A New Approach to Performance Measurement of Irrigation Projects: A Case Study

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ABSTRACT

THIS PAPER DESCRIBES a new approach in performance measurement of irrigation systems. The newness of the approach lies in viewing the delivery of irrigation water from a marketing perspective. The approach links technical aspects of irrigation to farmers' attitudes. Two indicators developed in the marketing discipline but with wide applicability are used for the purpose of farmer-oriented performance measurement: perception analysis and preference analysis.

After defining the marketing concept, an attempt is made to present the essentials of perception analysis and preference analysis in nontechnical terms. The methods were applied in a recently concluded investigation in a farmer-managed irrigation system (FMIS) in Mendoza, Argentina. Results of this investigation include the quantification of farmers' perception on the performance of the current water distribution method, as well as their preferences towards certain changes. The survey of the farmers was based on a thorough preliminary study on the restrictions of the irrigation layout and on water availability. This was necessary in order to perform a realistic investigation.

The results, being quantitative, may be used for management decisions. The paper concludes with some suggestions for application of the results to management decision making.

INTRODUCTION

The area irrigated by the Lower Tunuyan River is a cultivated oasis of 67.449 hectares (has) with water rights. Water resources in this region are regulated by a storage reservoir called the Carizal Dam. Water distribution is based on the number of hectares with water rights within a farm, and on the water requirements of the traditional crop, *the grape*. Privately owned pumps are used for supplementary groundwater irrigation (Chambouleyron 1990).

In the past few years many farmers have changed or abandoned their crops, thereby altering their water requirements. Due to these changes, the current water distribution might lead to misallocation of water (Menenti 1990).

In this investigation the emphasis is on the recording and quantification of the opinions of the farmers in the evaluation of the water distribution methods. The method of investigation used

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is new in the irrigation sector. The approach stems from the discipline of marketing and was found to be very useful in dealing with performance measurement in an irrigation project.

It should be mentioned that all the questions were confined to the restrictions of the irrigation network layout. In the recommendations for improvements, it was recognized that most farmers would be reluctant to implement any change or improvement which might result in a reduction in his profits or increased risks in farm operations (Baars and van Logchem, 1991). Furthermore, the study does not pretend to offer ready made solutions; rather, it should be seen as a performance measurement, made from farmers' point of view. The results can contribute to improve managerial decision making. Two indicators were used for the purpose of farmer-oriented performance measurement: *perception analysis and preference analysis*. The data collection method for perception and preference analyses is fairly simple. It makes few demands on the farmer and the resulting data are likely to be very reliable.

PRELIMINARY STUDY

A prerequisite for the successful implementation of perception and preference analyses is a thorough study of the layout of the irrigation network, its organization, the water requirements and the water distribution method. This is necessary to identify evaluative aspects of the water distribution method which, if necessary, can be improved within the restrictions of the layout and at low cost. Thus, the farmer is limited to evaluating predetermined aspects of the water distribution method that can be adapted in a technically and economically feasible way.

THE MARKETING CONCEPT BEHIND PERFORMANCE MEASUREMENT

In this research, the following two definitions of marketing are adhered to (Kotler 1988):

1) ***Marketing*** is getting the right goods and services to the right people, at the right places, at the right time, at the right price, with the right communications and promotion.

2) ***Marketing*** is a social and managerial process by which individuals and groups obtain what they need and want by creating and exchanging products and value with others.

The "red line" through this research, then, is the marketing concept. In this context, irrigation water is seen as a "product." The farmer is the "consumer" of this product, because he buys it and uses its services; and the role of management is the *marketing* of irrigation water (see definition above).

Relating the marketing concept to FMIS, it may be seen that a specific marketing situation faces an FMIS, namely the need for performance measurement and identification of necessary improvements in the irrigation system. For the linkage of technical aspects of irrigation to farmers' attitudes, two indicators may be used: *perception analysis and preference analysis*.

Perception identifies the key dimensions that are most relevant to the farmer in evaluating the water delivery system, for example, the dimensions of "reliability" and "sufficiency" of water delivery. Besides identifying dimensions, perception tells how farmers view the current irrigation system relative to alternative systems along each relevant dimension.

Preference identifies how farmers *use* the perceived dimensions to evaluate the current water delivery system. For example, do farmers prefer a highly flexible water delivery program, or do they prefer the current, fairly rigid program? Should possible improvements emphasize traditional techniques, or should they emphasize new techniques? Preference answers these questions and, together with perception, helps management select the best "positioning" of an improvement relative to the current system and alternatives (Urban and Hausel 1980).

A stepwise execution of the measurement process is applied to the FMIS of Mendoza, Argentina. The steps of the process including the two indicators are described below.

RESEARCH OBJECTIVES

To measure the performance of the current water distribution method as perceived by its users, the following specific research objectives were formulated:

1. What are the farmer's considerations in evaluating the current water distribution method?
2. How does the farmer perceive the functioning of the different aspects of the current water distribution method? Can farmers be meaningfully segmented into groups according to their perceptions?
3. How can these aspects be combined and/or adjusted so as to best comply with the preferences of the farmers concerning the water distribution method?
4. Can the farmers be meaningfully segmented according to their preferences on water distribution, and can these groups be explained by farm- and farmer characteristics?
5. The irrigation system is divided into segments, in order to indicate which adaptations are needed where. A comparison is made between the preferences of the farmers with respect to water distribution, and the actual water distribution method.

PERCEPTION ANALYSIS

The perception analysis starts with the identification of the key aspects or "perceptual dimensions" that are most relevant to the farmer in the assessment of the performance of the water distribution method. For this, the knowledge obtained in the preliminary study is used to draw up a list of attributes or characteristics relevant to water distribution.

To measure the respondent's perception of the attributes, the attributes are presented to the farmer in the form of psychological scales. The scale type used in this research is the semantic differential. Semantic differential scales (Figure 1) measure *intensity* of feeling and are easy to administer or respond to (Churchill 1987).

Figure 1. Semantic scale for perception measurement.

THE INTERVAL IS VERY GOOD . ____ . ____ . ____ . _*_ . ____ . THE INTERVAL IS VERY BAD

An alternative water distribution method which, technically speaking, is realistic for the area of research and its implementation feasible (Baars and van Logchem 1991), is then presented to the farmer. The farmer is asked to evaluate this alternative method by giving scores (ratings) on the same list of attributes that was presented to them for the evaluation of the current method.

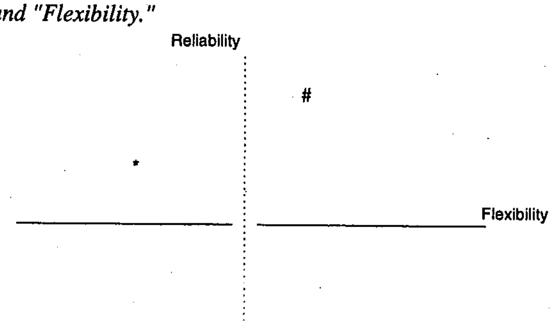
In order to get the total number of attributes down to a workable level, this was followed by a data reduction technique, factor analysis. Factor analysis attempts to find a minimum number of dimensions that can represent the information in a large set of attribute ratings (Urban 1980). Application of this technique resulted in the following underlying dimensions (Baars and van Logchem 1991):

F1 = Sufficiency of the water delivered,
F2 = Flexibility,
F3 = Ease of use (of the distribution method for the user),
F4 = Reliability of water delivery, and
F5 = Expenses for services (money).

For the interpretation of the perceptions, "perceptual maps" are drawn. They help managers understand a product and recognize opportunities by providing a succinct representation of how farmers view and evaluate products (Urban 1980). Figure 2 gives an example of such a "perceptual map" for the products "current water distribution method" versus the "alternative method."

The perceptional maps revealed a more favorable perception of the alternative method on the factors "reliability," "flexibility," and, to a lesser degree, of "sufficiency," The current distribution method scored slightly more favorable on "ease of use."

Figure 2. Perceptual map of the current and an alternative water distribution method on the dimensions, "Reliability" and "Flexibility."



* = Current water distribution system.
# = Alternative water distribution system.

Cluster analysis was used to group farmers with similar perceptions on the dimension being analyzed. Analysis of the clusters showed statistically significant relationships between farmers' perception on "flexibility" and "reliability," and the following explaining variables:

1) The current interval the farmer receives (time lapse between two irrigation gifts, in days),
2) The application time of water allowed to the farmer,
3) The availability of a pump for groundwater irrigation, and
4) Farm size.

The variables "interval" and "application time" are so-called "actionable" variables, in that they are physical attributes which can be changed or adapted.

Perceptual mapping showed that the alternative system which was presented to the farmer clearly had a positive influence on the dimensions "flexibility," "reliability" and "sufficiency."

The alternative system offers "the possibility of water delivery on demand." This means that the farmer would be able to demand water volumes himself. For the area of research, this means that the absolute amount of water that the farmer can receive annually remains limited due to climatological factors. But he can save water in some months and use this water in other months. Another consequence would be that instead of paying a fixed amount of money per year depending on the area (the number of ha) with water rights, he would pay according to the volume of water used.

Inherent in an alternative system is a rise in cost of surface water due to the necessary technical and administrative adaptations. This would be compensated for by a decrease of pumpwater use, pumpwater being four times as expensive as surface water under current conditions. The on-demand delivery can be put into practice in various technically possible ways (Baars and van Logchem 1991).

It was decided to continue the study with the attributes "*flowsize*," "*interval*" and the option of the "*on-demand*" system, as described above.

PREFERENCE ANALYSIS

The technique used for analyzing farmer preferences regarding water distribution is called *conjoint measurement.* Conjoint measurement provides answers to the following questions:

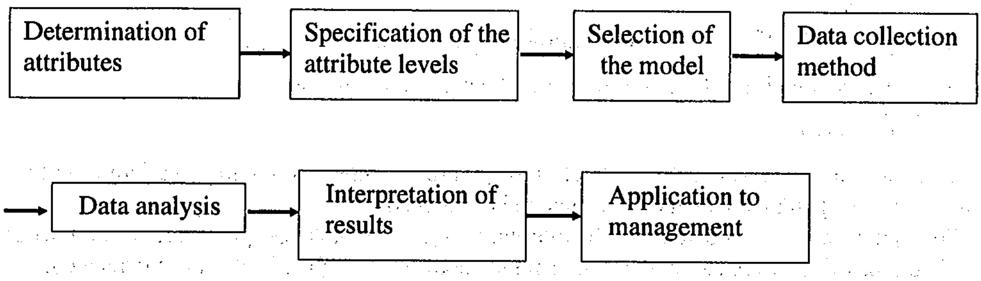
1) What is the utility of each attribute level for the farmer?

   Utility functions indicate how sensitive farmer perceptions and preferences are to changes in product features. An attribute level is the specification of an increase or decrease in the attribute itself. They are used to set the features of an innovation. See Table 1.

2) How important to the farmer is each attribute?
3) What kinds of trade-offs can be made among attributes?
4) How do answers to the above questions vary across farmers and how can they be segmented in a meaningful way?

The use of conjoint measurement involves a number of steps to be included in the complete research design. In Figure 3, an overview of the different stages is given (Anttila et al. 1984).

Figure 3. Flow chart of the research design of a conjoint measurement application



Perception analysis provided the actionable variables or attributes. Also this pre-study gave an indication as to the levels of the attributes that should be used in this study (Baars and van Logchem 1991). (See Table 1.)

The selected model is the additive model. This means that the total utility of the product is equal to the sum of the utilities of the separate attributes (Urban 1980).

The data collection consisted of a complete rank ordering of "hypothetical products" (water distribution methods) described by a specific level for each attribute. Altogether nine different hypothetical products or "profiles" were presented to the farmers for ranking in order of preference.

The profiles are constructed using the basic plans of Addelman (Malhotra 1984). Table 1 below lists the selected profiles.

Table 1. Hypothetical products or "profiles."

Profile	The interval	Minutes per ha	Flow size	Possibility to demand
1	8 days	22	250 l/s	yes
2	8 days	11	500 l/s	yes
3	8 days	5	1000 l/s	no
4	10 days	27	250 l/s	no
5	10 days	13	500 l/s	yes
6	10 days	7	1000 l/s	yes
7	16 days	43	250 l/s	yes
8	16 days	22	500 l/s	no
9	16 days	11	1000 l/s	yes

The application time is automatically fixed when the interval and flowsize are set, because the total volume of water delivered monthly must be the same.

A large number of computer programs are available to analyze the data. Although this obviously depends on the actual application, there is some freedom in choosing the algorithm (Anttila 1984).

Data collection consisted of 151 personal interviews with farmers from the Lower Tunuyan District. Certain background data were collected to facilitate a possible segmentation.

INTERPRETATION OF RESULTS

The individual data were aggregated for the entire sample to obtain an impression of the utility for the target group as a whole. A summary of the results of the aggregate analysis is shown in Table 2.

Table 2. Results of the analysis of the aggregated data.

Relative importance of attributes	
Flowsize	35 %
Interval	30 %
On-demand possibility	35 %
	100 %

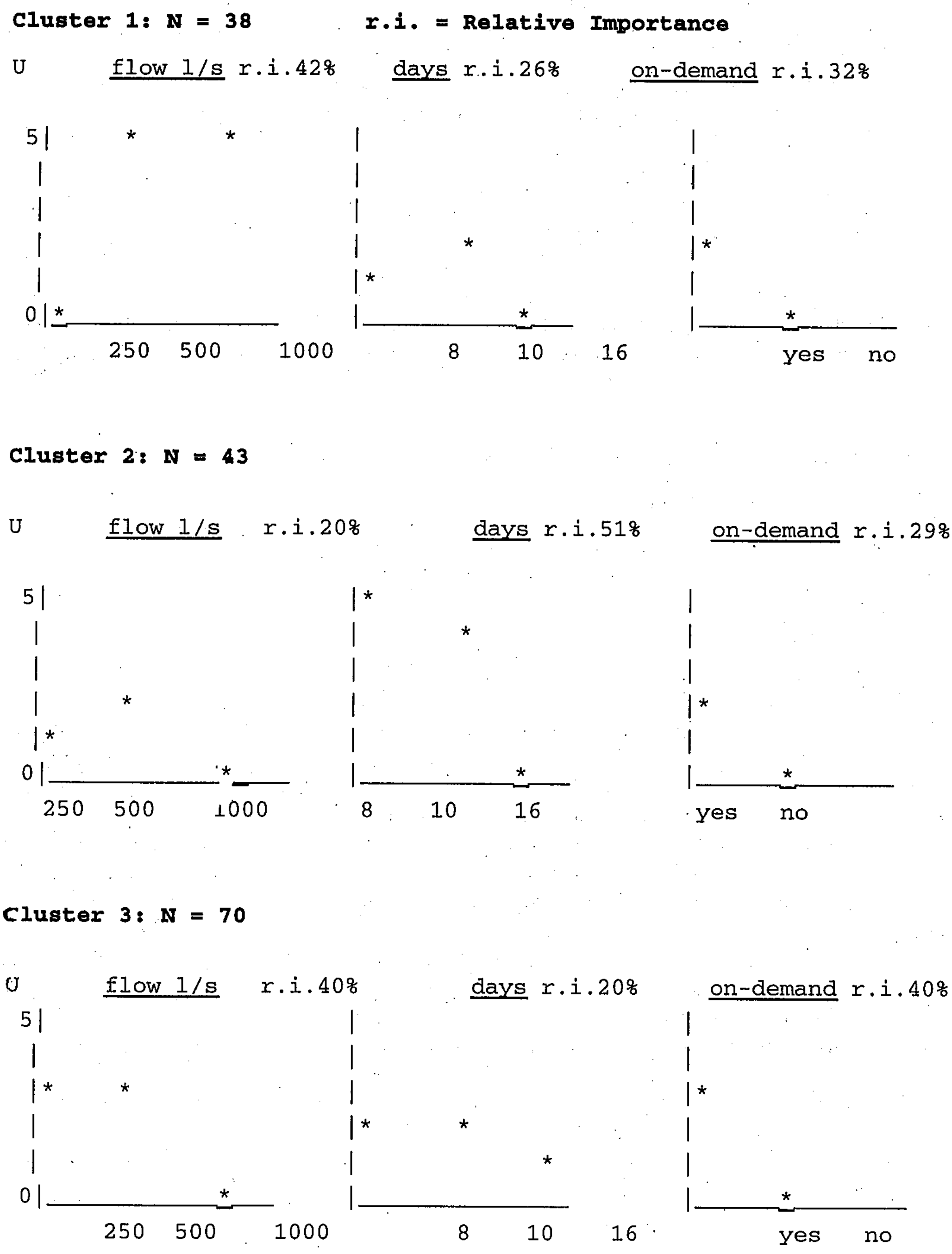
The next step in the analysis is to check whether any meaningful segments can be distinguished. The method used was cluster analysis. Three clusters were identified by looking at the development of the sum-of-squares, the group sizes and the stability of the groups. The attribute level utilities for the three segments are illustrated in Figure 3.

From these results a number of conclusions can be drawn. The possibility of delivery on demand within the limits of the system and the total water available, is of equal importance as the flowsize to explain preferences. No "on-demand possibility" causes an important reduction in utility for all three segments.

Such a straightforward relationship does not exist for all attributes. In the case of flowsize, for example, Cluster 2 assigns the lowest utility to both 250 and 1,000 l/s, indicating a preference for the medium flowsize of 500 l/s. The largest cluster has equal preference for 250 l/s and 500 l/s and no utility at all for 1,000 l/s, while cluster 1 attaches a high utility to 1,000 l/s as well as 500 l/s.

The utilities attached to the intervals can be interpreted in a similar way. The majority of the farmers do not care for an interval of 16 days; here, a sharp drop in utility occurs.

Figure 4. Average attribute utility levels per segment.



The results clearly indicate the differences in relative attribute importance between segments. Significant in explaining the clusters were the following variables (Baars and van Logchem 1991):

1) The ratio, hectares of vegetables/total cultivated land per farm,
2) The ratio, "area irrigated with groundwater"/"area with water rights,"
3) Actual interval (days between two irrigation turns),
4) Actual application time received, and
5) Farm size.

For example, farmers with vegetable crops are represented mainly in clusters 2 and 3. Farmers with a long interval between irrigation turns (12 days or more) attach more importance to the on-demand possibility (Cluster 3) than farmers with shorter intervals (9 days or less).

AN APPLICATION TO MANAGEMENT

Data on current water delivery may be compared with the clusters' preferences towards water delivery. The evaluation showed that the 10-day interval has a high utility for all three groups. The actual situation is that the farmers located close to the Carrizal Dam **do** enjoy short intervals (8–10 days), but the farther away from the dam a farm is situated, the longer the interval becomes (from 15 to 23 days).

Furthermore, a flowsize of 500 l/s every 10 days gives an application time of about 13 minutes/ha, which the farmers considered to be the best application time. Currently, the application time varies from 5 to 25 minutes/ha, with the respective large to small flow sizes (Baars and van Logchem 1991).

The analysis reveals that the system would significantly increase its utility to the user if he himself had more control/influence in regulating the water volume delivered to his farm. This result may be surprising, considering that the farmers in this region are known for their reluctance to change (Menenti 1990).

For management it is very useful to know where (within the scheme) the clusters are located. A map of the clusters may be drawn. Data on flowsize, intervals, crops grown, salinization, etc., describe and explain the location of the clusters. Command and subcommand units can be assigned to specific locations (defined by the clusters) so that water can be administered according to the specific needs and preferences of the units.

CONCLUDING REMARKS

As was mentioned in the introduction, this study does not hold that the farmers' wishes should or can always be acted upon. However, till now the perceptions and preferences of the farmer in the area of investigation has been a black box." The method used quantifies farmers' perceptions and preferences. It can fill up this black box and link technical aspects of irrigation to farmers' attitudes.

The method can be a useful tool in performance measurement and in the detection of possibly necessary improvements in an irrigation system.

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