that the system management problem is to achieve internal objectives and it is a national policy problem in setting these objectives or influencing to change objectives if internal objectives are not congruent with national policy decision making. First, if internal and national policy objectives are different, second, if internal objectives of different irrigation systems are different such that results of ISPA studies are not comparable (Svendsen and Small, 1990). Nevertheless, the contention is that the system management problem is to achieve internal objectives and it is a national policy problem in setting these objectives or influencing to change objectives. If internal objectives are not congruent with national policy interventions should be directed to change the internal objectives. Once such a change of objectives has occurred then rectifying problems of irrigation system management could be addressed.

It is also evident that no single objective could be concluded as the most important objective of irrigation management that could be considered for ISPA. Economists who assume the objective of irrigation management as maximizing system's net income as important need to be aware that the objective of risk minimizing to be more important as perceived by the irrigation system manager. Similarly, agronomists and engineers who would prefer to use water supply efficiency as the objective for ISPA need to be aware of the importance of non-technical objectives such as minimizing of farmer conflict *etc*. This suggests that

ISPA assessment ought to be done by a multidisciplinary team of technical social - economic and political expertise, who would recognize the possible trade - offs of objectives that are presumed as important under each discipline.

CONCLUSIONS

Where trade - offs between multiple objectives are pursued by multiple persons in irrigation system management, particularly when social and political in nature, system performance standards should be set on the basis of consultation and consensus of the interaction of the values of those persons effected by irrigation management. In reality this remains an ideal that is not perfectly achievable by available scientific methods. However the method used in this study of eliciting the objectives and trade - offs among those is an advancement of applying available scientific methods towards achieving the above ideal. Kotagama (1992) has used the weighted objectives of irrigation management estimated in this study in a multiple objective linear optimization programme, that allows trade - off among objectives internal to the optimization process to estimate irrigation system performance standards objectively.

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