Performance Measurement in Farmer-Managed Irrigation Systems

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Proceedings of
an International Workshop of the
Farmer-Managed Irrigation Systems Network

Organized by
The International Irrigation Management Institute (IIMI)
and
The Instituto Nacional de Ciencia y Técnica Hídricas (INCYTH)

and held at
Mendoza, Argentina
from 12 to 15 November 1991

Shaul Manor and Jorge Chambouleyron, editors

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Foreword

THE INTERNATIONAL IRRIGATION Management Institute (IIMI) recognized from its inception in 1984 that Farmer-Managed Irrigation Systems (FMIS) represent an important mode of system governance that may have transferable lessons for others; and that not enough was known about the performance, the needs and management characteristics of these systems. FMIS is expected to play an important role during this decade. While there will continue to be a need for large projects, vast, potentially irrigable areas can be productively utilized through the development of small-scale irrigation systems and improving existing traditional irrigation systems.

The International Workshop on Performance Measurement in Farmer-Managed Irrigation Systems held in Mendoza, Argentina, during 12-15 November 1991 was the third in a series of workshops recommended by the Advisory Committee of the FMIS Network. Consequently, the FMIS Network links more than 1,300 professionals from 75 countries representing a wide variety of disciplines and professions from several geographical regions. The Network has been facilitated generously by various donors and principally supported since 1987 by grants from the International Fund for Agricultural Development (IFAD), and the Federal German Ministry of Economic Cooperation (BMZ).

This workshop was organized jointly by IIMI and the Instituto Nacional de Ciencias y Tecnicas Hidricas (INCYTH). The workshop was attended by 95 participants (including 30 from Argentina) from 25 countries. It offered an opportunity to a large number of professionals of different disciplines to share their experiences and interests, and to exchange ideas. The workshop was conducted in Spanish and English with simultaneous interpretation. Forty-five papers were presented in both languages and were discussed at three working groups. This volume includes 25 papers which were selected for publishing in full and 20 abstracts of the other papers that were presented. An International Committee was established several months prior to the commencement of the workshop to review the 128 abstracts received and to recommend those to be included. The Committee consisted of Charles Abernethy (IIMI), John Ambler (Ford Foundation), Madduma Bandara (University of Peradeniya, Sri Lanka), Jorge Chambouleyron (INCYTH, Mendoza), C.M. Wijayaratna (IIMI) and was chaired by Shaul Manor (IIMI).

The workshop contributed toward further understanding of the importance of FMIS and created awareness amongst researchers, professionals, donor agencies and government officials about the potential role of FMIS in irrigated agriculture. As a result of this workshop, there is a significant increase in the number of professionals in the FMIS Network, particularly from Latin America.

IIMI appreciates the efforts made by all those who took part in planning and organizing this event. In particular, our gratitude is extended to Dr. Jorge Chambouleyron of INCYTH, Mendoza, and to Dr. Shaul Manor, the FMIS Network Coordinator, for their endeavors in making the workshop a success. We also thank the Ford Foundation offices in Indonesia, China and the Philippines, the United Nations Development Programme (UNDP) and the International Development Research Center (IDRC), for providing us with specific grants to cover the cost of sponsoring several participants of the workshop.

Dr. Jacob Kijne
Director for Research
International Irrigation Management Institute

Objectives

IRRIGATION SYSTEMS FALL into two broad categories: those in which the principal management responsibility is exercised by government agencies with the farmers playing a subsidiary role, and those in which most management activities are carried out and decisions made by the farmers themselves with the government providing periodic technical or logistical support. The latter category in which farmers assume the dominant role is referred to as Farmer-Managed Irrigation Systems (FMIS). In general, an important characteristic of FMIS is that the farmers also control and manage the water abstraction from its source. Governments often classify these systems as "small-scale irrigation systems" or "minor irrigation systems," although examples of FMIS may be found with command areas of 15,000 to 20,000 hectares (ha). FMIS are also known as traditional, indigenous, communal or people's systems. The precise set of activities and functions that the farmers and their organizations perform varies from country to country and from system to system.

FMIS cover a wide range of environments and technologies and in many countries they contribute to the production of a significant portion of the subsistence food supply. Some FMIS are hundreds of years old, well-managed and very productive while others perform far below their potential. In many developing countries FMIS cover large areas with a large number of beneficiaries, not only in relative terms, but also in absolute terms. FMIS represent a sector in which there is much scope for performance improvement with a relatively low level of investment.

The many successful examples of FMIS have sparked interest among irrigation agencies in transferring to farmers increased responsibility for the management of all or some parts of government irrigation systems. These developments may contribute to an increase in the number and total area of irrigation systems under farmer management.

As many FMIS do not perform as well as they should, there is a need to identify the areas in which they fall short of their potential. It is therefore important to measure and evaluate their success or failure objectively and identify specific areas in need of improvement.

There is a growing body of knowledge on the performance and evaluation of irrigation systems in general, and there is much that can be learned from it. In this context, FMIS may be perceived as an integral component of the whole irrigation sector rather than as unique or esoteric systems. It is likely, however, that fresh and innovative approaches may become necessary to deal with any special problems associated with FMIS in particular.

Irrigation performance may be defined as the degree to which an irrigation system achieves its objectives. One must distinguish:

(i) Output objectives aimed at measuring the results which are directly related to the irrigation systems.

(ii) Impact objectives aimed at measuring the more indirect and longer-term results of the irrigation systems.

(iii) The "process" or "management" objectives employed by the managers of an individual system in order to meet the policy directions which are usually passed over to them by a higher authority such as a Farmers' Assembly, a Ministry or a Board of Directors.

The performance indicators should be linked to the objectives of a particular system and they should be of interest to a wide variety of users, national irrigation agencies, international development agencies, donors and the farmers. Should there be some performance indicators specifically for FMIS which are different from those for agency-managed systems? How can we promote the use of whatever performance indicators we believe to be meaningful and useful among farmers and others?

The specific workshop objectives were:

* To exchange experiences and ideas on criteria best suited to achieve distinct goals and objectives and to come up with a set of indicators based on them, which are manageable within the existing framework and data constraints for assessing FMIS performance. It should be emphasized that many indicators have already been proposed in the literature. The challenge is to develop meaningful indicators likely to be accepted for operational use by the farmers, farmers' organizations, policymakers and others.

* To discuss and develop appropriate cost-effective methodologies for the collection of data relevant to the proposed performance indicators.

* To review case studies of the performance of different FMIS and synthesize their findings to draw general conclusions and recommendations.

* To create the awareness that performance evaluation is an important factor in ensuring goals of economic viability, social equity and sustainability.

* To discuss the possibilities of generating future programs for action in performance and evaluation of FMIS.

Program

THE WORKSHOP WAS held at Hotel Aconcagua in Mendoza, Argentina. It included three days of work and a one-day field trip. Plenary sessions were limited to the opening and closing sessions, while three separate sessions were held for three working groups. Each group was composed of 30–35 participants from various disciplines and countries. Each session was conducted through the means of a simultaneous translation facility. A total of 11–13 papers were presented and discussed in each group during each of the three sessions.

Following paper presentations, each group discussed a list of issues. This list was given to the participants in advance so that they could be better prepared for the discussions. The same list was given to each group. The following list of issues served as a guideline for the discussions in each group:

A. Objectives of Performance Measurement in FMIS and Specific Indicators

Each group will discuss and reach an agreement (consensus opinion) on such aspects as:

a) Objectives: why? by whom? for what? etc. These should concern inputs, process, output and impact.

b) Performance measures related to *each one* of the objectives listed above, with emphasis on the water users' perspective.

c) Deriving a small set of simple potential indicators related to the performance measures specified.

d) Identifying a number of indigenous performance indicators used by farmers in different settings.

B. Measurement

In relation to *each one of the indicators* listed above, the *same groups* will clearly define:

a) The *minimum* data needs.

b) Sampling requirements.

c) Cost-effective, simple and acceptable procedures/mechanisms of information gathering.

d) The types of systems and agro-ecological environments most relevant.

C. Analysis and Interpretation of Results

Next, the *same groups* will recommend procedures to be followed in the *analysis* of information and *interpretation* of results. Each group will recommend:

a) Simple, cost-effective and acceptable ways of analyzing information gathered.

b) Specific procedures to be followed in the *interpretation* and *dissemination* of results, feedback mechanisms, etc.

D. Utilization of Results and the Internalization of the Performance Assessment Process

This is the most important aspect of how to introduce performance assessment — how farmers can use it for their own benefit and how agencies can use it for assisting farmer-managed systems. After brain-storming sessions, each group will recommend:

a) How to assess water users' perspectives on performance.

b) How to identify local practices or needs for performance assessment (PA).

c) Procedures to fully utilize the results generated by the PA process.

d) Measures to encourage the use of PA as a *routine* procedure in FMIS.

e) Strategies to ensure the participation of all relevant actors.

f) Procedures to ensure funding for PA.

g) Strategies to make PA sustainable; (farmers and agency staff should find it useful for assessing and improving their own work, be convinced of the importance of PA and see its benefit).

h) Examples where PA used by farmers or tested in field research have been disseminated.

i) The gap between what is actually being implemented in the field versus what is recommended. List working hypotheses explaining lack of adaption of PA practices in certain settings.

j) Methods for communicating water users' perspective on performance to related agencies.

Discussions and Outcome

SUMMARY RESULTS OF SMALL GROUP DISCUSSIONS

THE WORKSHOP WAS an opportunity for most participants to obtain an initial understanding of the basic concepts and principles of performance evaluation and its role in the management of irrigation systems. It also afforded the opportunity of bringing together the irrigation management experiences of Asia, Africa and Latin America, thus promoting the possibility of continuing dialogues and exchanges of experiences between Latin America and the countries of Asia and Africa. During the group sessions, participants discussed the issues on performance measurement and evaluation and also made recommendations concerning follow-up activities to this workshop, which could contribute to enriching the knowledge base on this subject as well as to promoting the use of performance measurement. A summary on the outcome of these discussions is given following the discussion.

Objectives of Performance Measurement in FMIS and the Relevant Performance Indicators

Discussion on this issue focused on why, by whom and for what purpose performance measurement was needed in conjunction with input, process, output, and the impact of the activity, and what the relevant indicators were for expressing performance.

The question "in whose interest is the measurement of performance?" revealed that participants with Asian experience regarded performance in terms of food security rather than in terms of profit. The perspectives on FMIS vary: while farmers are always interested in keeping labor and investment costs down, agencies which support FMIS are more concerned with the profitability of irrigation, reducing the cost to central authorities, gearing agricultural production toward marketable surpluses, justifying agency programs and ensuring sustainability of the systems.

In view of the conflicting objectives, it was recognized that performance measures of universal application might not be feasible, especially since some systems are extremely culture-bound. It was also apparent that quantitative criteria alone could not provide an adequate basis for performance measurement.

While universal performance indicators could not be identified, the following were considered to be of general value: 1) extent of farmer participation, 2) nature and mode of water distribution, 3) maintenance of the system, 4) water use efficiency, 5) social and economic profitability of the system, 6) aspects of sustainability, and 7) methods adopted for conflict management. Issues of equity, reliability and timeliness associated with water distribution were considered valuable performance indicators of FMIS, but no parameters for measurement were identified or agreed upon.

Participation may be measured by such parameters as the percentage of farmers attending meetings, willingness of farmers to pay for water as reflected in the collection of fees, percentage of participation in collective labor activities and the extent of representation in management bodies.

Measurement of the extent of canals, the quality of their maintenance, the cost of O&M per unit of length of canal, the number of days of labor contribution are suitable yardsticks for performance measurement.

Measurement of total water availability and actual water use at farm level may be useful parameters. Yield per unit of water is also a meaningful measurement of performance. However, measurement of water at farm level may involve prohibitive costs as well as practical difficulties. It was proposed that Internal Rate of Return (IRR) and Benefit/Cost (B/C) ratios be used to gauge economic profitability. Social profitability may be measured from the social benefits accrued and from phenomena such as emigration. However, it is doubtful whether these parameters can be applied in systems in which agency interventions and injection of capital are at a low ebb.

It was agreed that performance cannot be isolated from the sustainability of an irrigation system. Environmental impact was considered to be an important issue in this context. Other performance indicators discussed were the institutional strength and modes of conflict management. The discussions did not generate suitable parameters to measure the performance of the FMIS in these fields.

Methodology of Performance Monitoring and Measuring

The discussion on the methodology of performance monitoring and measurement focused on the minimum data needs, sampling requirements, cost-effective, simple and acceptable procedures and mechanisms of information gathering, and relevant parameters of the agro-ecological environments.

Discussion of the general performance of FMIS specifically dwelt on the internal potential and identified internal constraints focusing particularly on what can be done by the internal system itself, but also taking note of external points of view.

The monitoring required for performance measurement and the evaluation of the data collected are costly activities. Accordingly, the absolute minimum necessary to be used as management tools must be defined. Otherwise its cost will exceed its benefit.

Analysis and Interpretation of Results

An issue in analysis and interpretation that must be addressed is the willingness of both an FMIS management and agencies that may be related with them, to bare the results to the eyes of the users and to the public in general. As this may occasionally cause embarrassment, it is conceivable that those in a position to decide may be unwilling to start a process potentially fraught with danger. It is possible that even rank and file members may be unwilling to enter into such an issue as it offers considerable potential for intermember conflict, something which is generally better avoided and contrary to social values in many societies.

Internalization of Performance Measurement, Users' Perspectives and Local Practices

The monitoring and evaluation of performance measures must be integral to the irrigation management system. The methodology must stress their use in management and must be consistent with management needs. The indicators chosen must be consistent with the users' perception of their system and of its objectives. The benefits of performance measurement must be obvious and recognized by a majority of the users within a short time after implementation of a performance measuring system. This would indicate the need for unsophisticated indicators and methods of collection, and for data sources which are easily accessible.

As a corollary to the above, it is essential that performance monitoring be included as an item in the budgets of FMIS and its cost should be included in the water fees paid by the users.

Understanding the specific agroclimatic and ecological conditions of the area in which the FMIS is located as well as the cultural framework is essential to a recognition of the users' perspectives and to developing appropriate indicators and systems.

It is important to appreciate the existing rules of an FMIS and to use them in performance measuring, even if they are not perceived as useful by the agencies. These represent the monitoring measures which the users find meaningful. These are already internalized by them.

Insofar as outside agencies contribute to FMIS, they may require that they collect certain data, maintain monthly or seasonal records, make periodic comparisons, etc. In this way, performance measurement would gradually become routine. One participant suggested that performance measurement should be included as part of a periodical festival of the FMIS, thus contributing to its internalization.

Other Issues Raised in the Course of the Discussions

Some participants proposed a new structure of FMIS, methods for improved profitability of the irrigation systems and finally discussed ways and means to make FMIS sustainable.

Some participants held the view that farmers should be involved in all stages of an irrigation system, while others felt the planning and designing of the system was too specialized for such participation. However, there was agreement that added responsibility in operation, maintenance and decision making should be devolved upon the farmers.

In the following pages graphic and tabular summaries of the major issues discussed in the small groups, may be seen. These are 1) proposed indicators of FMIS performance, 2) the objectives of FMIS performance monitoring as viewed by farmers and by agencies, and 3) the process of introducing performance measurement.

SUGGESTED WORKSHOP FOLLOW-UP

* Publication and wide dissemination of the workshop papers.

* Preparation of a practical manual on performance measurement in irrigation for use by professionals, irrigation agencies and by FMIS.

* Planning and implementing pilot projects using different environmental settings in different countries. There is a need to identify suitable, applicable methods and to

field-test them and the variables of performance measurement and then to reformulate indicators on the basis of pilot study.

* Future workshops on this subject should be regionally delimited due to the large differences in concepts and needs among regions. Only when advanced products of general application are available or where issues are of general concern should a worldwide workshop be convened.

Summary of indicators of FMIS performance proposed in the small group discussions.

INDICATOR	PARAMETER
1. Participation	
In planning, design and decision making	Percentage of farmers attending meetings
	Representation of farmers on the board
Operation and maintenance	Willingness to pay
	Collection efficiency
	Percentage of participation in collective labor activity
Access to information	
2. Water Distribution	
Equity	Amount
	Quality
	Percentage of area actually irrigated
	Percentage of farm lots with adequate water
Reliability	Timeliness
Opportunity	Quantity
3. Maintenance	
	Percentage of canals properly maintained
	Percentage of days in which system is interrupted (due to repairs, hazards)
	Costs per unit of canal length
	Number of days of labor contribution

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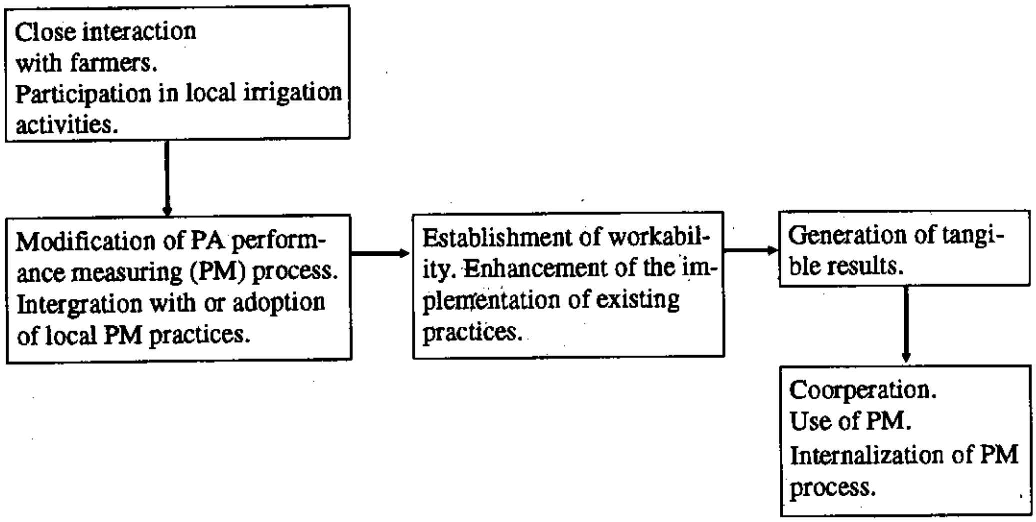
4. Efficiency & System Performance	**Available water at farm-gate and field in relation to water used**
Water use efficiency	
General irrigation efficiencies	Yield per m^3 water
Access to water in relation to rights	Indices of irrigation water utilization
System performance	Status of canals
	Status of structures
5. Profitability of the System	
Economic profit	IRR, B/C ratios
Social profit	Social benefits and costs
	Rural migration
	Production increase
6. Sustainability of System	**Technology costs in relation to the increased benefits**
Investment cost index	
Environmental impact	Rate of change of groundwater table
7. Productivity	
Adoption of new technology	
8. Conflict Management	
9. Organizational Dynamics & Institutional Strength	
	Upward/downward linkages
	Resource mobilization for O&M
	Compliance with irrigation rules
	Number of conflicts beyond the capacity of farmers' organization

The objectives of FMIS performance monitoring as viewed by farmers and by agencies.

Farmers	Objectives	Agencies
* Security not just profit	* Standard of living	**A. Existing FMIS** Independent systems Joint systems
* Multiple benefits	* Productivity	
* Maintenance of rights	* Effectiveness of operations	**AGENCY ROLE**
* Keep labor and investment costs down	* Efficiencies	1. Providing services for clearly defined internal goals
* Maintain harmony within groups and between groups	* Conflict management	2. Transformation for external goals or disputed internal goals
	* Profitability of irrigation	**B. Creating New FMIS**
	* Sustainability	
	* Reducing central expenditure	
	* Producing marketable surplus	
	* Recouping financial costs	
	* Justifying program	
	* Evaluating work	

Process for introducing performance measurement.



Overview

Charles L Abernethy[1]

THE PERFORMANCE OF any irrigation system is the degree to which it achieves desired objectives.

There are various reasons why people may want to measure or assess the performance of a particular system. Some of these reasons we can regard as internal to the system: performance should be monitored by those who operate and manage the system, so that they can better identify any areas needing improvement, and their management arrangements are transparent and accountable to the system's users. There are no doubt many irrigation systems today whose management does not follow this reasoning; but it is nonetheless desirable.

There is also an external logic of performance assessment. People who are not direct participants in the irrigation system still have reasons for wanting to know how well it performs. Some of these people may be from finance ministries or they may be aid donors wishing to verify the success of different sorts of investment or different agricultural development strategies; or design consultants and other kinds of planners, seeking indications of successful development paradigms; or academic researchers of many kinds and many disciplines.

The papers offered at Mendoza illustrate all these diverse viewpoints, and more. The ways in which the authors perceive and interpret performance are correspondingly diverse, so the first problem of a reviewer is whether synthesis and integration of these perspectives should be attempted.

The concept of performance depends upon knowing the objectives of the system. Unless we know what the goal is, we cannot say how close to it we have progressed, and so the very idea of performance lacks meaning. But who has the right to set objectives, and to vary them from time to time, in an irrigation system?

Here again we should recognize that there are internally generated objectives and externally imposed ones; that these are both necessary, but for different reasons, and so they may differ quite widely.

In the case of an FMIS, there can be clarity at least about the internal source of objectives; but the nature of these organizations is often such that the objectives remain largely implicit, and identifying them becomes a research task in itself. However, the autonomy of FMIS means that even in adjacent systems objectives may differ significantly. Researchers wishing (as many of the authors here do) to integrate findings from some regional set of systems have no alternative but to impose their own external frame of evaluation and comparison, rather than to evaluate each in terms of its own internally generated objectives. This dilemma probably cannot be resolved, but it is as well that we bear it in mind.

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Bagadion, describing Pinit, an advanced irrigators' association in the Philippines, shows an excellent example of the internal perspective. The association sets its own goals, monitors their level of achievement, and develops management feedback processes to remedy observed weaknesses.

Several authors, such as Ostrom and Benjamin, Sengupta, Kagubila, Thapa and Banskota, and others, present multivariate evaluative frameworks suitable for investigating sets of systems, more or less independent of their specific internal perceptions. The multidisciplinary character of our subject is well-revealed in the substantial differences among these various generic approaches.

Ostrom and Benjamin go farthest in offering a theoretical framework for identifying organizational sustainability, with empirical validation in the Nepal context. Their list of eight criteria or predictors of sustainability is valuable and would bear restating here: they propose that a sustainable system should possess clearly defined boundaries; fair proportioning between the benefits received and the contributions made by each irrigator member; collective decision-making arrangements; accountable monitoring; graduated sanctions against rule violations; swift, low-cost, accessible conflict resolution processes; governmental recognition of the irrigators' right to organize; and nested or layered organizations for addressing different functions.

Others would probably add to such a list. Mehreen Hosain draws attention to the importance of clear rights to both water and land. It can be said too that the Ostrom and Benjamin list addresses primarily internal characteristics of the association, and that external factors such as product prices can also have strong influences on sustainability. Thus Herrera and others and some of the other South American contributions give a picture of associations weakened by an adverse economic climate.

The importance of boundaries, the first item on the Ostrom and Benjamin list, is stressed by Ambler and Mehreen Hosain. Ambler particularly addresses the question of hydraulic interconnections: since FMIS are usually small, the chain or "cascade" of systems dependent on a shared waterway is a common occurrence, which seems to need (but does not always get) joint resource management. In these situations, performance concepts like irrigation efficiency or water "losses" which are readily accepted in the literature of larger systems, need careful handling, since one system's loss may be another's gain.

The question of tensions between farmers' goals and officials' goals, or internally generated and externally generated goals, is pursued by several authors. De Jong, describing a Sri Lankan situation, points out that the difficulty is compounded by different levels of clarity in the two categories: official goals "have usually been explicitly formulated" and are "comparatively readily accessible" whereas those of farmers are "at best implicitly expressed" and "difficult to unearth." He also points out that within the farmer group, goals are "rarely mutually shared."

One quite common manifestation of this problem is the case where a project for physical rehabilitation, executed benevolently by governments, provides to officials an enhanced opportunity to determine or at least to influence goals and rights in an old-established irrigation system. Bleumink and others describe such a case in Bolivia. The outcome was that "the project was confronted with unplanned and unexpected farmer behavior." The unexpected behavior went as far as destruction of new works by explosives. Perhaps not all such situations lead to quite such violent responses; but the general syndrome is a familiar one. As the authors rightly say, given such circumstances, the behavior should not really have been unexpected. Imposition of externally determined objectives may sometimes be practicable, say at the inception of a brand-new system based on new land settlement; but in established systems it violates a basic property of the existing set of users. Certainly a rehabilitation may require reformulation of objectives, so that new opportunities can be seized. The point is that the process of reformulation must be performed in and by the user community, who otherwise are likely to find some means or other to reject the imposed objectives.

Baars and Van Logchem, working in Argentina, used market-research approaches to identify the farmers' own perceptions of which attributes of the system mattered most to them, and their preference as to the condition they wanted in respect of each important attribute. Dayaratne describes a Sri Lankan case and emphasizes that irrigated agriculture (for small-holders owning 0.2–0.6 ha each) is not the core of their personal economy "since the farmers' main cash incomes come from other agricultural and non-agricultural means." So in the farmer's matrix of personal objectives, and labor- and resource-allocation decisions, irrigation is not the dominant consideration: an important point that is often neglected by those for whom irrigation is the dominant professional activity.

Equity is often referred to as a major feature of FMIS, so it is surprising that few of the papers report attempts to quantify it. Perhaps it is becoming assumed as an almost automatic property of FMIS rather than a goal; but that could be an illusion, and the need to monitor it remains. Pitana describes its importance in the expansion of a system in Bali, Indonesia, where farmers tried three alternative procedures to achieve equitable water distribution before settling upon one based on time measurement. Advocates of the "warabandi" system of Pakistan and northwest India will be interested to note that the Balinese considered that the equitable share should be measured at each individual's land boundary, so that differential conveyance losses, arising because of farmers' different locations along the canal, are borne by the community and not by each individual farmer.

Thapa and Banskota describe six rehabilitated systems in Nepal, and also rank equity as a significant goal. They employ the Inter-Quartile Ratio (IQR) as their equity indicator; but they apply it to a Water Availability Index whose mode of computation restricts its possible values to between 1.0 and 2.0. This produces IQR values that seem too favorable, since in these circumstances it cannot possibly exceed 2.0. The use of IQR should be restricted to variables that have a zero minimum. Thapa and Banskota's data show that the idea of tail-end deprivation does not hold; inequity exists, in the systems as a whole, but it is not related to a head-to-tail comparison.

Several authors, including Miah, Pande, Metawie and others, and Hakim and Parker have compared performance in FMIS and public systems. They generally find the FMIS systems better, but it would be wrong to claim that the matter is proved. The data are rarely clear, and other variables intrude as possible determinants of the performance differences that are observed. Work on this topic remains an urgent need for policy guidance.

Numerous authors — the most numerous group of all — looked at the outcomes of interventions, almost all of which were performed by state agencies. The interventions were of two main kinds: management changes (turnover of functions to farmers) and rehabilitation. It is interesting that we so often see the state intervening in physical construction, while divesting itself of operational responsibilities. The papers indicate much scope for doubt over the application of each of these policies.

The outcome of physical rehabilitations, performed by government agencies on FMIS, may (as we noted above) have the effect of reducing farmers' control, and thereby creating dependency on the implementing agency. This comes about especially for two reasons: "up-grading" of the facilities may bring in technical elements which the farmers cannot handle or cannot sustain without external help; and design may be carried out without adequately ascertaining and accommodating the farmers' wishes.

A further complication can occur when the physical intervention goes well beyond rehabilitation of existing items and significantly increases the water-control capacity of the system. Such an intervention may undermine the basis of a network of interconnected water rights, which may well be derived from some combination of implicit understanding of seasonal water flow probabilities, and past history of communal adjustments to these. Not infrequently the physical intervention may make more water capture possible for some groups, but leave others at a disadvantage. Ambler describes this kind of situation in Sumatra. He says "the placement of a government-paid gatekeeper at the (new) weir transformed the canal from an FMIS into a government-controlled system ... government gatekeepers are not accountable to farmers or to the larger network, and the performance goals of those assisted canals have been defined unilaterally by government staff." The circumstances that can initiate both a dependency syndrome in the relations with external agencies, and social conflicts internally, are very clear here.

Some of the papers from South America, where historically the linkage of farmers' organizations to government agencies has been more close, look at the matter differently. Le Goulven and Ruf perceive the traditional Ecuadorian farmers' organizations as conservative and potential impediments to beneficial change, and their solution is to strengthen and adapt the organizations themselves and also the state's relationship with them. They find that "water management obeys inherited social rules that do not fit in with the actual situation, and that in many cases prevent any evolution of productive systems."

Zuleta and others investigated the effect of organizational size as a determinant of performance and behavior. In the Mendoza oases in Argentina, the organic link between farmers' organizations and the government has been the Inspector, elected by the farmers and working closely with the provincial authorities. In recent decades, associations have been beset with problems, largely of economic origin. Since the smaller organizations tend to have higher costs per hectare, the organizations are being encouraged to amalgamate. The larger organizations are found to have different levels of participation, with more frequent elections but lower proportion of members voting.

Dayaratna considers the difficult question of how to remove the dependency syndrome once it has become established. He describes a nongovernmental organization's intervention scheme in Sri Lanka, based on helping farmers to do things that are essentially within their own labor and management capacities. As quantitative performance indicators, he uses area cultivated (15% increase over 5 years), yield (about 90% increase) and benefit/cost ratio (about 1.24). These are quite impressive gains and suggest that a sustainable development path, returning these systems to true FMIS, has been identified.

Not all of the reported experience of turnover policies seems to be so happy. There is a clear difference between turnover to older communal structures, and turnover to organizations that have no endogenous origins but have been promoted by the state in order to perform this function. Hendriks describes the latter case in northern Peru and calls the results "frankly alarming." This experience seems to demonstrate the need for careful preparation of such a program, the importance of communication and transparency in its implementation, and the need for an adequate time span for its application, so that changes can be brought in stages, and each stage can be assimilated before embarking on the next. The much more satisfactory account given by Bagadion refers also to a government-instigated organization, showing that it is not the external promotion of the organization that causes the problems, but rather the way in which the new organization is nurtured towards independence.

Economic performance may, as yet, not be receiving as much attention as it deserves. Sustainability is certainly an issue for small organizations in most countries, and economic factors have a powerful influence upon institutional sustainability. Often we need to distinguish three distinct levels of profitability: the individual farmer or farm household; the farmers' association; and the larger organization (governmental, farmer-managed or jointly managed) which may oversee the water resources of the whole basin or the national irrigation sector, and provide certain services, in the manner of the Philippines National Irrigation Administration or the Mendoza General Department of Irrigation (DGI). The system production and the flows of resources must be such that benefits satisfactorily exceed costs at each of these (and perhaps other) levels.

Herrera and others report on the profitability of farmers in two Argentinean associations. The success levels of the two systems differed, and, therefore, the capacity of the farmers to pay irrigation fees to their associations also differed. In this case, the areas under the two systems were each about 11,000 ha, and the total number of users were also similar. One system was much more equitable than the other in the distribution of land, having large numbers of small farms, while nearly half the land was in the hands of large owners. It may be discouraging for those who are in favor of equity to learn that the less equitable system performs much better, and is, therefore, better able to sustain its own association, with the fee collection per hectare amounting to 2.7 times as much and capital investment 4.6 times as great, as in the more equitable case. They suggest the existence of a " vicious spiral" in the poorer case, where the lack of fee collection prevents adequate capital re-investment and so causes future income deficiencies.

Nevertheless, even the better of Herrera's two cases seems to face economic stringencies, with 28 percent of its land uncultivated, fee collection averaging 44 percent of the assessment, and actual fee payments by farmers accounting for less than 0.6 percent of their total revenue, or 1.2 percent of their gross returns. This does not yet sound like a case where farmers are strongly motivated to support the financial viability of their organization. In turn, this financial weakness seems to pose future difficulties at the third level where financial sustainability is needed, namely the parastatal DGI.

Bagadion shows a very different economic story at Pinit in the Philippines, where the association's income averaged US$66 per hectare in 1989-90 and enabled it to save at a rate of US$20 per hectare. Fee collection was 100 percent. Perhaps intercountry comparative studies could teach us why it is that the levels of farmer support are so different, in these Philippine and Argentine examples. One possible explanation is the much smaller size of the Philippine group. Another is the level of labor and resource competition exerted by the external economy, which in Argentina is three times as strong as in the Philippines.

Environmental performance has, as yet, been addressed very little. It seems unlikely that this will remain the case in future, as concerns for this area increase. In this set of papers, however, only Fasciolo and others have addressed it directly, and they take the rather special case of public health protection under irrigation with sewage effluent, at Mendoza, offering a set of guidelines for monitoring.

Another important area that needs a greater amount of attention and research is the benefit/cost analysis of the performance monitoring activity itself. This is especially necessary in the particular case of FMIS. Academic researchers and government agencies may from time to time find reasons to expend significant resources on some performance measurement exercise; but a FMIS committee is not likely to allow its members' scarce funds to be allocated to this end, unless they can see some consequent benefit (greater than the cost) arising from the activity. This cost question should always be in our minds when we scrutinize lists of potential indicators of performance.

Hakim and Parker address this issue of cheap but relevant data-gathering methods, in the case of Bangladesh tube wells. They made a case for improving the performance data situation by training of farmer managers in the making of measurements, improved record-keeping or storage of data, and the processing, interpretation and use of various types of measurements. Kagubila makes much the same point in Tanzania: "the goal should be to transform our peasants into qualified irrigation technicians and engineers .... the training of farmers should become an aspect of performance measurement in FMIS."

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PAPERS

Bounding the System: Precursors to Measuring Performance in Networks of Farmer-Managed Irrigation Systems

John Ambler[1]

ABSTRACT

EFFECTIVE MEASUREMENT OF farmer-managed irrigation requires not only that the goals of farmer managers be understood in relation to their practices, but also that the boundaries of their physical and social fields be well specified. In hilly areas of Indonesia — which provide the field data presented in this paper — apparently independent irrigation canals are often hydrologically and socially interconnected with one another. The ways in which one canal is managed directly affect management in lower canals in the vicinity. A case study from highland West Sumatra shows how this interconnectedness has been traditionally acknowledged and actively managed by farmers in both space and time through different physical and managerial techniques. These practices included staggering of planting time between canals, prohibitions on certain types of building materials in canal headworks and rules for sharing water during times of scarcity. Thus, each canal was simultaneously both an individual entity and a part of a larger network of canals with an expanded social and physical boundary. This configuration was inadequately understood by the Irrigation Department, which sought to improve the canals. By defining the boundaries of the irrigation systems too narrowly — that is, by not appreciating the canal network and the rules of intersystem water rights — the performance of existing farmer-managed canals was underestimated and suboptimal physical and managerial interventions were implemented. Analysis of the effects of these interventions reveals that farmer technologies and rules were considerably more intricate than were first believed, and that understanding management boundaries as well as management practices is a prerequisite for accurate performance measurement.

INTRODUCTION

Performance measurement of farmer-managed irrigation systems (FMIS) in hill environments poses a special set of operational and definitional problems. One common error is to misspecify system boundaries. Failure to understand local irrigation networks and management goals and the rigid application of externally constructed standards can lead outsiders to mismeasure FMIS performance and misprescribe action to improve outputs. Here an example is drawn from West

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Sumatra, Indonesia. Lack of space prevents the extending of the analysis to other types of irrigation networks, such as tanks in series (e.g., in South India) and clusters of wells (e.g., in India and Bangladesh), where issues of user-defined system boundaries are also more important than have been generally recognized.

Internal Goals and External Standards

At a fundamental level, performance measurement in any irrigation system refers to identifying the managers' goals, and assessing the degree to which the managed system actually meets those objectives.[2] In this sense, performance measurement begins not by specifying particular output measures (standards) and achievements (performance), but rather by defining the multiple goals of the managers, which themselves may change across seasons and over years. Having identified these *internal* goals, then specific performance measures can be developed (see, e.g., Bottrall, 1981). When outsiders are involved in performance measurement of FMIS, it is even more critical to start by first understanding these internal or local goals.

Performance measurement may also refer to comparing the level of various outputs of a system against generally accepted standards. This type of *external* performance assessment compares individual systems to generalized norms. Formal evaluations and performance appraisals are commonly of this type. General standards also change over time, but usually in response to developments in technology, to changes in resource endowments or to external demands on the system to produce, but not usually in response to changes in local goals.

A major difference between internal and external evaluation is that in the former the managers of the irrigation system itself set the goals. Managers choose between complex sets of possible objectives and make decisions accordingly. Not all of these objectives may be benign or even mutually compatible, and different groups may have conflicting goals.[3] But whatever the mix of options, in internal assessment the dynamic of setting goals and evaluating how well the group meets those goals is negotiated locally.

External performance measurement, on the other hand, stresses more absolute standards. Criteria such as yield and production, irrigated area, cost per unit of water, etc., are examples. External measures draw heavily on standards and conventions in civil engineering, agronomy and economics. These indicators are important, but they cannot encompass all the complex sets of local constraints and opportunities that influence how system-specific management goals are set and met. Managerial options in the field may be strongly influenced by local factors such as labor availability, water rights, risk-taking behavior, microecologies, etc. A system may appear mediocre against many external standards, but may perform quite well (i.e., "efficiently") according to farmer-set performance measures.[4] The reverse, of course, is also possible.[5]

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2 Scott (1989, 321–332) discusses evaluating the effectiveness of organizations in relationship to their goals in three dimensions: output (end product of the organization's efforts), process (the way in which the outputs are achieved, including the quality of the outputs), and structures (the capacity to produce outputs and to continue to produce).

3 A discussion of these multiple goal-setters can be found in Walker, 1981 (in Jurriens and de Jong 1989).

4 Failure to account for local goals and constraints also tends to overestimate the "gap" between a system's assessed performance on standard dimensions and its imputed potential performance. If local goals are taken into account, many irrigation systems may actually be performing better than they might otherwise appear.

5 Some studies of the early adoption of green revolution technologies in Northern India, for example, illustrate the conflict between agricultural systems that achieved national food production goals, but which performed poorly against local goals of equity or sustainability.

In the case of FMIS, government agencies usually do not directly set system goals, and they may have little experience with understanding farmers' internal performance objectives. Yet, because of the desire to assist FMIS — a desire that itself is usually related to national food policy and employment objectives — governments tend to rely on external standards rather than on internal goals to judge FMIS and to prescribe interventions. It is here that failure to distinguish between the external and internal dimensions of FMIS performance measurement often arises.

When judging how an FMIS can be improved, outsiders assume that they can accurately measure water availability, irrigable area, benefit-cost ratio, etc. Yet, even these apparently straightforward measures are dependent on farmers' internal management goals and options. Failure to understand the system qua system can lead to a misspecification of the boundaries of the "target" system and a consequent mismeasurement of performance.

HYDRAULIC INTERCONNECTEDNESS AND BASIN PERFORMANCE

The hydraulic interconnectedness of large irrigation systems located along a common river has long been recognized. Indeed, "overappropriation" of waters is a frequent source of regional and international dispute. However, what is less well appreciated in FMIS is that many of the same basin-wide issues of goals, rights, and management are of equal importance.

The Case of Hill Irrigation Networks

Networks of small, hydrologically interconnected canals are not uncommon in hill irrigation. Figure 1 shows an example from the highlands of West Sumatra, Indonesia. In many hill areas of Asia, these canal networks were originally developed entirely by farmers. To serve the limited irrigable land in hill environments farmers have often built a series of small parallel canals, rather than one large canal.[6] Besides reducing the landslide risks that large canals pose in steep terrain, a series of canals can also tap springs and seepage that would not be captured if farmers relied on just one large diversion structure.

Understanding irrigation performance goals and outputs in the hills requires a knowledge of inter-canal relationships within this network. Standard external performance measures are easy to be misapplied here. Take, for example, the engineering concept of "conveyance efficiency" (the amount of water that reaches the plant root zone divided by the amount of water diverted into the system multiplied by 100). This indicator is practicable to apply when a system stands in isolation and when all major sources of the system's water supply can be measured, a situation most commonly found in flat areas. It also assumes, as with other system-wide performance measures, that the boundaries of the system are well understood.

One of the first technical impediments to using such a measure of efficiency in hill irrigation is that water supply for the system is *not* limited solely to the water that is diverted from the stream at the headworks. The command area of a higher system frequently abuts the supply canal of the next lower system in the series. Losses from an upper system, whether as leakage or drainage,

6 For examples of such networks, see Pradhan 1991 (pp. 105–106); Pande 1991 (pp. 62–74); and Ambler 1989 (p. 292).

become supply for the lower system. Springs, seepage and rivulets from hillsides also augment supply.

Depending on the nature of these augmenting water sources and the season, canal discharge in hill systems may actually be higher at a point lower down than it is at the headworks, especially during the rainy season when water supply exceeds demand, and farmers may even temporarily close the headworks. Conversely, during spells when river water may be a canal's only source of supply, headworks become structures for both water acquisition and for water distribution to lower canals. Thus, the performance of any individual canal and its command area must be measured not only against farmer objectives in that particular canal, but also against the influence of its management on a larger network of neighboring canals and farmer groups.

So what "is" the "system" in these cases? As the case below shows, "system" boundaries for maintenance may be different from those for operations. It is this possible local distinction between boundaries for different tasks that most external performance measurements fail to appreciate. A study of irrigation developed by the Minangkabau people in a mountain valley in West Sumatra illustrates how farmers traditionally adjusted technology and management to control water on a basin-wide basis. The impact on "performance" in this basin by a state program designed to assist FMIS is discussed.

A case study from West Sumatra. The Tampo River provides water directly for 61 small canals located along a 15-kilometer stretch of the stream (see Figure 1). Average distance between weirs is only 250 meters. Mean command area per canal is 25 ha, with the largest being about 150 ha. Ownership of irrigated rice lands averages less than one-half hectare. Irrigated fields in the valley are situated between 250 and 1,000 meters above sea level. All canals in the valley were originally constructed by farmers, beginning at least 650 years ago.

Precipitation is bi-modally distributed and ranges from 2,000 mm per year in the tail of the valley to about 2,800 mm at the head. Monthly rainfall during the periods September-January and April exceeds 200 mm; during July-August it is less than 100 mm per month. Precipitation during February, when the rice plants are in the crucial grain-filling stage, may also be low.

Before the introduction of high input varieties in the late 1960s, one crop of slow-maturing rice was grown annually. The land was left fallow during the dry season. Now, most farmers with good irrigation are able to harvest two crops per year. Those in the most favored locations — i.e., those with good water supply and at an altitude less than 600 meters — are able to harvest five crops in two years. Yields of unhusked rice today range from about 3.5 mt to over 6 mt rice per hectare per crop.

Coordinating mechanisms and network performance. During low rainfall periods, the discharge in the river in the central part of the valley (zones B, D, and E), falls drastically, and most supplementary rivulets and springs go dry. (Discharge in the river in zone A also falls, but as it is located at the head of the valley, water supply is still sufficient while systems in zone C benefit from the inflow of a small stream, Bt. Kawai.) At those times, all available water in the Tampo River is diverted for irrigation. That is, the discharge in the river at point x in Figure 1 is negligible. Thus, on a basin-wide basis, there is no surplus water in the network, and the network performs the function of capturing water very efficiently.

Although there was no formal written system governing the apportionment of water among the canals, farmers had mechanisms for sharing and conventions regarding water rights.[7] Accord-

7 Written texts of "traditional" intersystem water rights codes in FMIS are rare, but not unknown. See Coward, 1990, for an example of the *riwaj-i-abpashi* record in Himachal Pradesh, India.

ing to *adat* (custom) in zones here labeled A, B, C, and D, farmers enjoined against building permanent masonry weirs, permitting instead only loose stone construction. These weirs were also not allowed to extend to the opposite bank, but rather were permitted only to jut part way into the river. During times of water scarcity, it was further prohibited to chink the spaces between the stones with mud or straw. Labor requirements for rebuilding washed out weirs in this stretch of river were not onerous.

In zone E, farmers allowed permanent weirs because the dry-season water supply to this area was never sufficient for a rice crop anyway. Canals higher along the river took all the dry-season water, in accordance with their acknowledged rights, so there was no coordination problem to sort out. In zone E, permanent weirs, which began appearing in the 1930s were better suited to capturing surplus rainy season flows, and they reduced the labor burden for reconstructing the stone and brushwork weirs, which here needed to be taller than in the upper reaches of the river.

Higher along the river, however, the stone weirs acted as water division as well as diversion structures. "Leakage" at the headworks of one canal automatically flowed to downstream weirs. When downstream canals needed additional water, each evening small groups of farmers took turns walking upstream (*manjapuik aia*) to ask for a "stone's worth of water" (*mintak aia sabatu*). A few rocks from each of several upstream weirs were removed. The group walked upstream as far as the "mother canal" (*banda induak*), the largest canal in the vicinity. Within each command, priority turns for the night's irrigation went to the group that made the trek.

What constituted a "reasonable" height of weir, and what was a "reasonable" request from downstream users for additional water was more a matter of mutual agreement than strict measurement. Although higher systems were acknowledged to have priority rights over lower systems, what might be called a "first in line, first in right" arrangement,[8] their powers of appropriation were also tempered by a cultural ethic that prescribed moderating one's own demands to take into account the needs of others (*lamak di awak katuju di urang*).

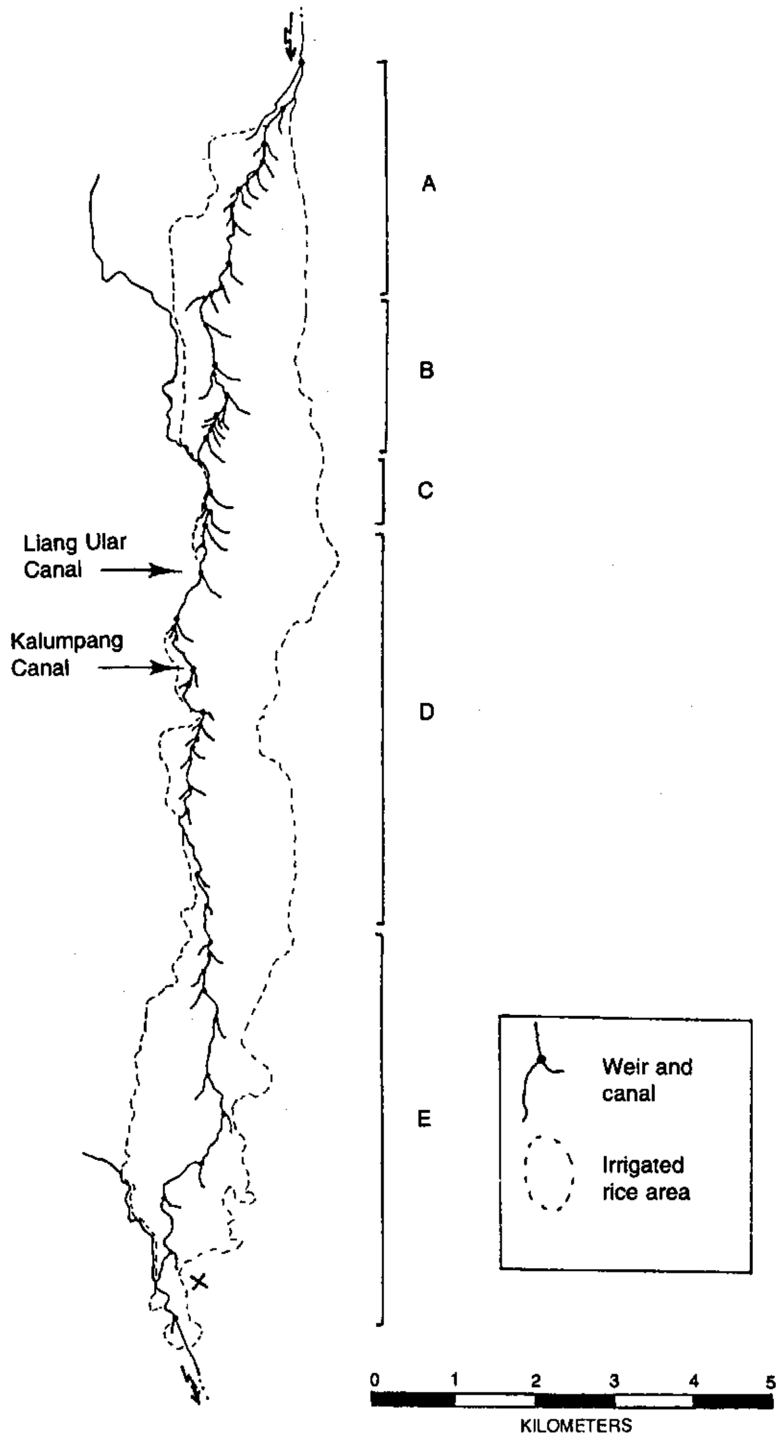
Under this arrangement, then, the permitted materials and design of weirs served to reduce conflict during the dry season, while still utilizing all available water in a relatively equitable manner. The headworks did not need to be constantly adjusted, as the "leakage" downstream was automatic supply for downstream users, even under very low discharge conditions.

Finally, at a more macro level, farmers coordinated planting time throughout the valley. Fields at the colder head of the valley were planted three to four months earlier than those at the tail. Traditional cultivars of rice in these highest reaches took nearly nine months to mature. The staggered planting schedule helped spread out the demand for water during land preparation. Harvest throughout the valley occurred in May, thus helping to minimize pest infestations.

Maintenance for each canal and weir is performed only by those farmers directly served by that canal, which makes a strong correlation between physical and social boundaries. Thus, in Figure 1 there are 61 separate maintenance systems. However, the boundary for operations in the network surpasses the individual canal during water scarce times. Thus, the boundaries of the social fields operative for different irrigation tasks expand and contract according to water supply conditions, even though the physical boundaries appear to be the same.

8 This differs from a "first in time, first in right" rule. Construction of some of the highest canals in the Tampo Valley may postdate that of those in the middle reaches.

Figure 1. Tampo River and its canals.



Furthermore, the managerial and technical parameters of the network developed not as a rigid code of "water law," but rather as a negotiating "text" — that is, a basic foundation of shared principles that undergird the flexible negotiations needed to respond to complex fluctuations in resource conditions and management objectives. The concept of equity in water distribution, while not strictly a "goal" of the network — for that implies anthropomorphic characteristics that organizations do not have — was an important part of this cultural text. The invisibility to outsiders of both this text and the different social fields in the network had implications for the pattern of state assistance to improve irrigation performance in the Tampo Valley.

State Intervention to Improve Performance. Beginning in the early 1970s, as part of its drive to increase rice production, the Government of Indonesia stepped up efforts to improve the physical facilities of many FMIS in the Tampo Valley. Although there was little additional area that could be irrigated in the valley, the state felt that farmers' "primitive" structures needed to be "upgraded." Farmers were not consulted in specifying the problems or solutions for improving their systems.

The engineers' first priority was to replace the loose stone weirs with concrete gated structures. Based on their training in lowland irrigation systems, state engineers were predisposed to think of permanent gated headworks as essential in any irrigation system. Second, they observed that during the rainy season the traditional weirs were washing out and not diverting as much water as a permanent structure could, while during the dry season these farmer-made weirs "leaked."

This evaluation of traditional weirs missed the mark on several counts. First, addressing the condition of the headworks is essential where the only source of water is that obtained via the weir. In the case of the Tampo Valley network, however, during the rainy season, overland drainage from higher systems, springs and seepage all act to supplement most irrigation systems from points other than the weir. Thus, the apparently poor performance of the headworks during the rainy season was incorrectly assumed to translate into poor system performance. The presumed need for a permanent weir was predicated on the erroneous assumption that the system must be water-scarce because the headworks leaked or washed out.[9]

Second, the new designs assumed that leakage at the weir was a loss to the "system." While it was a loss to an individual canal, there was no loss to the larger network of canals. Recall that even before the government program, all available water in the river during the dry months was being utilized. Because the boundaries of the "system" were too narrowly circumscribed, the weir was seen only in its diversionary capacity and not in light of its additional inter-canal water distribution functions.

State intervention raised the overall performance of the assisted canals by increasing their ability to capture water. During the rainy season this caused no problems because there was a net surplus of water for the whole valley, and in a few cases it allowed the extension of the state-assisted canal into limited areas that had previously been rainfed. However, during times of water shortage, these select canals monopolized the water, making some previously dry areas wet and other formerly wet areas dry — a recipe for conflict.

For example, farmers located below the Liang Ular System, one of those "upgraded" with a permanent weir by the government, became particularly upset. After improvements by the state, Liang Ular *de facto* began to control the fate of all canals in zone D during the dry months. Not only could it disrupt downstream water distribution during times of low discharge in the Tampo,

9 Combining small adjacent irrigation systems into one system under a larger weir has frequently been attempted in hill areas on the grounds of increasing efficiency, especially for canal maintenance. Experience has shown that these efforts are often unsuccessful because of complex inter-canal water rights and hydraulic issues. See WECS/IIMI 1990, p. 4; and Ambler 1989, p. 489.

but its location significantly disadvantaged farmers in zone D. Farmers now had to travel up past their original "mother canal" (the Kalumpang System) and trek up past three more headworks, an additional distance of 1.5 km, to ask for water from Liang Ular. It also meant that they now had to cross into another *nagari* (a cultural, and formerly political unit), where the traditional elites were less accommodating.

The situation was further complicated by changes in management authority. The placement of a government-paid gatekeeper at the Liang Ular weir transformed the canal from an FMIS into a government-controlled system. On the basis of wet season water availability, the Liang Ular Canal had been extended and the government operators were keen to supply water to the entire area even during dry months. Farmers downstream were understandably upset that their traditionally honored water rights were now abrogated, and they had to repeatedly request water from an unsympathetic bureaucracy. Even farmers served by the canal just below Liang Ular complained because new lining in Liang Ular's canals reduced overland drainage to their canal. Increasing acquisition and conveyance efficiencies in Liang Ular did not necessarily increase net efficiency throughout the larger network. The new weirs and canals gave farmers and government operators in the assisted canals the physical capability to overappropriate dry-season flows in the valley. Liang Ular is only the most dramatic case. Lesser but similar dramas involving other new government-built weirs now interspersed among the traditional weirs are being enacted all along the river.

For the first time, the introduction of new varieties of rice and multiple cropping made irrigation during the height of the dry season an option. This accentuated farmers' demand for scarce water and would have put even the traditional arrangements under strain. The government missed an opportunity to act as an independent agent who could broker updated water rights texts for the whole basin under the new agricultural technology. However, the blindness to farmers' traditional inter-canal water rights and their supporting physical and managerial technologies led the government to too narrowly define system boundaries and led to sub-optimal interventions for increasing performance.

Comparing farmer priorities in managing canal irrigation with those of the government brings out several striking differences. First, traditionally, farmers took a wider basin perspective that sought to minimize conflict during times of water scarcity. Inter-canal water distribution during the rainy season was not an issue because water was plentiful. Diametrically opposed was the government's approach to performance that centered on the potential of certain individual canals to appropriate wet season flows, with little consideration for the impacts this would have on water distribution during the dry season.

Second, farmers had embedded into their apparently "simple" technology a number of management considerations that supported the overall performance goals of operation in the basin. All elements of the basin-wide network were formerly under farmer authority, and local technologies were mutually agreed upon, automatically operative regardless of discharge levels in the river, and objectively verifiable to all concerned.[10] The government, on the other hand, took over some canals, thus opening the door for a divergence in performance goals that spawned conflict. Furthermore, government gatekeepers are not accountable to farmers or to the larger network, and the performance goals of those assisted canals have been defined unilaterally by government staff. In the end, the government a) had failed to properly identify the collectivity of irrigators by misspecifying the boundaries of the network of social relations among the farmers from different

10 Some of the design characteristics of these loose stone weirs are also found in traditional proportioning devices often located at canal branches in hill irrigation systems (Ambler 1991).

canals, and b) had not properly understood the normative order regarding water distribution applicable to the participants linked by the network.[11]

RECOMMENDATIONS

From this case study follow the recommendations regarding performance measurement in FMIS hill irrigation listed below:

* The link between existing techno-managerial arrangements and local performance goals must be understood before measuring performance or proposing interventions. External performance evaluators should seek to form partnerships with farmers and their leaders to identify locally appropriate performance goals and measures within locally defined boundaries.

* Performance measures in irrigation networks must take into account inter- as well as intra-canal goals, potentials and constraints. The boundaries of "the system" may be a function of management tasks, water supply conditions and water rights texts, and may include more than an individual canal and its command area.

* Existing codes of water rights must be factored into defining the performance goals of the basin. To the extent that local water rights are often formulated to deal primarily with situations of scarcity — not of abundance — performance-enhancing measures that empower certain parts of the network will have to include appropriate conflict-resolution mechanisms for dealing with the other members of the social field.

* Physical structures to increase output performance must be accompanied by mechanisms to promote or maintain high social performance. Management authority should be structured in such a way that a local negotiated order is possible when defining canal and network boundaries and larger performance goals.

11 For a further analysis of the concept of boundaries in collectivities see Scott (1981, 180–181).

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Performance Indicators:
A Case of a Newly Developed FMIS in Bali, Indonesia

I. Gde Pitana[12]

ABSTRACT

WATER USERS' ASSOCIATIONS in Bali, normally called *subak*, have been in existence for centuries. However, there are also subak of more recent origin. To analyze performance indicators of Farmer-Managed Irrigation Systems (FMIS), one newly built FMIS, Subak Gunung Mekar Mertasari, was selected.

This FMIS is located in Bunutin Village, Kintamani District, a hilly region around 940 meters (m) above sea level. It is located some 80 kilometers (km) northeast of Denpasar. The physical facilities of this FMIS which were constructed in 1977, consist of a dam, a 1.646-km tunnel, a 1.5-km canal and a number of division structures. In the development of these facilities, this FMIS has invested US$49,356.60, with equal contributions from its 70 members. The first irrigation facilities were constructed in response to the regular drought experienced by the village.

To expand the present 25-hectare (ha) command area, this FMIS is now constructing a new 3-km tunnel, to utilize a new water source. The new water source will expand the cultivated rice land area by about 75 ha.

From its historical background and the current practices adopted by Subak Gunung Mekar Mertasari, a set of performance indicators can be proposed, namely: 1) equity in water distribution; 2) equity in members' contribution for FMIS development (investment as well as operation and maintenance); 3) social functions of irrigation water; 4) relationship between FMIS and the broader society in which the FMIS exists (the village, in this case); 5) economic productivity; 6) social productivity; and 7) the irrigated area ratio.

INTRODUCTION

Old inscriptions and artifacts suggest that subak in Bali were in existence as far back as 1071, or more than nine centuries ago (Purwita 1986; Pitana 1988). The number of subak increased over time, along with the expansion of rice fields and population growth. The latest data indicate that there are now 1,733 subak in Bali (Pitana 1991).

Aside from the old subak, there are also subak of more recent origin. The newly developed subak are generally small in size and are located in the hilly regions. One of these is Subak Gunung Mekar Mertasari.

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This paper attempts to explore Subak Gunung Mekar Mertasari as a case study in order to analyze performance indicators of FMIS. Most of the data for this article are drawn from researches conducted by Rendari (1990) and Jemet (1991), as well as from the author's investigations.

HISTORY AND DEVELOPMENT OF THE SYSTEM

This subak (as mentioned in the Abstract) is situated in Bunutin Village, Kintamani District, Bangli Region, in the hilly region. It is about 940 m above sea level, located some 80 km northeast of Denpasar.

The idea of developing this subak emerged in June 1977. However, the first intention of diverting water was not for irrigation, but for domestic uses. By then, water was already a scarce resource in Bunutin. The villagers had to walk some 6 km along a steep path to fetch drinking water. Around January 1977, Bunutin experienced a serious drought and famine. Aside from plants and animals, the drought also took the lives of nine villagers.

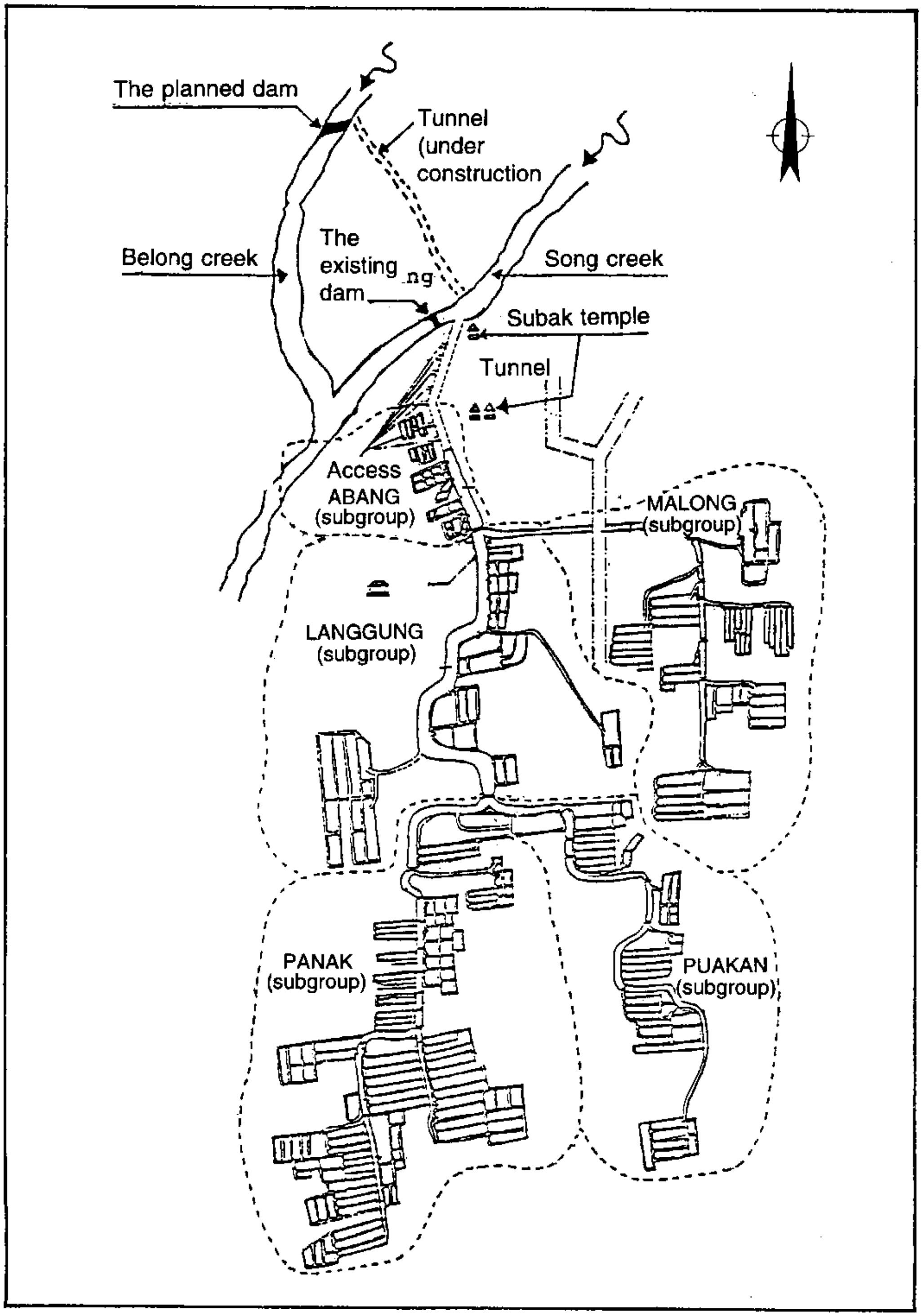
Faced by this difficult situation, a group of villagers, consisting of 50 persons headed by Nang Daging, tried to locate a water source. This group failed in its attempt, however. In July 1977, a second group, this time consisting of 70 persons were organized and coordinated by Nang Pelung. Nang Pelung was a member of the village advisory body, *adat* (customary law society) leader, and a traditional healer. He is also a veteran of the Indonesian War of Independence (1945–1959). After conducting intensive surveys and investigations, the group finally located a water source in Song Creek, in Ulian Village some 2.5 km from Bunutin. The flow of this water source was estimated at about 67 liters per second in volume.

Using traditional methods, the group concluded that the water source was at a higher level than Bunutin and, therefore, could be used as a source for the village. In order to convey this water, a dam, a tunnel 1.646 km long and a canal of about 1.5 km length had to be constructed. To construct these facilities, the (emerging subak) group itself designed everything, carrying out its own measurements, designing and laying out the dam, tunnel, and the canal. The office of Public Works of Bangli regency was consulted only when necessary. Construction began in September 1977. The dam and canal construction were done by the group members themselves, while for tunnel digging, the group used hired labor. To pay for hired labor, each group member contributed US$21.00 per month.

Construction of the above facilities was completed in November 1978. The total sum expended was US$6,823.16 for hired labor, US$29,024.68 for dam construction, and US$13,508.76 for constructing the canal (calculating the value of mobilized labor according to the wage rate prevailing at that time), or US$49,356.60 altogether, excluding the value of local materials used (bamboos, wood trunks, earth, stones, etc.). It should be noted that in the construction of the dam and canal the group was helped by other villagers whose labor was free of charge. The villagers voluntarily assisted the group because the water would be used not only by group members, but by all villagers who would have access to it for domestic purposes.

Realizing that the volume of water was more than necessary for domestic use alone, the group decided to distribute the water to its members for irrigation. Each member then converted his dry land to rice land. The group then changed its name and became Subak Gunung Mekar Mertasari.

Figure 1. Irrigation scheme of Subak Gunung Mekar Mertasari, Bunutin Village, Kintamani District, Bangli Regency, Bali, Indonesia.



Since the subak members felt that irrigated land would be much more productive than nonirrigated land, rice land became a "status symbol" of the villagers. As a result, Subak Gunung Mekar Mertasari tried to find another water source to expand its rice land. After carrying out investigations over a long period, the subak found a water source in 1980 in Belong Creek, located in Gunungbau Village, about 3 km from the existing dam. The flow of water was estimated at 430 liters per second.

After consulting the authorities, the subak decided to divert this water by damming the Belong Creek and digging a 3 km tunnel. Water from this source was to be conveyed by means of a tunnel to Song Creek just above the existing dam (see Figure 1). It is estimated that the water from Belong Creek can irrigate some 75 ha rice land.

As with the first water source, everything for this source was done by the subak itself. Construction was begun in 1980. At present, the tunnel is still under construction using hired labor. By January 1991, 1.752 km of tunnel had been completed (valued at US$17,302.49) and some 1.247 km still remain to be completed.

WATER DISTRIBUTION

Since the farmers had invested considerable resources to obtain the irrigation water, it had to be distributed in a manner satisfying the standards of equity of the subak members. In the Balinese Subak System, there are at least two considerations in water distribution. One is the method of water distribution employed by the subak over the course of time; and the second is the subak's method of defining the water rights of its individual members.

In the case of water distribution over time, Subak Gunung Mekar Mertasari employs the continuous flow method, meaning that all subak members in any part of the rice land receive water continuously. This method was adopted because in addition to its use for irrigation, the water is also used for domestic uses and animal watering. Hence, the availability of water at all times is the preferred one, though in very small volumes.

The rights to water of each individual member is equal to his or her contribution in the development of the subak. Since all contributed equally to the development, all farmers enjoy equal rights to water, i.e., "one portion," regardless of their land size.

The water from the dam is divided into 75 portions: 70 portions for 70 members; one portion for the subak head (the head of the group); two portions for the village's communal lands; and one portion for the communal lands of Ulian Village (because the water source is located in that village).

In the efforts to achieve a fair water allocation and distribution, the subak has experimented with three methods of water distribution/allocation in terms of the rights to water of individual farmers. These are *tektek, pelampias* and *nguu.*

Tektek Method

In this method, irrigation water is divided (in the division structures) based on the number of members. Example: If there is a two-inlet division structure, say, the right inlet is used by seven members and the left one by three members, the width proportion of the inlet will be 7:3. This method probably favors the upper stream farmers, because the loss along the canal (evapotranspiration, percolation, etc.) is not taken into account. Hence, the downstream farmers usually get much less water and plant a smaller area of rice. This method was applied in 1979.

Pelampias Method

This method is similar to the tektek method, except that, water loss along the canal is considered. To compensate for losses along the canal, the downstream farmers are given "additional water." In the above example, for instance, the width proportion of the canal would not be 7:3, but say 7:4, if the three farmers have a longer canal than the seven. Theoretically, this method was acceptable for all farmers. However, it was very difficult to define who gets how much additional water. Furthermore, the upstream farmers complained, because their rations were reduced. This method was only used for one month, in 1980.

Nguu Method

This method measures the volume of the actual water entering the individual rice fields, i.e., just below the individual inlet. The subak measured the volume of water in an individual inlet using a two-liter can. The time consumed in filling in this two-liter can was measured. After conducting trials, the subak decided that one portion of water (for one member) was 2 liters in 36 seconds, or 0.06 liter per second. (When measured in November 1990, the volume of water of individual farmers was 1 liter in 12 seconds or 0.083 liter per second). This method has been employed since 1980, and no complaints have arisen yet.

The size of irrigated rice land has increased over time, because of the increase in efficiency of water use. In 1979, only 7 ha of land could be planted. In 1982, the irrigated area rose to 15 ha, and now (1991), it is around 25 ha.

OPERATION AND MAINTENANCE

Operation and maintenance is one of the main tasks of any irrigation system (Coward 1985). To supervise the water distribution method agreed upon, the subak appoints a *patalik* (water master). The water masters also supervise all of the subak facilities, including the dam, tunnel, canals and division structures. In cases of minor damages, they repair them, or they report to the subak head if they cannot manage the repairs themselves. The subak head then mobilizes subak members to repair the damages.

To maintain the irrigation facilities, the subak conducts regular maintenance works (canal cleaning, grass cutting, bank rehabilitation, etc.) eight times a year on the average, generally three days for each period. Every member has to contribute one laborer. Labor consumed in routine maintenance activities is about 5,040 man-hours per year.

When the subak needs materials for rehabilitation, each member has to contribute "one portion" of materials needed. When it is necessary to purchase materials (cement for example), the amount of the expenditure is calculated, and then equally divided among all members.

DISCUSSIONS AND CONCLUSIONS

Subak Gunung Mekar Mertasari — the FMIS being discussed — cannot be assumed to be representative of all FMIS in Bali. However, some of the principles of this FMIS are not unique to it. They hold true in general for Balinese subak systems.

With regard to performance indicators, some of the principles discussed below are of interest.

Equity in Water Allocation

As mentioned above, the rules of defining water rights for individual members had changed three times. This implies that equity in water allocation among members is a matter of great concern. The sense of equity, in turn, will determine the frequency and intensity of conflict among farmers.

Equity in Resource Mobilization

Resources contributed by each member should be in direct relation to the amount of water he receives, as is highlighted by Subak Gunung Mekar Mertasari. Interviews with subak members and subak officials clearly showed that a member is allowed to sell his water right to his fellow, whether a "half portion" or the "entire portion." A member who has rights to only a half portion of water, owes labor and other duties of only a "half portion." Stated differently, the ratio between the rights and the duties in this FMIS is constant.

Relationship between FMIS and Village

In constructing irrigation facilities, the subak was helped by village members. After the physical system came into operation, the village was given irrigation water (two portions), for village communal land. The village of Ulian, where the water source is located, is also given one portion of water.

This suggests that although the subak, as a water users' association, is entirely separate from the village, as a residence-based association (Geertz 1967; Pitana 1988), coordination between the two is very harmonious. This harmonious relationship is very important for the subak for several reasons: 1) Subak members are also village members. Should the subak and village conduct activities simultaneously, subak members will be freed from village activities, and could concentrate on the subak's activities. 2) Village members, especially those who are not subak members, will not disturb the irrigation facilities; and 3) There will be no problem for "right of way," even though the canal of the FMIS crosses land belonging to the villagers here and villagers elsewhere.

Social Functions of Irrigation

Before this FMIS was formed, drinking water and water for other domestic uses was very scarce and the villagers had to walk some 6 km to fetch water. This hard and time consuming work is no longer burdensome since the irrigation facilities have started operating. This nonirrigation use of water is a very important factor to bear in mind.

Yield of the Irrigated Land

Land productivity (indicated by yield per ha) is an important indicator in measuring performance of the irrigation system (FMIS). In Subak Gunung Mekar Mertasari, the irrigated land is significantly more productive than the nonirrigated land. Calculated in economic terms, the Internal Rate of Return (IRR) of the conversion of dry land into irrigated land is over 18 percent (economically "go").

Aside from productivity in economic terms (production), the productivity in social terms has also to be considered. In the FMIS being discussed, the social productivity is quite high: rice land has become a "status symbol" of the wealth of the villagers, and the main staple food of the villagers has changed from sweet potato-maize to rice-rice.

Irrigated Area Ratio

Theoretically, the irrigated area ratio, i.e., the ratio between the actual irrigated area to the planned irrigated area, is one of the performance indicators. The higher the irrigated area ratio, the better the performance of the FMIS.

In the case of Subak Gunung Mekar Mertasari, the irrigated area ratio must be very high (more than one), because the first intention of diverting water was not for irrigation, but for domestic uses.

WRAP-UP

To wrap up this article, it is concluded and proposed that in evaluating irrigation performance (especially for small-scale FMIS), the following indicators be taken into consideration:

1. Equity in water distribution;
2. Equity in members' contribution;
3. Social functions of irrigation water;
4. Relationship between irrigators' association with the larger society, in which the system is located;
5. Economic productivity of the irrigated land;
6. Social productivity of irrigation; and
7. Irrigated area ratio.

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A Comparative Assessment of Farmer-Managed and Agency-Managed Irrigation Systems in Northern Pakistan

Mehreen Hosain[13]

ABSTRACT

THIS PAPER FOCUSES on irrigation management in Pakistan's Northern Areas and analyzes the differences between farmer-managed irrigation systems (FMIS) and agency-managed irrigation systems (AMIS). The paper identifies the following performance indicators:

1. *The development of new systems.* Over 4,000 FMIS have been developed by local inhabitants, while only a handful of AMIS have been developed despite heavy financial backing. The ability to initiate and develop new channels is a distinct measure of performance.
2. *Maintenance.* FMIS have been unable to mobilize the users to manage them and have often failed as a result. FMIS are exceptionally well-maintained, applying maintenance systems involving all beneficiaries. Proper maintenance of irrigation schemes is a useful measure of performance.
3. *Management of scarcity.* FMIS are characterized by intricate methods of water allocation which ensure equitable distribution of water. AMIS lack equitable allocation systems appropriate to the variability in the area. The ability to manage distributional issues under highly variable conditions is critical to the performance of irrigation systems.
4. *Management of equity.* FMIS ensure the equitablity of both water distribution and the contribution of labor. The costs of construction and maintenance are shared by the beneficiaries. Where equity in water distribution, labor and cost inputs is absent, the viability of the scheme is in doubt.
5. *Innovation in design.* FMIS apply design methods appropriate to local conditions based on centuries of trial and error and local wisdom. AMIS generally apply standard textbook design criteria which are often ill-suited to local conditions. Engineering design to suit local conditions is vital to ensure that channels are constructed suitably and perform adequately.

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INTRODUCTION

This paper focuses on irrigation management in Pakistan's northern areas. Looking at Gilgit District in the Northern Areas and Chitral District in the North-West Frontier Province, it attempts to analyze the differences in farmer-managed and agency-managed systems. Through this analysis, it attempts to define variables which are critical to the performance in Pakistan's high mountain irrigation systems. In the Northern Areas there are more than 48,800 hectares (ha) mainly irrigated by small-scale FMIS. In Chitral District small-scale schemes irrigate over 18,000 ha of land.

These high mountain areas with difficult terrain have been traditionally isolated from the mainstream of development in the country. In the past, development efforts were initiated by feudal overlords and local inhabitants. With feudal authority abolished in the early '50s (Chitral) and '70s (Northern Areas) these areas were faced with an institutional vacuum, which government agencies failed to fill. More recently a host of development efforts aimed at improving agricultural infrastructure have been initiated.

Critical to these efforts is the development of irrigation infrastructure, as agriculture is entirely dependent on the approximately 4,000 small-scale FMIS in the area. For centuries, these irrigation systems have been developed and managed by farmers, but now their capacity to continue investment in this sector has been exhausted. While the government will be required to play an increasingly important role in the irrigation sector, its attempts at developing the sector have been marked by failure. In understanding the differences in the management of farmer-managed and agency-managed systems, and the reasons behind the failure of agency-managed systems, useful indicators for performance measurement will be defined.

BACKGROUND TO THE AREA AND TRADITIONAL MANAGEMENT OF IRRIGATION SYSTEMS

The Northern Areas

Pakistan in its northernmost extremities forms the meeting point of the world's mightiest mountain ranges. This area contains not only the greatest concentration of high peaks to be found anywhere on the surface of the earth, but also the longest glaciers outside the subpolar regions. The area comprises the upper watershed of the Indus, which forces its way between the Karakoram and the Himalaya through Ladakh, then to Baltistan, and onwards to the distant plains of the Punjab. Despite giving birth to this mighty river, the area itself is arid mountain desert, bearing no resemblance to the lush green of the eastern Himalaya. As the yearly monsoon moves northwestward from the Bay of Bengal, the moisture it carries is rapidly dissipated and the Hindu Kush and Karakoram are sequestered in a partial rain shadow.

The area is located in the heart of the Karakoram mountain range. "Karakoram" in Turkish means black rock, a fitting name for the most rugged range on earth. The people living amongst these desolate and barren slopes suffer from the greatest collection of natural hazards known to man including floods, glacial movements, avalanches, mudflows, earthquakes and rockfalls. The natural environment of those living among mountains is far "noisier," and far more eventful than the plains. The weather is more severe and the rapid erosion interferes with the stability necessary for a landscape to sustain agriculture, communication and domestication.

Among the valleys of the Karakoram, a community has to live on sufferance in the midst of a primal war being waged between the mountains, the glaciers and the rivers. The communities in the Northern Areas have learnt to adjust and adapt their lifestyle to the harsh environment they have to face.

In the arid intermountain valleys of this area much of the precipitation in the mountains above an elevation of 1,800 meters is in the form of snow which may take up more than 50 percent of the annual rainfall and which, above 2,400 meters, is normally persistent for several months every year. Snowmelt commences in May reaching a maximum in June and continues, at the highest snow fields, right into August. Temperature ranges are very wide and diverse and are in accordance with the elevation range. Many of the interior valleys become snow-blocked and inaccessible after October when the higher passes are snowed in.

The key concern for the Northern Area dwellers is land. Only a tiny proportion of the landscape is fit for cultivation. With scarcely any rainfall and no technology for transferring water uphill, land is viable only where it lies below irrigation channels, precarious snow-fed watercourses and glaciers.

Irrigation in these mountain areas is provided by FMIS. Villagers have relied on the forces of gravity, some rudimentary tools and an infinite amount of courage and perseverance to channel glacial meltwater across treacherous slopes to their lands below. Originally *kuhls* or irrigation channels were constructed by the early settlers, and later the *Mirs* and *Rajas* (traditional rulers) initiated construction efforts.

In the Northern Areas, the traditional system of *rajaki* (presumably from Raja) is used to mobilize labor and other farmer-owned resources for repairs and maintenance, particularly at the beginning of the year. Mountain irrigation channels require substantial amounts of investment in annual repairs: they require new diversions and weirs and regular desilting and repairs before they can be made operational for the year. Under rajaki, fines equal to the cost of absentee labor are charged from defaulters who do not show up at the prescribed time. The origins of rajaki are feudal; since the demise of the last of the feudal states (in the early 1970s), rajaki is managed by the villagers themselves.

In conjunction with rajaki, community management entails well-defined rules for water allocation (rights) as, for instance, under the *warabandi* (the rotation by which each farmer is allotted water for irrigation) the mechanisms for infrastructure maintenance (obligations); and sanctions for the enforcement of the social contract. Under the warabandi system, each household in a kuhl command takes its irrigation turn on a specific day, at a specified and equal period of time. Food crops are given priority in water use, followed by fodder crops such as alfalfa and then trees. Amongst food crops vegetables take priority over grain.

Maintenance of these small-scale systems reflects their common property origin and collective management. Traditionally, all farmers contributed annually to maintenance in the form of labor or produce. Today, cash contributions may substitute for either of these. Spring is normally the time for annual maintenance, though mid-season desilting may be necessary. A *chowkidar* (watchman) may also be employed during the irrigation season to patrol the common portion of the channel to adjust and clear debris from the intake, plug leaks, repair small breaches and monitor water supply conditions. Where chowkidars are not employed, farmers themselves take over their role. Whenever a major breach occurs, all farmers participate in the repair process.

Many of these irrigation-related institutions depended for enforcement on the authority and legitimacy of an established social institution, such as the village *numberdar* or feudal authority. With the passage of time, these social institutions have become weak and new institutions have not yet emerged in their place. Government investments in irrigation development have been marked by failure. However, by 1987 over 9,000 ha of irrigable land have been added by irrigation system development activities covering 166 irrigation schemes, by the Aga Khan Rural Support

Programme (AKRSP) (Vander Velde 1989). AKRSP investments have been notably successful in comparison to government interventions.

Chitral

Chitral District borders on Afghanistan on the north and west, the Northern Areas on the east and Dir and Swat districts towards the south. Surrounded by the Hindu Kush and Karakoram mountains, it is separated from the rest of the country by the Hindu Raj Range, the only access being through mountain passes of over 10,000 feet. For much of the year the area is cut off. The poor communications with the rest of the country and within the region are the main factors hampering any socioeconomic progress.

This rugged, mountainous area is characterized by deep, narrow and tortuous valleys through which run the Chitral River and its tributaries. Settlements spread from about 3,700 feet at Arandu to 12,000 feet at Baroghil, and are usually found on alluvial fans or river terraces where soil fertility coincides with easily available water. Irrigation is essential to cultivation, and in all but the extreme south-west, no crops are grown without it. Rainfall in most of the valley bottoms is too low to support more than semidesert scrub, but higher on the mountains heavy precipitation during the winter ordinarily ensures plentiful meltwater. Rainfall is low during the late spring and summer seasons, which are critical periods for crop cultivation in Chitral, and snow and glacial meltwater is diverted from streams and rivers through channels for irrigation. Irrigation systems are constructed by traditional methods and are all gravity flow.

Channel construction is a highly skilled and arduous task and maintenance is no less difficult. Channels were traditionally constructed with support from the feudal authorities. All these channels are maintained by the villagers themselves. Currently, the government is intervening in channel construction through the Irrigation Department and local self-government. AKRSP and the Chitral Area Development Programme (CADP) are also assisting with channel construction in certain parts of the district. AKRSP has initiated 182 schemes of which 106 are complete and CADP has initiated eight of which none had yet been completed by 1990 (Hussein et al. 1990). Almost all the cultivated area, which was estimated at 18,000 ha in 1980, receives irrigation water through about 1,000 small, community-owned channels. Of all the irrigated area, about 90 percent is served by private channels while only 5 percent is served by government canals (Israr-ud-Din 1989).

Channels were traditionally constructed by the original settlers of villages, with each household contributing an equal share of labor for construction. When damaged, they are maintained and reconstructed by the inhabitants of the village. Israr-ud-Din's (1989) description of the *Ra Joi* (main channel) of the Khot Valley and the study by Hussein et al. of FMIS in Chitral, are useful in understanding the physical features and management systems prevalent. This is particularly relevant as it highlights the intricate physical features and management practices which are important to a successful irrigation system. The channel may be divided into several parts:

Hurdur (headwork); this is usually located in a perennial stream. The intake structure is constructed of stone, with shape and size subject to water flow fluctuations in the source and to the requirements of the beneficiaries. An intake tank near the head of a channel ensures a sediment-free supply of water to the villages. Location of the headwork is moved downstream in the summer to avoid their being washed away by summer floods. At this point several persons perform round-the-clock duty, particularly during the flood season.

Madok (overflow and desilting sluice gate); these gates are constructed of wood or flat stones and are opened and closed to regulate flow. Again, several people perform duty at these points. The day time duty is called *wali* and night time duty *basi*.

Ghospans (turnouts); these are usually in the form of a cut in the bank of the channel and are closed with silt, sand or stones. Size varies according to the size of the farm, type of soil and slope. The size of ghospan varies according to the area to be irrigated.

Urfi (main channel); this may serve several villages. Apart from this, the channel may have several extensions and distributaries. Villagers face severe problems in channel maintenance including seepage, silting, landslides and flash floods. A constant vigil is necessary to avoid loss of property and heavy investment in repairs.

The level of development of water rights and the system of water management are directly related to water availability. In water-scarce areas, complex user rights have evolved, which stipulate the allocation of water among the original owners. The system of warabandi is locally known as *sarogh*. The sarogh allocates water by time or flow. Original water rights are not connected to land ownership, but sale of land rights is in conjunction with water rights. There are no specific institutions for irrigation development and management; these are undertaken collectively with each beneficiary household contributing the labor required for cleaning or repairs. The *Mer Joi* (chief of the channel) used to be responsible for channel management, but this institution is rarely encountered today.

DIFFERENCES IN CHARACTERISTICS BETWEEN FARMER-MANAGED AND AGENCY-MANAGED SYSTEMS: THE IDENTIFICATION OF PERFORMANCE INDICATORS

Definition of a System

To understand the characteristics of a system it is important to, first, define the term. An irrigation scheme together with all the villages irrigated by it may be considered a system; or a village with all its irrigation channels may be considered a system. Another alternative would be to view all the irrigation channels and villages in one region (e.g., one valley) as a system. Israr-ud-din in his study of Chitral focused on a valley. Social scientists have tended to focus on the village or the social unit, while physical scientists have preferred the physical unit. What is important to note, however, is that regardless of the unit chosen, it is crucial to identify the critical variables and define a system with respect to those variables (Hussein et al. 1990).

In the complex irrigation systems that have developed in the mountain areas of Pakistan, it is essential to study the entire system of irrigated agriculture in order to understand the institutional aspects of the irrigation system under study. Government agencies have viewed irrigation from a technical perspective and have considered an irrigation system as comprising a channel, while farmers have always had to consider the whole system and not the channel in isolation. It is crucial to view the system from the farmer's perspective to be able to identify meaningful indicators for measuring performance in irrigation systems.

Construction and Maintenance

Construction holds different implications for farmers and agencies. While an agency may view the construction of a channel as an end in itself, farmers would view it as a means to an end. For the farmer the ultimate goal is to increase his water supply or bring new lands under cultivation. The construction of the channel, therefore, is only the beginning of the story. Even effective construction does not imply appropriate water supply or the provision of other necessary inputs for the farmer. In the village of Passu a kuhl was completed in 1985. After three years, only 10 percent of the command area had been developed (Vander Velde 1989). Successful construction of the channel is only one of the factors which determines its performance. New irrigation systems require adjustment before water supplies are adequate. Moreover, other constraints such as labor or input delivery play an equally important role in land development, which to the farmer is the ultimate objective.

Local inhabitants have accumulated generations of expertise in the construction and maintenance of channels in this precarious environment. Villagers have mobilized their internal resources and constructed channels through collective efforts. Later, the Mirs assisted in this construction. However, just prior to the abolition of the Mirdoms this system had reached its capacity. It required more than just collective endeavor to blast through the mountains to reach more distant water sources. After abolishing feudal rule, the government took over the development needs of the area. In the Northern Areas, the Northern Areas Public Works Department (NAPWD) began constructing some 20 large irrigation schemes, each at an average cost of 1.85 million Pakistani rupees. Only one of these schemes is still functioning (Hussein et al. 1986).

Successful construction requires a combination of local wisdom and contemporary engineering technology. On their own, neither will be successful; the failed NAPWD schemes bear testimony to this. The failure to involve the farmers in the planning and design of schemes has led to the construction of poorly performing or failed systems after considerable investment of scarce resources. The traditional method for determining the slope of a channel was the use of water as a level. Beginning from the source, water flowed along the channel as it was dug on a carefully estimated but unsurveyed line, with the objective of achieving the desired command (Vander Velde 1989). Village elders were consulted for advice on past glacial movements, avalanche and mudflow paths and stream flows from glacial and snowmelt or springs. Modern engineering science, often designed to suit uniform conditions found in the lowlands, has not, under these diverse conditions, been able to produce the results that these age-old, tried and tested technologies have.

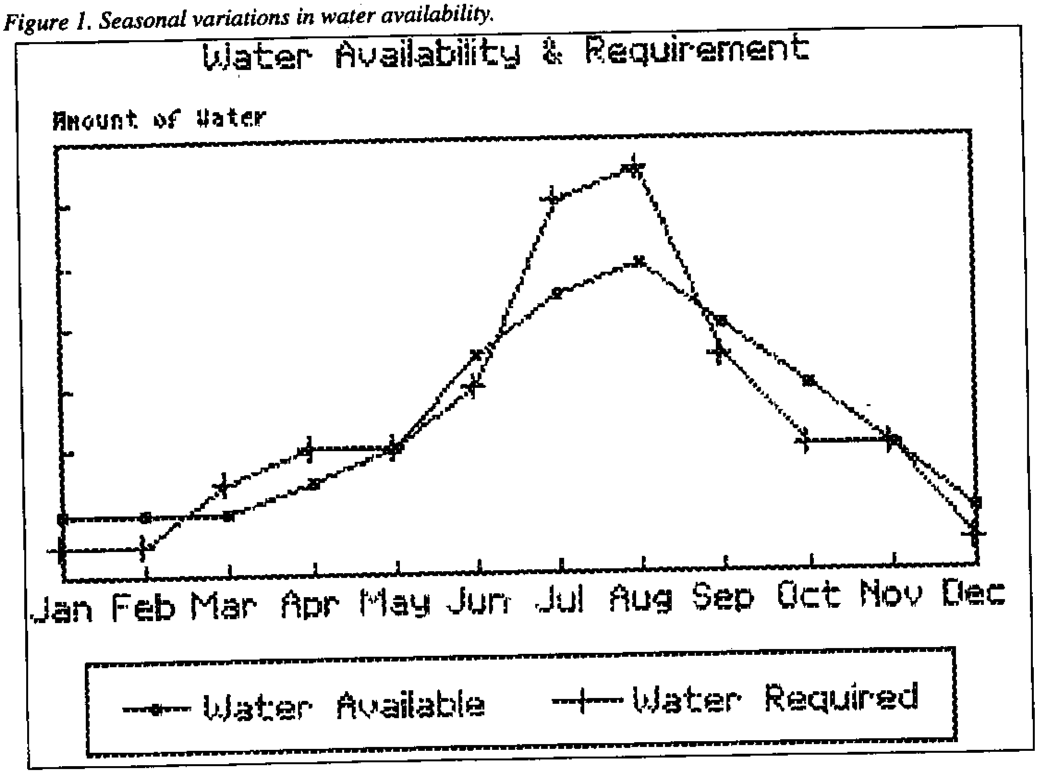
Construction by agencies is further characterized by bureaucratic delays, corruption and inefficiency. Delays in payment of installments were responsible for the failure of some irrigation schemes initiated by the Local Bodies and Rural Development Department (LB&RD). The piecemeal method of disbursement meant that no scheme could be completed. The previous years' work would be washed away before the next installment was received. Farmers had neither the capacity nor the incentive to maintain an incomplete channel which gave them no economic returns (Hussein et al. 1986)

The previous section highlighted the intricate procedures necessary to maintain channels in the mountain environment. Village communities have developed complex maintenance and repair systems that are responsive to the needs of their environment. It is not possible for an agency to respond to the maintenance needs of these channels with the immediacy that is required. A critical factor in the failure of NAPWD schemes was the department's inability to devise a system to transfer maintenance responsibilities to the beneficiary households. The AKRSP has devised such procedures.

Scarcity and Variability

Both seasonal and spatial variation can be found in the irrigation systems in these areas. It is, therefore, difficult to establish a priori the availability of water in a system. Water availability is considered always with reference to a particular season and a particular point along the length of a channel (Hussein et al. 1990). Seasonal variation is influenced by temperature, amounts of snowfall in winter months and the availability of perennial and other non-perennial water sources. Peak flows occur in July and minimum flows in March. Seasonal shortages coincide with the period in crop production when water requirements are at their lowest. Figure 1 shows the seasonal variation in water availability in an irrigation channel in Chitral. Occasionally, variations in water availability also occur, which farmers are unable to explain.

Figure 1. Seasonal variations in water availability.



Source: DRMS/IIMI Survey.

Spatial variation occurs due to the low conveyance level of the irrigation systems in their tail reaches. While water supply in the head and middle reaches may be sufficient, the tail end of a channel is often water-short due to the varying design capacity along the channel length. An additional reason for water shortages in the tail reaches of the channel is the fact that with gravity flow there must be a gradual slope all along its length. As a result of the slope the location of the tail reach is often above the channel (Hussein et al. 1990).

It is also important to define the concept of scarcity within the system. Scarcity is not only an economic concept, but also a technical one depending on the physical capacity of the channel. While water supply may be inadequate for crop water requirements it may be entirely adequate given the carrying capacity of the channel.

system which is owned and managed by an irrigation association (IA) organized by the water users and vested with legal powers by the government. The other category is the private irrigation system owned and managed by a farmer who often makes water available to other farmers for some consideration. This case study is on a communal irrigation system (CIS). As a group, CIS serve about 696,000 ha nationwide. The average service area is about 100 ha. Most landholdings range from 1.0 to 1.5 ha with rice as the principal crop. Most of these CIS are run-of-the-river systems that draw water from low diversion weirs on streams with their maximum flows in the wet season and minimum flows in the dry season. Because of lower water supply in the dry season from the stream source and little or no rainfall, the hectarage of the dry season crop is often smaller than the wet season crop.

Many CIS have existed in the Philippines for more than a hundred years. They were originally built by farmers with stones, brush and earth for diversion weirs and earthen canals for bringing water to their fields. Since the early 1950s the Government of the Philippine has been assisting communal systems through the construction of permanent physical facilities and through farmer training. At present, the National Irrigation Administration (NIA) undertakes these activities as part of its mandate.

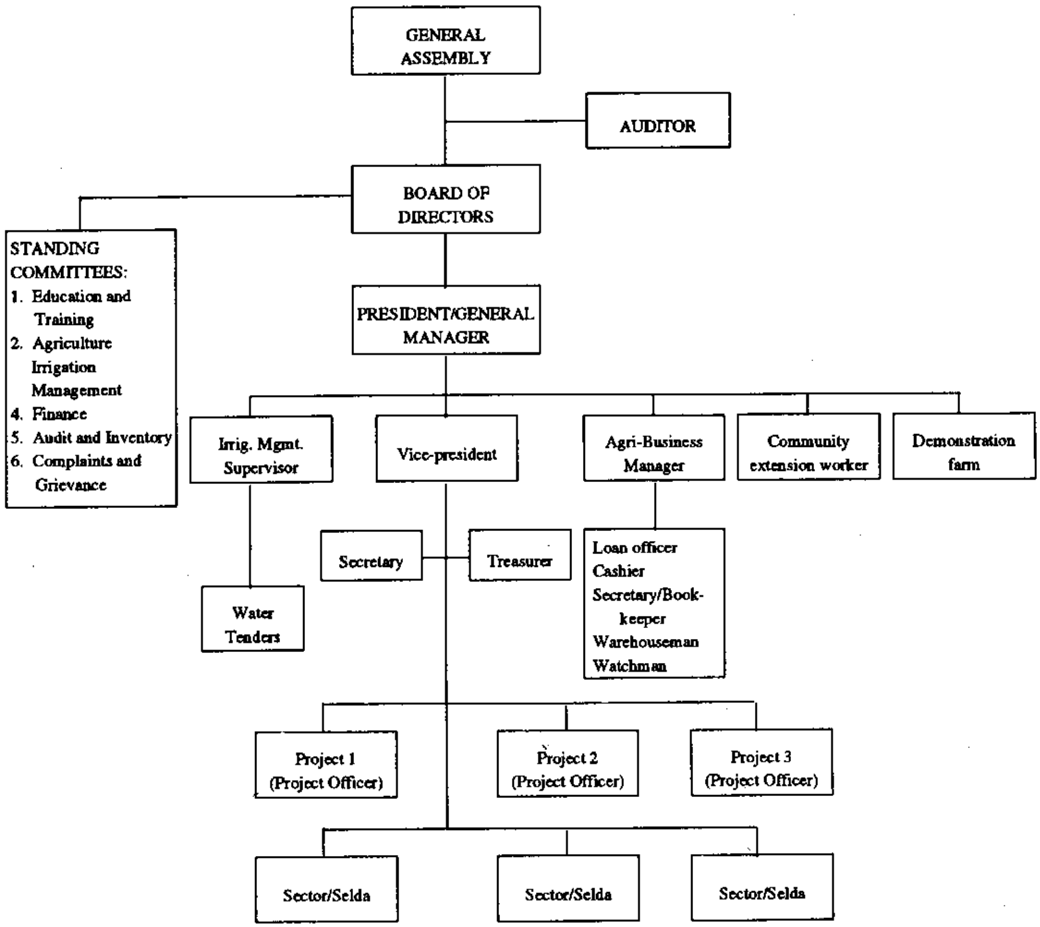
THE PINIT COMMUNAL IRRIGATION SYSTEM (PINIT CIS)

The Pinit CIS, the subject of this study, is one of those assisted by the NIA. It is located in the province of Camarines Sur and is owned and managed by the Pinit Irrigation Association (PIA). It covers 103 ha and serves 90 farmers. The irrigated crop is rice, raised twice a year. The PIA is a corporate body with legal status registered under the Securities and Exchange Commission. It has two main operating units, one for irrigation water service and the other for agribusiness. These two units are under the supervision of its President who reports to a Board of Directors (BOD). The BOD is responsible to the General Assembly of members for running the business of the irrigation association (IA). The President of the IA is also the chairman of its BOD. The IA has two other operating units: a community extension program and a demonstration farm. As these are of relatively minor importance, they are not included in this study. Figure 1 shows the organization diagram of the Pinit IA.

The water service unit is headed by a BOD member who is also the irrigation management supervisor of the IA. Under him are water tenders of the three sectors of the service area. The agribusiness unit is headed by an agribusiness manager who has under him a cashier, a loan officer, a secretary-bookkeeper, a warehouseman and a watchman. The unit undertakes credit facilitation, procurement and distribution of agricultural inputs and marketing of unhusked rice on behalf of the members.

For representation in the BOD and for overall planning the service area is divided into three sectors. Each sector is subdivided into "seldas." Sector 1 has two seldas; sector 2 four seldas; and sector 3 three seldas.

Figure 1. Organization diagram of Pinit Communal Irrigation System.



PERFORMANCE EVALUATION

In the Pinit CIS, performance evaluation is a tool for: 1) improving the management of the irrigation system and the PIA, and 2) measuring the progress of the PIA towards its goals. Under the first

Performance Evaluation in a Farmer-Managed Irrigation System in the Philippines: A Case Study

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ABSTRACT

THIS PAPER IS about performance evaluation in a farmer-managed irrigation system (FMIS) in the Philippines that undertakes the following activities:

1. Management of the cropping calendar;
2. Irrigation water allocation and distribution, including conflict management;
3. Agricultural credit arrangements for its members;
4. Procurement and distribution of agricultural inputs; and
5. Marketing of production of its members.

Generally, FMIS in the Philippines do not undertake the last three activities mentioned above. Thus, this is not the usual FMIS.

The paper starts with a brief background of the FMIS situation in the Philippines and then discusses the subject of the study, Pinit Communal Irrigation System (Pinit CIS) and Pinit Irrigation Association (PIA) which owns and manages the system, focusing on the organizational structure and other matters related to the performance evaluation activities.

In the Pinit CIS, performance evaluation is a tool for (a) improving the management of the irrigation system and the PIA and (b) measuring the progress of the PIA towards its goals. The paper describes the monitoring and evaluation processes being used by the PIA along with its various activities to meet those two objectives. It also gives some examples of performance evaluation results.

Finally, the paper cites some lessons being learned by the Philippine government agency assisting FMIS on the enhancement of performance in irrigation systems.

INTRODUCTION

Farmer-managed irrigation systems (FMIS) in the Philippines, according to the most recent estimates, cover about 848,000 hectares (ha) constituting about 58 percent of the total irrigation service area in the country. There are two categories of FMIS. One is the communal irrigation

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While agency-managed systems recognize the aspect of technical scarcity, they rarely consider it in relation to the needs of the farmer and the entire farming system. Similarly, they are unlikely to take into account the seasonal variability in water flows and differential availability of water for head and tail users. FMIS, on the other hand, tend to be sensitive to these issues and have evolved complex systems of use rights, particularly where water is scarce.

Equitability and User Rights

Water management systems that have evolved in these areas are very sophisticated and complex. Rules and regulations regarding the allocation of water rights and the distribution of land are clearly defined. Where water supplies are scarce and uncertain, property rights must be asserted for survival. Formal and informal institutions have evolved to meet the needs of specific ecozones. Distribution is sensitive to issues of variability and scarcity. There is a degree of equity inherent in the system.

Agency-managed systems lack clearly defined user rights. Not being sensitive to the appropriate issues, they are often perceived as inequitable. External and artificial systems of management are imposed which are alien to the local populations and not suited to the highly variable local conditions and fluctuating needs of the farmer. In agency-managed systems, often, distribution is skewed in favor of farmers with the most clout.

Villagers will be willing to invest labor in the system, only if clear and fair tenurial and user rights are provided. If these rights are not guaranteed, as is most often the case in agency-managed systems, the agency cannot expect local participation in the management of the system. Failure to recognize this and understand the different types of ownership patterns and rules guiding different resources have been major weaknesses in agency-managed systems.

Where schemes have failed, it has often been due to ambiguity over the distribution of benefits and issues of maintenance. Where land and water property rights are disputed, a system cannot succeed (Hussein et al. 1986).

CONCLUSIONS

Several important differences emerge from this discussion. It is evident that differences between farmer-managed and agency-managed systems determine their successes or failures. It is critical that the government link up with people to improve performance of irrigation systems. Increasing high channel disrepair is testimony to the fact that the people can no longer manage their irrigation channels on their own. New construction is entirely beyond their financial and technical means. This is mainly the result of the disintegration of certain parts of the socio-agricultural system, with declining gains from agriculture. Similarly, the government is constrained in its financial and human resources and cannot succeed without the participation of communities. The role of the government and its linkages with the people, therefore, become increasingly important.

Irrigation management is a sociotechnical process. Agencies initiate irrigation schemes when they have funds, and their concerns are primarily technical. The farmer, on the other hand, has a host of different needs. Approaching irrigation systems with a weak technical viewpoint has resulted in several disasters in the agency management of schemes. The siting of villages on geologically unstable terrain and the variation of channel flow due to dependence on snowmelt demonstrate the fragility and unpredictability of mountain environmental systems. Choosing to impose their own textbook engineering standards under these circumstances has served only to enhance the failures of government schemes despite considerable investment. The government approach was divorced from the wealth of traditional knowledge built up over centuries. It attempted to address technical and distributional issues in its own way.

The AKRSP which has demonstrated success in the construction and maintenance of channels provides a useful model for government agencies to follow. By working together with existing social organizations it has access to an organization with procedures for decision making, patterns of communication and means for building consensus and resolving conflicts. These are capabilities which would ordinarily take a considerable time to develop. Farmers have demonstrated their willingness to fine-tune their traditional methods for greater efficiency. Agencies that impose an external management structure tend to alienate local people from the system (Dani and Siddiqi 1987). Such attempts are bound to fail. It is beyond the capabilities of an agency to develop on its own the intricacies of water management that users have evolved over generations.

A high level of village participation is crucial to future successes in irrigation development. Agencies cannot expect local communities to share resources and responsibility for channel maintenance unless they are willing to share authority and the powers of decision making over financial and natural resources.

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category, activities are evaluated regularly during the cropping season. Under the second, results are evaluated after the cropping season.

In the management of water resources the PIA does the following:

1. Plans its cropping calendar for two crops of rice in one year on its 103 ha service area to be raised from June to October as the wet-season crop, and from November to April as the dry-season crop.

2. When there is a shortage in supply, water delivery is rotated among the three sectors. The period of the rotation cycle is based on observing the hectarage that can be saturated in one day by the available water supply. Then the number of days in which one rotation cycle can be completed is calculated. Rotational distribution is implemented with the fields watered to saturation point only.

As Pinit CIS is a run-of-the-river system, the PIA is very concerned about timely implementation of its cropping calendar. A prolongation of farming activities that requires more irrigation water than is available in April and May when water supply is at the lowest, would greatly diminish the total rice production of the system and IA income. Thus, it monitors closely the farming operations at the sector and selda levels. For each lot, the water tender notes the area, rice variety, date of initial water delivery and the starting and ending dates of 1) land soaking and land preparation, 2) seedbed preparation or direct seeding, 3) transplanting, 4) crop maintenance, 5) terminal drainage and 6) harvesting. These data are reflected in the attached form 1 (Record of Farming Activities and ISF Collection Information). The irrigation supervisor summarizes the water tender's report into a sector report indicating the area of the sector, the area irrigated and the starting and ending dates of the farming activities that have taken place in the sector as a whole. On the basis of the existing situation in the sector he makes a forecast of succeeding activities focusing on a projected comparison with the planned cropping calendar and informs the BOD of the situation in this regard.

The PIA employs two water tenders under an irrigation supervisor who is a member of the BOD and who chairs its irrigation management committee. A water tender is required to make a circuit of the area of his assignment once a day to distribute water equitably and gather data on the status of farming activities for each lot.

Each day his presence in the area is certified by the sector leader; otherwise he is not allowed to collect his pay. Problems in his area are reported by the water tender in a log book at the IA office for action by the appropriate officer of the IA.

The data on rice variety and dates of seeding or transplanting are specially important when there is an extreme water shortage, and priorities on water distribution are adopted to reinforce the rotation system cited above. The data are used in determining the stage of the rice crop and the harvest dates of each lot in the irrigated area during periods of extreme water shortage. At such times the IA sets into motion the following system of priorities in water distribution:

First Priority : Crops which are in the milking stage or about three weeks before harvest time;

Second Priority: Crops which are in the flowering stage or about four weeks before harvest; and

Third Priority : Crops which are in the booting stage Extreme water shortage occurs for one to two weeks near the end of the dry-season cropping in April.

To enable farmers to follow the cropping calendar, the agribusiness unit supplies cash needs and agricultural inputs at the same time to all members of a selda in accordance with the cropping schedule. Selda members help each other when necessary to meet the schedules of land preparation and planting. As these cash needs and inputs are financed by the IA through relending from its credit line with the bank, the PIA monitors the preparation of loan papers of its members and the processing of its credit line so that the funds are available before the beginning of the cropping season. It also monitors the release of cash needs and agricultural inputs to its members. Information on these is furnished daily by the cashier who releases the cash and the warehouseman who releases the agricultural inputs.

As the irrigation and farming activities proceed, the data on farming activities are evaluated and compared by the BOD with the cropping calendar. If performance is not satisfactory steps are taken to improve it. For instance, if the preparation of loan papers is behind schedule, action is taken to speed them up. If land preparation in a selda is delayed due to the sickness of a member, selda and sector leaders mobilize other members of the selda to help meet the schedules.

As part of the evaluation of policies and procedures, members with complaints write them in a log book at the PIA office for action by the President. Resolution of complaints is given top priority by the President who also chairs the Complaints and Grievance Committee of the IA. Where the action requires amendments in the policies or procedures, the matter goes to the BOD and, if necessary, the General Assembly.

Other performance evaluation activities undertaken regularly pertain to Capital Build-up (CBU), Farm Management Take Over (FMTO) and marketing of unhusked rice.

1. CBU is a scheme which was agreed upon in the General Assembly to raise capital from members within 5 years. The General Assembly established policies and systems for its operation. Five percent of every loan taken by a member is deducted from the proceeds of the loan and contributed to the CBU in addition to other amounts he may contribute. Each member is allowed a maximum of 10,000 pesos (about US$363) as contribution to CBU. No member is allowed to exceed this maximum. For monitoring, a separate record of members' contributions is kept. CBU is evaluated regularly for compliance with policies and comparing with targets.

2. Under lending policies approved by the General Assembly a production loan is a group loan of a selda. Failure of a member to pay his loan makes the whole selda ineligible for further loans. To forestall problems to the seldas, the General Assembly instituted FMTO whereby the delinquent farmer continues to work on the farm but voluntarily transfers management of the farm to the BOD on a temporary basis until the loan is repaid. As farming activities proceed in farms under FMTO, the BOD conducts regular monitoring and evaluation to ensure that the loan is repaid from the production of the farm.

3. For marketing operations, the PIA monitors the prices of wet unhusked rice and dry unhusked rice daily as well as the amount of unhusked rice it has bought, dried and sold. It sets its buying price from members at least ten centavos (about one third US cent) higher per kilogram than the local market price. It dries and stores the unhusked rice and sells it later at a profit that forms part of the IA income. Price monitoring guides decision making on the purchase and sale of unhusked rice to maximize IA income.

At the end of the cropping season, the PIA conducts an evaluation of the operation and maintenance (O & M) of the Pinit CIS, cropping calendar, production, loan operations, sales of agricultural inputs, palay trading and capital build-up. Each year it makes a comparison of its income and expenses.

Self-Assessment of Performance by Irrigators' Associations

Fay M. Lauraya, Antonia Lea R. Sala and C.M. Wijayaratna[15]

ABSTRACT

THIS PAPER EXAMINES a *participatory* procedure of *self-assessment of irrigation system performance* by farmers in a River Irrigation System (RIS) in the Philippines. It is aimed at improving system performance through *strengthening Irrigators' Associations'(IA)* managerial capacity in planning and decision making in system operation and maintenance (O&M), improving communication processes and conflict resolution, etc. Leaders and members of IAs, using symbols, maps and simple records, assessed the performance of a) system O&M, b) organization and group dynamics, c) crop management, and d) financial management including fee collection. Evidence to date shows success in the self-assessment process specially a) in eliciting candid appraisals on system performance, b) in developing work plans and follow-up monitoring and evaluation, and c) as a self-correcting mechanism. It also motivates the farmers to act collectively on problems identified as they realize that the "problems" are within their "power" to resolve.

INTRODUCTION

Farmer's organizations or Irrigator's Associations (IAs) with their increasing responsibility in irrigation management need to adopt mechanisms for planning and performance assessment. To respond to this need, a participatory procedure of self-assessment of performance was introduced in some FMIS in the Philippines as an integral component of a large-scale pilot (research) intervention program implemented jointly by the National Irrigation Administration (NIA), Regional Universities in the Philippines and the International Irrigation Management Institute (IIMI). This paper describes and analyzes the self-assessment and self-correcting process adopted by the farmers.

15 Project Leader and Study Leader, BU-NIA-IIMI Project on "Improving Irrigation Systems;" and Head, IIMI-Philippines Field Operations, respectively.

This NIA policy is now undergoing change. Using the Pinit CIS as an example, Region V of the NIA has, in two pilot projects, developed a process for building capacity in irrigation associations for increasing production and income through activities on facilitation of credit, supply of agricultural inputs, and marketing of produce. From the lessons drawn from the Pinit CIS this is expected to result in enhanced performance of farmer-managed irrigation systems as shown by:

* Increased motivation of members;
* Enhancement of IA vision resulting in the adoption of long-range plans;
* Improved implementation of cropping calendars through effective synchronization of water and agricultural inputs;
* Improved water use and O & M of the irrigation system;
* Increased production in the irrigation system; and
* Improved viability of the FMIS.

Annex

FORM 1

Record of Farming Activities and ISF Collection Information

__ NATIONAL IA
__ COMMUNAL IA

IWD: ________
Target date: ________
Actia; date: ________

TSA/Section ____________
YEAR/Season ____________

Service area ____________
Actual area ____________

Lot No.	Landowner or Tiller	Farm Area	FARM ACTIVITIES (WEEKS)																											Planted area (HA)	Harvest area (HA)	Benefitted area (HA)	Gross prod'n (CAV)	I S F					Amount Paid (P)	O.R. No.	Date Paid	Remarks
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27					ca (P)	be (P)	ca (P)	Interest (P)	Total (P)				
Weekly totals																																										
AMS (mm/day)																																										
ALS/LP																																										
ACM																																										
ATD																																										

Legend:

- LSP - Landsoaking/Preparation
- SP - Seedbed Preparation
- DS - Direct Seeding
- T - Transplanting
- CM - Crop maturity
- TD - TERMINAL DRAINAGE

Prepared by:

____
TSA/ Sector Leader

Noted by:

____
Chairman, IMC

1. O & M are evaluated in terms of water distribution, canal maintenance, collection of irrigation service fees, and incidence of conflicts.
2. The cropping calendar is evaluated in terms of how well it was followed for purposes of improving implementation of farming activities.
3. Production is evaluated from records of threshing operations. The PIA has a mechanical thresher which members use for more efficient threshing operations. In this way, the PIA is able to compile data on the harvest of its members.
4. For evaluating loan operations, the PIA looks at the hectarage covered by loans, the number of members who took loans, the amount of the loans and the percentage of repayment. Collections of loan repayment as well as irrigation service fees are in terms of unhusked rice after the member completes harvesting and threshing operations.
5. For the marketing operations, the daily data gathered on amount of unhusked rice bought are summarized to obtain the volume of unhusked rice marketed by the IA and the profit realized. Similarly, the volumes of agricultural inputs procured and distributed are obtained from records of the warehouseman for comparison with the previous cropping season.

EXAMPLES OF PERFORMANCE EVALUATION RESULTS

The PIA in evaluating its performance cites the following:

1. Before 1987, the Pinit CIS operated as an informal group of water users with facilities that irrigated about 70 ha. In 1987 with technical, institutional and financial assistance from NIA, the farmers organized themselves into an irrigation association, registered with the government, legalized their water rights, and improved the irrigation facilities. By mid 1988 the service area had increased from about 70 ha to 103 ha.
2. Water distribution is now satisfactory as the whole service area is now irrigated in the dry season through a rotation system that enables equitable distribution in times of water crisis.
3. Maintenance of the 5.25 km. length of canals is satisfactory. All canals are maintained by farmers in each of the three sectors. Funds for canal maintenance are provided by the IA to each sector from its budget. Of the irrigation fee of 87 kg. of unhusked rice per ha per cropping, the IA appropriates 12 kg. per ha for canal maintenance to be done by the sectors.
4. Collection of irrigation service fees and repayment of loans are both 100 percent.
5. There are no serious internal conflicts that impair the O&M of the system or the management of the IA and its agribusiness.
6. The PIA is able to observe its cropping calendar in both the wet and dry seasons through timely delivery of farmers' cash needs and agricultural inputs. However, there is still scope for improving the cropping calendar through more mechanization that will shorten the period for land preparation.

7. In October 1989, the PIA obtained a loan of 311,500 pesos (US$11,300) to finance relending and supply of agricultural inputs to members. It started these activities in the cropping period from November 1989 to April 1990. During that period, average production of the Pinit CIS increased to 4.0 tons per ha from the 3.3 tons per ha of the previous year. During that period, 83 percent of the irrigated area was serviced with loans and agricultural inputs by the IA. In the next cropping season, June to October 1990, 99.1 percent of the area was serviced with loans and inputs and average production further increased to 5.5 tons per ha.

8. In the crop season November 1989 to April 1990 when it first supplied agricultural inputs to members, total fertilizer sales of the PIA amounted to 260 bags. In the next crop season, June to October 1990, fertilizer sales increased to 1,100 bags and nearby farmers outside the Pinit CIS started buying from the PIA.

9. A marketing target of 30 cavans (1.5 tons) per ha of palay in the area serviced by its lending operations, was set by the IA. This amounted to 2,568 cavans (128.8 tons) for the period November 1989 to April 1990 and 3,068 cavans (154.3 tons) for the cropping of June to October 1990. In both cropping seasons these targets were exceeded.

10. A review of capital build-up of PIA showed that members' total contributions to CBU as of September 1990 were 54,779 pesos (US$1,990) and 80,040 pesos (US$2,910) as of April 1991. As the target of the PIA is to accumulate 1 Million pesos (US$36,364) by 1995, progress so far has been slow. PIA officers say that this could have been much faster, but the General Assembly policy of limiting individual contributions to 10,000 pesos (US$363) per member to prevent dominance by a person or a minority group of persons, has limited capital accumulation.

11. The PIA evaluates its yearly financial operations by comparing its total income with total expenses. In 1989 and 1990 the comparison was as follows:

	1989	1990
Total Income	128,116.85 (US$4,568.79)	250,016.40 (US$9,001.51)
Total Expenses	104,971.99 (US$3,817.16)	156,937.88 (US$5,706.83)
Savings	23,144.86 (US$751.63)	93,078.52 (US$3,384.68)

LESSONS FROM THE PIA

Studies on Philippine communal irrigation systems in the early 1980s indicated that irrigation associations that ventured into activities beyond water failed in those activities. Thus, the NIA in its program for assisting communal irrigation systems confined its program to developing the physical facilities and the capacity of the irrigation associations to operate and maintain the systems.

RATIONALE

IAs have been organized to operate and maintain the systems in cooperation with the NIA. In recent years, IAs have been assuming important system management responsibilities, particularly those under Type II and III contracts. Under Type II contracts, farmer organizations assume the system operations and irrigation service fee (ISF) collection functions. Systems operations include: 1) planning the O & M activities and undertaking the O & M from the turnout to the main farm and supplementary farm ditches; 2) planning, implementation and monitoring of the cropping calendar; 3) water allocation and distribution; 4) conflict management and; 5) maintaining linkage between the farmer-users and the NIA. Collection functions include: 1) planning effective collection strategies; 2) distribution of ISF bills and; 3) undertaking ISF collection. Meanwhile, under Type III contract, there is full turnover of the whole or part of the irrigation system to the farmers. Although the farmer leaders of IAs receive leadership training before their organizations assume these tasks, they have not successfully internalized mechanisms that strengthen their management capabilities to face the challenges presented by their new irrigation management responsibilities. As Bottral emphasizes, much of the poor performance (in irrigation systems) stems from fundamental weaknesses in the human process of planning and management, which no amount of investment in technological hardware is going to overcome on its own (Bottral in Uphoff 1986: XV).

Thus was conceived the self-assessment of performance by farmer members and farmer leaders. By adopting a self-correcting mechanism on a continuous basis, farmers' organizations (or IAs) can attain self-dependency and self-reliance. A participatory procedure of self-assessment of performance could be used by the farmers to measure and monitor (or evaluate) the performance of the IA as well as the irrigation system objectively, as the data utilized represent the points of view of the farmer members and the farmer leaders. The self-assessment mechanism, as described in the second part of this paper, can also serve as a tool for the farmer leader to effectively and systematically carry out his function as a manager.

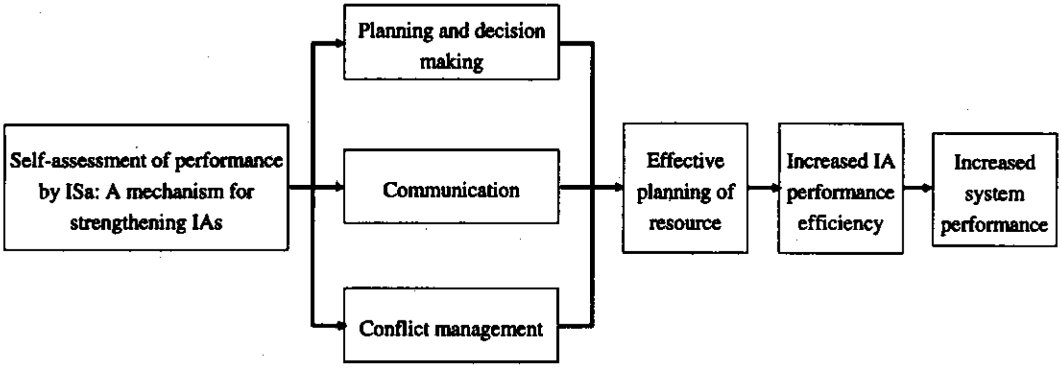
The objectives of the self-assessment experiment included: 1) monitor and evaluate performance of irrigation systems in general and IAs in particular; 2) introduce a learning process to identify and characterize the types of strategies that could be used internally by farmers to catalyze collective action and thereby to improve system performance as an alternative to external catalyst/intervention; 3) strengthen the IAs' managerial capability by introducing a systematic process for planning and monitoring IA activities (both for operations and organizational) and; 4) promote self-reliance by encouraging and training the IAs in doing their own monitoring and evaluation (M & E) and self-correcting activities.

CONCEPTUAL FRAMEWORK AND METHODOLOGIES USED

Conceptual Framework

The self-assessment of performance by IAs is a participatory mechanism introduced to strengthen the farmer organizations' managerial capacity in planning and decision making, communication process and linkage formation, as well as in conflict management which in turn should result in effective planning of the organization's resources. All these should result in higher IA performance efficiency and eventually higher system performance efficiency. The schematic flow of the expected effect of the self-assessment experiment is shown in Figure 1.

Figure 1. Conceptual framework.



Methodologies Used

The self-assessment of IA performance is a component of a 13-month intervention program begun in December 1990 which called for organizing the farmers into smaller groups lower than the turnout service area (TSA) level. Grouping is based on water and task distribution primarily to increase membership participation in IA activities. Participating in the project are two relatively large IAs in the Barit River Irrigation System in Nabua, Camarines Sur, (about 400 km south of Manila), LAPSEFIA with 1,814 members and BRISDAFIA with 2,521 members. The present organizational structure of these IAs is a two-tiered type with the first tier representing the IA central-level officials and the second representing subgroup officials called turnout service area leaders. BRISDAFIA which has a type II management contract with the NIA has 1,160 hectares sub-divided into 57 turnout service areas (TSA) while LAPSEFIA has about 745 hectares spread over 44 TSAs. It has a type II contract with NIA but is now gearing toward a type III contract. Both IAs were organized by Farmer Irrigators' Organizers (FIOs).

The project team evolved two phases for the self-assessment schemes. The first is self-assessment of performance as a strategy for organizing farmers and catalyzing collective action and is *done by farmer members* within one TSA who are being organized into small groups referred to as supplementary turnout service area groups (STSAGs) or main farm ditch groups (MFDGs). This self-assessment phase is spearheaded by the STSAG or MFDG leader with the FIO and TSA leader acting as facilitator. During a one-day seminar-workshop, the farmers, making use of symbols and maps, assess the situation in their area on aspects of water delivery and distribution, maintenance, collection efficiency and relationships between members as well as between members and leaders. The symbols used by the farmers are shown in Annex 1. As the intervention plan aims to increase membership participation in IA activities by having each member become part of a task committee, this self-assessment scheme, if done regularly, i.e., at the start of every cropping season, should become the basis for developing work plans and group activities which in turn sustain members' active involvement in the IA.

The second phase is self-assessment as a strategy for measuring and monitoring performance and it introduces a questionnaire to be *processed by the leaders* of the Turnout Service Area Group (TSAG) who by virtue of the IA by-laws, automatically comprise the Board of Directors (BOD) of the IA, from among whom the central-level officials are chosen. On the same date every month the TSA leader answers the questionnaire to assess his performance in the following categories: 1) water management: adequacy, reliability and equity in distribution, water saving practices, adherence to rotation schedules, task distribution, communication, and conflict resolution; 2) maintenance: magnitude and quality at different levels, contribution of voluntary labor, group action, etc.; 3) crop management, cropping calendar, extension, credit, etc.; 4) planning, organization and group dynamics: interactions between farmers, between farmers and leaders and with the agency, attendance and participation in meetings, planning process; and 5) financial aspects and benefits: yield and income, collection of irrigation service fee, services rendered by the IA and NIA.

The questionnaire reflects at a glance the comparative performance of the IA in the above aspects on a monthly basis. Completion of the questionnaire may be planned to coincide with the monthly BOD meetings. It can even become part of the meeting agenda and the data can then be rapidly consolidated to reflect the situation of the IA. Such data may be used by the officials to assess the situation in their IA and the performance of each TSAG. Farmers, TSA leaders as well as the IA central-level officials may from time to time compare the results of the assessment done by farmers at the STSAG level and the assessment done by the TSA leader.

It would be noted that the areas to be assessed by the TSA leaders run parallel with the measures of IA performance developed by the project team which include: 1) collection efficiency, 2) application efficiency; 3) extent of irrigation related activities; 4) ratio of resolutions implemented to resolutions formulated; 5) regularity and amount of remittance to NIA; and 6) satisfaction of members with IA services.

A recent study (Lauraya and Sala 1990) established a significant and positive relationship between organizational climate existing in IAs and IA performance. Improving the organizational dimensions identified in the self-assessment questionnaire would directly improve IA performance. Parallel to these assessments, an independent assessment has been conducted by a team of researchers. This included participant observations and a comprehensive water flow measurement exercise.

RESULTS AND LESSONS LEARNED

Self-Assessment of Performance as a Strategy for Organizing Farmers and Catalyzing Collective Action

The experiment showed that the participatory self-assessment was quite successful in eliciting candid appraisals of the existing situation in the STSAG or MFDG. In particular, the pictorial analysis of the existing condition of the supplementary canal or main farm ditch was a learning experience wherein the farmers realized that most of their irrigation problems were caused by the lack of discipline among themselves (for instance illegal turnouts, canals obstructed by vegetable plants grown by farmers, oversized canals due to bathing of farm animals, uncleaned canals due to dumping of garbage, etc.) or by the lack of "*pagbibigayan*" (give-and-take attitude) as in the case of inadequacy of irrigation water due to noncompliance with rotation schedules. The discovery that these problems are within their power to resolve coupled with the farmer's natural desire to see immediate action contributed a lot in making this self-assessment scheme achieve results. The ultimate result of the self-assessment was the formulation of work plans and follow-up activities relative to the identified problems. These included scheduling of "*rabus*" (or voluntary work) to clean the canals, imposition of penalties against nonconforming farmers, creation of task committees and setting dates for regular group meetings. Table 1 presents some of the activities identified by the farmers after their self-assessment exercise. (Annex 2 shows the complete plan of a TSAG called RAMC 21). The subsequent self-assessments by the farmers may then be used as an in-house M & E mechanism to see the end results of the action plans formulated. The information resulting from the self-assessment should be utilized, otherwise as Pradhan and Yoder say, the "unit becomes defunct" (Pradhan and Yoder 1989).

Among other things, acceptability of the self-assessment scheme among farmers lies in the use of the symbols which overcome difficulties such as farmer's inferiority and nonparticipation due to illiteracy. Experience shows that it has been very useful in motivating farmers to collectively act on identified problems, if in the process, organizers and leaders have simultaneously with the self-assessment activity, emphasized to the members that they have "collective responsibility" for managing the system. Thus, the IA can use the self-assessment process to generate membership participation in carrying out the regular operation and maintenance concerns of the system.

Table 1. Farmer's action plan.

Name of turnout	Activity	Time frame	Persons responsible
RALAT – B3	meeting	April 28	leaders/members
RALAT – 34	meeting	April 28	leaders/members
RALAT – B5	rabus regular meeting	2nd Sunday of every month	leaders/members
RALAT D1–5	rabus	2nd wk. of June	leaders/members
RALAT C–X3	meeting rabus	May 20	leaders/members
RALAT D1 – 4	Organize task committees clean MFD	May 25	leaders/members
RALAT AX6	Organize task committees	May 13	leaders/members
RALAT – C6	rabus	June 10	leaders/members
RAMC – 14	canal lining	May 20	leaders/members
RALAT – C1	rabus	May 5	leaders/members
RAMC – 17	rabus improve communication	May 1991	members/leaders
RAMC – 18B	meeting to create task committees rabus	April 15	members/leaders
RAMC – 19A	clean ditches re-structure canal outlet	April 11	members/leaders
RAMC – 25	widening and cleaning of canal	May 6	members/leaders

Self-Assessment as a Strategy for Measuring and Monitoring IA Performance

The second phase of the self-assessment experiment was initially introduced in May, 1991. The succeeding graphs present the comparative results of the self-evaluation done for May and June, 1991. In general, there appears to be an increasing trend in the responses in almost all categories assessed. This may imply improvement in the performance of individual leaders, which when viewed entirely would reflect the overall performance of the IA.

The improvement could be attributed to the intervention activities introduced such as the reorganization of farmers into smaller groups, the self-assessment scheme undergone by members and the value-focused training experienced by the farmers. The fact that the farmer leaders revealed a relatively low assessment at the outset is an indication that an objective documentation of the situation in their areas of responsibility was desired. The validity of the succeeding assessment results could be checked by the self-assessment done by the farmers. Moreover, the TSA leaders are compelled to report to the monthly BOD meeting on the situation of their TSA based on the self-assessment responses. Thus, it would be difficult for the TSA leader to fabricate assessment results as the BOD can check these out. It would be advisable that officials of the IA validate the self-assessment results from time to time.

CONCLUDING REMARKS

Both phases of the self-assessment scheme being introduced aim to improve IA performance through "homespun" improvements and active involvement at the farmer members' and IA leaders' level. Considering that the self-evaluation and corresponding action shall be made at the STSAG/MFDG and TSA leadership level, improvements may be small but comprehensive for the IA as a whole.

For the scheme to work effectively, however, it would need members and leaders who are sensitive and able to perceive the problem and its effects on the performance of the STSAG/MFDG/TSA. Lastly, and most important, it would need members and leaders who perceive that the IA is crucial to their success as farmers in order for them to care enough to do something about improving its performance for the betterment of service delivery.

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Annex 1

Symbols used in Farmer-Member Self-Assessment Activity

– Area has adequate amount of water

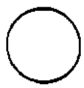
– Area has excess amount of water

– Area had deficient amount of water

– Canal is clean

– Canal is unmaintained/ grassy canal

– Structure is obstructed or defective



– Structures are functional

– Structures need rip-rapping

– Proposed structures

– Leaders and members have good relationship

– Leaders and members do not have good relationship

100% 50% 25%

– Collection efficiency

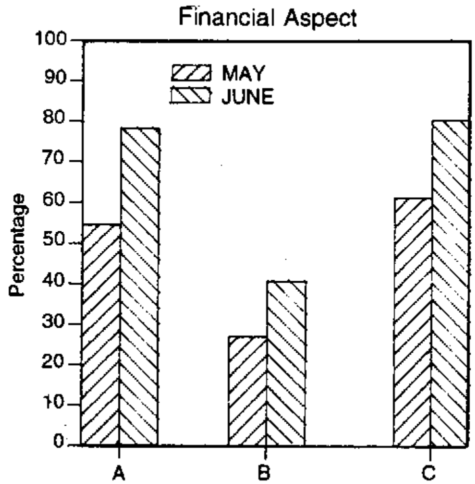
Annex 2

RAMC-21 Action Plan

Activities	Group/persons responsible	Date to be implemented
1. Consolidation/reorientation of members	Core groups/Committee groups I&II	1 week
2. Bayanihan/rabus	Group II (service committee, lead committee)	18 July 1991
3. Rabus	Group I (service committee, lead committee)	18 July 1991
4. Review and finalization of TSA policies (re: penalties for absent members and those who defy TSA rules and regulations)	Education and training committees and STSAG/MFDG leaders	5 August 1991
5. Monthly TSA meeting	MFDG leaders/education training committee	3rd Saturday of July
6. Organizational meeting for Group III	TSAL/FIO	Within July

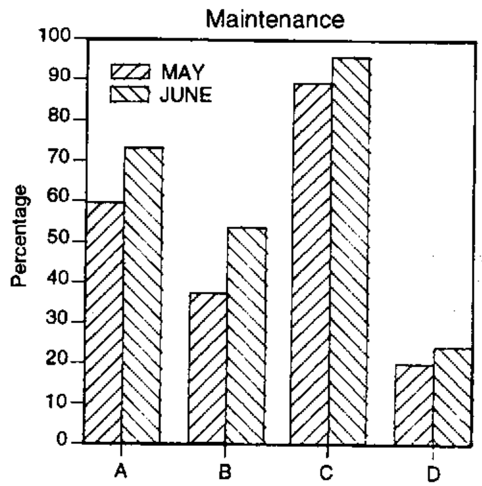
Annex 3

Comparative Results of Self-Assessment, May to June



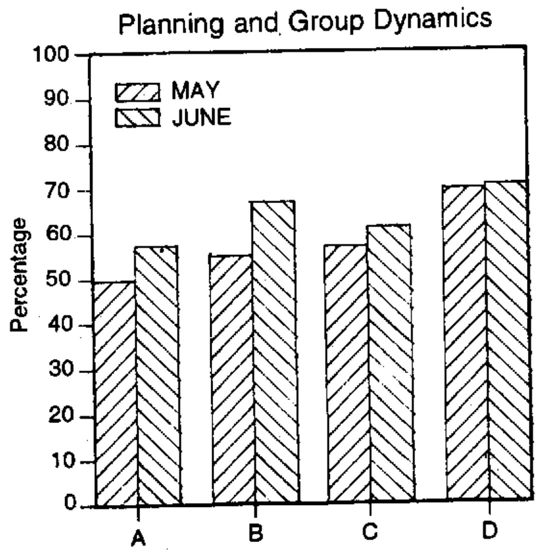
Legend:

A - Affordability to pay ISF: farmers in TSA who can afford to pay
B - Timeliness of payment: farmers who pay ISF on time
C - Willingness to pay: farmers willing to pay ISF



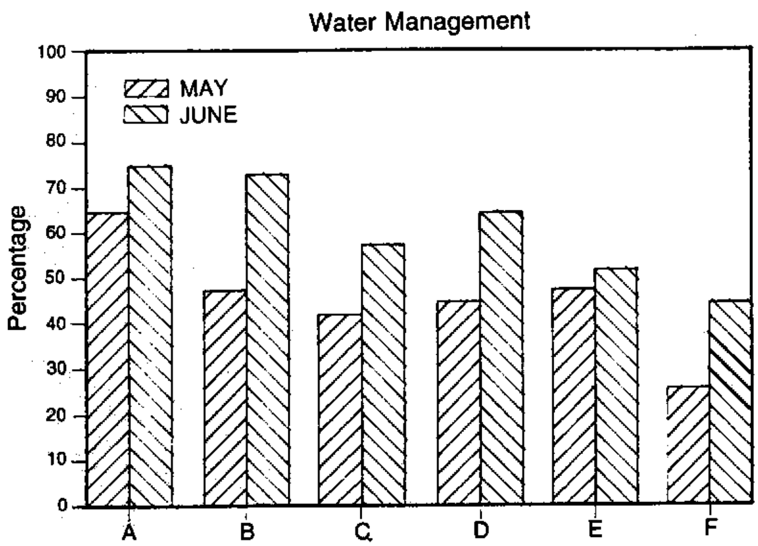
Legend:

A - Turnout maintenance: MFDs kept clean
B - Rabus (voluntary work): farmers who participate
C - Rabus: farmers who participate and perform well
D - Preventive maintenance: farmers who give notice when there is a possible damage in structure or when repairs ~~are needed~~



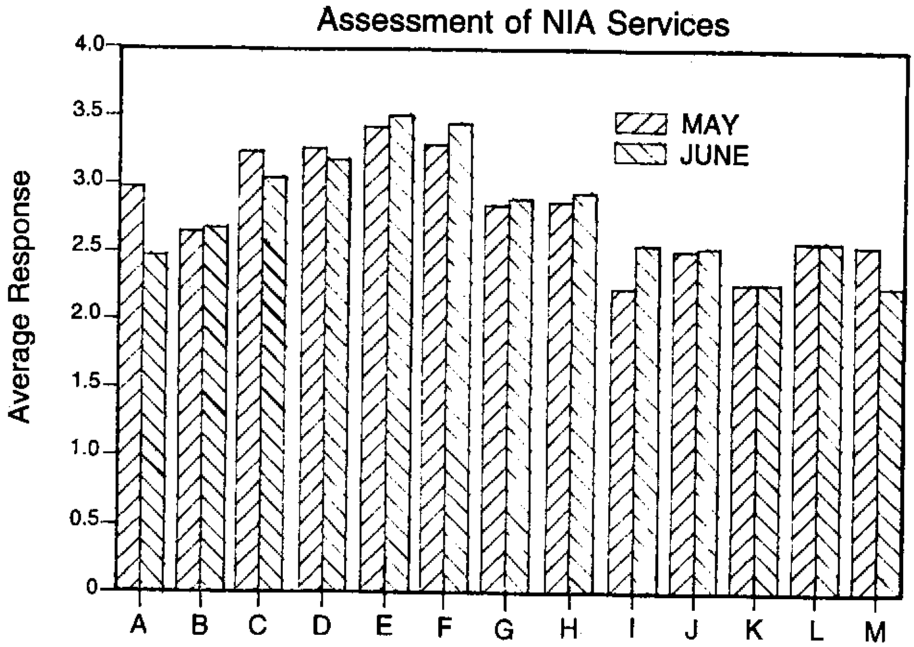
Legend:

A - Attendance in meetings: farmers in TSA who attend meetings
B - Participation in meetings: farmers who participated in meetings
C - Upward linkage: problems brought to the IA or BOD
D - Downward linkage: IA or BOD decisions disseminated to farmers



Legend:

A - Water distribution: farm holdings with sufficient water
B - Communication: farmers informed when they will be given water
C - Water saving: farmers who close gates when farm has sufficient water
D - Rotation: farmers who help in rotation when there is lack of water
E - Conflict management: conflicts resolved in one month
F - Task distribution: farmers in the TSA given specific tasks



Legend:

A - Relations with NIA officials
B - Familiarity of TSA members with IDO
C - Familiarity of TSA members with IDO
D - Familiarity of TSA members with WMTs
E - Familiarity of TSA members with DTs
F - Familiarity of TSA members with FIOs
G - Participation of FIOs in IA activities
H - Participation of WMTs in IA activities
I - Participation of DTs in IA activities
J - Participation of IDO in IA activities
K - Timeliness in cropping calendar
L - Cleanliness and repairs of structures
M - Incentives for early payment
N - Timely resolution of NIA-IA problems

Notes: For A and B.1 - not good, 4 - very good
For C to F.1 - not familiar, 4 - very familiar
For G to J.1 - no participation, 4 - full participation
For K to N.1 - not satisfied, 4 - very satisfied

Design Principles and the Performance of Farmer-Managed Irrigation Systems in Nepal[16]

Elinor Ostrom and Paul Benjamin[17]

ABSTRACT

EIGHT "DESIGN PRINCIPLES" are introduced as fundamental features underlying long-enduring farmer-managed irrigation systems (FMIS). The design principles are: clearly defined boundaries, proportional equivalence between benefits and costs, collective choice arrangements, monitoring, graduated sanctions, conflict resolution mechanisms, minimal recognition of rights to organize and nested enterprises. These design principles are conceived to be relevant, in addition to the performance measure longevity, to other performance measures: water adequacy, equity and timeliness. The relationship between the design principles and performance measures is being examined through a structured database that contains over 130 case studies of irrigation systems in Nepal. Coding forms based on the Institutional Analysis and Development Framework developed at the Workshop in Political Theory and Policy Analysis are used to code the case study materials. Questions in the coding forms are sensitive to the definition of the irrigation system under study, an operational level "action situation," and to operational rules, such as boundary, authority and scope, information and payoff rules. The data are entered into a relational database and will be analyzed by a variety of techniques. We anticipate identifying configurations of rules in each irrigation system, based on design principles and crafted by irrigators to fit their particular circumstances that address performance measures such as water adequacy, equity, and timeliness.

INTRODUCTION

Extensive studies of farmer-managed irrigation systems have documented the diversity of specific rules used on many long-enduring and successful FMIS (Uphoff 1986; Levine and Coward 1986; Siy 1982 and 1988; Tang 1991). Recent research has uncovered a diversity of rules used even on

16 This report is a product of the Decentralization: Finance and Management (DFM) Project, sponsored by the Office of Rural and Institutional Development of the Bureau for Science and Technology (S&T/RD) of the U.S. Agency for International Development (USAID). Associates in Rural Development, Inc. (ARD) is the prime contractor for the DFM project under USAID contract number DHR-5546-Z-00-7033-00, with subcontracts to the Metropolitan Studies Program of the Maxwell School of Citizenship and Public Affairs at Syracuse University and the Workshop in Political Theory and Policy Analysis at Indiana University.

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separate branches of small FMIS. Rita Hilton's 1991 study of the Karjahi Irrigation System in Nepal — a "generations-old" FMIS — illustrates the multiplicity of rules used within one small, self-governed system. The Karjahi System serves between 460 to 500 hectares and around 200 households, It is divided into 7 *maujas* (branches) for administrative purposes, and each mauja has the authority to make its own rules.

> *In Karjahi and Bergain, the head area always receives water first, and the tail last. In Buruwagaon, the pattern is reversed: the tail always receives water first. Gurgain mauja also uses a fixed pattern, but the starting point of distribution rotates annually. The plot which received water first in year "t-1" receives it last in year "t." Two additional maujas (Guruwagaon and Pakwai) use some sort of rotation in their areas, but the starting point of rotation is not fixed in any pattern. It is determined annually. The remaining mauja (Bachaha) determines the pattern of water distribution on an annual basis. The primary criterion used in setting the pattern in any one year is need: the driest plots are given water first (Hilton 1991: 25).*

DESIGN PRINCIPLES

Specific rules are like specific blueprints for constructing successful irrigation projects around the world; no blueprint is the same. No set of rules-in-use is the same either, if local participants have actively crafted rules over time to fit their own changing circumstances. Blueprints vary but common engineering principles underlie the blueprints used to construct physical structures. Similarly, design principles underlie specific rules that users have developed in crafting their own irrigation institutions.

In our own theoretical and empirical work on institutional design, we have attempted to elucidate the core design principles used in many long-enduring, farmer-managed institutions (E. Ostrom 1986). By "long-enduring" we mean institutions that have been in operation for several generations. By "design principle" we mean an element or condition that helps to account for the success of these institutions in sustaining the physical works and gaining the compliance of generations of users. In long-enduring farmer-managed irrigation systems, farmers agree to maintain the physical works. The repeated willingness of farmers to invest large amounts of labor and other resources is strong evidence that farmers receive more benefits from these systems than the costs they have to pay. It is common for farmers to devote 20 or more days of labor per year to the operation and maintenance of a farmer-managed system. Farmers who divert valuable labor from other activities to dig out canal sections, repair diversion works, and operate weirs are "voting" with their backs; this work demonstrates a continued willingness to contribute resources to the sustenance of their joint facility. We will attempt to show that design principles underlie this willingness of farmers to invest in this manner. The design principles we have derived from long-enduring, farmer-managed irrigation institutions are listed below and an initial explanation is presented as to why these principles might enhance the longevity of FMIS.[18]

18 The next four pages draw on Chapter 4 of Crafting Irrigation Institutions by Elinor Ostrom (1990b).

Design Principle One: Clearly Defined Boundaries

The boundaries of the service area and the individuals or households with rights to use water from an irrigation system are clearly defined.

Defining the boundaries of the irrigation system and of authorized users can be thought of as a "first step" in organizing irrigation. Vague boundaries that do not define clearly who has and who does not have rights to water will lead to uncertainty about what is being managed and for whom. If boundaries are not clearly defined and the system is not legitimately closed to "outsiders," local irrigators face the risk that benefits they produce will be reaped by noncontributors. Closing the boundaries is not alone enough. If those irrigators who have authorized access can profitably use more water than is available, farmers at the head end of the system will take so much water that those at the tail end may not have an adequate and predictable flow of water. Consequently, although some farmers may reap considerable benefits, the whole system will not be producing as much as it could.

In addition to clearly defined boundaries, recent empirical analysis shows that the *type* of boundary rule in use is crucial. In a study on the effect of boundary rules on water adequacy in 27 irrigation systems that used land as the sole boundary rule, S.Y. Tang found that only 6 (22%) had adequate water. Of 16 systems that used other types of boundary rules 12 had an adequate water supply. Further, reliance on land as the sole boundary rule was not associated with high levels of rule conformance, while 94 percent of those using more specific boundary rules were characterized by high levels of rule conformance.

Design Principle Two: Proportional Equivalence Between Benefits and Costs

Rules specifying the amount of water that an irrigator is allocated are related to local conditions and to rules requiring labor, materials, and/or money inputs.

Adding well-tailored appropriation and provision rules to boundary rules helps account for the sustenance of irrigation systems themselves. Different rules are used in FMIS to mobilize resources for construction, maintenance, and to pay water guards. In long-enduring systems, those who receive the highest proportion of the water are also required to pay the highest proportion of the costs.[19]

Design Principle Three: Collective Choice Arrangements

Most individuals affected by operational rules are included in the group who can modify these rules.

Irrigators can tailor the rules governing irrigation systems to local circumstances. Individuals who interact personally with one another and with the physical world can modify their rules over time and expeditiously fit rules to the peculiar nuances of their setting. If users can keep costs of changing rules low, self-managed institutions characterized by the first three principles should be able to devise effective operating rules.

The presence of effective operational rules does not, however, mean that users will observe them. The problem of gaining compliance to rules — no matter what their origin — is frequently

19 Walter Coward (1979) identified this design principle as a major characteristic of the successful irrigation systems he had examined. It was also identified by Mancur Olson (1969) as a very general principle — called fiscal equivalence — of any public institution that would achieve efficient use of resources.

assumed away by theorists positing all-knowing and all-powerful *external* authorities that enforce agreements. In many FMIS, no external authority has sufficient presence to play a role in day-to-day enforcement of the rules-in-use. External enforcement cannot be used to explain high levels of compliance. In long-enduring systems, irrigators themselves make substantial investments in monitoring and sanctioning activities.

Design Principle Four: Monitoring

> *Monitors, who actively audit physical conditions and irrigator behavior, are accountable to the users and/or are the users themselves.*

Design Principle Five: Graduated Sanctions

> *Irrigators who violate operational rules are likely to suffer graduated sanctions (proportional to the seriousness and context of the offense) from other irrigators, from officials accountable to these irrigators, or from both.*

In long-enduring systems, monitoring and sanctioning are undertaken not by external authorities but by the participants themselves. The initial sanctions used in these systems are also surprisingly low. Even though it is frequently presumed that participants will not spend the time and effort to monitor and sanction each other's performance, substantial evidence exists that irrigators do both in long-enduring user organizations.

Design Principle Six: Conflict Resolution Mechanisms

> *Users and their officials have rapid access to low cost, local arenas to resolve conflicts among users or between users and officials.*

Applying rules is rarely an unambiguous task. Even such a simple rule as "each irrigator must send one individual for one day to help clean the irrigation canals before the rainy season begins" is open to multiple interpretations. Who is or is not an "individual" according to this rule? "Interpretations" of rules can be developed by those seeking to slide past or subvert rules. Ambiguities will even exist for those intending to follow the spirit of a rule. What happens if the only able bodied worker is sick, or unavoidably in another location? The continuance of rule conformance is dependant on some mechanism for discussing and resolving what is or is not a rule infraction. Some individuals may "free ride" and send less-valuable workers. Others, sending their strongest workers, come to view themselves as "suckers." They are paying more than others for the same benefits. Eventually, only children and old people will be sent to do work that requires strong adults. The system, both in its physical and social manifestations, breaks down.

While the presence of conflict resolution mechanisms does not guarantee that institutions will endure, it is difficult to imagine how any complex system of rules could be maintained over time without such mechanisms. In many FMIS, conflict resolution mechanisms are informal and individuals selected as leaders are also skilled in conflict resolution.

Design Principle Seven: Minimal Recognition of the Right to Organize

> *The rights of users to devise their own institutions are not challenged by external governmental authorities.*

Many FMIS organize in a *de facto* manner and are not recognized by national governments. Consequently, the officials of the FMIS may not legally open a bank account in the name of the FMIS or represent the interests of their members before administrative or judicial bodies. Without official recognition of the right to organize, it is difficult to hold either user-group leaders or members accountable for their actions. De facto organization is sufficient in isolated locations where irrigation is used primarily for subsistence agriculture. But when roads are constructed that create market opportunities for surplus products, the level of conflict over the allocation of water to different farmers or uses can escalate. If government agents use their authority to support those who refuse to follow the rules of a de facto organization, other participants will find it difficult to continue to follow rules as well. When its authority to make legitimate rules for its own members is challenged and not supported by the formal government, an effective but formally unrecognized FMIS may crumble rapidly.

Design Principle Eight: Nested Enterprises

> *Appropriation, provision, monitoring, enforcement, conflict resolution and governance activities are organized in multiple layers of nested enterprises.*

Long-enduring, large and complex irrigation systems are often organized into several tiers of nested organizations. Work teams as small as four or five farmers may be established. Irrigators using a particular branch of an irrigation system may be the basis for another level of organization. A third layer may involve all farmers served by one headwork. A fourth layer may involve all systems served by the same river. By nesting layers of organization within one another, irrigators can take advantage of different scales of organization. Small-scale work teams are an effective technique for overcoming free riding; everyone monitors everyone else. Shirking is not easy while communicating about it is. Large-scale enterprises allow systems to realize economies of scale where they are relevant and to aggregate capital for investment. By utilizing more than a single scale of organization, many FMIS have sustained large-scale irrigation systems for long periods of time. The long-enduring and successful efforts of farmers to sustain their own complex systems håve much to teach external agencies who build projects with no investment from the irrigators themselves.

These eight design principles are stated generally. The specific way that suppliers and users of irrigation water have crafted rules to meet these principles vary in their particulars. Successful, long-enduring, irrigation institutions that appear to be based on quite different underlying designs have all developed methods to equate the costs of building and maintaining the irrigation system appropriate to the benefits that are achieved. Their underlying principles, we hold, are similar.

Our work on design principles has focused so far on another performance measure, long-term survival of common property regimes. To examine long-enduring common property institutions, we have analyzed a small number of well-documented cases from several countries. Design principles were derived from studies of long-enduring common property institutions including *huerta* irrigation in Spain (Mass and Anderson 1986; Glick 1970), communal tenure in Swiss Alpine meadows and forests (Netting 1981), and common lands in the mountains of Japan regulated by local village institutions (McKean 1986).

We now have the opportunity to examine a range of other performance measures that relate to annual production. An interest in longevity as a performance measure, in fact, depends eventually on short-term performance, or the kinds of performance farmers and irrigation managers are concerned with each year. If an FMIS fails to perform according to expectations of adequacy for a period longer than a few years, it is unlikely that it will endure long. So, we are now examining the relationship of the design principles to performance measures from what Svendsen and Small (1990) call the farmer's perspective.

We will choose three performance measures that Svendsen and Small propose for the farmer's perspective: equity, adequacy, and timeliness. According to Svendsen and Small (1990,

p. 393), *adequacy refers to the average depth of water delivered over a season relative to some standard. It is the most fundamental of performance measures.* As the findings from Tang's study indicate, the relationship between Design Principle 1 (Boundary Rules) and the adequacy of water supplied to farmers is likely to be complex.

Equity of water distribution is always measured in terms that relate the quantity of water (or the opportunity to receive water) to some basis such as the amount of labor contributed to maintenance, the amount of investment made in capital facilities, the need for water measured in terms of the quantity of land owned, or some combination of these. The specific concept of equity used in particular irrigation systems varies, but the importance that farmers place on equity as a performance variable is always high. Coward and Levine (1986: p. i) conclude that for traditional FMIS: *Equity of water distribution is the priority rule that drives distribution decisions or is the criterion against which all those decisions are tested.* Levine and Coward state in another article (1989:17) that *systems which appear to be successful, in technical and economic terms as well as from a social point of view, have clear equity rules, appropriate physical structures and organizational procedures that permit effective implementation of those rules.*

Timeliness is another measure of performance from the farmers' point of view. Svendsen and Small (1990: p. 395) state that timeliness *relates to the distribution of water across the seasons relative to some utility-based standard. This standard is typically derived either from crop requirements or customary or contractual obligations.*

Conducting a large-scale comparative study of irrigation systems within a single country is expensive. Fortunately, many case studies of irrigation systems in Nepal have already been conducted and written up. Much credit goes to Prachanda Pradhan and Robert Yoder of IIMI in Kathmandu for organizing research and collecting reports on Nepali farmer-managed irrigation systems from disparate sources.

Creating a Structured Database from Textual Descriptions

The sheer quantity of case studies written about irrigation systems in Nepal represents both an opportunity and an obstacle. No amount of in-depth reading and organizing these case studies could ever provide the basis for empirical testing of how design principles are related to specific performance measures. Both the number of cases and the number of variables involved are too large. But, by establishing a structured database, it is possible to undertake qualitative and quantitative analyses of these variables and their interrelationships.

During the last several years, colleagues associated with the Common-Pool Resource (CPR) Project at Indiana University have developed a general way of coding CPR resources and have coded about 50 irrigation systems and 50 fishery systems around the world (Tang 1991, 1992 and Schlager 1990) and a limited number of forestry resources. We have recently revised and focused the general coding system to apply to the extensive materials on Nepal irrigation systems.

In coding a case, we first read the written description(s) carefully and then answer a series of questions about the case that are contained in our Coding Manual. In our physical archive, we now have at least one written description for each of over 130 Nepal irrigation systems. Some of these systems have been described by multiple authors at different time periods. Some of the descriptions are the result of rapid rural appraisals. Some of the descriptions are theses written a considerable time after completion of the field work.

For each case, we complete the following forms: Appropriation Resource, Location, Operational Level, Subgroup, Operational Rules, Organizational Inventory, and Organizational Structure and Process Coding. The basic design of the coding forms is closely related to the Institutional

Analysis and Development (IAD) framework developed at the Workshop in Political Theory and Policy Analysis during many years (Kiser and E. Ostrom 1982; Oakerson 1986; V. Ostrom, Feeny, and Picht 1988; V. Ostrom 1991). The coding forms were also developed so as to use the enhanced capabilities of a relational database for storing and analyzing complex, multitiered, information. We use RBASE, a popular commercial database, so that the database may eventually be installed at other research sites. Copies of the coding forms and the manual will be made available at the conference or by written request. Here we will briefly describe each form.

The Appropriation Resource Coding Form is used to describe the physical works involved in the distribution of water to a series of field channels. As Robert Hunt has frequently pointed out, a major problem facing any researcher interested in studying the governance and management of irrigation systems is gaining a consistent definition of what is meant by the term "irrigation system." Some "systems" include everything from the headworks of a major multi-purpose dam to the field channels of all farmers who eventually receive water passing through the headworks. Others focus on smaller subsystems of large projects. Still others combine studies of subsystems with studies of larger systems.

We take a bottom-up view. We focus first on the immediate, physical works on which a set of farmers are dependent for their irrigation water. We call the process of withdrawing water "appropriation" and use "appropriation resource" for the resource from which water is withdrawn (Gardner, E. Ostrom and Walker 1990). This allows us to compare institutional arrangements and results across sectors such as fisheries, groundwater and grazing. Having identified this first unit, we also code information about the distribution system (if any) that connects the appropriation resource to a headworks and about the production systems or headworks themselves. Our database contains information about the full system of which an appropriation resource may be a subsystem or indicates that the appropriation resource is equivalent to a full irrigation system. In this way, we insure comparability in the database.

The Location Coding form allows us to place a particular Appropriation Resource into a geographical and jurisdictional milieu. On this form we record information about the specific region surrounding an irrigation system. On the Operational Level and the Subgroup Coding Forms, we operationalize the concept of an "action situation" used in the IAD framework. We attempt to capture here information about the level of analysis in which individuals take actions that directly affect the physical world. On the Operational Level Coding form we code information about the number of participants and their stakes, on the information available to them, on the strategies that they could and do adopt, and on the payoffs distributed to different participants. We also record here whether there are more than one subgroup using the irrigation system and the differences that exist among subgroups in regard to their rights and duties in using a system. Most Nepal cases involve one subgroup.

In the IAD framework, operational rules are prescriptions that specify what direct actions individuals (belonging to a particular subgroup) are permitted, forbidden, or required to undertake (Gardner and E. Ostrom 1991). Thus, we use a specific symbol (called a deontic operator) for each action listed in this form that is specifically permitted, forbidden, or required. We also use a specific code for a default condition when no rule has been specifically developed regarding a particular action.

The Operational Rules coding form focuses primarily on the rules-in-use that affect: (1) who is authorized to use the system — boundary rules, (2) what actions can be taken and what effects are allowed — authority and scope rules, (3) the information that individuals must or must not share — information rules, and (4) rewards and punishments assigned to actions and outcomes — payoff rules. Our operational rules coding form is both the most complex and the most innovative of our coding forms; we know of no prior effort to code detailed rules-in-use of this type.

The Organizational Inventory Coding Form comprises a matrix that relates types of activities — provision, production, distribution, appropriation, and use — to types of organizational units that may exist to undertake operational, collective choice, or constitutional choice actions. If the case describes sufficient information about one or more of the organizations listed in the Inventory, we complete the Organizational Structure and Process Coding Form. Information is coded about the size and purpose of an organization, the means that people in the organization can use to express their needs and concerns to officials, how an organization is financed, how revenue is collected, and whether interventions by external agencies have been involved and their relative success or failure.

For analysis of the data we use a variety of techniques. We have identified variables within our coding manuals that will serve as indicators for each of the design principles and the performance measures defined above. Drawing on the theory of collective action, we try to ascertain relationships among variables such as size of group, transaction costs, simplicity of organization with performance measures. We anticipate that there will be *configurations* of design principles that will be associated with performance measures. That is, the design principles will "lean on" one another, in a way analogous to the individual stones that combine to form an arch; if the stones were totally independent of one another, the arch would not work. In this sense, we anticipate that forms of monitoring and sanctioning will support one another; if graduated sanctions are available, monitoring will be an empowered and efficacious task. If farmers monitor, sanctions do not need to be as large. With this expectation, we are beginning to experiment with Qualitative Comparative Analysis (QCA), a computer program that excels in identifying configurations of variables and their relationship to performance measures.

The advantage of having a large number of cases in our effort to analyze the relationship between design principles and specific performance indicators is that we cannot expect simple relationships. As Svendsen and Small (1990: p. 394) remind us, *when water is abundant across the system, there is no motive for farmers anywhere in the system to concern themselves with equity issues. When water is short, questions of equity among farmers may become more important.* With more than 100 cases, we can begin to undertake far more complex analyses than has been the case in prior work. We expect to have completed our coding by November and to bring with us for discussion some preliminary findings.

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Performance Measure for Improving Irrigation Management

Ramchand Oad and R.K. Sampath[20]

ABSTRACT

A MEASURE TO evaluate performance in irrigation systems is formulated using the mean square prediction error concept. In the context of irrigation systems, the term error means the deviation of actual performance from a reference performance. The measure analyzes performance in terms of the management objectives of adequacy, dependability and equity of water delivery. It provides an understanding of the management capacity to schedule and distribute water in an irrigation system. Application of the performance measure is demonstrated by evaluating performance of an irrigation system in the North-West Frontier Province of Pakistan.

RESEARCH BACKGROUND AND OBJECTIVES

Reliable measures of system performance are extremely important for improving irrigation policymaking and management decisions. Several researchers have proposed a number of performance measures (Seckler et al. 1988; Oad and Podmore 1989; Sampath 1989; Abernethy 1986). Sampath (1989) analyzed these measures and suggested that most indicators violate some properties desired in a performance measure. There is a consensus on the management objectives that need to be evaluated, but inconsistency is observed in the selection of performance measures that appropriately describe those management objectives.

This paper reports our research to formulate a measure that can evaluate the level of managerial performance in terms of achieving the objectives of an irrigation system.

ANALYSIS

The research premise is that performance evaluation is meaningful only in terms of certain management objectives, and these must be defined for a given social and economic context. Then,

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some key variables that describe these management objectives are formulated and used to develop a performance measure. Analysis of the existing system performance, using this performance measure, can identify required improvements.

Irrigation Management Objectives

Barker et al.(1984) propose that an irrigation system, consisting of a water delivery and a water use subsystems, can be conceptualized to have two sets of objectives. One set relates to the outputs from its irrigated area, and the second set relates to the performance characteristics of its water delivery system. They state that "...inherently, the two sets of objectives are linked. If the water delivery performance objectives are met, then the output objectives should be achieved." This argument implies that one needs to only analyze water delivery subsystem performance for understanding performance of the whole irrigation system. The authors suggest the following most common management objectives of water delivery systems.

Adequacy in water delivery systems may be defined as the ability to deliver the amount of water to meet farmers' irrigation needs. Farmers' irrigation needs can be based on the knowledge of a crop consumptive use and/or social norms of equity. Dependability is defined as the delivery of a relatively uniform amount of water over time. Dependability reflects the combined effect of reliability and predictability and describes the arrival of a scheduled amount of water at a given place in a given time. The concept of equity deals with the distribution of irrigation water among users in a fair and just manner.

Water Delivery Performance Indicators

There are two properties that the irrigation water delivery variables should satisfy. The variables should represent both the farm and the water delivery system, and be subject to management control so that they can be manipulated to improve system performance (Merriam 1987).

In gravity flow irrigation, the variable that satisfies the two properties is the flow rate. Also, if the duration of a certain flow rate at a control point is known, then any other form such as water volume or depth can also be used. Denoting Q as water flow measured at a point x in the system at a time t, we define water flow required by the farmers to be $Q_r(x,t)$. Also, we can define $Q_s(x,t)$ as the flow rate scheduled or planned for delivery and $Q_a(x,t)$ as the flow rate actually delivered by the system management.

Formulation of the Performance Measure

The performance measure analyzed in this research, called the performance error, is based on the mean square prediction error theory proposed by Theil (1966) and adapted by Sampath (1989) and Seckler et al. (1988). Theil (1966) states that if we have n number of pairs (P_i, A_i) of corresponding predicted and achieved forecasts, then the seriousness of a given forecast error can be measured by:

$$e^2 = \frac{1}{n}\sum_{i=1}^{n} (P_i - A_i)^2 \qquad (1)$$

In Equation (1), e^2 is the mean square prediction error for the set of n observations, and its square root gives us a measure of performance.

The term error, in the context of water delivery performance, may be defined as the deviation of actual amount of water delivered from the required or scheduled amount of water. For a given time period, therefore, Equation (1) can be written in terms of flow rate variables, Q_r, Q_s and Q_a. This error in actual flow rate may be due to reasons such as inadequate water supply, inappropriate scheduling and lack of physical capacity. When actual flow rate (Q_a) is equal to the required flow rate (Q_r), the error is zero and the system is performing perfectly. If no water is delivered in the system, that is Q_a=0, then e^2 is equal to one. Thus, the higher the value of e^2, the higher the error in water delivery and the lower the system performance.

Since we want to evaluate performance in terms of adequacy, equity and dependability, the total error can be decomposed into corresponding terms as follows:

$$\frac{(1)}{R}\blacksquare_R\,[Q_r(X) - Q_a(X)]^2 = (M_Q r - M_Q a)\,2 + (S_Q r - S_Q a)^2 + 2(1-r)S_{Qr.}\;S_Q a \tag{2}$$

where MQ_r and MQ^a are arithmetic means (over a region R) of required and actually delivered flow rates, SQr and SQa are the standard deviations of Q_r and Q_a, and 'r' is the correlation coefficient of Q_r and Q_a.

The statistical properties, means and standard deviations are calculated by standard procedures shown in the notes at the end of this paper.

In Equation (2), the first right side term which we call error in water adequacy (E_a), is a measure of water shortage. For a given time period at a control point, the difference in arithmetic means of actual water flow from the required flow indicates the level of inadequacy in system water supply. The second right hand side term in Equation (2) is the error due to unequal variations in actual water flow compared to the required flow and is, therefore, a measure of the spatial nonuniformity. At the outlet level, unequal variations of the delivery canal flow will cause unequal variations in the outlet discharges. For the outlet level performance, therefore, the term indicates inequity of water distribution among various farmers' groups. As such, the second term is defined as error in water distribution equity (E_e).

The third right side term in Equation (2) is the error due to incomplete covariance of required (Q_r) and actual (Q_a) irrigation water flows. This is a measure of the management capability to implement a scheduled irrigation water delivery pattern. The management capability is conceptually a function of the physical capacity of the system and the organizational procedures. If the scheduled water flow rates are derived from the requirement and water is distributed according to the schedule, then Q_a=Q_r and the correlation coefficient of Q_a and Q_r is unity, and the third term will be zero. A positive value of the term will indicate either an inadequate system physical capacity to deliver water according to the schedule, and/or inappropriate organizational procedures. We define the third right side term as error in management capacity (E_m).

It is desirable to divide the right side terms of Equation (2) by the sum of squares of the total error to get a proportional contribution of each error term as follows:

$E_a = (M_Q\ r - M_Q\,a)^2$ /right side of Equation (2)

$E_e = (S_Q\,r - S_Q\,a)^2$ /right side of Equation (2)

$E_m = 2(1-r)\,S_Q\,r.S_Q\,a$/right side of Equation (2) so that, $E_a + E_e + E_m = 1$

RESULTS AND DISCUSSION

Data Source

The application of the performance measure formulated in the previous section is illustrated by using data from an irrigation system in North Pakistan. The Warsak Lift Canal (WLC) irrigation system is jointly managed by the farmers and the Department of Irrigation. The design discharge of the main canal is 5.67 m^3/s at the source, but during the study period (Nov–Dec, 1989) the discharge at the source was 4 m^3/s. The design agricultural command area is about 14,000 ha, but the Irrigation Department targets a command area of about 12,000 ha for water delivery. The command area is served through 108 watercourse outlets or water users' groups. The watercourse outlets are ungated pipe outlets which flow continuously whenever there is water in the main canal. Irrigation water below the outlet is managed by the farmers' groups and this includes water distribution among themselves. In the main canal, it is managed by the Irrigation Department.

Management Objectives and Performance Indicators

The Irrigation Department has two water management objectives: to maintain an adequate water flow and depth in the main canal, and to distribute water equitably among various outlet groups. The objectives are related and have the common goal of delivering each outlet its fair share of irrigation water. If an adequate flow, and correspondingly an appropriate flow depth is maintained along the canal length, then the pipe outlets can withdraw their fair share.

The department has established some monitoring points along the main canal where it wants to maintain a certain flow rate, which may be called the scheduled or required flow (Q^r). This required flow is based on the considerations of agricultural command area below that point and an assumed cropping pattern in that area. In our study of the irrigation system, we measured actual flow (Q_a) at the monitoring points. These two flow variables, Q_r and Q_a, will be used to analyze the system performance at the main canal level.

Towards the objective of equity, each farmers' group is allocated a flow rate through its outlet called the sanctioned discharge (Q_s). The sanctioned discharge of an outlet is primarily a representation of the agricultural land serviced by that outlet and the system would be fair if the actual discharge through all outlets equals their sanctioned discharge.

In this study, ten outlets were selected and the flow through these outlets was measured (actual discharge, Q_a). In addition to the sanctioned and actual discharge, we need one more flow variable which will indicate the discharge capacity of the outlets as determined by their hydraulic design. This may be called the outlet design discharge (Q_d). The design discharge of an outlet is determined by hydraulic factors such as pipe size, its setting and hydraulic head over the pipe. A proper engineering design of an outlet would determine its size and setting based on its ability to deliver the sanctioned discharge. That is, if an irrigation delivery canal is managed close to its design condition, then the actual, design and sanctioned discharges of an outlet are essentially equal.

A qualification about the data is that the actual measurements reflect the system behavior during a two-month time period. Results of the analysis, therefore, may not truly reflect the long-term average behavior of the system, which is not the purpose of this analysis. The purpose of using these data is only to illustrate field application of the methodology.

Analysis of Performance at the Main Canal Level

The results of actual and required flow measurements at the monitoring points along the main canal are presented in Figure 1. The actual flow at all points is much less than the flow scheduled by the system management and there is serious shortage of water in the downstream sections. Water barely reaches km 36 compared to the targeted length of 45 km and the total canal length of 57 km.

Using the methodology of mean prediction error (Equation 2), we estimated the contribution of water adequacy, equity and the management capacity to the error in system performance (deviation of actual from required performance). The relative error terms for adequacy, equity, and management capacity are presented in Table 1. The high value of the correlation coefficient (r=0.97) indicates that the actual flow consistently deviates in the same direction, from the required flow (actual flows are always less than the required flows). Also, about 84 percent of the performance error is explained by the error in water adequacy (E_a). The results indicate that the system management is unable to maintain its target or required flow at the key monitoring points.

Figure 1. Water delivery pattern in the main canal.

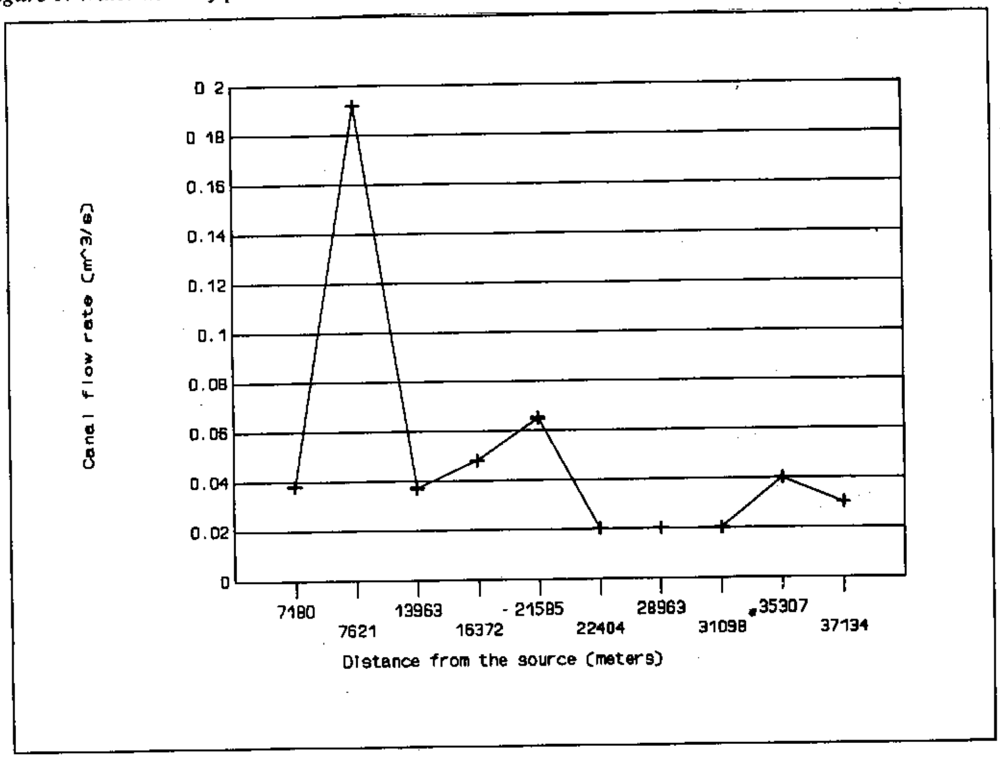

Table 1. Performance error in water delivery canal.

Distance from source(m)	Required flow (m^3/s)	Actual flow (m^3/s)	Performance error terms
80	3.95	3.95	Correlation coffefficient = 0.97
7,000	3.64	2.6	Error in adequacy (E_a)
14,500	3.13	2.5	Error in equity (E_e)
19,800	2.3	1.17	Error in management capacity
23,500	1.68	0.84	
30,500	1.23	0.42	
33,500	1	0.3	
37,000	0.75	0.01	
43,500	0.5	0	

Analysis of the error terms can provide possible explanations for this low performance. Note that the remaining two error terms, E_e and E_m, are small. The implication of the E_e term being small is that variation of the actual flow rate along the canal is the same as variation of the required flow. The fact that the management capacity term is small indicates that the physical capacity of the canal is not limiting. Also, available and required flows at the source are equal and seepage losses were measured to be none.[21]

All these results indicate that the reasons for the low performance are somewhat external to the system. Using the methodology of participant observation and informal interviews, the reasons were identified. In the upper sections of the canal, there are water withdrawals in excess of the planned use causing water shortages in the canal. This observation is supported by the flow measurement results in Figure 1 which indicate the sections in which excess withdrawals occur: in section 0–7 km and in section 14–20 km. The excess withdrawals are mainly due to additional water use by Afghan immigrants from across the border.

Analysis of Performance at the Outlet Level

The analysis of water flow in the main canal showed that the canal flow and the resulting water surface level are not maintained as planned. This finding and the fact that the outlets are ungated pipes indicate that the actual outlet discharge will not equal the design and the sanctioned discharge. That is, water distribution among various outlets may not be equitable. A comparison of the actual and sanctioned discharge of ten selected outlets confirm the inequity of water distribution (Figure 2). In the upstream and middle sections, outlets receive 140 to 200 percent of their due share, which means that either no water or little water for the downstream users (about 30 percent of their due share) will be available.

Using the methodology of mean prediction error, we calculated the three error components to explain the performance error in actual discharge with reference to the sanctioned discharge

21 This is explained by the fact that the canal runs on a contour with higher lands on one side. The water loss due to seepage on the lower side is compensated for by the incoming seepage from the lands on the higher side.

(Table 2). The Table also shows performance error components when sanctioned discharge is compared to the design discharge and when actual discharge is compared to the design discharge.

Comparing actual and sanctioned discharges, the error terms for equity (E_e) and the management capacity (E_m) explain about 87 percent of the total error. Water distribution among various outlets is certainly not equitable. The primary cause for this appears to be the management capacity (E_m=53 %) and not water adequacy (E_a=12 %). Recall that the error term for management capacity reflects the combined effect of the management decisions and the structural capacity of the system. In the context of ungated pipe outlets, no discharge regulation or other management decisions are involved. This implies that an explanation for the inequitable water distribution can be provided by the hydraulic features of the outlet.

Figure 2. Water distribution among outlets.

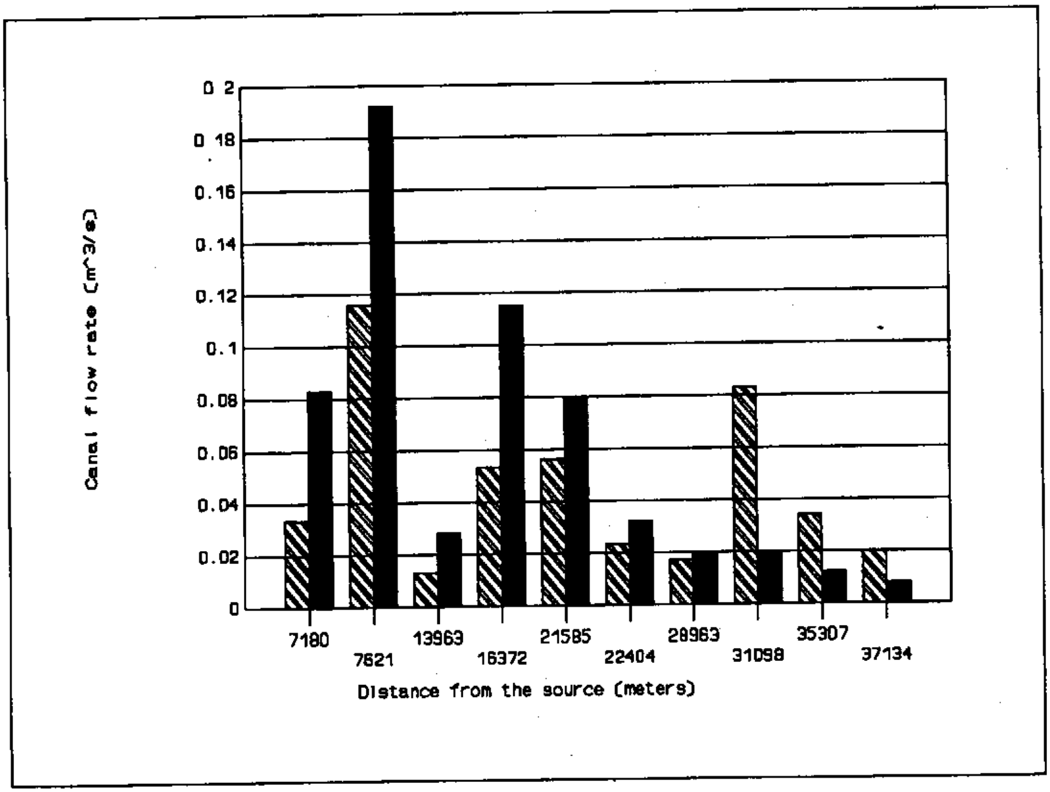

Table 2. Sanctioned, actual and design discharges of outlet.

Outlet	Discharges			Error terms			
Outlet location (m)	Q_s (m³/s)	Q_a	Q_d	Discharge variables	E_a	E_c	E_m
7180	0.03	0.08	0.04	Q_s and Q_a	0.12	0.34	0.54
7621	0.12	0.19	0.19				
13963	0.01	0.03	0.04	Q_s and Q_d	0.03	0.28	0.68
16372	0.05	0.12	0.05				
21585	0.06	0.08	0.07	Q_d and Q_a	0.08	0.06	0.86
22404	0.02	0.03	0.02				
28963	0.02	0.02	0.02				
31098	0.08	0.02	0.02				
35307	0.03	0.01	0.04				
37134	0.02	0.01	0.03				

As mentioned, actual discharge of an ungated pipe outlet is a function of water depth in the delivery canal and the pipe size. Since the flow rate and depth in the downstream sections of the delivery canal are less than the design, actual outlet discharge in those sections will be less than their design discharge. In Figure 2, we compare the outlet design discharge with the actual and sanctioned discharges. Note that in the upstream sections, design and actual discharges are generally equal, whereas in the downstream sections actual outlet discharge is consistently lower than the design discharge. An unexpected finding is that the design discharge for outlets does not equal their sanctioned discharge. The standard procedure is to design outlets by equating their design discharge to their sanctioned discharge.

The comparison of the outlet design and sanctioned discharge (Table 2) confirms the performance error, that the design discharge is not correctly related to the sanctioned discharge. About 67 percent of the performance error is explained by the management capacity term alone. The most convincing information of the inadequate management capacity is obtained when the actual discharge is compared to the design discharge. Now, the management capacity term explains about 85 percent of the performance error which implies that the system is not managed in accordance with design conditions.

CONCLUSIONS

The irrigation system performance measure formulated in this research (the performance error) is derived from the methodology of mean prediction error proposed by Theil (1966). In the context of irrigation water delivery systems, performance error means the deviation of actual system behavior (canal flow, for example) from scheduled or required behavior.

The performance error methodology provides an estimate of the total error in water supply relative to the farmers' water requirements. The farmers' water needs can be derived from the crop and soil water requirements, and/or they may be based on the social norms of equity and fairness. The total error can be explained by three additive error components related to water adequacy, equity and management capacity. Since the error terms are additive and decomposable, their analysis is effective in identifying the sources and levels of low system performance.

Application of the methodology was illustrated by analyzing the performance of an irrigation system in Northwest Pakistan. It is seen that the methodology is effective in analyzing the system performance in reference to actual and required water deliveries. The methodology also indicated possible causes for error in the water delivery system performance. The methodology was also effective in analyzing water distribution equity among various water users' groups in the irrigation system. The performance error in actual discharge for selected outlets was evaluated in reference to their design and sanctioned discharge. The evaluation identified possible sources, both managerial and structural, as causes of the performance error.

Notes:

1. The arithmetic mean of Q_r and Q_a is defined as,

$$M_Q\, r = \frac{1}{R} \blacksquare_R\, Q_r(X)$$

$$M_Q\, a = \frac{1}{R} \blacksquare_R\, Q_a(X)$$

2. The standard deviation is defined as,

$$S_Q\, r = [\frac{1}{R} \blacksquare_R (Q_r(X) - M_Q\, r)^2]^{1/2}$$

$$S_Q\, a = [\frac{1}{R} \blacksquare_R (Q_a(X) - M_Q\, a)^2]^{1/2}$$

3. The correlation coefficient is defined as,

$$r = [\frac{1}{R} \blacksquare_R (Q\, r(X) - M_Q\, r)\, (Q_a(X) - M_Q\, a)] / S_Q\, r . S_Q\, a$$

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Resource Mobilization and Water Distribution in a Large Farmer-Managed Irrigation System: A Case Study of the Chhattis Mauja Irrigation System in Nepal

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ABSTRACT

THE 600,000 HA which are irrigated under farmer-management in Nepal establish the importance of farmer-managed irrigation systems (FMIS). Recent policy changes in irrigation emphasizes improving the productivity of FMIS. Management improvement efforts would require an understanding of the present levels of performance of FMIS. Through this type of understanding an effective management improvement assistance package to FMIS could be developed.

This paper reports on observations and measurements made on performance specially related to the process of resource mobilization, the resulting water distribution and agricultural production in the Chhattis Mauja Irrigation System with nearly 3,500 ha, located in Rupandehi District of Nepal. Of 54 irrigated villages, one village each from head, middle and tail part of the system was selected for observations.

An analysis of the nature and extent of resources mobilized for operation and management is presented. The resulting water distribution at the head, middle and tail sample branches are also examined. Conclusions are drawn that resource mobilization, water allocation and distribution procedures have implications and use for performance measurement in other large FMIS as well as in agency-managed irrigation systems in Nepal.

INTRODUCTION

The improvement of irrigation services to farmers throughout Nepal is essential if higher levels of agricultural productivity are to be achieved. Intensive project-specific irrigation management programs must be implemented on all large irrigation systems. Such a program might not be possible for small schemes in the hills or in the Terai due to their scattered nature or for logistic reasons.

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It is estimated that an area totaling 943,000 ha of land is now under irrigation in Nepal. Of this, agency-managed systems which command over 2,000 ha, total nearly 216,733 ha. The rest comprises farmer-managed irrigation systems.

Predominance of irrigated area under farmer-management in Nepal establishes the importance of increasing agricultural production through improving performance of FMIS (CIWEC 1990).

FMIS in the Terai having command areas in excess of 1,000 ha, total nearly 100,000 ha. This research study was undertaken by the International Irrigation Management Institute (IIMI) to assess the potential and the needs of large FMIS. One of the purposes of the study was to extend the findings to other large systems in Nepal.

Many facets of farmer-management were observed and documented in the Chhattis Mauja Irrigation System (CMIS) during the study period (1988–1989). This paper, however, attempts to document only the performance observations specifically related to the processes of resource mobilization and water distribution.

To observe the activities of resource mobilization for water acquisition, water allocation, water distribution and system maintenance, one village each from head, middle and tail sections of the system was selected from among the 54 irrigated villages. Observations were made during the period 1988–1989 covering a complete crop cycle. The bases for resource mobilization and the process itself were monitored. The resulting water distribution was also measured.

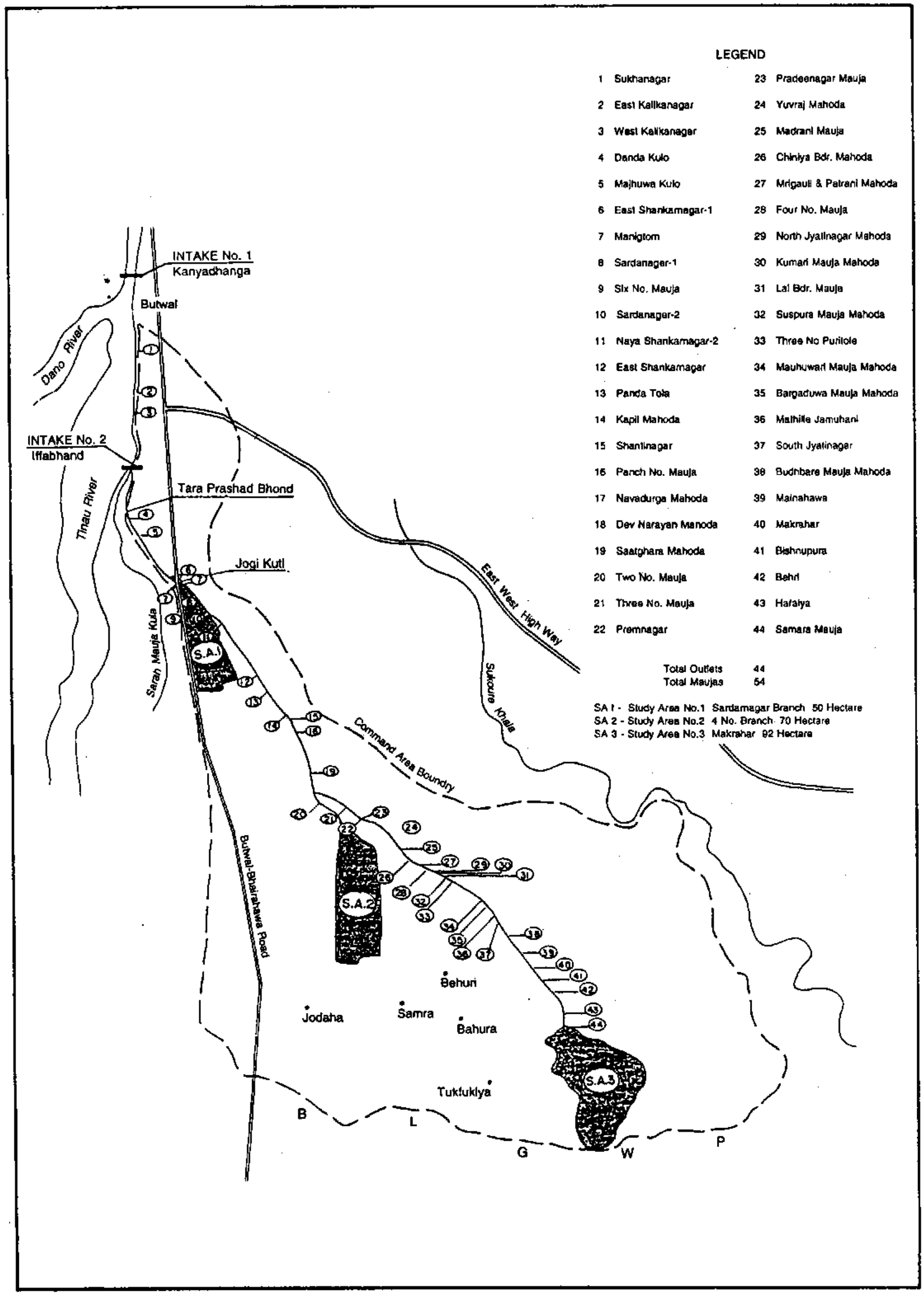
Findings on various aspects of the resource mobilization procedures for water allocation and distribution, which were observed and examined, are presented. The bases for resource mobilization as a key feature of the Chhattis Mauja Irrigation System were examined in-depth. Conclusions are drawn concerning resource mobilization and decision-making procedures through the four tiers of the CMIS organization. Attempts are also made to establish the potential and determine the needs of the CMIS. Finally, discussions are presented on the use and the implications of the resource mobilization procedures observed in the CMIS, towards improving the performance of both farmer-managed and agency-managed large irrigation systems in Nepal.

BACKGROUND

General

The Chhattis Mauja Irrigation System (CMIS) is one of the large farmer-managed irrigation systems located in the plains of Nepal. This system has a 3,500 ha command area and is located in Rupandehi District, a map of which is given in Figure 1. This system was initially constructed in the years 1846–63 by the local Tharus during the regime of Jung Bahadur, then Prime Minister of Nepal. When built, the system served only a few *maujas* (branches). Over time, significant expansion has taken place due to migration of people from the hills and it presently serves 54 maujas. At one time, when it served 36 maujas, it took the name of the Chhattis Mauja Irrigation System and has retained that name ever since. It receives water from a perennial river source: the Tinao River. This river has a catchment area of 554 km^2.

Figure 1. Chhattis Mauja Irrigation System.



Distribution System

The distribution network of the CMIS is complex. It consists of earth canals mostly in loose and gravelly soils (Figure 1). The complexity of operation is compounded by the very limited numbers of permanent outlets serving the individual branches. Most of the outlets are temporary and made of brush and wood with loose soil.

Management System

The irrigation organization of the CMIS has four tiers which are well-defined. The daily management at the different levels of the system is controlled by functionaries who are elected at the respective level or tier of the system. Meetings are held at each tier to direct the functionaries, resolve conflicts, discuss financial matters and adjust rules and operational policy.

Climate

Rupandehi District where CMIS is located is within the monsoon belt. Consequently, its climate is subtropical to tropical. Winter is quite dry and warm while summer is very hot and humid. As in other parts of the Nepal Terai, the Bhairahawa-Butwal area has three distinct seasons: a warm, wet season from mid-June through September, a cool dry season from October through February and a pre-monsoon hot season from March to mid-June. The average annual temperature in the area is about 24^0 C. The average rainfall is about 1,700 mm per year.

Water Allocation and Delivery Rules

The CMIS has rules and regulations to allocate and distribute water for rice crop whenever there is a shortage of water at the main source at Tinao River. In a good wet season it is usually not necessary to rotate water turns. All maujas requiring water for rice seed-bed preparation till transplanting and for the entire duration of the growing period have access to irrigation water in accordance with the water share or *kulara*[23] assigned. Usually, the *meth mukhtiyar* (system-level manager), *mukhtiyar* (branch-level manager) and *sipahi* (messenger) of the mauja receiving irrigation water decide and adjust the opening at the outlet to let in the quantity of water in accordance with the water share or kulara assigned. The duration is fixed according to water availability at the main weir at Jogikuti.

CMIS has a tradition of distributing water on a rotation basis whenever there is shortage of water at the time of seed-bed preparation and the time of transplanting and for successive irrigations. Normally, if there is a water shortage at the time of sowing rice seed, rotation distribution is put into effect from the head towards the tail end. The number of maujas to receive water in each rotation is decided on the basis of the quantity of water available at the main weir. If water is very scarce, only one mauja may be served at a time. The meth mukhtiyar in consultation

23 Originally one *kulara* was fixed as the requirement for one person-day of labor for each 25 *bigha* (5 ha). Now one kulara is determined on the basis of the water allocation of the village. The term is now used to refer to the allotment of water for each village as well as to the person who goes to work on the canal.

with the branch level mukhtiyars decides on the number of maujas in each rotation. Normally, water rotation for rice seeding is effected from the head of the system. For transplanting and for successive irrigations it may be alternated from head to tail end from one year to the next. The kulara is also the basis for allocation of water for principal winter crops like wheat and maize.

Features of the Three Sample Study Branches

For the performance study of the CMIS, three sample branches, one each from the head, middle and tail of the system was selected. The salient features of the three study branches are given in Table 1.

Table 1. Summary features of the sample village branch canals.

Features	Head	Middle	Tail
Name of village	Sardarnagar	Char number	Makrahar
Households	45	69	56
Distance from intake (km)	4.9	8.8	11.0
Distance from outlet to the starting point of command area (km)	0.2	0.7	2.3
Command area (ha)	50	70	92
Water allocation and labor responsibility for main system (kulara)	5	4	2
Land area per water allocation (ha/kulara)	10	17.5	46
Average land holding (ha/household)	1.0	1.0	1.6

RESULTS

Resource Mobilization

During the 1988/89 crop season, 7,599 person-days for main canal desilting and 16,100 person-days for main canal emergency maintenance were mobilized. If these figures (7,599 and 16,100) are valued at Nepali rupees (NRs.) 25 per person-day, the value of the labor would be NRs. 592,475. The total O&M cost of the entire system including main canal desilting and emergency maintenance, branch canal desilting, remuneration of village committee officials and cash contributions (information extrapolated from sample branches) and remunerations of executive committee officials then equals NRs. 355 per ha. (On 19-8-91, US$1.00 = NRs. 42.70).

However, the O&M cost of the main system from the perspective of the three sample branches was NRs. 356.73 per ha. Average O&M cost of three sample branches was NRs. 395.80 per ha (Table 2). The individual branch systems apply their own rules and regulations for desilting of main and branch canals. The cash contributions and the remuneration of the village committee officials also differ from one village to another, resulting in different O&M cost per ha among the sample branches.

Water Distribution

Rice crop. Water measurements were made to estimate the shares of water received by the sample branches as per their kulara entitlement. Measured discharge per kulara during part of the 1988 monsoon rice season in the sample branches showed that the largest water delivery was made to the head branch, whereas the middle branch received less water and the tail branch received almost no water. Irrigation water delivery on a per hectare basis was less than 4 l/sec/ha and 2 l/sec/ha in the middle branch. With evapotranspiration, seepage and percolation rates observed at 100 mm/day for the head branch, 70 mm/day for the middle branch and 20 mm/day for the tail branch, observed differences in actual delivery of water compared to allocation appears to justify the above differential to satisfy the local perception of equity and to meet the crop water requirements and other losses.

Average stream size made available for seeding and transplanting (1989 season) was 45 l/sec for the head branch, 49 l/sec for the middle branch and 46 l/sec for the tail branch.

Table 2. Total O&M cost of three sample branches.

Nature of O&M	Head	Middle	Tail
Main canal desilting (person-days)	186	174	74
Main canal emergency repair	443	339	158
(person-days)	(27)*	(25)*	(16)*
Branch canal desilting (person-days)	138	198	162
Cash paid in lieu of labor contribution (in NRs.)	4,600	9,800	6,200
Remuneration of executive committee officials (in NRs.)	275	220	110
Remuneration of village-level committee officials including torch light batteries (in NRs.)	3,900	2,032	0
Total (in NRs.)	28,625	30,452	16,560
O&M cost per ha (in NRs.)	572.50	435	180

*Person-days are calculated at NRs. 25 per day; absent person-days for which fine was paid.

Winter crops. The CMIS management distributed water for wheat and maize which are the principal winter crops. Mustard and lentil were also grown in winter, but they do not require frequent irrigations. Wheat and maize require large amounts of water but little is required for mustard and none for lentil.

Average discharge of 1 l/sec/ha (based on total command area of study branch) was made available for the head branch for the entire period during which winter crops were grown. An average discharge of 0.14 l/sec/ha was allowed for the middle branch and 0.02 l/sec/ha for the tail branch. Based on the actual areas cropped during the winter season, the average discharge for all three branches was much higher. Average discharge based on actual area cropped is 2.83 l/sec/ha for the head branch, 0.60 l/sec/ha for the middle branch, and 0.23 l/sec/ha for the tail branch.

Water availability appeared to be the determining factor for the observed variability in actual areas cropped in the winter season in the branches studied. Almost no water was made available to the tail branch and only a small amount to the middle branch, while the average discharge received by the head branch was almost 3 l/sec/ha. As farmers reported, with no water shortage in winter crops, and the average discharge of 1 l/sec/ha based on total command area of head branch, it was possible for the farmers to grow winter crops under the total area in the branch. However, for various reasons farmers did not grow winter crops on the whole area of the branch.

Farmers in the head and middle branches had access to as much water as they wanted for irrigation of wheat and other crops.

Agricultural Yields

The actual areas cropped by the farmers in the 1988–89 season are given in Table 3 and the respective average crop yields from crop cut observations in study areas are given in Table 4.

Table 3. Percentage of area under major crops in the sample branches, 1988–89.

Crop	Head	Middle	Tail
Rice	100	100	100
Wheat	35	24	12
Lentil	31	53	17
Mustard	24	5	5
Maize	34	15	0
Mixed (Lentil+Mustard)	10	18	6
Fallow	66	85	160
Cropping intensity	234	215	140
Total area (ha)	50	70	92

NB: In the winter season, 60 percent of the land in the tail end was left fallow and in the maize season 100 percent of the tail end remained fallow. In the maize season, 66 percent in the head branch and 85 percent in the middle branch remained fallow.

Table 4. Average yields of the major crops grown in the sample branches. Compiled from sample crop cuts for 1988–89 (tons per hectare).

Crop	Head	Middle	Tail
Rice	3.75 (7)	4.00 (8)	2.88 (11)
Wheat	3.69 (6)	3.10 (6)	2.07 (7)
Lentil	1.27 (3)	0.91 (2)	0.98 (2)
Mustard	0.75 (5)	0.81 (4)	0.95 (2)
Maize	2.19 (6)	2.17 (7)	–

NB: Rice, maize and wheat yields are reported at standard moisture content of 14 percent. Yields of lentil and mustard refer to field moisture at harvest. Figures in parentheses represent the numbers of samples of each crop that were harvested for yield sampling.

Rainfall

Rainfall measured during the 1988 rice season from June 1988 to mid-November was 1,900 mm. The average for the same period is about 1,400 mm, indicating a higher-than-average rainfall in that year. The total amount of rainfall during the rice seeding and transplanting season (June, July and August of 1989) was 1,660 mm. The average rainfall for the same period based on data of the past 14 years is 1,179 mm. The 1988–89 rice season had a higher rainfall than the normal.

CONCLUSIONS

Some of the conclusions based on the resource mobilization and water distribution observations made in the CMIS are given below.

Agricultural Yields

It is desirable that large numbers of farmers in CMIS should obtain the high yields observed in CMIS. The Irrigation Master Plan Document (CIWEC 1990) establish the present irrigated yield levels for the western Terai stratum of Nepal at 2.5 metric tons (mt)/ha for rice, 1.8 mt/ha for maize, 2.2 mt/ha for wheat and 0.7 mt/ha for mustard. The crop yields observed establish the potential of the CMIS both in the system and in the national context.

Resource Mobilization

The ability to mobilize cash, labor, and materials is clearly established in the CMIS. Beneficiaries of the CMIS depend on the resource mobilization ability of the system, which is well-executed by the executive committee of the CMIS. Farmers in CMIS have established the kulara as the unit for resource mobilization for O&M of the system. As the system expanded, water became scarcer and the present notion behind the kulara is tied to actual O&M needs for water acquisition and distribution. Initially, one unit of kulara was equivalent to 1 man-day of labor for a fixed land area of 17 ha when water was abundant, and a proportional allocation on land area basis was tried.

Water Distribution

The ability to divert and distribute water from the river source (specially during the monsoon season) is established in the CMIS at a high cost in the number of laborers. Fairness in equity of water distribution is related to the resource mobilization needs. Branches requiring more water must mobilize resources in the required or a higher proportion.

Organizational Ability

The organizational ability to capture, convey and deliver water to the beneficiaries of the CMIS is established through the functioning of the four-tier organization and its ability to take decisions to mobilize cash, labor and materials for O&M. The organizational ability to adjudicate disputes related to water distribution and resource mobilization is also established in CMIS.

Changing Needs

Large FMIS in other locations in the Terai of Nepal may have similar needs as the CMIS. However, based on this study it appears that the following efforts may be required to improve the CMIS:

* Development of a low-cost diversion structure which can safely pass high discharges with a large amount of silt, gravel and boulders.

* Development of an understanding of the irrigation organization in depth and making of improvements to satisfy the grievances of the users.

* Development of an understanding of system losses and suggesting suitable outlets and distribution plans according to crop requirements.

* The failure of the government policy to understand the O&M practices of FMIS like the CMIS, have made it difficult to obtain the forest products required for system maintenance. Consequently, there has been an increase in the number of person-days required for the maintenance of the system. The government forestry policy should support FMIS by guaranteeing that forest in nearby areas are open to community management and the area protected and promoted. This would encourage the farmers/users to work in the FMIS while it would help the user management system to reduce the involvement of person-days in the O&M.

* The increasing trend of payment of cash fines is not favorable to the user management system. The majority of farmers favor labor contributions. If the cash contribution practice is encouraged, the user management system may meet the same fate as that

of the neighboring Bhairahawa Lumbini Ground Water Project which is neither able to collect water charges nor able to involve the farmers/users in the O&M.

Use of Study

It is in the interest of the government of Nepal to promote participatory management (PM) in large agency-managed systems (AMIS). It is now accepted that PM at all levels is essential in large AMIS if they are to be effective. This must be promoted parallel with required physical improvements and O&M procedures. Much can be learned from the resource mobilization and the related O&M procedures prevalent in the CMIS and can be of direct use in AMIS. In particular, the concepts of kulara and the organizational model are of direct relevance. The crux of the problem in other large systems (both under farmer- and agency-management) which are not performing well is the lack of effective resource mobilization for system O&M.

Performance Measurement in Farmer-Managed Irrigation Systems

Performance measurement in FMIS is important to determine the potential for assisting FMIS and organizing farmers for improved management. The study conducted in CMIS by IIMI in 1988–89 aimed at documenting several facets of farmers' involvement in system operation and management (Tiwari et al. 1989).

Building analytical frameworks for determining O&M cost on a per hectare basis and water distribution are important aspects of performance measurement needs in FMIS. This paper has attempted to present the resource mobilization procedures for system O&M and the resulting water distribution in a large FMIS in Nepal.

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Irrigation Efficiency as a Measurement Factor of Farmers' Performance in Irrigation Systems

Walter Olarte Hurtado[24]

ABSTRACT

THIS PAPER IS part of the sociotechnical research on irrigation water use and management conducted in the High Andes communities (Province of Acomayo, Department of Cusco) during 1987–1990. It aims to show how irrigation efficiencies attained by the farmers constitute a measurement factor of the performance of Farmer-Managed Irrigation Systems (FMIS). To this end, two communities were selected both of which practice subsistence agriculture (in which production is destined for self-consumption with the surplus sold in the market). The Choseccani community has a traditional irrigation infrastructure, while the Santo Domingo community has an improved irrigation infrastructure.

In both communities all the farmers are irrigation water users. Twenty Choseccani and thirty Santo Domingo families were chosen at random. An inventory of their farms reveals that among the former, the number of irrigated plots per family ranges from 1 to 6 (0.12 hectare [ha] per family), whereas in the latter the number of irrigated plots per family ranges from 1 to 10 (0.80 ha). It may be observed that there is greater uniformity in irrigated plots per family in Choseccani.

Irrigation evaluations yield conveyance, distribution and application efficiencies in the order of 84.4 percent, 72.0 percent and 60.5 percent, respectively, and an overall efficiency of 35.4 percent for the Choseccani community, while the figures corresponding to the Santo Domingo community were 77.6 percent, 64.97 percent and 39.0 percent, with an overall efficiency of 20.1 percent.

Given the same labor availability in both communities under study, the system with less water irrigates more efficiently. The quality of the irrigation infrastructure does not improve efficiency when the social organization is rather weak. Finally, irrigation management in the hands of farmers with fewer plots is less efficient in the improved irrigation system, as the increase in irrigation volumes exceeds their use and management capacity.

BRIEF DESCRIPTION OF THE STUDY AREA

The study area comprises the Pomacanchi and Acopia districts in the province of Acomayo in the Department of Cusco located between 71°28' and 71°40' longitude W and 13°58' and 14°00'

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latitude S at 3,700 and 4,000 m, respectively above mean sea level; the total area of the Santo Domingo community is 1,869 ha and that of Choseccani is 1,095 ha.

The average annual temperature is 11.9^{0}C, with a minimum of -4^0 C in June and a maximum of 22^{0}C in October. Mean annual relative humidity is 58 percent, ranging between 52 percent in September and 70 percent in February. There are 2,261 hours of sunlight a year. Mean annual rainfall is 827.5 mm; the highest rainfall is in January with 175.5 mm and the lowest in June with 2.1 mm. Potential evapotranspiration reaches 1,184.3 mm/year, with a maximum 11.7 mm in October and a minimum 83.4 mm in June.

The hydrological year is divided into two well-defined seasons: a humid season, December to March, with 75 percent annual rainfall, and a dry season, March to August. The climate in the region may be classified as subhumid to semiarid while, according to L.R. Holdridge's bioclimatic diagram, it belongs to the bh-Ms life zone.

Soils are of the "epipedion ocrico" type; their texture is clayey-loam, and their pH ranges from 6.0 to 7.9. The cationic exchange capacity (CIC) ranges from 7.8 to 36.4 meq/100; the salt content is low (110 mmhos/cm^2), as is the organic matter content (2%). Nutrients are N = 0.7 percent (poor), P = 0.6 percent (P2 O5) (low), and K = 2.1 percent (medium). They may thus be considered as soils of low to medium fertility. The slope of the irrigable areas ranges from 2 to 10 percent. Both communities draw water for irrigation from a main river. Gauges during low water periods range from 48 l/sec in Santo Domingo to only 12 l/sec in Choseccani.

THEORETICAL APPROACH

There is no research on this subject, especially on traditional irrigation technology. However, some conclusions have been drawn concerning the social organization for irrigation water management. L. Selligman (1986) states that good performance of irrigation systems depends upon the strength of the social organization: *Where the community is well-organized, performance is good, but where the organization loses strength, performance is poor.* Poor water management resulting from excessive use is evident in cases where community control and system maintenance are very weak.

Some authors such as Golte (1980) point out that the greater the water scarcity, the better the conditions to organize a centralized system: *Water shortage leads to community interests directing all cropping-related matters; therefore, the degree of cohesion and centralization of the decisions is dependant upon the degree of scarcity of the resource.* In this respect, C. Fonseca agrees that water abundance requires only canal maintenance and that community-individual interdependence does not exist (Gelles 1983). However, Guillet and other researchers hold that water management systems appear to be a function not only of physical factors (lack of humidity) but also of sociological factors (family autonomy). Following this trend, Grondin (1986) states that irrigation infrastructure would benefit each farmer in a different way. Finally, Gonzalez E. points out that despite inequities, all farmers obtain greater productive benefits than they would without the infrastructure and certain Andean community regulations on water distribution (Grondin 1986).

J.V. Kessel holds that the rational objective of water use in the Upper Andes is to ensure the production of foodstuffs. Farmers assume potential capital investment risks by constructing simple infrastructure systems, designed according to the location and size of their farms that ensure an equitable water distribution (Gelles 1983).

It is imperative that technical explanations to the statements made by the social scientists be found. In this way, the objective and empirical evaluation of irrigation efficiencies could explain users' attitudes.

SOCIOTECHNICAL CHARACTERISTICS OF IRRIGATION IN THE COMMUNITIES UNDER STUDY

Irrigated Land Tenure

The values given in Table 1 show that all the families use irrigation water: some farmers own up to ten irrigated plots, while others have only one (Santo Domingo). On the other hand, there are farmers in Choseccani who own one parcel and farmers who own six. Farmers with less irrigated land may be expected to be more efficient.

Table 2 shows that the average irrigated land tenure in Santo Domingo is 3.62 plots with 0.61 ha. Of these, farmers with 1 to 3 plots have an average of 0.45 ha and those with 4 to 6 plots an average of 0.76 ha. Only 3 farmers possessing 7 to 10 plots had an average of 9.7 ha. Because of their small number, they were not taken into account in the statistical calculations. In Choseccani, on the other hand, each family owns an average of 3.35 plots with 0.45 irrigated hectares; farmers with 1 to 3 plots have an average 0.27 ha and those with 4 to 6 plots have 0.63 ha. There are no farmers with more than 6 plots. When comparing these values, it may be observed that farmers with 1 to 3 plots in Santo Domingo have twice the area of those in Choseccani, although the number of plots is the same. There are no significant differences between farmers with 4 to 6 plots.

Family Size and Labor Force

Table 3 shows the size of the nuclear family (resident and nonresident members) and the total labor force, which includes all family members over 6 years of age. It also shows the adult labor force, including all family members over 18 years of age. There are no significant differences between the two communities. In Santo Domingo, the size of the nuclear family is 5.5 members of which 4.4 are resident and 1.1 migrates. The total average labor force among resident members is 3.6 while the adult labor force is 2.3. In Choseccani the size of the nuclear family is 6.0 members of which 4 are resident and 2 migrate. The total labor force is 3.4 and the adult labor force is 2.4. The two communities present similar labor force conditions.

Under these circumstances, it is may be expected that — given the same labor force availability and provided the other intervening factors remain constant — irrigation efficiency will also be similar in both communities.

Water Flows and Volumes Available at Community Level

There is a manifest difference in flows and volumes available in the two communities in the months when crops are irrigated. In the peak month of October in Santo Domingo, water availability is three times that in Choseccani.

According to some social scientists, greater water availability entails greater waste and less care. Therefore, lower irrigation efficiency may be expected in Santo Domingo, as water availability from both natural sources and the reservoirs built by the farmers is greater.

Table 1. Number and area of irrigated and dry-farmed plots.

Family number	Irrigated plots		Dry-farmed plots	
	Number of plots	Total area (ha)	Number of plots	Total area (ha)
Sto. Domingo				
1	5	0.83	10	2.31
2	4	0.74	4	1.16
3	5	1.32	7	1.98
4	4	0.11	10	0.53
5	6	0.74	5	0.99
6	10	2.06	6	1.98
7	3	0.33	5	0.83
8	4	0.37	14	2.15
9	2	0.66	13	2.89
10	4	0.44	10	1.63
11	10	1.57	11	1.57
12	4	0.38	6	1.24
13	3	0.39	7	1.22
14	1	0.17	4	0.58
15	3	0.58	9	2.23
16	4	0.66	10	1.65
17	5	0.74	8	1.82
18	4	0.91	7	2.15
19	4	0.58	8	1.82
20	2	0.50	12	2.31
21	9	2.15	5	1.82
22	3	0.33	5	0.41
23	3	0.53	11	1.98
24	5	1.44	10	2.89
25	6	0.75	11	0.81
26	2	0.24	11	1.27
27	6	1.49	12	3.55
28	5	0.44	9	0.86
29	3	0.74	5	2.64
30	5	0.58	7	1.57

continued on p. 87

Family number	Irrigated plots		Dry-farmed plots	
	Number of plots	Total area (ha)	Number of plots	Total area (ha)
Choseccani				
1	3	0.26	5	0.25
2	2	0.33	4	0.50
3	3	0.41	5	0.69
4	2	0.25	6	1.24
5	4	0.36	7	0.91
6	5	0.75	5	0.98
7	4	0.69	3	0.33
8	1	0.08	5	0.66
9	3	0.49	5	0.54
10	4	0.91	5	1.66
11	4	0.64	5	0.34
12	1	0.08	3	0.25
13	3	0.25	5	0.66
14	4	0.85	3	0.23
15	2	0.17	3	0.25
16	3	0.41	4	1.07
17	2	0.25	3	0.25
18	4	0.66	2	0.25
19	6	0.45	6	0.36
20	5	0.39	3	0.13

Table 2. Irrigated land tenure (per family).

Communities and farmers' groups		Number of plots	Area (ha)
Santo Domingo	-X	3.62	0.61
	SD	1.10	0.11
1 to 3 plots	-X	2.50	0.45
4 to 6 plots	-X	4.75	0.76
more than 7 plots	-X	9.70	1.93
Choseccani			
1 to 3 plots	-X	3.35	0.45
4 to 6 plots	SD	0.90	0.14

Table 3. Nuclear family and labor force size.

Community		Nuclear family size			Labor force	
		Total	Resident	Non-resident	Total	Adult
Sto.Domingo	-x	5.5	4.4	1.0	3.6	2.3
	SD	1.2	1.7	0.5	1.0	0.5
Choseccani	-x	6.0	4.0	2.0	3.4	2.4
	SD	0.6	0.9	0.4	0.4	0.5

Table 4. Available flows (l/s) and volumes (m^3).

Community	Data	Months				
		August	September	October	November	December
Sto.Domingo	Flow	48	58	70	105	156
	Volume	128,568	150,336	187,488	272,160	417,830
Choseccani	Flow	12	17	22	36	58
	Volume	32,141	44,064	58,925	93,312	155,347

Irrigation Infrastructure

The irrigation infrastructure in Choseccani is traditional, that is, it was systematically planned, designed and built by the farmers according to their increasing water needs. They themselves defined their irrigation regulations and chose their water authorities. The construction materials are manufactured in the area and the works are quite simple; flows are regulated by piling up stones, a structure which, in case of deterioration, is easy and cheap to repair. But with these simple catchments the total available flows cannot be diverted. The irrigation infrastructure in Santo Domingo, on the other hand, is the result of two technologies: a traditional one similar to that of Choseccani, and a modern one. The initial planning, design and construction were performed by an extra-communal agency. It was necessary to introduce new construction materials (Portland cement and iron) and technology to be used in combination with some of the locally manufactured materials. Though Portland cement structures prevail, distribution structures are still traditional. As these works were only recently built, users have not been encouraged to devote time and money in maintenance, management and rehabilitation activities, with the exception of those which demand urgent attention. To this we should add the lack of training in the operation of the new system. Therefore, irrigation infrastructure helps determine irrigation quality inasmuch as it provides the minor works required for water diversion, conveyance and distribution. In view of the above, Santo Domingo is likely to be the one to achieve higher irrigation efficiencies.

Technical Aspects

At present, both communities use gravity and flood irrigation methods. The irrigated plots have very peculiar characteristics: they are small areas located close to the farmers' dwellings and they are enclosed by trees for protection against thieves and possible damage by animals and frosts. There are usually from one to seven different crops grown in these plots. Traditional production technology (manual tools, animal traction, limited use of pesticides and fertilizers, etc.) is used and harvests are almost always guaranteed, unless severe frosts or hailstorms occur.

The first and only irrigation is done to prepare the soil, sow and store humidity to meet all crop needs until the rainy season. In other words, it is saturation irrigation. When the rains are delayed, additional irrigation is occasionally done. This practice, however, is not common because farmers fear that subsequent rains may result in the asphyxiation of the crops, in the proliferation of diseases, or in the main irrigated crop (beans) prolonging its vegetative cycle and exposing it to early frosts. Finally, in rainy years, the irrigation infrastructure is not used to capacity.

Socio-Organizational Aspects of the Communities under Study

The level of community organization for irrigation purposes is measured as in compliance with established rules. Table 5 contains some socio-organizational variables to provide an idea of the different levels of organization in the two communities.

Table 5. Socio-organizational variables for irrigation purposes.

Variables	Santo Domingo	Choseccani
Everybody has irrigation rights	Yes	Yes
Community determines irrigation period	Yes	Yes
Community elders accorded priority when distributing turns	No	Yes
Water distributed according to rotation until plot irrigation is complete	Yes	No
Irrigation turns complied with	Yes	Yes
	(Frequent water theft)	
Theft punished	No	Yes
Maximum irrigation area per turnout	No	Yes
Night irrigation permitted	No	Yes
Users' committees deal with conflicts	Sometimes	Yes
Irrigation charge complied with	Sometimes	Yes
When turn is missed, farmers wait for the next one	Sometimes	Yes

The most outstanding variable is the one that shows that in Santo Domingo a turn permits the irrigation of a plot, whatever its size. In Choseccani, on the other hand, each turn permits the irrigation of 0.33 ha. In the latter case more efficient irrigation is to be expected.

EFFICIENCY LEVELS

In Santo Domingo, water is conveyed through lined canals whereas in Choseccani it is conveyed through earth canals. Evaluation yields average values of 77.6 percent and 84.7 percent, respectively, which show that lining does not always improve conveyance efficiencies when there are organizational and maintenance problems. However, the lowest efficiencies (74.8%) are found among the Santo Domingo farmers who have a smaller number of irrigated plots. Higher efficiencies (85.8%) are attained in Choseccani. Water distribution from the main canal intake to the farm is done by earthen canals in both communities and rather high volumes are lost. Under these conditions, distribution efficiencies are 64.9 percent in Santo Domingo and 70.42 percent in Choseccani. There is also a substantial difference between farmers in Santo Domingo with smaller irrigated areas and efficiency values of 62.0 percent and those in Choseccani with efficiency values of 73.2 percent.

Application efficiency depends on farm management. In Santo Domingo efficiency value is 39.0 percent while in Choseccani it is 58.8 percent.

Finally, total efficiencies yield values of 19.2 percent for Santo Domingo and 34.6 percent for Choseccani, variability ranging from 58.2 percent and 54.9 percent, respectively. This shows that in both communities there are farmers with good irrigation management practices.

CONCLUSIONS

1. When the same labor force is available, the system with less water availability (Choseccani) attains higher efficiency and vice versa; Santo Domingo, with greater water availability, attains lower efficiencies. Thus, Golte's and Fonseca's hypotheses are confirmed: resource management is the best way to structure the organization in a centralized manner.

2. The quality of the irrigation infrastructure as a factor to improve irrigation efficiency is not always decisive. This is particularly so when the social organization of the community tends to be weak because of noncompliance with irrigation regulations. This conclusion coincides with W. Kelly's opinion.

3. There is a marked deficiency in irrigation water management, both at plot and general levels among farmers with small irrigated areas in the Santo Domingo improved system. Low efficiencies are achieved because applications far exceed the farmer's management capacity as well as the soil's water retention capacity. This is due to the fact that this system, only recently put in operation, permits farmers to increase irrigation water volumes per plot.

Table 6. Irrigation efficiencies as a function of number of plots per household: Santo Domingo.

Household number	Irrigated land		Ec (%)	Ed (%)	Eap (%)	E.Total (%)
	No. of plots	Total area				
7	3	0.33	73.5	81.8	15.7	9.1
9	2	0.66	65.2	91.6	25.1	15.0
13	3	0.39	63.7	63.5	12.6	5.1
14	1	0.17	68.9	66.4	43.1	19.7
15	3	0.58	76.4	52.4	12.7	5.1
20	2	0.50	92.1	46.7	86.4	38.8
22	3	0.33	71.5	43.9	12.8	4.0
23	3	0.55	67.9	69.4	14.3	6.7
26	2	0.24	90.4	43.3	52.9	22.1
29	3	0.74	78.1	58.2	28.4	12.6
x	2.5	0.45	74.8	62.0	30.4	13.8
SD			9.3	15.0	22.9	10.3
1	5	0.83	83.4	67.9	12.7	63.3
2	4	0.74	72.4	69.4	26.6	13.4
3	5	1.32	74.1	82.1	17.1	10.4
4	4	0.11	71.9	71.8	56.2	18.2
5	6	0.74	65.9	80.2	48.5	25.6
8	4	0.37	81.3	79.5	27.8	18.0
10	4	0.44	70.4	84.7	42.0	25.0
12	4	0.38	75.2	87.6	32.9	21.1
16	4	0.66	84.0	38.1	42.4	13.6
17	5	0.74	90.7	46.4	35.2	14.8
18	4	0.91	91.9	59.6	18.6	10.2
19	4	0.58	83.2	45.7	100.0	38.0
24	5	1.44	82.7	60.6	26.5	13.3
25	6	0.75	89.4	77.4	77.0	53.3
27	6	1.49	88.6	70.1	56.6	11.5
28	5	0.44	79.1	66.6	25.0	11.5
30	5	0.58	76.6	75.6	70.0	44.0
x	9.7	1.93	70.9	70.6	35.1	20.8
SD			4.8	9.5	20.1	17.4
Community average			77.6	64.9	39.0	19.2

to evaluate the performance of selected FMIS supported by the Agricultural Development Bank of Nepal (ADB/N) using selective output and impact performance indicators. Given the important role that FMIS can play in meeting national food production goals and the significant contribution made by ADB/N in assisting FMIS in recent years, it is important to evaluate the performance of ADB/N supported FMIS with a view to identifying the areas for further improvement.

METHODOLOGY

Intensive and extensive data collection methods were applied to attain the study objectives of obtaining in-depth data and wide coverage. The intensive and extensive methods, or rapid appraisal data collection techniques, were applied to generate the information necessary for technical and economic performance evaluation respectively. The selection of sample systems was made purposively considering representativeness in terms of region, degree of project success, accessibility to the systems and availability of secondary data.

Six surface schemes, three each from the hills and Terai (lowland plains) were selected for technical performance assessment. A set of measures of technical performance was given by the total water discharged to the system command area during the rice cultivation season, and water requirements.

The amount of water discharged was measured daily at the head of the command area using simple measuring devices. Using irrigation delivery information and data on rainfall, evapotranspiration (ET) and seepage and percolation (S&P), overall water adequacy for the irrigated area was assessed by computing relative water supply (RWS). If daily rainfall was less than 15 mm it was assumed that the irrigation was fully effective; for additional rainfall between 15 and 50 mm per day it was assumed 80 percent effective and with rainfall above 50 mm per day was only 50 percent effective. ET was assumed to be 5.5 mm per day for all schemes and average S&P was estimated for each scheme.

Another measure of technical performance was made through daily observation of the soil moisture status of geographically dispersed field plots in each system to determine the uniformity of water distribution. These plots were selected after the rice crop was transplanted. Instead of a random selection of sample plots several branches of the main canal that gave a reasonable distribution from head to tail were chosen. The number of sample plots selected varied from 30 to 58 among schemes. Four degrees of water availability were specified with regard to the adequacy of water at the individual plot level: standing water, water in footprints, moist but no visible water, and dry and cracking soil. On the basis of the condition observed, a water availability index was computed for each plot using a simple system of weighing to indicate the degree to which a plot had more or less water available during the period 20 and 70 days preceding the harvest as this period was considered to be the critical, water sensitive phase of the rice varieties grown in the scheme areas. To calculate the index, the number of days in the first category (standing water) were weighted quadruple and added to the number of days in the second category weighted triple plus the number of days in the third category weighted double plus the number of days in the last category (dry and cracking). An inter-quartile ratio was also computed to assess the equality of water distribution.

Economic performance of irrigation projects was assessed on the basis of two criteria: rates of return to the investments and effectiveness in mobilizing local resources for productive capital formation. Rates of return to the investment were estimated at two levels: to the society or economy,

Table 7. Irrigation efficiencies as a function of number of plots per household: Choseccani.

Household number	Irrigated land		Ec (%)	Ed (%)	Eap (%)	E.Total (%)
	No. of plots	Total area				
1	3	0.26	77.8	68.9	84.3	41.3
2	2	0.33	80.5	74.3	40.7	24.3
3	3	0.41	94.7	60.1	77.1	43.9
4	2	0.25	90.7	38.5	46.0	16.0
8	1	0.08	89.1	78.2	56.3	39.2
9	3	0.49	84.1	78.6	21.6	14.3
12	1	0.08	81.1	71.7	100.0	58.1
13	3	0.25	99.0	76.5	88.7	67.2
15	2	0.17	89.7	86.5	44.6	34.8
16	3	0.41	76.5	84.0	38.7	24.9
17	2	0.25	81.2	88.1	37.9	27.1
x	2.3	0.27	85.8	73.2	57.8	35.6
SD			6.9	13.4	24.3	15.9
5	4	0.36	87.8	78.8	64.1	44.4
6	5	0.75	87.7	28.8	100.0	25.3
7	4	0.69	90.3	73.3	39.9	26.4
10	4	C 91	84.5	39.1	16.4	12.3
11	4	0.64	87.5	85.5	59.0	44.1
14	4	0.85	79.9	64.8	81.6	42.2
18	4	0 56	87.2	68.7	45.5	27.3
19	6	0.45	69.7	78.7	100.0	54.9
20	5	0.39	73.5	86.8	52.6	33.6
x	4.4	0.63	83.5	67.5	59.7	33.5
SD			7.1	20.3	26.9	12.7
Community average			84.7	70.4	58.8	34.6

Performance Evaluation of Selected Farmer-Managed Irrigation Systems in Nepal

Ganesh Thapa and Madhav Banskota[25]

ABSTRACT

ABOUT TWO-THIRDS OF the total area irrigated in Nepal are presently under farmer management. While some farmer-managed irrigation systems (FMIS) are managed well with intensive cultivation, others are operating below the production level they could achieve with their available water and land resources. This study attempts to objectively measure and evaluate the performance of selected FMIS supported by the Agricultural Development Bank of Nepal using selective output and impact performance indicators. Both intensive and extensive methods of data collection were used to generate necessary information. Technical performance indicators such as relative water supply and water availability index (WAI) suggest that the farmer groups have learned to balance the total irrigated area in the wet season with overall water conditions, and that there is no discrimination between head- and tail-end parts of the system. However, there is a big difference in WAI between plots. This suggests some room for improvement in water distribution among neighbors. Economic analyses show that there is a great payoff to society in investing in FMIS and that they are financially attractive to farmers. Our analysis also shows a high inducement effect of public funds in local capital formation and farmers' participation in such projects.

INTRODUCTION

Farmers in Nepal have constructed and managed irrigation systems for centuries. It is estimated that about 67 percent of the total irrigated area in the country is presently under farmer management and at least 45 percent of the population's subsistence cereal requirement is being met by the increase in food production made possible by irrigation from farmer-managed systems (IIMI 1990). The FMIS in Nepal vary in size from less than 10 ha to as large as 15,000 ha. Most FMIS are simple run-of-the-river diversions with temporary headworks and are mainly used for supplementary irrigation of rice during the monsoon.

Some FMIS are well-managed with intensive cultivation of three crops a year giving an annual production in the range of 7.5 to 9 tons per ha (Yoder 1986). Others are operating far below the production level they could achieve with their available water and land resources (Pant 1985; Tiwari 1986; Hydro-Engineering Services 1987). This study attempts to measure objectively and

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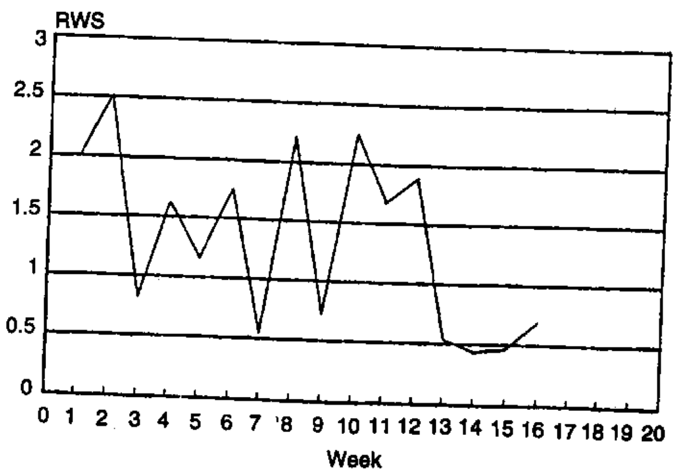
the scheme does not irrigate the potential command area (266 ha) due to the absence of a canal network. Farmers are in the process of converting the remaining upland into a rice field. RWS results show that there will be a sufficient supply of water to irrigate the potential command area for monsoon rice.

In the Laxmipur System, (134 ha), RWS results showed that water supplies in the main canal were not stable (Figure 2). Rainfall data show that when there is little rainfall, the river level drops quickly and farmers may face shortages of both canal water and rainfall. As a result of this hydrological pattern, there was considerable daily variation in RWS but when averaged on a weekly basis the RWS was normally greater than 1.0. However, because there were weeks in which RWS was less than 1.0 there may have been periods when there was an overall water shortage. It is therefore likely that farmers in this system will need to be a bit conservative in determining the area to be irrigated because if rainfall is less than average, there may be an overall shortage of water supplies which will affect crop production badly.

Figure 2. Weekly RWS of Laxmipur Irrigation Scheme.



In the smallest Terai system, Tulsi (70 ha), the situation was more complex. RWS was not very stable: with rainfall, weekly RWS was extremely variable (Figure 3). Except for two weeks (2nd and 9th) weekly RWS was always higher than 1.2. The fluctuation in water discharge was due to variations in river discharge by localized rainfall in the upper catchment of the river.

and to the farmers. The first measure enables us to judge whether the bank-assisted projects are economically viable as compared to other public investment opportunities. The second estimate measures private rates of return to the farmer beneficiaries, which is a critical indicator to represent the farmers' loan repayment ability.

The bulk of data for most of the economic analyses was collected in the field through rapid appraisal surveys. Beneficiary farmers were the primary source of data. In each site, five to ten farmers were interviewed with the help of checklists and questionnaires. Farmers were selected randomly from various reaches of the command area.

RESULTS AND ANALYSIS

Technical Performance Assessment

Overall water supply and response to rainfall. The six systems, three each in the hills and the Terai had different patterns of water supply in the main canal. This was due to different hydrological characteristics of the river source and due to the nature of diversion structures and the intake.

In the largest Terai System, Parwanipur (218 ha), the weekly Relative Water Supply (RWS) was more than 1.0 for the first half of the observation period suggesting that at system level there was no serious water shortage (Figure 1). While the RWS appeared to decline in the latter part, this was probably not critical to crop because some of the area had been harvested so that the actual demand for water was declining. In this system the river has a much larger discharge than required for the system itself, and due to the provision of head regulator gate, farmers only extract sufficient water to meet their requirements. This suggests that the farmers have adjusted their command area well to the total river water supplies, supplementing any deficits during periods of rainfall. Yet,

Figure 1. Weekly RWS of Parwanipur Irrigation Scheme.

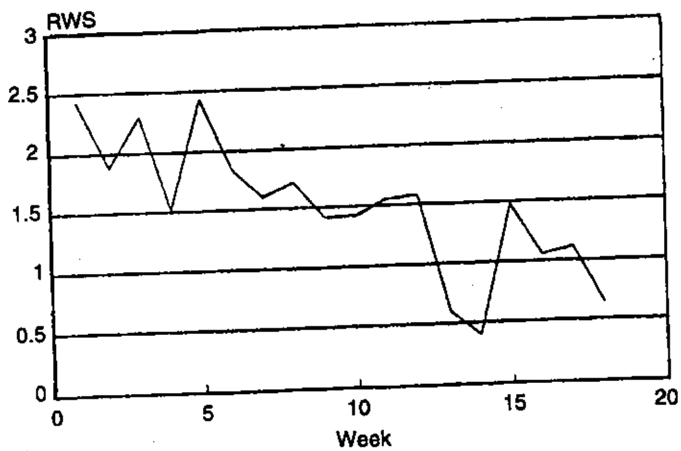
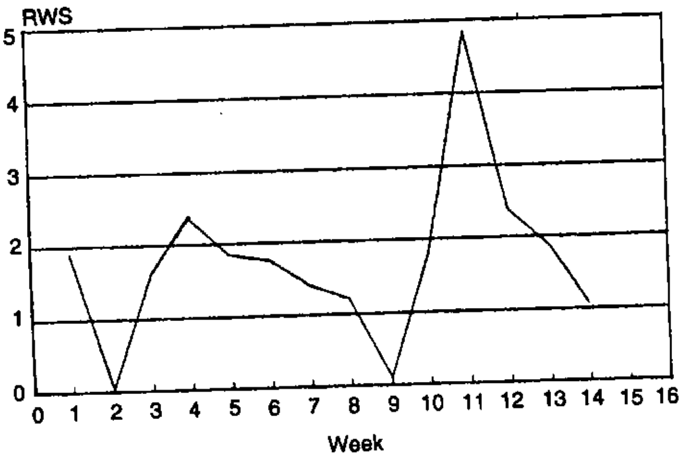
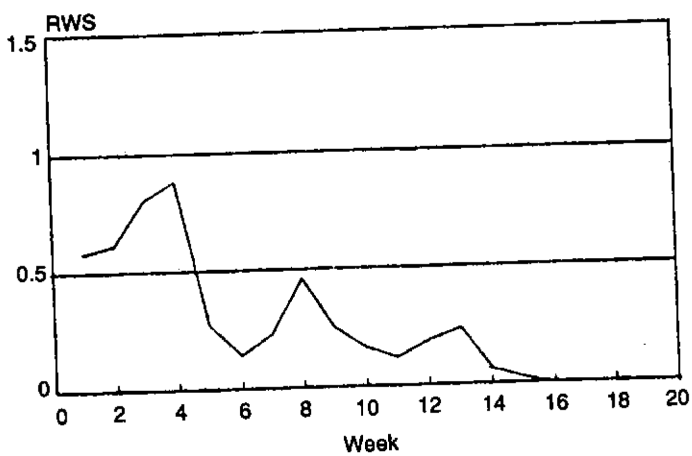


Figure 3. Weekly RWS of Tulsi Irrigation Scheme.



In the hill systems of Bandarpa and Jamune, the weekly RWS including rainfall was less than 1.0 throughout the season (Figures 4 and 5). This was mainly because of high seepage losses from the main canal and poor intake conditions. Furthermore, in these systems farmers do not feel the need to tap water from the main river source to irrigate their fields because springs which originate in different locations of the schemes supply the necessary water.

Figure 4. Weekly RWS of Bandarpa Irrigation Scheme.



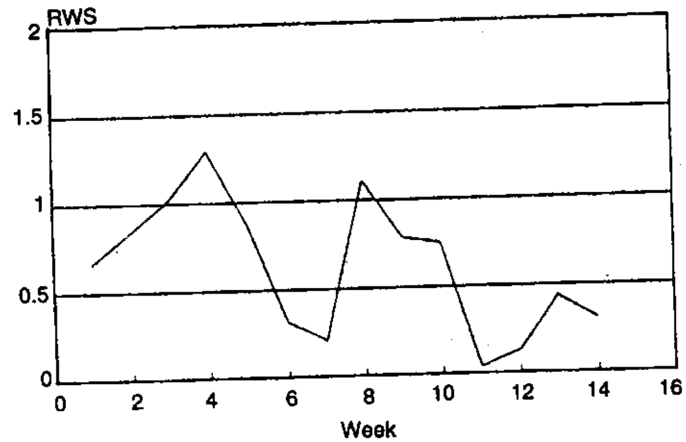
Investment and participation inducement coefficients. Table 4 also shows investment and participation inducement coefficients for selected surface schemes. The average estimated investment inducement coefficients (IIC) was 2.54 in the hills and 1.98 in the Terai. This implies that one rupee of public funds (capital subsidy, interest subsidy and technical assistance) generated Rs.2.54 worth of capital in the hills and Rs.1.98 in the Terai. These results, on the whole, indicate a fairly high inducement effect of public funds in local capital formation. These estimates are comparable to those reported for community irrigation projects in the Philippines (Kikuchi et al. 1977).

The participation inducement coefficient (PIC), on the other hand, measures the total contribution of the farmers in erecting the project per rupee of public funds. The average PICs for the hill and Terai schemes were 1.27 and 0.76, respectively, indicating that one rupee of public funds induced farmers to contribute Rs. 1.27 and Rs. 0.76 in the hills and Terai, respectively. On an average, farmers' contribution per unit of public funds is higher in the hills. On the whole, these results show encouraging inducement effects of public assistance towards farmers' participation in the project.

Table 4. Rates of Return to the government and Investment and Participation Inducement Coefficients in farmer-managed surface schemes.

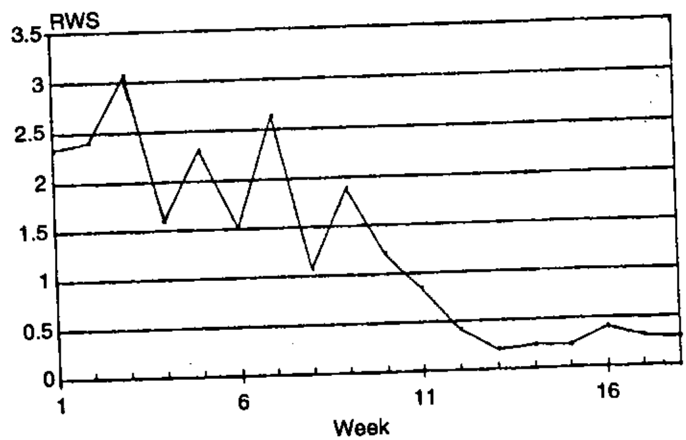
Irrigation scheme	Rates of return to the government		Investment Coefficient	Participation Inducement Coefficient
	BCR	IRR (%)		
Hill schemes				
Bhalutar	2.57	33.8	1.77	0.52
Baretar	4.54	51.9	2.28	1.06
Bepariraha	11.54	122.5	3.70	2.27
Thulochaur	17.03	252.0	1.55	0.47
Bandarpa	16.19	168.2	3.72	2.41
Jamune	7.71	110.2	1.98	0.78
Balthali	26.67	201.6	3.76	2.55
Barhakol	13.08	138.7	1.58	0.11
Average: Hills	12.42	134.9	2.54	1.27
Terai schemes				
Parwanipur	27.48	18.18	2.91	1.77
Laxmipur	40.07	458.1	1.63	0.39
Kumroj-2	10.12	61.2	1.69	0.40
Balimkhola	10.76	110.1	1.80	0.48
Kanjawar	6.90	78.9	1.89	0.77
Average: Terai	19.07	178.0	1.98	0.76
Overall average	15.75	156.5	2.3	1.07

Figure 5. Weekly RWS of Jamune Irrigation Scheme.



In the third hill system of Baretar, the weekly RWS was quite high in the initial phase, with more variation in the early days of observation (Figure 6). After the 11th week RWS declines, but farmers do not need much water during this period because rice is in the harvesting phase. The RWS is high in this scheme because the river has a high discharge and the intake of the scheme, though not permanent, draws water naturally without much effort on the part of the farmers. The presence of essential structures and lined canals in most of the critical parts also allows for a reliable supply.

Figure 6. Weekly RWS of Baretar Irrigation Scheme.



of more than one and four had FIRR of more than 25 percent. The results improve when only the farmers' costs are included in the construction cost. In this case, only one hill scheme had a BCR of less than one. In the computation of financial rates of returns the opportunity cost of labor was assumed to be 50 percent of the market wage rate. This estimate of the opportunity cost of labor approximates the average of estimates made by earlier studies, which reported the lean season wage rates to vary between 48 and 62 percent of the peak season wage rates (IDS 1989; MacDonald and East Consult 1990).

Rates of return to the government. The rates of returns to society from the investment of scarce government capital funds (direct subsidies plus subsidies in the form of concessions on interest rates for loan) are shown in Table 4 in terms of BCR and IRR. The average IRR both for hill and Terai schemes are well over 100 percent indicating very high rates of return to government investment (in the form of subsidies) in ADB/N supported irrigation schemes. The BCR is also equally encouraging. These results confirm the cost-effectiveness of investments made by the government in these types of irrigation projects.

Table 3. Economic and Financial Rates of Return to Investment in farmer-managed surface schemes.

Irrigation schemes	Economic rates of return		Financial rates of return			
			Assuming no subsidy		Assuming subsidy	
	BCR	IRR (%)	BCR	IRR (%)	BCR	IRR (%)
Hill schemes						
Bhalutar	0.83	5.7	0.53	-2.3	0.75	4.8
Baretar	1.21	18.9	0.95	13.5	1.30	24.7
Bepariraha	1.51	32.7	1.40	26.4	1.66	38.2
Thulochaur	1.78	84.7	1.68	43.3	2.06	79.0
Bandarpa	1.68	45.5	1.63	35.2	1.92	50.4
Jamune	1.22	24.8	1.09	18.4	1.41	33.2
Balthali	2.36	83.3	1.96	50.4	2.11	59.7
Barhakol	2.17	69.8	1.43	29.1	1.82	46.3
	1.60	45.7	1.33	26.8	1.63	42.0
Terai schemes						
Parwanipur	2.15	77.8	2.98	97.7	3.50	187.2
Laxmipur	2.19	171.4	3.55	148.9	4.03	279.0
Kumroj-2	1.58	30.9	1.50	24.6	1.98	34.2
Balimkhola	1.89	50.0	1.95	43.7	2.50	70.5
Kanjawar	1.38	27.4	1.23	22.9	1.69	45.2
Average: Terai	1.84	71.5	2.24	67.6	2.74	123.2
Overall Average	1.69	55.6	1.79	47.2	2.19	82.6

Table 2. Inter-quartile Ratio (IQR) of Water Availability Index (WAI) in schemes selected for intensive study (without considering distance).

	Terai			Hill		
	Parwanipur	Laxmipur	Tulsi	Bandarpa	Jamune	Baretar
WAI Top 25%	170	199	162	173	177	195
WAI Lowest 25%	120	158	138	127	130	124
IQR	1.40	1.26	1.17	1.36	1.36	1.57
Equality	Fair	High	V.high	Fair	Fair	Poor

Overall, it is clear that water distribution within each system is above average. Based on the present data it is difficult to determine the real cause of local variations in WAI. There are certain other factors which may influence the WAI such as soil depth and its type, land preparation and management practice, seepage and percolation, maintenance of bunds and the presence of rat holes in particular fields and water-sharing practices between farmers in adjacent plots.

Economic Performance Assessment

Cropping intensity and yields. On average, cropping intensity increased by 35 percentage points in the hills and by 41 percentage points in the Terai following irrigation development. In most cases, this increase in cropping intensity was realized due to an increase in acreage under winter crops, particularly wheat. In addition, significant changes have taken place in cropping patterns. In the hills, rice-based cropping patterns have replaced maize-based ones. In the Terai, mustard has been substituted by wheat in most schemes. Another important change in cropping patterns has been the introduction of high value crops such as vegetables.

Irrigation development has also led to significant gains in yields of major crops. Average rice yields have increased by about 56 percent in hill schemes and by about 37 percent in Terai schemes. As expected, yield gains have been higher in wheat than in rice both in the hills and the Terai. In hill schemes, average wheat yields increased by about 84 percent after irrigation development whereas the increase in the Terai was about 71 percent.

Economic and financial rates of return. Discounted measures of project returns, i.e., the benefit-cost ratio (BCR) and internal rate of return (IRR) were computed for 13 surface schemes. The estimated indicators of economic and financial returns are summarized in Table 3. Only one hill scheme had a BCR of less than one and ten schemes had economic internal rates of return (EIRR) in excess of 25 percent. These results show that most sample projects generated positive returns to the economy well in excess of the opportunity cost of capital.

Table 3 also shows two sets of results on financial rates of return. The first set presents results assuming that there is no subsidy and farmers incur 100 percent of the construction costs and the second set shows results when only farmers' costs are included in the construction cost, i.e., when subsidy is excluded from costs since this is not a cost to the farmers. Even when we assume that the farmers have to bear the entire costs of construction, on average both hill and Terai surface schemes are financially attractive to farmers. An average hill scheme was found to have a BCR of 1.33 whereas an average Terai scheme had a BCR of 2.24. However, two hill schemes out of a total of eight had a BCR of less than one and three had financial rates of return (FIRR) lower than 25 percent (the prevailing interest rate in the informal sector). All five Terai schemes had a BCR

CONCLUDING REMARKS

The overall impression from these analyses is that, in terms of water distribution, farmers do a generally good job. There is little or no difference in average water conditions between head and tail. All of these indicators suggest that the farmer groups have indeed learned to balance the total irrigated area in the wet season with overall water conditions, and that there is no discrimination between head- and tail-end parts of the system.

This does not mean that there is not some room for improvement in water distribution between farmers of adjacent plots. In all six systems there are big differences in WAI between plots. In terms of overall equality, Tulsi is the best, because the average WAI is about 146, with no farmer recording above 175 or below 125. At Parwanipur the range is a little greater, but still there are no farmers with the maximum score of 200. At Laxmipur, however, several fields had standing water for the entire observation period, while other farmers got WAI values as low as 130. In case of hill schemes, Bandarpa and Jamune equality was fair with average WAI of 146 and 144, respectively. At Baretar, water distribution was not equitable as WAI varied between 101 and 200. This suggests some room for improvement in water distribution among neighbors.

Although performance is not as high as it could be, the data suggest that performance is probably better than would be found in larger systems in the Terai both in terms of the system-level management and in terms of sharing water among farmers. This is probably because the farmers are fully in control of their own water supply. If this is true, then it is likely that moves towards joint management which also guarantee more reliable water supplies at the head of each subsection of larger systems will result in more opportunities for farmer groups to develop equitable ways of distributing water among themselves.

The economic analysis shows that there is a great payoff to society from investing in surface schemes. The EIRR is substantially greater than the assumed cost of funds. This result makes a strong case for further expansion of investment in FMIS. At the current level of subsidy, these schemes are financially attractive to farmers. In fact, results of financial analyses show that the current rate of subsidy is essential for the hills, whereas a lower rate may suffice for the Terai schemes. Our analysis also shows a high inducement effect of public funds in local capital formation and farmers' participation in such projects.

For all six systems, it is clear that active management is applied by the farmer groups, and there is no evidence of excess water use at system level. In most cases the RWS was normally within the range of 1.0 to 2.0, or a system-level efficiency of between 50 and 100 percent. This is quite high for the wet season when there is normally plenty of rainfall in addition to the river supplies, and shows that the total area planted has been well-adjusted to the likely overall water pattern received in each system.

Water distribution within each system. The second measure used to assess the performance of the farmer groups in managing the available water supply is the extent to which water is equally distributed throughout the system.

In all six systems there was very little evidence of a marked difference in Water Availability Index (WAI) between the head and the tail of the system. Using the Interquartile Ratio (IQR, or the ratio between the 25% of fields nearest the head of the system and the 25% furthest from the head), the data show almost no such differences. In the case of Terai schemes, the IQR are 1.14 at Parwanipur, 1.15 at Laximpur and 1.03 at Tulsi, while IQR of the Hill schemes are 1.06 at Baretar, 0.87 at Bandarpa and 1.19 at Jamune (Table 1). These values are so close to 1.0 that there is no significant difference in water availability between the head and the tail parts of the system.

Table 1. Inter-quartile Ratio of Water Availability Index between head and tail portions of the schemes

	Terai			Hill		
	Parwanipur	Laxmipur	Tulsi	Bandarpa	Jamune	Baretar
Average	144	179	146	146	144	161
WAI Top 25% (at head)	154	186	153	134	168	160
WAI Lowest 25% (at tail)	135	162	149	154	141	151
IQR	1.14	1.15	1.03	0.87	1.19	1.06
Equality	Good	Good	Good	Fair	Fair	Very high

However, in all six systems there was considerable variability in the individual values of the WAI, with quite large differences between neighboring plots. The variation does not appear to be related to the values of seepage and percolation measured in the field. The IQR based on the highest and lowest 25 percent of sample plots independent of distance shows much larger values than those based on distance: 1.4 for Parwanipur, 1.26 for Laxmipur and 1.17 for Tulsi (Terai schemes), and in case of hill schemes 1.57 for Baretar and 1.36 at both Bandarpa and Jamune (Table 2). In comparison to other systems these values are not excessively large, except for Parwanipur and Baretar, but it is not uncommon to find such variations in larger systems (Parwanipur) because the cohesion of farmer groups is somewhat less when there are many members. No doubt, WAI may vary widely by soil type, land preparation and management practices of the individual plots even though an equal amount of water is delivered. In case of Baretar, equality in WAI may be because there are two distinct types of land: upland rice terraces and lowlying rice fields.

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Some Issues Pertaining to the Performance Measurement of Farmer-Managed Irrigation Systems: Empirical Evidence from Sri Lanka

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ABSTRACT

THE PRESENT STUDY focuses on the performance measurement of farmer-managed irrigation systems (FMIS) with reference to two tank-based villages in the Dry Zone of Sri Lanka. A distinction is made between "output" and "impact" objectives of the irrigation systems. Performance indicators pertaining to each have been analyzed in the light of the field evidence.

Age-old practices based on ecological and sociocultural considerations such as the delaying of irrigation until the tank attains high water levels and preoccupation with shifting cultivation, indulgence in partial cultivation of old fields, use of traditional control structures for water distribution and monocropping of rice in the irrigated lands need considerable modifications vis-a-vis the rapid changes associated with the FMIS. Failure of the recent technological and institutional innovations to improve low levels of performance as indicated by the impact objectives of the systems, such as the existing cropping intensities, yield levels and farmer incomes are highlighted. However, the policies geared to increase the performance of the FMIS have placed much emphasis on increasing inputs alone to attain higher outputs, to the neglect of important secondary considerations such as tenurial adjustments, facilitation of marketing and improvement of postharvest technologies.

INTRODUCTION

Increased government and donor agency attention on farmer-managed irrigation systems (FMIS) has been evident in recent years. Poor performance of the large-scale irrigation works especially with reference to the rates of return vis-a-vis the colossal investments involved in building irrigation infrastructure and settlement of farm families, together with environmental considerations have largely contributed to this changed emphasis. On the other hand, rehabilitation of FMIS proved to be cost-effective and spread the benefits to a wider range of the rural community. Enhanced interest in these systems induced current research on many facets of the FMIS. The objective of this paper is to focus on their performance measurement on the basis of empirical evidence.

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It is pertinent to note that throughout the island's history, the management of small village tanks[27] in the Dry Zone[28] of Sri Lanka rested entirely on the community. However, the institutional innovations introduced since 1958 and the developments which ensued subsequently increased direct government involvement in village irrigation. Thus, the local communities became excessively dependent on the government for repair and maintenance work leading to a deterioration of the efficiency of the village tank systems (Gooneratne and Madduma Bandara 1990). As water distribution and decisions pertaining to cultivation still rest in the hands of the farmers, the term FMIS is used for the purpose of this study to indicate the small tank-based village irrigation systems.

Performance of the FMIS can be defined as the degree of achievement of the system objectives which can best be distinguished as "output," "impact" and "management" objectives (Manor 1990). The output objectives are directly related to the functioning of the irrigation system and can be measured with reference to the maximum utilization of the available water resources reducing waste to a minimum, meeting the water requirements of a given cropping pattern, effecting distribution of water with a view to minimizing the differences in quantities received among irrigators and initiating and ending irrigation in a timely manner. Impact objectives are more direct and have long-term implications for agriculture. Performance indicators such as the intensity of cultivation, level of production, increase of land productivity and farmer incomes, inter alia, fall within this category. Both types of objectives are closely linked with the management capacity of a system and exhibit some degree of overlapping. Measures related to these objectives and their strengths and weaknesses in establishing the levels of performance of the FMIS are discussed after the comments on the methodology and the village setting.

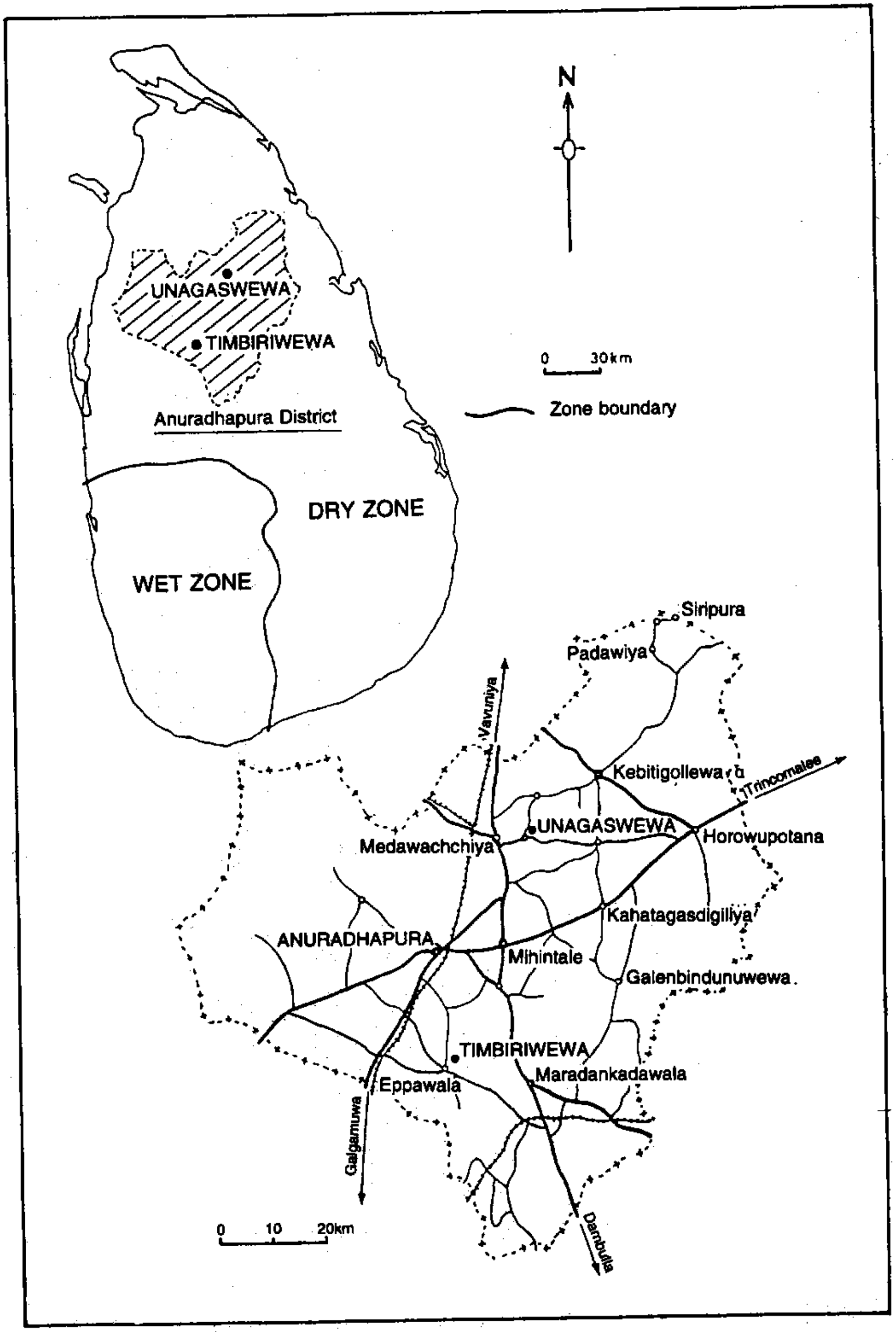
METHODOLOGY

The present paper is based on an in-depth study of two FMIS viz., Unagaswewa and Timbiriwewa purposively selected from the Anuradhapura District in the interior Dry Zone of Sri Lanka (Figure 1). The district possesses as many as 1,047 minor irrigation tanks with an average capacity of about 49 hectare meters (Gooneratne and Madduma Bandara 1990). A questionnaire survey was conducted during *maha* (major cultivation season coinciding with northeast monsoonal rains) in 1987/88 to collect data from the villages. The author made frequent visits to both villages to make observations and to hold discussions with the key informants. Follow-up studies were also made in subsequent cultivation seasons. In addition, available literature on the FMIS was extensively used for purposes of comparison and interpretation of data.

27 Small-scale irrigation works in Sri Lanka serve up to 200 acres (80 ha) of agricultural land.

28 The Dry Zone covers 3/4 of the country and is defined according to the concentration of rainfall within four months of the year and the presence of an effective dry period.

Figure 1. Location of study villages.



THE SETTING

Although Unagaswewa and Timbiriwewa are *purana* (traditional) villages with similar agroecological characteristics, their location vis-a-vis the other settlements has exerted a considerable influence on the degree of exposure to the outside world. Unagaswewa is situated off Medawachchiya, a small township, and the only access to the village is a gravel road from Medawachchiya-Horowupotana main route. It is an isolated village with a predominantly subsistence economy and the employment opportunities for the villagers outside their own settlement, are very restricted. On the other hand, Timbiriwewa which is situated near Eppawala, a service center of the area, is in close proximity to the newly developed Mahaweli settlements[29] and the villagers have opportunities to work in the Mahaweli Scheme as permanent employees as well as casual laborers. Their interest in cultivation is marginal and the village irrigation system has deteriorated at a rapid rate during the recent past. Some basic data pertaining to Unagaswewa and Timbiriwewa are provided in Table 1.

Table 1. Basic data on the selected villages.

Item	Unagaswewa	Timbiriwewa
Catchment area of the tank (sq. km)	1.81	1.14
Extent of puranawela (old field) (ha)	16.80	17.60
Extent of leasehold block (ha)	33.20	14.40
Total command area (ha)	50.00	32.00
No. of farm families	125	48
No. of landless households	6	10

Source: Field survey and Agrarian Services Department.

Both Unagaswewa and Timbiriwewa conform to the basic structure of the Dry Zone *purana* villages which consists of five components, viz., the tank, *puranawela* (old field), leasehold field blocks, unirrigable lands where the settlements and some leasehold blocks are located, and secondary forests which provide land for *chena* (shifting) cultivation (Figure 2). Of the varied components, puranawela lying just below the tank bund, is the oldest irrigated land where almost all descendants of the village have shares. Leasehold blocks are later additions in response to the increase of population and decreasing land/man ratios. At Unagaswewa these leaseholds have existed since 1956 while at Timbiriwewa they originated in the late 1970s and are rare.

29 This is a large trans-basin project which developed much land in the Dry Zone of Sri Lanka.

OUTPUT OBJECTIVES

The two FMIS studied have similar output objectives. Nevertheless, variations in the functioning of irrigation systems, particularly with reference to the control of flow, distribution of water to irrigators and timing of cultivation, are evident. The following section attempts to isolate the output objectives and to treat them separately in the light of the empirical evidence.

Effective utilization of water resources by the beneficiaries constitutes a useful indicator of the performance of a FMIS. It has been shown that if early September rains are utilized for land preparation and cultivation of rice, much water in the tanks can be preserved to supplement water deficit periods in maha and to cultivate a yala (dry season) crop, totally based on irrigation (Upasena 1982). Nevertheless, in the FMIS studied, farmers habitually delay land preparation until tank water levels reach two meters when the release of water from the storage tank is effected. Although this practice results in underutilization of early rains, farmers' indulgence in it may be explained by their preoccupation with chena cultivation and risk minimization (Karunanayake 1983). It also results in the waste of tank water without any productive use, owing to evaporation and percolation losses. However, in the future, villagers will be forced to concentrate on irrigated lands to raise crops as the land resources available for chena cultivation are fast depleting. Furthermore, the government has imposed restrictions on the clearing of forests.

Success or failure in meeting crop water requirements is also an indicator of the performance of an FMIS. Crop water requirements are met in a number of ways, particularly when water scarcities arise. The cultivation of drought-resistant and short-maturing varieties of rice and the adoption of *bethma* (partial) cultivation of the old fields — are more noteworthy cultural adaptations (Karunanayake 1976, Madduma Bandara 1982). The usual practice of bethma where the *yaya* (rice tract) is divided *crosswise* to select a portion for cultivation, is followed at Unagaswewa, while Timbiriwewa adopts a slightly different system called *Irawilla — lengthwise* division of the yaya and the cultivation of all sectors between irrigation and drainage channels (Figure 3). When the irrigators do not possess land in all sectors of the yaya, crosswise division for cultivation purposes becomes too complicated and Irawilla is better suited to cater to such situations.

If water scarcities occur at later stages of crop development the usual practice is to resort to rotational distribution of water. The idea is to save the standing crop. However, to effect such distributions the channel network and control devices of the irrigation system must be intact.

Minimization of differences in quantities of water supplied to the irrigators also enable performance measurement of the FMIS. Many writers have observed that numerous devices are built into these systems for this purpose (Leach 1961; Karunanayake 1976; Goonaratne and Madduma Bandara 1990). The most noteworthy among them is the use of *karahankota* — a log bearing one or more flat-bottomed groves cut into it where the width of each weir is made proportional to the volume of water to be carried to each portion of the yaya.

This system, still prevalent at Unagaswewa, permits control of the flow of water to each section of the yaya, ensuring an equitable distribution of water to different sections of the yaya. However, this practice fell into disuse about two decades ago at Timbiriwewa. Furthermore, unlike the practice at Unagaswewa, here the traditional sluice has not been replaced by a concrete tower sluice. The earthen sluice at Timbiriwewa is not properly maintained and is often subject to water leaks. When coupled with the absence of control structures, effective water distribution, particularly allocation of water on a rotational basis, has become virtually impossible at Timbiriwewa.

Figure 2. Schematic diagram of a Purana (traditional) Village in the Dry Zone.

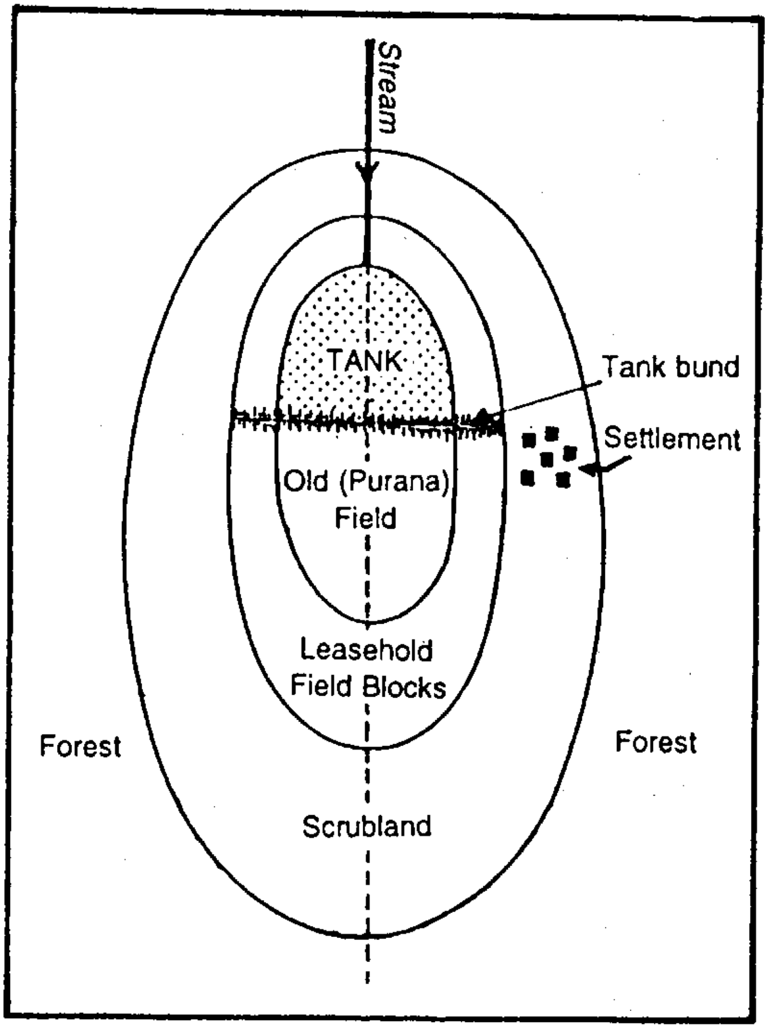
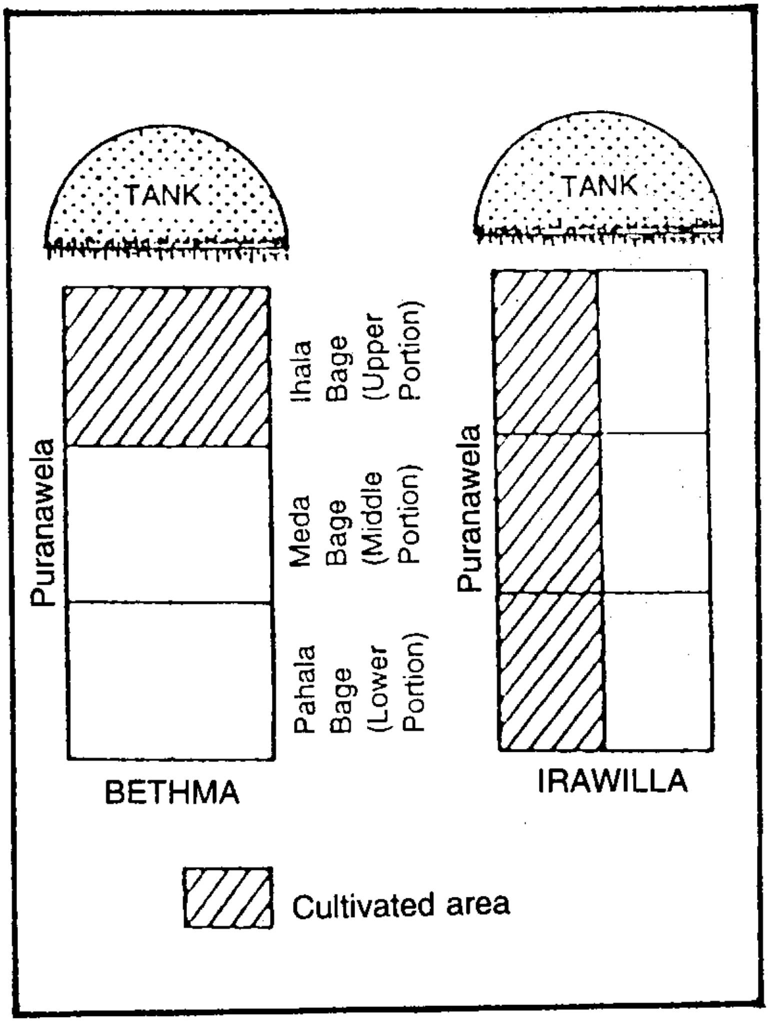


Figure 3. Bethma and Irawilla.



Minimization of differences in water supply cannot be explained only with reference to the physical capability of the system to distribute water. Equity considerations built into the tenurial system by way of apportioning land in all sectors of the puranawela, facilitated a fair distribution of water to a considerable degree. Nevertheless, this output objective has largely been eroded with the changing tenurial conditions of the FMIS. Many instances are recorded at Timbiriwewa, where the villagers have sold land only in certain sectors of the puranawela. Purchasers have been mostly "outsiders" who are least interested in sharing water on an equitable basis.

Commencing and ending irrigation services in a timely manner can also be considered as a performance indicator in the sense that it leads to the conservation of water resources. When all farmers agree to the date of commencement of irrigation and the last date of water issue and if this calendar is adhered to, waste of irrigation water owing to the staggering of land preparation and provision of extended irrigation to late cultivators, can be avoided. However, as field evidence indicates, in the absence of preconditions such as active farmer participation, adequate resource availability and strong supporting institutions, timely cultivation cannot be effected.

IMPACT OBJECTIVES

Promotion of agriculture is the prime concern of any irrigation system. Hence, indicators which measure the success of agriculture are often considered suitable to gauge the impact of FMIS. However, these measures should be treated with caution as agricultural performance cannot be attributed to irrigation alone, although irrigation in a water-scarce setting exerts a profound influence on the intensity of cropping and averting risks in farming.

Intensity of cultivation is a useful measure to establish the impact of an irrigation system, as the cropping intensity is directly related to the provision of water. In both villages under scrutiny, addition of irrigated land in the form of leasehold blocks has increased the demand for water and as the process continued, rice cultivation had to be essentially restricted to the maha season. All irrigable land in the village could rarely be cropped entirely with the water drawn from the tank, as the supply has been insufficient to meet the demand for irrigation water. Field evidence indicates that the cropping intensities for Unagaswewa and Timbiriwewa during the cultivation year 1987/88 (i.e., maha 1987/88 and yala 1988) were 80 and 76 percent, respectively, thus indicating that the levels of performance attained are below potential.

Low cropping intensities in both villages are the direct outcome of land fallowing which can be attributed to many factors. Scarcity of water is the prime physical attribute restricting the cropped area. This can be caused by reductions in the rainfall and/or in the water-holding capacity of the tank. Contrary to popular belief, October rainfall which is of crucial importance to the filling of tanks in the Dry Zone has not recorded a significant decline in Anuradhapura during the recent past (Gooneratne and Madduma Bandara 1990). However, there is conclusive evidence to suggest that silting of the tanks progressed rapidly during the last few decades in both villages thus reducing the water-holding capacity of the tanks.

Attribution of land fallowing to social considerations, particularly to tenurial conditions, is not uncommon in the Dry Zone of Sri Lanka. Excessive fragmentation of land and the scattered nature of small plots under different village tanks have forced the farmers to resort to noncultivation even when water is available. Although this factor is of no significance in the villages studied, noncultivation under village tanks owing to unfavorable tenurial conditions has been observed elsewhere in the Dry Zone (W.R.B. 1968).

Farmers in both villages claim that the present levels of production are higher than in the past. The reasons attributed to the change are the adoption of High Yielding Varieties (HYVs) and the use of chemical fertilizers. However, Table 2 indicates that the rice yield stagnated at very low levels, especially with reference to better-watered Mahaweli areas and the average yields for Sri Lanka. It is established that the potential of HYVs of rice presently grown in the villages, when coupled with good management practices is as high as 7–10 tons/ha. Nevertheless, the yields realized in both villages seem to have stabilized at about 1/3 of this potential. As Gooneratne (1991) has observed with reference to irrigated agriculture in Sri Lanka, the situation leads to "underproduction" with numerous negative consequences on the economy.

Table 2. Average yields of rice during maha 1987/88.

Location	Yield (tons/ha)
Unagaswewa	2.35
Timbiriwewa	2.52
Mahaweli (System H)	5.08*
Sri Lanka	3.47*

*Figures relate to maha 1986/87.
Sources: Field survey for Unagaswewa and Timbiriwewa, Mahaweli Projects and Program (1988) for others.

It is pertinent to note that the use of production levels to measure the performance of an irrigation system has to be treated with caution as water supply is not the only factor affecting yields. Other considerations such as soil fertility, drainage, resource constraints experienced by the farmers and the tenurial conditions can be of much significance in different locations.

There is no doubt that improved cropping patterns lead to enhanced land productivity and hence, can be considered a performance indicator of the FMIS. It is observed that in both villages irrigated lands are devoted to monocropping of rice during maha while yala cropping is of rare occurrence. Nevertheless, there exists a potential to introduce new cropping patterns in yala. Factors other than irrigation also play a significant role in the introduction of new cropping systems and their adoption by the farmers.

High returns from agriculture provide the basis of enhanced farmer incomes. Although reliable water supplies and the availability of water for double cropping are of direct relevance to farmer incomes, the variation among as well as within the FMIS are caused by a combination of physical, cultural and socioeconomic factors. Quality of the soil, availability of traction, ability to use improved farming techniques and the degree to which the commercial crops are grown, are the more significant among them. Hence, it would be an effective criterion to measure the performance of FMIS only when the differences other than irrigation are minimal.

It was observed that farmer incomes in the villages studied are extremely low. Of the sampled households 88 percent and 80 percent in Unagaswewa and Timbiriwewa, respectively, received food aid from the government as their corresponding incomes were below the official poverty line of Rs. 700.00 (US$21)[30] per month. Impact of the irrigation system which restricts cultivation to one season has been an important causative factor in this context. However, the significance of

30 Conversion was done at the official rate of exchange prevailing in 1988, i.e., Rs. 33.00 per US dollar.

other phenomena such as the financial constraints which retard the application of inputs, unfavorable tenurial conditions, restrictions or virtual unavailability of a marketable surplus of rice and the absence of cash crops under irrigated agriculture, cannot be overlooked.

CONCLUSIONS

Criteria used to measure performance of the FMIS studied indicate that output as well as impact objectives have not been adequately realized. A rapid disintegration of these irrigation systems is evident owing to the repeated attempts at changing the tradition-bound village institutions. However, it was observed that the performance of the FMIS depends on a multiplicity of factors which exhibit both regional and temporal variations. Therefore, the utilization of common criteria for performance measurement without a profound understanding of these deep-rooted systems in their correct perspective will not be meaningful. Hence, the methods adopted need refinement on the basis of considerations more specific to each FMIS. Field evidence suggests that the production-based development strategies strictly depending on input-output relationships should be modified to accommodate the important secondary considerations of marketing and postharvest technology.

Acknowledgements

The author wishes to thank Prof. M. M. Karunanayake, University of Jayawardanapura, for his valuable comments on the first draft of the paper and suggestions for improvement and Mr. G. F. de Alwis, staff cartographer, University of Sri Jayawardanapura for drawing the illustrations.

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Performance of Irrigation Systems in Hill Areas of Uttar Pradesh, India

U. C. Pande[31]

ABSTRACT

AGRICULTURE IN HILL areas in India is largely dependent on rainfall. A small percentage of the cultivated area (averaging 10%) has however, always enjoyed irrigation facilities. These irrigation systems of the preplan period were built and managed by communities of irrigators. With the beginning of planning in India irrigation systems were created by the state in hills in the early fifties by the simple process of modernizing some of the existing traditional irrigation systems and creating new ones in easily accessible areas. The traditional systems exist in large numbers even today though they do not fit the description of "technical adequate" engineering systems and as such are not acceptable to the state irrigation departments. Hill irrigation systems are usually small in size (2 to 50 ha). FMIS fall in to the smaller-sized category and have apparently very simple design features.

INTRODUCTION

Agriculture in hill areas in India is largely dependent on rainfall. A small percentage of cultivated area (averaging 10%) has however, always enjoyed irrigation facilities. These irrigation systems of the preplan period were built and managed by communities of irrigators. With the beginning of planning in India, irrigation systems were created by the state in hills in the early fifties by the simple process of modernizing some of the existing traditional irrigation systems and creating new ones in easily accessible areas. The traditional systems exist in large numbers even today though they do not fit the description of "technically adequate" engineering systems and as such are not acceptable to the state irrigation departments. Hill irrigation systems are usually small in size (2 to 50 ha). FMIS fall into the smaller-sized category and have apparently very simple design features. Table 1 gives an indication of the area covered by various categories of minor irrigation systems in the hill areas of India.

Information on Uttar Pradesh (U.P.) hills is not included in this Table as the publication does not separately show figures for U.P. hill areas. However, an irrigation potential of 33,200 ha had been created by state irrigation systems up to March 1985 and approximately twice as much area lies under private minor farmer-managed irrigation systems (FMIS). Similarly, in the Western

31 Water Management Consultant, Consulting Engineering Services, New Delhi.

Ghats hill region on the west coast of the Indian subcontinent a substantial area exists under the FMIS category.

Table 1. Net area (in '000 ha) irrigated by various sources (1984–88) (provisional).

State/U.T.	Canals			Tanks	Wells, including tubewells	Other sources	Total
	Govt.	Private	Total				
Arunachal	–	–	–	–	–	22	22
Assam	71	291	362	–	–	210	572
Himachal	7	–	7	1	3	84	95
J and K	120	168	288	3	4	14	309
Manipur	–	–	–	–	–	65	65
Meghalaya	–	–	–	–	–	50	50
Mizoram	–	–	–	–	–	8	8
Nagaland	–	–	–	–	–	50	50
Sikkim	–	–	–	–	–	16	16
Total	198	459	657	4	7	519	1187

Source: Indian agriculture in brief, 1989. Ministry of Agriculture, Government of India.
Notes: Govt. = Government; U. T. = Union Territory

From Table 1, it can be seen that in these states and U.T.s, as against a total area of 198,000 ha covered by state irrigation systems, the area under private canals accounts for 459,000 ha. In addition 519,000 ha included under the heading "other sources" also represent private nongovernment systems. If the area covered by FMIS in the U.P. hills and Western Ghats is added, the FMIS provide irrigation to a total of nearly 1.1 million hectares. Little is known about these systems but it is certain that productivity levels of FMIS are on par with those of state systems.

UTTAR PRADESH HILL AREAS

The hill region in the state of Uttar Pradesh (henceforth to be referred to as hills) lies in the Central Himalayas and covers nearly 53,000 km^2 which is nearly 15 percent of the total area of the state. Average landholding size of 75–80 percent of the landholders is less than 1 ha. Each holding is fragmented and may consist of between 5 to 10 small parcels distributed in various locations in a village or in more than one village. Nearly 10 percent of the total geographical area in the hills is currently under cultivation and, in recent times, marginal and range lands as well as forest areas have come under great pressure of encroachment due to population increase. Irrigation facility is available on average, to 10 percent of the cultivated area.

The best class of cultivation and crops are found in villages of moderate altitude between 3,000 ft and 5,000 ft. having access on the one hand to good forest and grazing ground and on the other, to riparian fields in the depths of river valley. Here all the crops that can be grown in the himalayas grow to perfection. If favored with irrigation water these lands yield excellent crops (Atkinson 1992).

RAINFALL IN THE HILLS

Rainfall in the hills is substantial and well-distributed during the year. In most of the area the monsoon rainfall (July–September) is between 100 and 150 cm and the winter-spring rain (December-March) of the order of 20 cm and above. There are some pockets which experience higher precipitation. Even before the regular monsoons begin in July, rains are experienced in April and June. Germination and sprouting of upland (unirrigated) rice and other crops are very much dependent on rainfall during this period of the year which may be the first segment of effective monsoon. During the monsoon period, sufficient runoff is expected in the meteorological weeks 27 to 34 and somewhat lower in the later weeks.

Climatic water balance over the year for Almora, one of the cities in the hills (elevation 1,600 m), indicates that evaporative demand is higher than rainfall in February-May and October–December and less during rest of the year. It is in these two periods, respectively, that the dough formation and ripening of winter wheat and monsoon rice crops occur. A study of the monthly soil moisture balance for Almora for 26 crop years showed that the winter wheat crop faces a moisture deficit almost every year (25 out of 26) while the monsoon rice crop seldom faced it (2 out of 26). A scrutiny of dry spells during the winter wheat season indicated that irrigation was required during 8 out of 26 crop years.

TYPES OF IRRIGATION SYSTEMS

Irrigation systems in the hills fall under the category of Minor Irrigation, i.e., systems with command areas under 2,000 ha. Generally, minor irrigation systems in the U.P. hills do not command areas larger than 300 ha and a majority of these cover between 10 to 150 ha. Many ancient privately managed gravity canal systems have been taken over by the Irrigation Department. Studies (R.C. Pant 1981) have shown that in the eight hill districts of U.P., FMIS cover an area which is more than twice that reported under government irrigation systems.

Lined gravity contour channels are the most common irrigation source in the hills. Other state-owned schemes include medium/small tanks, hydro-lift schemes, lift pumps and sprinkler systems. Privately owned small tanks and hydrams and gravity canals (partly lined - or plain earthen channels) are managed and operated either by individuals or groups of farmers. Irrigation channels rarely off-take from any major river stream for the obvious reason that this would call for construction of sophisticated diversion and control structures which are very expensive. The canals are fed from smaller perennial streams, which descend down hill slopes to meet the main drainage, and can be tapped at various elevations in their downward journey.

As may be expected from the above narrative, irrigation systems built by the state coexist with community/privately owned systems. State systems are run by an irrigation bureaucracy which builds new systems and thereafter takes on the responsibility of their operation and maintenance (O&M). A small irrigation fee is charged from the beneficiaries. Some of the FMIS may receive financial assistance from the state for their improvement but subsequent O&M responsibilities continue to be shouldered by the beneficiaries as before. No irrigation fees are payable to the state. A majority of FMIS, however, do not receive any financial or other support from the state or its institutions and are also totally free of any control or interference by the state.

STATE IRRIGATION SYSTEMS

The state Irrigation Department has a widely scattered network of functionaries at field level. They are employed in the construction of new systems and O&M of the existing ones, distribution of water and collection of irrigation revenues. Since hill channels are prone to frequent serious damage during monsoons, their maintenance is very problematic. The hills belonging to Shivalik Range are fragile and, therefore, frequent landslides are quite common. An entire section of the irrigation canals is occasionally washed away and has to be rebuilt. The transportation expenses of materials and labor and supervision charges to the remote sites for comparatively little work are very high. The time-lag between the occurrence of damage and its repair may take months. Assessment and estimate of damage, sanction for repair, allotment of funds, actual work of repairs and running of irrigation channel are processes that consume much time. The unavailability of irrigation water in a system for long durations as a result of administrative delays reduces productivity considerably.

FMIS

On the other hand, FMIS are generally earthen gravity canals which can be fed from a natural stream or spring by means of simple diversion structures. They are designed for least cost effort in maintenance. Damage to the system is usually such as can be repaired quickly. The systems are under constant pressure to deliver irrigation water to the beneficiaries who themselves operate the system and distribute the water. Repair to the damaged part of the system is carried out expeditiously.

In one of the valleys of the hills, there exists a unique system of management for FMIS locally known as *hara* (or contract) system. In this system of irrigation development or management, the community employs a contractor to build a brand new irrigation system from his own resources and operate it for a period of time of up to thirty years. During this entire period, the contractor receives a hara, which means share, of the total crop produced from irrigated land. For existing systems a similar contract is entered into at a reduced hara for O&M and irrigation functions. The efficacy of the hara system is to be viewed in the context of emigration from the hills which has been causing a severe drain on their manpower resources.

THE HARA SYSTEM OF IRRIGATION

The hara system of irrigation first came to the attention of researchers in 1988. Hara means share and in this management system, a contractor who takes on the responsibility of providing irrigation to farmers claims as his entitlement a share of the crop. There is always a contract between the farmers and the contractor, occasionally a written and registered one. Currently existing contract systems have only unwritten agreements.

MIGRATION FROM HILL AREAS

Emigration from the hills has been one of the recurrent features of U.P. hill areas. This was occasionally due to political reasons as happened between 1810 and 1825 in Garwhal District of the hills, which saw emigration of whole villages unable to cope with the usurious taxation policies of the conquering Nepali rulers. Climatic rigors faced in the subarctic conditions in villages in proximity of the great Himalayas occasionally resulted (1900–1901) in seasonal migration of 78 to 98 percent of the population to areas with warmer climates and better opportunities for employment or trade. In recent years, unemployment or partial/under-employment has created a push effect for migration of males in the age group 15–50 years. Outside of agriculture there are very few job opportunities. The manufacturing sector does not exist in rural areas and there are few jobs in the service sector, except in armed or paramilitary forces where representation of hill people is quite high.

It might be fair to assume that small landowners form the bulk of the migrants. The facts, however, indicate the contrary. In a survey of one of the most underdeveloped districts of the hills — Pithoragarh — it was found that compared to landless farmers or those owning less than 0.4 ha, those having comparatively larger holdings of 1 ha or more had a higher migration rate (Khanka 1989). Thus while farmers with landholdings of up to 0.4 ha had between 0.6 and 0.8 persons migrating per family, those with holdings of between 1 to 2 ha contributed between 2.33 to 2.75 persons per family.

Emigration has caused some distortions in the male-female ratio in the population. Thus in the age group 15–50, the number of females per thousand males was found to be 1,404 whereas in all other age groups it was between 800 to 900. Consequently, the average working hours per day for females are an inordinately long: 12 hours out of which 3.6 are spent in agriculture and 3.4 in tending cattle.

Partial employment leads to unproductive employment in the sense that the reduction in the number of people employed in agriculture as a result of emigration does not affect production. One ha land provides full employment to 1.77 person in the hills and results in maximum production. Members of a family in excess of this number may therefore be considered not to have been productively employed. If, as a consequence of emigration, money is to flow into the village, which actually does happen, then the emigration of unproductive agriculture labor is a positive and contributory factor to the well-being of a family.

STUDY OF IRRIGATION SYSTEMS — PERFORMANCE INDICATORS

A study comparing the performance of state irrigation systems and FMIS was carried out under a grant provided by the Ford Foundation (India). The main performance indicators which were selected for the study were productivity, costs to the government and farmers, equity in water distribution, management efficiency in terms of timeliness of irrigation supply, and cost-effectiveness in maintenance and sustainability. Other points to be considered related to access to resources including loan funds and subsidy and assessment of their consequences.

As the study progressed it was observed that loan and subsidy issues were only marginally relevant. The state either fully funded a project, managed the resulting system and charged a very nominal irrigation service fee, or provided small-scale assistance to a very small number of individuals or communities to develop or improve irrigation systems. Management parameters turned out to be the most significant indicators of performance and clearly established the considerable impact they have on productivity and farm incomes.

The best managed system from among the eight systems studied — four each of state irrigation department and FMIS— turned out to be the one operating on the hara basis. A brief description of this system is, therefore, being given below.

HARA SYSTEM OF IRRIGATION MANAGEMENT

This management system is peculiar to the Saryu Valley near Seraghat, a small village on the bank of Saryu River which at this location determines the boundary between Almora and Pithoragarh districts. The earliest of the contract systems came into being in 1894 and the most recent one in 1951. At present, two systems in Pithoragarh District and one in Almora District continue to be run by contractors. Two of the remaining four such systems which were taken over by the state Irrigation Department, have been severely damaged due to the construction of a road which runs in close to these systems at a higher elevation on the same hill face. A third one has barely started functioning after remaining out of commission for a decade. In this contract system evolved over the decades, the village community seeks a contractor to perform all irrigation functions — from capture and conveyance of water for irrigation, to actual delivery into each field. The O&M of the system is the total responsibility of the contractor. A typical contract is negotiated between the elected representatives of a community and other prominent persons of the village, on the one hand and a contractor on the other. In a written contract every eventuality of an irrigation situation is spelt out.

All hara systems have some common features:

1. There is a contract — written or oral — which determines the share of the contractor from each crop from irrigated land.
2. The contractor is selected by the village after calling a meeting which is presided over by the *Sarpanch* (elected village head). The person offering to take up the responsibility for the lowest hara is offered the contract.

3. In new systems, the hara rate is quite high initially but as time passes it is reduced. Also the first contract is usually for a long period, say 20 to 30 years. This enables the contractor to realize his investment costs.

4. The beneficiaries often try to run the system themselves. This usually happens at the end of a contract of long duration or one with a high hara rate.

5. The contractor must maintain the system at the highest level of efficiency and attend urgently to any damage to the physical system. He is also totally responsible to irrigate each field whenever required and as per rules framed by the community.

6. The contractor has to follow the sequence of irrigation determined by the community. Equity of water distribution is the concern of the community which orders the contractor to follow a mutually agreed schedule which is usually quite simple. If in one year irrigation is to start from head end to tail, then in the following year the order is reversed.

The following key points emerged from the study regarding contract-managed irrigation systems on the hara basis:

1. This management pattern is geared to efficient system operation to achieve high productivity which benefits both the farmer and the contractor. The entire irrigable command area is covered during each of the two main crops and even a third crop is attempted by both the farmers and the contractor.

2. Though the contractor runs the system much as he pleases, he works within guidelines already established and clearly defined either orally or in a written agreement. Some of these guidelines elaborate the duties of the contractor. At the same time, the contractor has great flexibility of operation.

3. A local contractor — one from among the irrigators — is more successful as he is amenable to the introduction of changes in operation, if needed. He is less likely to be cheated in hara collection by people of his own village. In all law suits involving a contractor and villagers, the former was invariably an outsider. On the other hand, a local contractor would rather resign his contract than proceed against delinquent farmers of his village.

4. The contract system is typical of Saryu Valley. Each of the two ID system of this area (Lweta and Jingal minor) has elements of the hara system in their management.

5. Beneficiary farmers invariably try to dislodge a contractor of long standing in the hope of getting a new contractor who will agree to a lower hara rate. Older systems have contract terms with progressively dropping hara rates

6. Whether oral or registered, terms and conditions of a contract are clearly known to all and are fully respected.

7. Successful hara-based systems invariably have sufficient water at the source. This results in overirrigation. Also, since the contractor does the entire work of irrigating fields, the farmers have little to do in the fields after plowing operations and broad-casting sprouted rice seeds in their prepared fields. Even though it is claimed by farmers that rice yields are as high under this practice as for transplanted rice, this is incorrect and unscientific. Very little area is under transplanted rice in most hara systems.

8. The contract system is appropriate where availability of agriculture labor is low and its cost high. Since per family landholding size in the hills is very small, family members have to migrate temporarily to earn an additional income. In the hara system, much of the work is performed by the contractor, obviating the need for hired labor.

9. A strong contractor may ignore the wishes of the less-articulate farmers causing dissatisfaction among them. A weak contractor is no more than a paid employee, who is also frequently cheated out of his hara.

10. The number of irrigation-related conflicts are reduced to a minimum as no cultivator is permitted to disturb an irrigation sequence which was agreed to in advance by the villagers or which has been in effect for a long time.

11. Since farmers pay for irrigation from their harvest, they make no investment for this activity at any time. This is an important consideration for the hill people who have very low incomes and rarely have ready cash.

12. The initial investment towards the cost of building a new system is borne entirely by the contractor, as are the O&M costs.

13. Detailed instructions regarding the duration of the irrigation to be provided in the various hamlets of a village are given.

14. The contractor is forbidden to give water from the system to any other village, without the prior consent of the village entering into a contract. On their part, the villagers may not bring water on their own or employ another contractor while the contract remains in effect. If the villagers violate this condition, they are liable to pay the costs incurred by the contractor.

15. The villagers surrender their right to transfer the system to the Irrigation Department. Any contrary action on the part of the villagers, or action taken by the ID to take over the system is considered illegal.

16. The contractor receives hara for a specified period. The share of different crops and vegetables grown in the irrigated land and other details such as those pertaining to default in payment by anyone, are given in detail in the contract.

While no one save the contractor is allowed to irrigate the fields, the contractor is not free to make any changes in the established irrigation sequence. He must not only be fair but must also appear to be so. Conflicts with clients can mean higher management costs and lower returns and ultimately loss of the contract. On the other hand, higher yields result in a happy client and happier contractor as he stands to collect larger absolute quantities as his share of the crop.

Contractor-run irrigation systems can be rated among the most user-friendly systems and that perhaps also represents a slight disadvantage. The clients become lazy and unthinking. However, under the circumstances created by migration of the male work force from the area, this innovative management method provides a much-needed service to the community.

PERFORMANCE OF CONTRACT SYSTEMS

Performance of contract-managed systems under all parameters, e.g., productivity, equity of water distribution, net return of income to the farmers and management efficiency, turned out to be the highest among all the systems examined. System sustainability was never in doubt for contract-managed systems.

SYSTEM OPERATED BY IRRIGATION COMMITTEE

Another FMIS which was run by elected representatives of beneficiary farmers had a very high level of equity in water distribution. The system suffers from insufficient water availability at the source, particularly during the hot summer months. Yet within the system, the location of a field whether, at head end, middle or tail end, did not affect water availability to the field. Productivity levels in this system were lower than those obtained under the contract system but quite satisfactory in the overall context of productivity of irrigated agriculture in the hills.

Insufficient water availability in state irrigation systems often leads to serious conflicts. In this system, shortages were handled by the committee quickly and effectively, by penalizing defaulters irrespective of their social or political status.

STATE IRRIGATION SYSTEMS

In state-owned systems performance depended very much upon 1) length of the canal and 2) distance of the system from a motor road and district administrative headquarters. Long canals were difficult to operate and to maintain and suffered from highly inequitable water distribution between head- and tail-end sections of the system. Their productivity levels were nonuniform and varied between and within systems. Sustainability of the system was ensured by the injection of substantial funds by the state as well as by "voluntary" though unwilling labor inputs by beneficiaries, in critical maintenance activities. In this sense, therefore, some of the state systems could be considered to be jointly managed.

CONCLUSIONS

Irrigation canals of short length (up to 3 km) appear to perform most satisfactorily under the conditions prevailing in the U.P. hills. As the average area of land held by an average family is small (less than 1 ha), and more than half of it is usually unirrigated, efficient performance of a system is reflected in productivity levels and in its uniformity across a system. This in turn affects net returns to farm family from irrigated agriculture.

Irrigation costs to the farmers represent another important parameter. Where these costs are high, farmers tend to neglect the system and community participation in O&M activities dwindles until it ceases altogether. Alternatively, the users of the system try to hand the system over to the state in order to pass the burden on to the state Irrigation Department. Such a transfer is not always and uniformly beneficial. Quite often, farmer distress and dissatisfaction with the system has been found to begin soon after the transfer has taken place.

Innovative O&M options such as the contract system, highlight the importance of system management as a critical parameter in performance evaluation. In backward areas within poorly developed economies, state intervention in the irrigation sector is a considered policy option and is designed to act as catalyst in development. Joint management of state-owned irrigation systems with the ultimate aim of turnover of the systems to the community is a desirable goal. Division of O&M responsibility between the state and the beneficiaries in such situations could spell out cost-sharing modalities. Costs to the farmers would determine sustainability of such systems and would therefore represent an important performance indicator.

Performance Measures of Irrigating River Nile Islands (Gezirahs)

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ABSTRACT

THE RIVER NILE is the main source of irrigation water in Egypt. Before construction of the High Aswan Dam (HAD) and during the flood season, the Nile waters used to carry soil minerals which led to the formation of many small islands in the stream of water. The location and area of these islands used to change from year to year and flood waters would cover them. After construction of HAD, flood waters no longer reached the levels of the past. The farmers on the islands were pleased with this change. The soil of the islands became very rich, the Nile water is now available all year-round and a unique micro climate exists during both the hot summers and the cold winters.

Farmers of farmer-managed irrigation systems (FMIS) in these islands have developed their own surface irrigation systems, cropping patterns and water delivery and distribution systems. A natural drainage system exists and care is being taken in applying and distributing water within the farmers' fields and throughout the islands.

The performance of these FMIS is unique since their outputs reflect their management practices in terms of soil, irrigation, drainage, cropping pattern and their impact on the economy of the islands. Their performance also reflects the use of farmer-produced inputs which tends to increase their expected profits by minimizing the transaction costs.

Questionnaires as well as field visits and observations were used to gather information on irrigation-related activities of these islands. Farmers' views of different systems such as the Centrally Managed Irrigation Systems (CMIS) were studied to gain insights and for purposes of comparison between FMIS and CMIS. After examining farmers' views on CMIS and FMIS, performance indicators are described.

Gezirah is an Arabic word meaning island. Gezirahs have an appealing significance in Arabic tradition due to expectations of what may be found on them. This paper covers some studies on selected islands in the River Nile. It describes the area cultivated, location, water lifting devices, surface irrigation systems, cropping patterns, returns and suggested plans for improvement of the FMIS. The paper also describes the technical and economic parameters used to evaluate the case studies, and relates these to performance indicators.

Technical and economic efficiencies are compared to show how the management of these systems makes compromises in their decision-making process. The social structures and the internal organization structures are described, analyzed and evaluated.

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FARMERS' VIEWS OF THEIR SYSTEMS

Two groups of farmers were met. The first was a group of elderly farmers who had experienced both the conditions prior to the construction of the HAD and after it came into operation; the second group consisted of young farmers who were children at the time of construction.

Before the construction of the HAD, irrigation activities were the most costly and time-consuming of all farming operations and involved very hard work. After the HAD came into operation, the rate of introduction of water pumps to the islands was very high in comparison with that of the Centrally Managed Irrigation Systems (CMIS). Irrigation is the main activity which farmers have to perform. 30 percent of their decisions deal with irrigation. Other decisions deal with fertilization, blowing, picking and marketing. The drainage system is natural due to the soil formation and the care taken in applying water to the crops. Maintenance of the water delivery system is done routinely. It is done every two to three weeks. At that time all farmers using the irrigation channel share in maintaining the headworks. There is no other water source except the intake from the Nile.

Vermillion (1991) states that "the ability to recover operation and maintenance costs from beneficiaries is directly related to the productivity of irrigated agriculture. The users have a personal interest in ensuring the long-term productivity of their irrigated agriculture. This is ensured through good operation and maintenance management performance."

The interval between irrigations is five to six days with no constraints on the availability of water. This permits raising crops such as vegetables which are sensitive to water stress and have high cash value. Because the production of the islands is not subject to government regulations, production is more consumer- and market-oriented.

THE ISLANDS IN THE RIVER NILE OF EGYPT

Table 1 gives the number of islands and their total areas (in feddans) along the different reaches of the River Nile from Aswan to Cairo. The zero location is the Rodda water level near Cairo. Table 2 classifies the islands according to size in order to highlight the number of islands in each size group and their distribution along the six reaches of the River Nile.

Table 1. Number of islands and their total areas in the different reaches of the River Nile from Aswan to Cairo.

Reach No.	Extent of the area	Location from Rodda Water Level near Cairo in km	Length of the reach in km	No. of islands	Total area in feddans
1	From Aswan to upstream of Esna Barrages	921.00 to 760.40	160.60	29	4,956.47
2	From downstream Esna Barrages to upstream Naga Hammadi Barrages	760.40 to 567.50	192.90	52	5,457.40
3	From downstream Naga Hammadi Barrages to upstream Assiut Barrages	567.50 to 382.20	185.30	89	10,748.00
4	From downstream Assiut Barrages to the City of Minya	382.20 to 242.00	140.20	46	7,022.14
5	From the City of Minya to the City of Beni Suef	242.00 to 117.00	125.00	85	5,411.98
6	From the City of Beni Suef to upstream Delta Barrages (North of Cairo)	242.00 to 117.00	142.90	55	6,039.82

Table 2. Classification of the detailed areas of the islands in feddans (F) and their numbers.

Reach No.	Extent of the area	No. of Islands	Area of the islands					
			Less than 50 F	from 50 to 100 F	from 100 to 200 F	from 200 to 500 F	from 500 to 1,000 F	more than 1,000 F
1	From Aswan to upstream of Esna Barrages	29	10	6	6	6	–	1
2	From Downstream Esna Barrages to upstream Naga Hammadi Barrages	52	28	5	9	8	2	–
3	From Downstream Naga Hammadi Barrages to up-stream Assiut Barrages	89	60	9	3	11	4	2
4	From Downstream Assiut Barrages to the City of Minya	46	29	4	6	4	1	2
5	From the City of Minya to the City of Beni Suef	85	68	7	5	2	3	–
6	From the City of Beni Suef to upstream Delta Barrages (North of Cairo)	55	34	9	5	3	3	1
Total		356	229	40	34	34	13	6

The Tables show that the largest number of islands (89) is in the reach from downstream Naga Hammadi Barrages to upstream of Assiut Barrages. The total area of the islands in this reach is 10,748 feddans (1 feddan=0.42 ha). The smallest number of islands (29) is in the reach from

Aswan to upstream of Esna Barrages. These have a total area of 4,956.47 feddans. Classified by area, the largest group contains 68 islands each with an area of less than 50 feddans. This group is located between the city of Minya and the city of Beni Suef. Only six islands exceed one thousand feddans. The largest island is Shebha, with an area of 2292.66 feddans, length 4.9 km and maximum width 2.50 km. Its location is 277.00 km south of Rodda or south of Cairo.

The information in Tables 1 and 2 was gathered by the High Aswan Dam Side Effects Research Institute (HADRI) of the Water Research Center, Ministry of Public Works and Water Resources (Shalash, S. 1986). The survey was done following an aerial survey of the River Nile made to monitor the erosion of the banks of the Nile as well as the stability of the islands. The location of the islands relative to the stream is to the right, to the left or in midstream. Some of the islands have submerged sections on the River Nile. The degree of submergence is relative to the water level of the River Nile which varies from season to season according to the water requirements of the different sectors such as agriculture, industry, navigation and hydropower generation.

There are many other islands in the Rossetta and Damietta branches of the River Nile. There are, in addition, two other types of islands. The first is not a complete island, as it is connected on one side to one of the banks of the Nile; the second type is cultivated only three months a year during the winter closure period and the winter season when water requirements are minimal. Farmers cultivate these islands only during that short period.

ECONOMIC PERFORMANCE OF GEZIRAH FMIS

Since the farmers develop their own surface irrigation systems, cropping patterns, farm management practices in terms of soil, irrigation and drainage, the economics of these practices merit study as a measure of their performance.

Barghouti and Le Moigne (1990) report that in various parts of Africa, there are signs that privately managed irrigation systems perform better than government-managed systems, especially in small-scale irrigation.

Farmers of Gezirahs were found to have their own economic concepts in managing their irrigation systems. The concepts focus on maximizing their returns and increasing irrigation water use efficiency, physically and economically. The application of this concept manifests itself in the cultivation of short-season case crops (SSCC) which have a rapid flow of returns. The flow of returns helps finance other operations and the cultivation of crops already planted as well as others still planned.

Gezirah FMIS cultivated parsley, lettuce, cucumbers, tomatoes, Egyptian leak and garden rocket, in addition to maize and occasionally Berseem. Other farmers cultivated flowers, trees and orchards. These crops can be cultivated three to five times a year (almost nine months for Gezirahs) and their returns are very high since they can be used fresh and thus sold at high prices.

The survey indicated that crop yields of El Gezirah FMIS were very high compared to those of CMIS farmers. Crop intensity in the Gezirahs was three times that of CMIS. Cost per feddan was also three times that of CMIS. Gross returns were four times that of CMIS. Irrigation efficiency for El Gezirah FMIS was high since irrigation water requirements were less than those of CMIS. The average estimated water requirements for one feddan cultivated at El Gezirah FMIS were 5,400–5,500 m^3 compared to 6,000 m^3 for an efficient CMIS.

Stegman E.C. et al. (1980) described the management models and procedures which have been used in applied irrigation scheduling as well as the arguments for those models and procedures. These are summarized as follows:

* Economics of near-maximum seasonal yield (relatively low cost of water application).
* Maximizing yield per unit area.
* Maximizing yield per unit water applied.

Table 3 summarizes the differences in economic benefits between El Gezirah FMIS and CMIS.

Table 3. Economics of FMIS at Gezirahs compared to CMIS.

Item	CMIS	FMIS
Type of crop patterns	CCP[35]	SSCC[36]
Crop Intensity (%)	200	300–50
Average cost/feddan (L.E.)	997	2015
Average gross returns/feddan (L.E.)	1511	4397
Average net return/feddan (L.E.)	514	2382
% of net return to gross return	34	54
Irrigation water requirements (m^3)	6000	5400
Return to one m^3 (L.E.)	0.086	0.44

Note: L.E. = Egyptian Pound

The following conclusions may be drawn from this Table:

* El Gezirah FMIS are technically efficient.
* Investments in FMIS at Gezirahs will yield acceptable economic returns.
* Returns to irrigation water per m^3 for Gezirah FMIS were Egyptian Pound (L.E.) 0.44 which is economically desirable compared to L.E. 0.086 for CMIS.

35 CCP: Centralized crop patterns managed by the Ministry of Agriculture; there are six to seven crop patterns:
Short berseem followed by cotton
Long berseem followed by maize
Long berseem followed by rice
Broad bean followed by maize
Broad bean followed by rice
Wheat followed by maize
Wheat followed by rice
Also, winter crops followed by summer vegetables or winter vegetables followed by summer crops.

36 SSCC: Short-season cash crops, mainly vegetable crops. Parsley, garden rocket, Egyptian leak, lettuce can be cultivated 3–4 times a year. Tomatoes and cucumber can be cultivated only twice a year.

* Gezirah FMIS may be seen as a model for encouraging a shift in irrigated cropping patterns from basic crops to high value crops.

* Economic indicators can be seen to be good measures of the performance of Gezirahs FMIS. The data presented provide public and private managers and planners with some general results on the economic value added from managed irrigation systems. These data may be applied for better water allocation between competing demands or uses and also for better decisions on investment in irrigation.

The technical conclusions from the data in Table 3 may be summarized as follows:

* Natural drainage from the FMIS of the Gezirahs helped the farmers to irrigate their crops frequently and efficiently.

* Management of the soil is done frequently: either each season or during the high water level stages of the Nile.

* The microclimate of the islands has positive effects on the maturity stages as well as on the quality of the products resulting in high market prices as compared to the CMIS products.

* The small size of the holdings as well as the large number of water lifting devices have served to develop self-management capacities and the ability to coordinate irrigation, agriculture and marketing activities. All these aspects have had positive effects on yield as well as on net returns of FMIS of El Gezirahs.

* The farmers of FMIS are more successful than those in the CMIS. There are many signs of this in the neighboring areas on the banks of the Nile.

* The decision to liberalize the FMIS created a strong movement towards irrigation improvement in terms of efficient water use and improved management practices.

The data in Table 3 are drawn from two sources. Data on FMIS of the Gezirahs were collected through a questionnaire which was designed to elicit farmers' responses (farmers' responses and interviews). Data on CMIS of the old lands in Egypt were obtained from the Irrigation Improvement Project (IIP) which was designed to improve the water management of both on-farm and water delivery and distribution networks (IIP 1990).

While the IIP is working to improve the CMIS, it is already clear that the FMIS of the Gezirahs are performing very well. Their management has resulted in high returns per unit of water and per unit of land, as may be seen from the data in Table 3.

FUTURE DEVELOPMENT

Due to the continuing settlement of the islands since the construction of the HAD and to the variable flows associated with changing water levels, the Mechanical and Electrical Department of the

Ministry of Public Works and Water Resources in Egypt has undertaken a new project denominated "37 Pumping Stations Project." Work on this project started one year ago. The pumping stations of the islands are of the floating type.

The location of the islands makes them subject to high risks such as contamination of the water by wastes, erosion of the shores and flooding in the event of high releases for the safety of the dam. The recent development of the islands as well as their future development needs necessitate research to protect the successful examples of performance and to alleviate or minimize the high risks.

It is reasonable to assume that farmers who own their own land and manage their own systems have a lifelong interest in the sustainability of their schemes and the surrounding lands. Prevention of environmental hazards and the dissemination of sound practices could enhance the ability of individual farmers and farmer groups to sustain their systems. Many studies have found a high correlation between security of land tenure and the motivation to make long-term investments in soil conservation by such means as terracing. Where centrally managed systems subsidize farmer landowners, it is politically difficult to withdraw support for the irrigation service. Historic analysis of existing schemes including economic and sociological factors could provide valuable insights for future development strategies (Chancellor 1991).

CONCLUSIONS

Analysis of the data on the FMIS of the Gezirahs in Egypt has shown that the settings of water availability, workability of the soil, natural drainage, absence of regulations on cropping patterns and the existence of a market-oriented economy, have made it possible to achieve high yield per unit of water and per unit of land and to achieve technical and economic efficiency. The Gezirah System may be taken as a model in matters of routine maintenance, the performance of irrigation and agricultural practices, high rates of adoption of new advances in technology, achievement of high yields, satisfaction of consumer demand, production under the high risk of environmental change and achievement of technical and economic efficiency. All the conditions and the working environment described in this paper must exist to reach the objectives of the model described.

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Evaluation of Performance Indicators Applied to Several Irrigation Systems in Portugal

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ABSTRACT

A NUMBER OF performance indicators for irrigation projects have been defined and applied to eleven irrigation projects in Portugal. All projects are operated and managed by Irrigation Associations (IA) with irrigated areas between 450 ha and 15,000 ha. All are surface irrigation systems, supplied by large reservoirs built with river dams, and using upstream regulated conveyance canals and low-pressure pipe distribution systems.

Data were collected using a questionnaire filled in during interviews of the persons responsible for the operation and management of the systems. Data collected by the operation, maintenance and management services were also utilized in this analysis.

The indicators cover several management areas: water availability, conveyance and distribution systems, operation and maintenance labor force, operation and maintenance costs, land use, water use and water costs. Selected results are presented. The study reveals that it is necessary to revise the definitions of some of the indicators utilized and, in particular, there is a need for a deeper analysis aiming at the selection of indicators to be used by operation, maintenance and management organizations.

INTRODUCTION

Operation and management of irrigation have often been unsuccessful due to an excessive focus on the physical infrastructure while ignoring the production objectives. This is mainly due to a lack of recognition of the complexity of the factors involved and the absence of a coordinated interdisciplinary approach both in design and in operation. In fact, the concept of operation and management should be expanded to include other activities including the physical, production and institutional components (Pereira 1988):

* The physical infrastructure for water conveyance and distribution must be coherent with the farm structures and the on-farm irrigation systems;

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* Management of the productive system and of the irrigation system requires adequate solutions for optimizing the available resources and appropriate organizational solutions to ensure active cooperation among the entities involved; and

* To guarantee the conditions necessary for the optimal use of those resources by the system agents (farmers and operators) as well as the adoption of appropriate technologies, other components such as education, training, experimentation and information are required.

This corresponds to a high level of complexity making it difficult to apply a structured analysis of the performance of irrigation systems (Rijberman 1987). Alternatively, an *a posteriori* analysis of the irrigation projects may help identify means of intersectorial action. This analysis constitutes the final stage of sequential phases: planning, design, construction and operation. It must be based on an accumulation of experience of the operating schemes (Carruthers and Clark 1981). Nevertheless, this analysis normally focuses on the socioeconomic components.

The importance attributed to functional monitoring and evaluation of the systems with a strong interdisciplinary component is increasingly being recognized. This should create a flow of information on project activities with consequent effects on the operation and management rules resulting in revised actions. However, insufficient attention has been generally given to this activity in irrigation projects (World Bank 1988).

The information necessary to perform the analysis should be reduced to its bare essentials and made available in a condensed form through indicators, which should aim at:

* Defining schemes of logical interference among projects components in order to locate the main functional relationships such as action—immediate result—effect—impact; and

* Evaluating the levels of results obtained and defining the corresponding acceptable target values.

This information can be obtained partially, through a rapid analysis of management conditions, using a comparative study of indicators applied to a number of irrigation projects (Pereira and Lamaddalena 1988). A preliminary definition of these indicators was presented by Pereira and Lamaddalena (1989), which serves as the base indicators utilized in this study.

METHODOLOGY

A study of eleven irrigation projects in Portugal was done with the purpose of identifying relevant indicators and preparing a monitoring and evaluation system.

The selected irrigation projects are: Campilhas (CAMP), Alto Sado (A.SA), Fonte Serne (F.SE), Caia, Divor (DIVR), Idanha (IDAN), Mira, Odivelas (ODIV), Roxo, Vale do Sado (SADO) and Vale do Sorraia (SORR). Three projects — CAMP, A.SA and F.SE — are all presently managed by one irrigation association (CASF). All the projects are managed by farmers' organizations, the Irrigation Associations (IA). All are surface irrigation projects with conveyance canals regulated upstream by means of automatic gates and distribution is mainly through low-pressure pipes.

The methodology applied in the analysis was developed as follows: 1) evaluation criteria were selected, 2) indicators characterizing the various subsystems were defined, 3) questionnaires were designed, 4) data were collected, and 5) the indicators were analyzed to evaluate the systems and to identify critical points.

The evaluation criteria concerned the productivity of the systems in relation to the irrigated areas and yields, the efficiency of water utilization, and the operation and management costs. Secondary objectives relating to environmental impacts and the socioeconomic development were considered but have not yet been analyzed.

Information was collected through questionnaires to the managers of the IAs and through analysis of data records on yearly irrigated areas, water consumption and costs (Frazao 1990). The last year in the time series data is 1988.

ANALYSIS OF SOME OF THE RESULTS

All calculated indicators were analyzed and a search made for functional and logical relations. Factors and agents relative to operation and maintenance of the irrigation projects were related to final results. Specific indicators were selected to characterize water management, agricultural production and efficiency of use of financial resources.

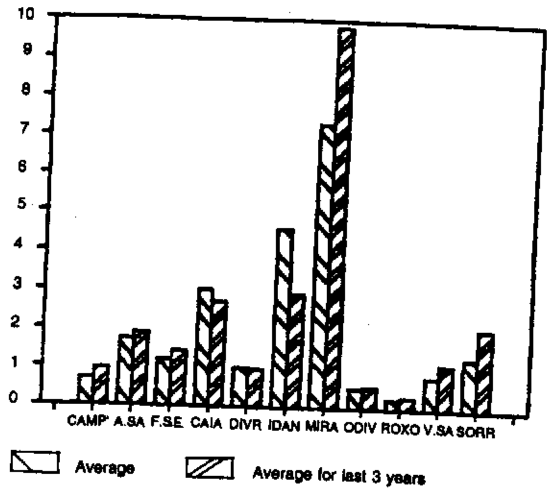
Water Management

Water availability. The evaluation of water availability was based on the frequency analysis of volumes of water stored in the reservoirs at the beginning of the irrigation season. Seasonal indicators were utilized. Among them was the indicator of guaranteed water supply (GWS) defined as the ratio of the first quartile of the series of volumes of water available for irrigation at the beginning of the irrigation season (VAI) to the storage volume required for the irrigated area (SIA). Figure 1 shows the GWS for the average area and for the average areas of the last three 3 years.

A value of unity for GWS corresponds to a condition of equilibrium in which water consumption equals water availability. Values greater than unity indicate that a potential exists to increase the area irrigated, while values below unity indicate that water availability does not permit such an increase.

Scarcity situations in water supply (drought conditions). Scarcity situations occur when the volume available at the beginning of the season is insufficient to satisfy normal irrigation demand. Two main indicators were selected:

Figure 1. Indicators for Guaranteed Water Supply (GWS).

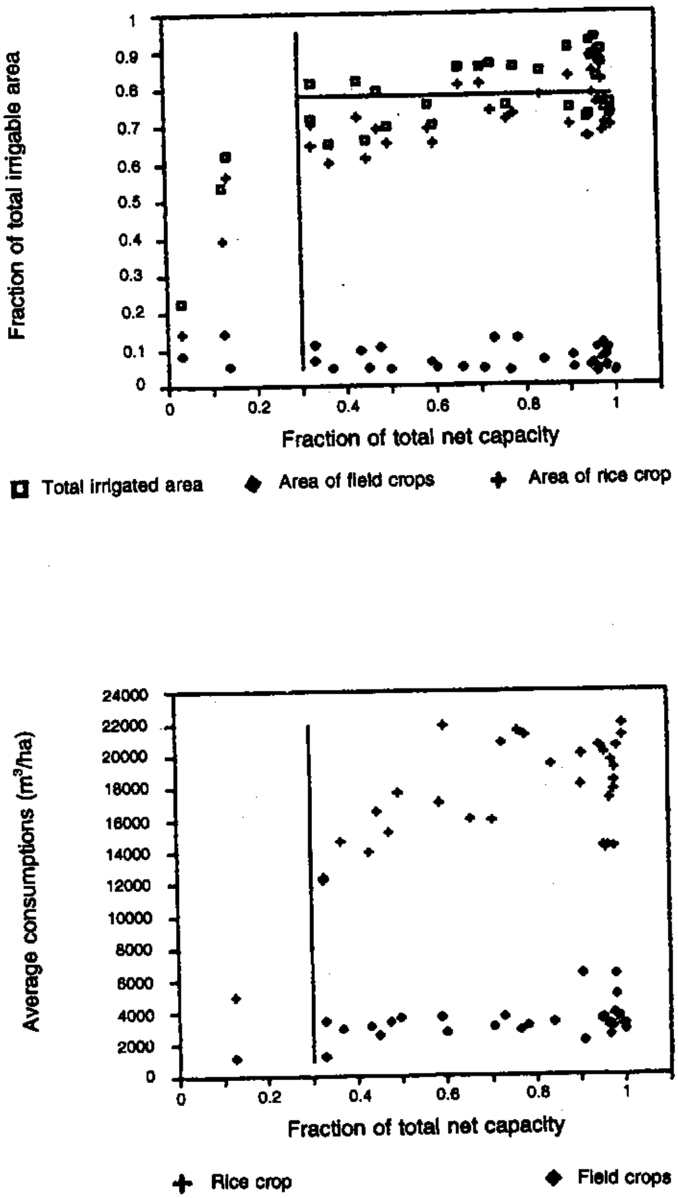


1. Water Deficiency Indicator (WDI), is a fraction of the total storage volume obtained after graphical analysis (see Figure 2. for SADO). Graph (a) shows the relationship between the fraction of the storage volume available at the beginning of the season (VAI) and the total storage volume (TSV), and the fraction of the irrigated areas during the same season (SIA) and the total irrigated area (TIA). These areas are divided into rice crops (high water demands) and extensive field crops. It may be observed that the variation of irrigated areas is independent of the fraction of storage water for values of this parameter above 0.3. Graph (b) confirms the selection of 0.3 as the threshold for the fraction of stored water (FSW). In fact, by relating these parameters to the volume of water consumed per irrigated unit area (m^2/ha) it can be seen that this unit volume tends to decrease for both rice and field crops, in the vicinity of the above threshold. Therefore, for SADO, we have WDI=0.3.

2. Frequency of drought conditions (FDC), which is calculated from the frequency analysis of the yearly ratios between VAI (volume stored at the beginning of the irrigation season) and TSV (total storage volume) by determining the experimental frequency corresponding to the above indicator WDI.

A low value for WDI indicates that irrigated areas and irrigation water consumption are only affected when initial storage volumes are exceptionally low. A higher WDI indicates that there is a strong dependency of irrigation areas on initial storage volumes, and that the reservoirs have low capability to regulate multiyear variations in water availability. This information is complemented with the FDC; for two projects with the same WDI, management must pay particular attention to measures to cope with droughts and water shortages when the FDC is high. Obviously, farmers can irrigate more readily under conditions of low WDC and FDC.

Figure 2. Graphic Analysis for selection of the Water Deficiency Indicator (WDI).



A comparison of values obtained from the IAs studied is shown in Table 1. It may be seen that SADO and SORR are able to make good use of their irrigated areas while severe problems occur in ROXO.

Table 1. Indicators for the analysis of drought and water scarcity.

	CAMP	A.SA	F.SE	CAIA	DIVR	IDAN	MIRA	ODIV	ROXO	SADO	SORR
WDI	0.45	0.30	0.60	0.30	0.35	0.50	–	0.13	0.25	0.30	0.40
FDC	0.32	0.29	0.40	0.15	0.35	0.03	–	0.33	0.65	0.08	0.07

Water distribution. The operation and maintenance of a collective irrigation system determine the global quality of water distribution to the irrigated area, which should be evaluated by means of efficiency and equity parameters (Bottrall 1981). The nature of existing regulation and water supply devices prevents major inequity problems in the systems under analysis. Though it was not possible to evaluate these parameters other aspects were analyzed.

To understand the physical conditions under which water is distributed to farmers, the following indicators were selected:

1. Irrigation Network Density (IND)

$$IND = \frac{Total\ Irrigated\ Area}{Total\ Length\ of\ Conveyance\ \text{and}\ Distributors} = \frac{TIA}{TCD}$$

2. Distribution Network Density (DND).

$$DND = \frac{Total\ Length\ of\ Distributors}{Total\ Length\ of\ Conveyance\ \text{and}\ Distributors} = \frac{TLD}{TCD}$$

The same network densities may be operated by a larger or smaller number of workers, which also influences supply conditions to farmers. Therefore, the following indicators can be used:

1. Density of Network Operators (DNO).

$$DNO = \frac{Total\ Length\ of\ Conveyance\ Distributors}{Number\ of\ Workers} = \frac{TCD}{NWM}$$

2. Density of Operators in the Irrigated Area (DIO).

$$DIO = \frac{Average\ Irrigated\ Area\ \text{for}\ the\ Last\ 3\ Years}{Number\ of\ Workers} = \frac{AIA3}{NWM}$$

3. Average Discharge by Operator (ADO)

Values for this indicator may be seen in Table 2. It is interesting to note (compare Table 3) that lower network densities do not correspond to higher intensity of irrigation. Also it may be noted that variations in the density of operators do not explain variations in the intensity of irrigation.

Table 2. Indicators relative to distribution conditions.

	CAMP	A.SA	F.SE	CAIA	DIVR	IDAN	MIRA	ODIV	ROXO	SADO	SORR
IND (ha/km)	27.01	20.80	18.61	30.60	28.14	27.84	19.95	24.03	25.58	31.67	39.81
DND		0.60		0.69	0.66	0.52	0.70	0.61	0.74	0.11	0.44
DNO (km/op)	6.82	11.47	21.92	9.30	8.68	12.80	14.24	17.81	10.37	2.38	5.96
DIO (km/op)	141.90	108.90	140.30	153.20	147.80	106.60	109.80	133.50	87.40	69.80	204.50
ADO (1/s/op)	212.90	174.30	210.50	176.20	151.40	117.30	103.20	193.60	87.40	90.80	275.30

Irrigation Intensity

The percentage of actual irrigated areas (PIA) is commonly used to measure the global performance of a project. The average PIA and the average for the last 3 years (PIA3) have therefore been used as the index for irrigation intensity. Results may be seen in Table 3.

Table 3. Indicators of agricultural intensity and water consumption by unit area.

	CAMP	A.SA	F.SE	CAIA	DIVR	IDAN	MIRA	ODIV	ROXO	SADO	SORR
PIA	0.77	0.46	0.34	0.54	0.61	0.30	0.39	0.31	0.34	0.93	0.86
PIA^3	0.62	0.38	0.25	0.52	0.50	0.38	0.33	0.22	0.28	0.75	0.73

As may be seen, the variations in the indicators shown in Tables 1 and 2 do not explain the variations in the irrigation indicators. Water consumption by unit area also has an independent variation.

Available information on the average consumption per unit of area for the rice crop (CRC) and field crops (CFC), is shown in Table 4.

Table 4. Average consumption of irrigation water.

	CAMP	A.SA	F.SE	CAIA	DIVR	IDAN	MIRA	ODIV	ROXO	SADO	SORR
CRC (m^3/ha)	10 042	17 268	13 277	16 247	10 535		11 676	17 311	16 227	14 341	15 389
CFC (m^3/ha)	3 048	4 861	4 356	5 415	3 065		3 097	4 957	5 955	3 145	5 368

Operation Costs

Operation costs of the systems are met by the users. This is essential for the economic stability of the projects, for their management and maintenance and in consequence for the quality of the services.

Table 5 includes several indicators:

(1) Operation and maintenance costs per unit of actual irrigated area (OMA)

(2) Operation and maintenance costs per unit length of conveyance and distributors (OMC)

(3) Percent of operation and maintenance costs covered by farmers' contributions: average (COM)

(4) As above, average for last 3 years (COM3)

(5) Water cost for rice crops (WCR)

(6) Water cost for field crops (WCF)

(7) Water costs as a percentage of the average gross income from rice (PCR)

(8) As above for corn (PCC)

(9) As above for tomatoes (PCT)

It may be seen that a positive relation exists between coverage of costs and intensity of irrigation (Table 3). Higher costs per unit length of distributors also correspond to higher intensity of irrigation. It may be concluded that good farming implies good operation and maintenance and that farmers are willing to pay for good service. Reduction of water costs does not have positive impacts.

Table 5. Indicators for the operating costs of the project and of irrigation.

	CAMP	A.SA	F.SE	CASF	CAIA	DIVR	IDAN	MIRA	ODIV	ROXO	SADO	SORR
OMA (US$/ha)				133	98	129	96	68	75	191	117	81
OMA (US$/km)				1 588	1 597	2 165	799	52	561	1 602	3 443	2 803
COM (%)				94	82	84	83			78	103	116
COM^3				105	105	110	48			104	126	116
WCR (US$/ha)	157	262	204		140	106		147	126	301	162	110
WCF (US$/ha)	65	71	73		53	41	29	43	41	118	87	57
PCR (%)	6.3	10.4	8.1		7.6	6.4		11.9	6.8	14.2	7.0	5.7
PCR (%)	3.5	3.8	4.0		2.6	1.7	1.4	5.2	2.8	5.6		2.5
PCR (%)	2.5	2.8	2.9		3.8	1.9	1.2	2.5	2.4	3.5	3.2	1.9

CONCLUSIONS

The study reported above covered a large number of indicators (Frazao 1990). The small size of the sample (11) did not permit a deep analysis of the relations among the indicators. Nevertheless, the study shows the usefulness of indicators in aiding an understanding of operation, management and maintenance.

The results obtained are now being applied in the preparation of a monitoring and evaluation study. Other management data, as well as measured data, should help to develop better indicators. This is necessary to help monitor the achievement of management goals of irrigation systems.

ACKNOWLEDGEMENTS

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Performance Measurement in Farmer-Managed Irrigation Systems: The Case of Kimani Irrigation Project in Tanzania

Mwanitu Kagubila[39]

ABSTRACT

THIS PAPER EXAMINES the current structural and organizational performance indicators of the farmer-managed rice irrigation systems run by Traditional Canal Committees (TCCs) in the Kimani Basin of Tanzania. Possible future performance indicators of a rehabilitated system through the Kimani Irrigation project have been hinted at. It is suggested that these indicators be treated as measurement parameters in rice irrigation systems in the country in the future.

The role of the individual farmer as a specific structure in an irrigation system and as a key player in performance measurement techniques has been highlighted. Land tenure, water use, the place of women, family and hired labor constraints, and technological measurement in FMIS based on the experiences in the Kimani Basin during the last 50 years have been dealt with in this paper.

It is recommended that the performance and behavior of individual farmers in irrigation systems be re-examined in relation to landownership, land renting, residence and cultural forces. Also, there is a need to focus attention on the concept of ownership of FMIS and on women's participation in them, and on the specific roles of engineers, agronomists and community organizers in the process of transforming farmers into irrigation technicians.

INTRODUCTION

The concept of farmer-managed irrigation systems (FMIS) is perhaps synonymous with the concept of "autonomous civil organizations." The emergence of these concepts in development literature is a testimony to the crude experiences concerning the gap which exists between government departments, development agencies and the beneficiaries of development projects. The distance that exists between the process of decision preparation, decision implementation and the population which will be affected by those decisions is the main reason for today's discussions on the concept of community participation in development work, and in particular, discussions on peasant economics in Third World countries.

This paper discusses how traditional irrigation systems in the Kimani Basin have shaped people's struggles for their own development through rice production, and the role of the Canadian

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International Development Agency (CIDA) as a donor agency in those struggles, through its financial, material and technical support in the rehabilitation of the Kimani Irrigation Project. Both the traditional and future performance measurement indicators in the FMIS are discussed from this perspective.

THE KIMANI CONTEXT OF EXISTING FMIS

The features of the traditional irrigation system in the Kimani Basin (Kagubila 1990, Manjalla 1991) briefly include:

1. Water control structures are temporary and seasonal.
2. The floodplain is composed of alluvial soils and it is within it that the intakes have been built. This causes the river and the intakes to relocate and the intakes and canals to silt over.
3. On-farm water control is a serious problem due, in part, to fields being unleveled and highly fragmented.
4. The canals are of different shapes resulting in fields with irregular layouts.
5. Many of the field-level canals are both supply channels and drains, forcing farmers to rely on a field-to-field water distribution format and networks.
6. Many of the main and secondary canals are eroded and deep, resulting in weak water supply routes into the fields.
7. Canals are often overgrown with grass and weeds.

Traditional canal committees called *Kamati za mifereji za jadi* (traditional canal committees, or TCCs) govern the FMIS in the Kimani Basin. The functioning TCCs include: Mbuyuni—Mabadaga, Mapula, Kwa, Makonji, Zambia, Roscampuni, Mayota, Lyandegele, Senyela, Wachalipite and Mdabadaba.

Table 1 below shows the traditional canals and drains used for irrigation in the Kimani Basin with their location, total numbers of farmers, their lengths and sizes (Manjalla 1991).

PERFORMANCE INDICATORS OF THE TRADITIONAL SYSTEMS

The existing traditional irrigation structures in the Kimani Basin are the means for the structural and organizational performance measurement. This approach helps to locate the rice farmers and to understand the nature of their confrontation with nature in the process of rice production.

Structural Performance

The measurement of the structural performance of the FMIS in the basin refers to the location and allocation of the resources for irrigation, i.e., water and land; the farmers' conceptualization in using these resources; their technological level; the way land tenure has evolved in the area as a means of production and as a force for the operation and management of the system; and lastly, the structure of other users of the Basin and how that affects rice irrigation.

Table 1. Traditional canals and drains in the Kimani Basin.

No.	Name of Canal	Length (km)	Size (ha)	Village	Farmers
01	Mbuyuni	6.0	450.0	Mbuyuni	650
02	Kwa Makonji	1.05	26.60	Mbuyuni	94
03	Mgalo	1.30	46.10	Mbuyuni	67
04	Mapula	2.25	186.00	Mbuyuni	400
05	Mayota	2.20	50.30	Uturo	16
06	Zambia	2.48	67.10	Mbuyuni	118
07	Roscampuni	3.83	148.10	Mbuyuni	316
08	Mtamba A&B	1.5	12.5	Uturo	9
09	Lyangegele	6.9	203.40	Uturo	340
10	Shule	1.0	23.8	Uturo	13
11	Miembe	2.9	82.40	Uturo	17
12	Mlelwa	1.0	28.0	Mabadaga	15
13	Mabadaga	2.25	116.60	Mabadaga	20
14	Senyela A & B	3.6	143.60	Mabadaga	132
15	Mdabadaba	1.40	30.0	Mabadaga	20
16	Old Wachalipite	1.8	67.5	Mabadaga	17
17	Wachalipite	2.15	67.50	Mabadaga	89
18	Lyahamile	11.0	1650.0	Mbuyuni, Mabadaga	150
19	Lyampande	2.8	200.0	Mabadaga	100
20	Mawendo A, B & C	7.7	466.30	Uturo	260
21	Idilu A	0.60	60.50	Mbuyuni	17
22	Idilu B	0.50	5.50	Mbuyuni	8
23	Ukwavila A & B	5.80	52.0	Ukwavila	104
24	Lifutufutu	1.6	50.0	Ukwavila	50
25	Ulongwa	2.50	13.60	Ukwavila	24

Farmers' concepts of land and water. Until the 1970s the Usangu Plains were considered an empty space free to be taken over by anybody from anywhere. Pastoralism as the main economic activity of the people depended on water and land. Ownership of land is still through the customary land tenure system while water rights are based on proximity to water sources. Water is understood to be a free commodity while land is now perceived as a village property to be shared equally by all members of a village. This differentiation is important: while village governments are supposed to own and benefit from the natural resources found within their boundaries, people do not consider water to be the property of a village, rather it is seen as a free resource to be exploited according to demand.

Land tenure and land fragmentation for rice production. Thirty to fifty years ago, before canalization, farmers cultivated rice using the broadcasting method and depended on rainfall and on flooding. The rice plots in the area range from 0.1 ha to about 3.2 ha. Farmers own rice plots in several farming zones thus complicating the agricultural system in use. Land for rice is scarce because of poor technological inputs which do not allow expansion into new irrigable areas. Farmers struggle for the same irrigated land throughout the year.

Access to and between fields is poor as there are no roads but only small footpaths between the fields. The most difficult problem involves crossing the Kimani River. There are only three main footbridges across the river. The problem of field accessibility has been compounded by the distance between homes and fields. Distances increased as a result of the villagization program of 1974/75, which moved people from the Kimani Basin localities into the upper areas five to eight kilometers from the farm fields. This has undoubtedly affected the performance of farmers and their irrigation systems. This is one of the major problems about which farmers have frequently complained to the project staff since 1989. This problem has been raised earlier in connection with agricultural performance following the villagization program (Dumont and Mottin 1980). People walk many kilometers to reach their fields, arriving tired and so work for only a few hours before they start their homeward trek.

Organizational Performance

Irrigated agriculture, unlike rain-fed agriculture, demands cooperation, discipline, organization and commitment to the interests of the whole community (Pradhan 1989). It is this type of formalized social structure of production that becomes the catalyst for all types of performance measurements since one may recognize some of the farmers' struggles for their survival in the process from production to consumption,

The TCCs versus village governments. The Villages and Ujamaa Villages Act (1975) created villages as both administrative and economic institutions in rural Tanzania. In 1982, the Local Government Act was enacted as a revision of the 1975 Act giving greater powers to village governments. Under this act, village governments have become the single, most powerful organs of state. Nothing may be done within the villages without the prior approval of the village governments. The traditional canal committees (TCCs) are tied to the village government structures.

Relations between resident and nonresident farmers. There are immigrant and indigenous resident farmers, nonresident farmers from within the Usangu Plains but from outside the Mapogoro Ward, and nonresident farmers from the neighboring districts.

It is the presence of nonresident farmers which raises some questions about performance measurement, since their participation in maintenance of the irrigation structures and access routes is minimal. Conflicts develop between resident and nonresident farmers over water distribution because nonresident farmers do not participate in water management.

Absence of women in traditional canal committees. The absence of women in TCCs is apparent in all canal committees. Women have been excluded from leadership positions in these committees even where they are as important as men rice farmers. Direct objection to the inclusion of women in TCCs has not been stated by male farmers.

Input support and land productivity. Land and water are the two main natural resources in the project area. Ownership, use, protection and future development of these key resources will depend on the development of the social and physical environment (Yaxley 1991). It was reported in the Kwa Makonjii Case Study that production per acre has fallen from 20 bags in the period 1970–79 to between 9 and 15 bags in the decade 1980–90. In general, many fields are still productive but require fertilizer application for increased productivity.

Input support is not a formalized and organized operation in the area. Farmers obtain farm inputs on their own. The village cooperative societies which are supposed to supply inputs are not economically viable and so cannot guarantee the provision of fertilizers, gunny bags, hand hoes, plows and other needs.

Rice marketing and the behavior of farmers. Until 1961, the marketing of crops in the Usangu Plains was controlled by the Baluchis, originally from Baluchistan in Iran, who settled in the area in the early 1920s, and by the Indo-Pakistani traders based in Mbeya town about 100 km away. In 1961, a cooperative system was established in the area through the creation of the Usangu Farmers' Cooperative Society. However, most trade in rice is carried out through the informal market. Farmers usually sell during the months between November and April when the price is high. Storage of rice is a common practice here although some farmers sell immediately after harvest.

POSSIBLE FUTURE PERFORMANCE INDICATORS

Possible new performance indicators emerge from the interventions of the Kimani Irrigation Project through CIDA as the donor agency. CIDA is involved in the agricultural development of the area and is committed to the modifications defined in the Project Objectives and to a philosophy of community participation. The new performance indicators have to be noted here. Our forecasts assume and believe that during the process of change, new types of rice farmers will emerge in the Kimani Basin. This calls for new thinking about possible new performance indicators. The following would appear to be key performance indicators.

Use of sustainable technology. One of the main objectives of the Kimani Irrigation Project is "to enhance sustainable irrigation-based agriculture" (KIP 1989). This objective considers sustainable technological intervention as the major factor in selecting rice irrigation tools which correspond to the level of the beneficiaries.

The performance of the Kimani Basin FMIS in the training of its farmers and how they respond to that process, merit measurement. Their current technology has a low rate of productivity. The aim is to introduce an appropriate and sustainable technology which is more productive and less dependent on human energy. Questions that come to mind are: Is technological and crop variety sustainability achievable under the climatic conditions of Usangu or must the farmers continue depending on natural forces for their agriculture? Can human manipulation of nature assist the FMIS performance? How long will it take for a sustainable technology to develop in the area?

Farmer participation in environmental issues. Farmer management and protection of the watershed and floodplain of the Kimani Basin have been stressed in the project objectives. It has been noted that skills in watershed and floodplain management have to be made available to the farmers in order to ensure long-term benefits of rice irrigation-based agriculture in the basin (KIP 1991).

Studies carried out in the area have shown that environmental destruction in both the watershed and the floodplain has increased since 1948. Vegetation cover changes have been alarming in some parts of the watershed (Malende 1991).

Farmer participation in the protection and management of the basin is crucial. It would be desirable to monitor the future performance of the FMIS in preventing further environmental damage to the basin and its vicinity. Sustainable irrigation-based agriculture can only be of long-term benefits if water and land are well-protected and judiciously used within a culture that seriously thinks about its posterity in its development planning.

Basin-level farmer organization. The current recommendation of the Kimani Irrigation Project is for a single basin-level organization. This recommendation is based on the experience with the Kimani River Canals Committee (KRCC), the interim basin-level farmer organization.

This recommendation will test the performance measurement indicator of farmer cohesiveness and unity of purpose. Will the future basin-level farmer organization be different from the current canal-based organizations?

New farm management techniques. In the future, it will be interesting to learn how the on-farm performance of the farmers improves with the improved water management system and extension services offered by irrigation technicians.

Table 2. Farm operations and hired labor by residence and sex.

Operation	Resident Laborers	Non-resident laborers	Sex	Rates per 0.4 ha
Land cleaning	Few	Many	Male	N/A
Cultivation	Few	Many	Male	4,000/= ($20)
Seedbed preparation	Few	None	Male	N/A
Puddling	Many	Few	Male	5,000/= ($25)
Transplanting	Many	Many	Male/Female	6,000/= ($30)
Weeding	Few	Few	Male/Female	4,000/= ($20)
Bird scaring	Few	Few	Male/Female	3,000/= ($15)
Harvesting	Few	Many	Male/Female	3,000/= ($15)
Threshing	Many	Few	Male/Female	N/A
Winnowing	None	None	N/A	N/A
Transporting	Few	Many	Male/Female Bicycles	N/A
	–	–	Trucks/Tractors	50/= ($0.4) per bag

Note: N/A = (Data) not available

Table 2 above illustrates the type of farm operations by sex, and rates paid for hired labor. Rates in Tanzania Shillings have been equated to US dollars. Data source is Kwa Makonji Canal Case Study in the Kimani Basin and shows the practice during each season.[40]

With the development of a common farming calendar, it is hoped that the current irrigation problems will disappear. The risk factor, however, remains as a persistent theme of peasant agriculture. Will the new farm management techniques improve the performance of the FMIS in the basin? It is the role of each individual farmer which is the determinant in measuring FMIS performance for any given indicator.

It is to be expected that the introduction of new rice varieties will require new farm management techniques. This implies that farmers will now become producers of high-yielding varieties using chemicals, different types of fertilizers, pesticides, etc. The disappearance of the traditional rice varieties will affect production, consumption and marketing patterns in the area.

New land use systems. With the development of a new irrigation system, new land use patterns will inevitably emerge. The negative impacts on the FMIS will likely be enormous because it will not be possible to accommodate all the demands for land and water within the same irrigation system, if we recognize the problems associated with such innovations in the developing countries, where designers often tend to ignore the needs of the new consumers.

RECOMMENDATIONS

The individual farmer as a key player. The immediate key player in the performance of the FMIS in Tanzania appears to be the individual farmer. This may be true for all FMIS in all parts of the world. The individual farmers are the key players because they participate in both worlds: in their own fields they are the leaders and managers of themselves and of their families and in the collective leadership and management of canal committees. In our attempt to measure the performance of FMIS, we necessarily measure the performance of individual farmers as they are now and the behavior of states in the geopolitical games in international relations. What is the behavior of farmers during certain times of the year or in certain types of organizations?

Ownership of FMIS in the future. One of the intriguing assumptions emanating from the reality presented here about TCCs and village governments, is that the village governments and Ward Development Committees might control and therefore "own" the FMIS in the future. If this develops into the future relationship between the basin FMIS, the villages and the Ward, it is clear that the farmers will have lost their autonomy. This process of space and autonomy within the community, must be monitored as a performance indicator in the Tanzanian type of FMIS. Can the FMIS remain independent of the state at village and ward levels? That is where the rub is in our country.

The experiences from other irrigation projects in Tanzania (Kagubila et al. 1990) show that donor agencies and banks have insisted on the formation of farmer organizations such as cooperative societies or water users' associations prior to funding of projects.

40 The Kwa Makonji Canal Case Study was carried out by David Rain and Mwanitu Kagubila during the 1990/91 farming season.

Women's participation in the future FMIS. Participation of women in different leadership positions at village, ward, district, regional and national-levels is low. The Traditional Canal Committees have had no women members as leaders. The interim Kimani Irrigation Canal Committee (KRCC) has six women and six male farmers and two male agricultural extension officers. It began with three women and six men in December 1989.

The monitoring of FMIS performance will require adequate evaluation of the participation of women throughout the years and of how they influence the direction of the FMIS.

Transformation of farmers into irrigation technicians. While we may be proud of the inherited knowledge of farmers in irrigation engineering and farm management techniques, we think that there is a mission link between old and new knowledge in irrigation demands. It is possible to claim that most farmers have not changed much even if new irrigation structures have been built and new organizational systems have been introduced. Why has the training of farmers in developing countries proved difficult? The goal should be to transform our peasants into qualified irrigation technicians and engineers. Unless land tenure systems change, our farmers shall remain poor and unproductive. The training of farmers should be one of the performance criteria of FMIS and should be measured.

CONCLUSION

It is obvious that the structure of production of the farmers within an FMIS is a crucial indicator of performance. The struggle for land in the area, for example, might characterize the agricultural scene in the foreseeable future. This indicates that the structure of production is bound to change drastically.

As the population increases, institutional structures and organizational forms must also change. Rapid change in Usangu Plains is to be expected due to high immigration into the area. The future Kimani Basin FMIS must also change in order to adjust itself to the new knowledge emerging from development research.

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

E. Baars and B. van Logchem[41]

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.

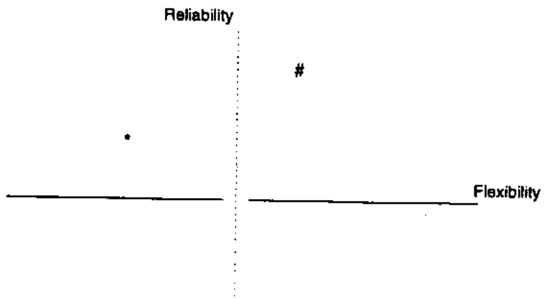
In order to get the total number of attributes down to a workable level, this was followed by a data reduction technique, factor analysis. Factor analysis attempts to find a minimum number of dimensions that can represent the information in a large set of attribute ratings (Urban 1980). Application of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

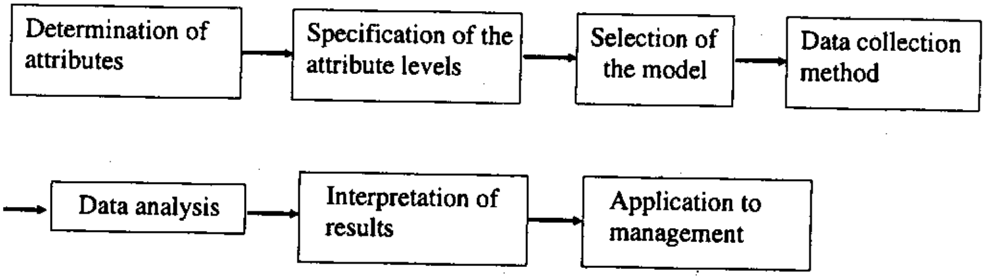
1) What is the utility of each attribute level for the farmer?

   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 %

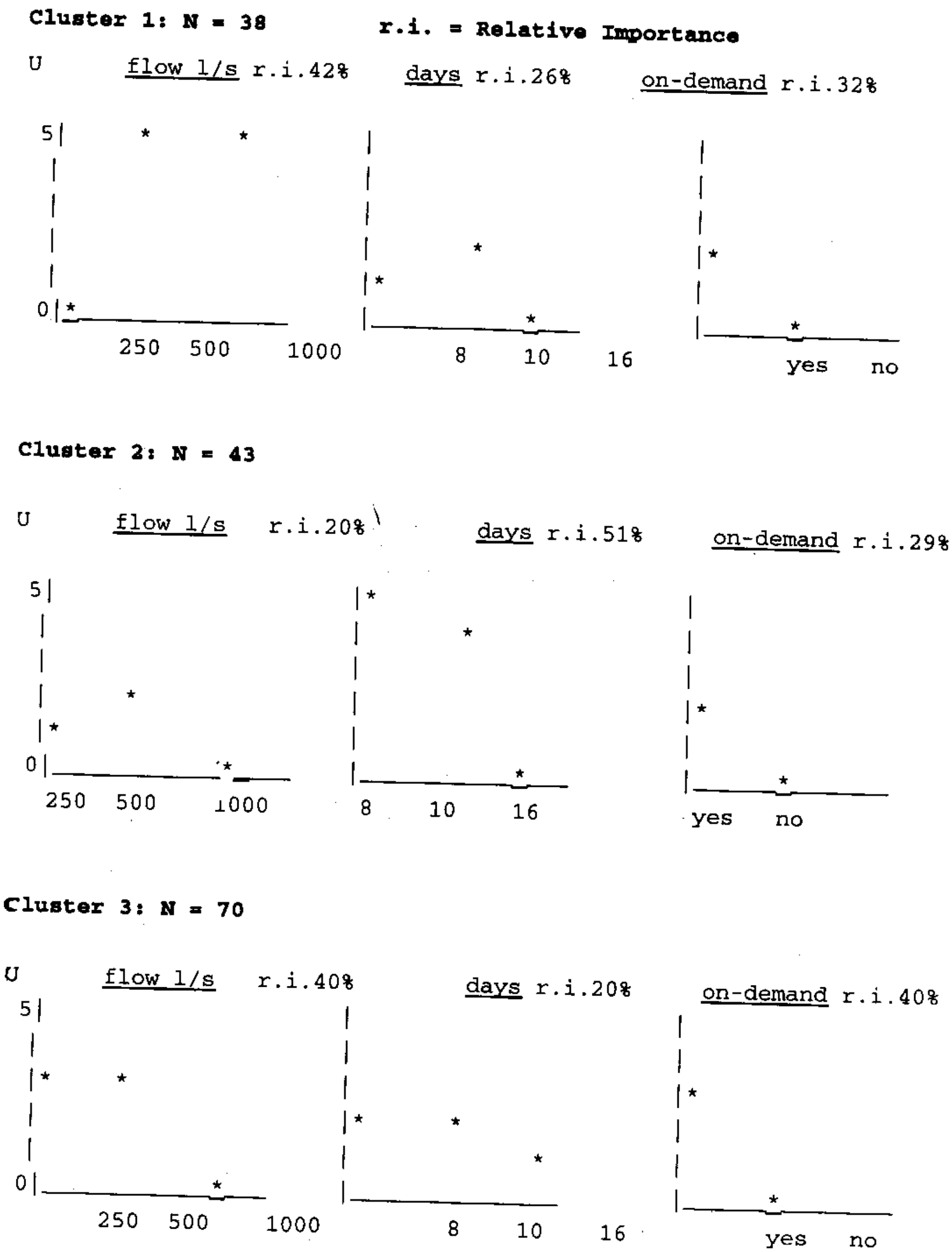
The next step in the analysis is to check whether any meaningful segments can be distinguished. The method used was cluster analysis. Three clusters were identified by looking at the development of the sum-of-squares, the group sizes and the stability of the groups. The attribute level utilities for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

ACKNOWLEDGEMENTS

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Sociocultural Factors in Farmer-Managed Irrigation System Performance Measurement: A Contribution to Methodological Approach

Ibrahima Dia[42]

ABSTRACT

THE POLITICAL DECISION to improve Farmer-Managed Irrigation Systems (FMIS) in Senegal makes it necessary to use a new monitoring method, different from those used in Agency-Managed Irrigation Systems (AMIS).

The lack of a theoretical and methodological framework using sociocultural and financial indicators makes performance measurement a difficult task.

Because of increasing powers of farmers in decision-making in FMIS compared to AMIS, sociocultural factors become more decisive. And, they must be used to measure farmers' management performance.

The aim of this paper is to find a method to identify and appreciate these factors.

After a theoretical discussion on performance concept measurement, we identified two units of observation levels: the plot level and the whole-perimeter level. In each level, it is proposed to measure FMIS from two perspectives: internal performance and external performance.

Tested in the **Thiagar** Perimeter case, this methodological approach gives interesting results which can be used to improve FMIS.

These sociocultural indicators must be linked with environmental and economic indicators to get a holistic approach in FMIS performance measurement.

INTRODUCTION

After a century of state-managed irrigation system policy, the Government of Senegal (under pressure from funders) decided to change its approach.

Societe d'amenagement et d'exploitation des terres du delta et de la falemè (SAED), the government institution which has been in charge of irrigation system development in the Senegal River Basin since 1965 is now withdrawing from many of its functions such as supplying inputs to farmers, and managing irrigation.

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The transfer of the irrigation infrastructure management, the credit system and the input supply to farmers' organizations and the private sector has been underway since 1986 but in any specific perimeter it started with the prior rehabilitation of the infrastructure.

The first experience of farmers' management of large-scale irrigation systems started only a year ago. Although strict conclusions, about farmers' management performance cannot be drawn at this moment, studies made by ISRA (Institut Senegalais de Recherche Agricole) researchers in the Senegal River Valley may help to identify performance indicators in both agronomic and socioeconomic aspects.

Conceptual Framework

With regard to performance measurement in farmer-managed irrigation systems, one must tackle questions such as:

* What do we mean by performance?
* Does performance relate to technical and economic achievements or to social ones?
* How may sociocultural factors may be conceptually linked to technical constraints?

In many cases, the concept of performance raises two kinds of questions:

* What goal were we pursuing? and
* What results do we get?

The discrepancies between goals and results may be considered as performance measurement criteria. In irrigation systems, one may say that good results mean achieving the water requirement of plants and increasing production.

When measuring production performance, for example, engineers (industrial approach) use yield per unit of land while farmers may use yield per unit of labor in addition to other sociocultural criteria.

In the same token, when looking for performance indicators in water management efficiency, the engineers' observation unit is the whole system itself whereas farmers' unit of observation is the individual plot. Therefore, in the farmers' approach, although the operation remains important, the performance of individual plots has priority.

Defining industrial approach Huibers and Speelman (1988) said: "... all irrigation elements are defined a priori to determine layout dimensions in order to find the optimal system scale."

From this system-scale perspective, the industrial approach assumed one productive goal, because production is not meant to be individualized.

AMIS are designed and operated from the industrial approach so that a central organization is useful.

Although many FMIS are also designed by engineers from this approach, they are operated from opposite perspectives.

It is the case of rehabilitated schemes of the Senegalese Delta River Valley, where the former technical conception is maintained for different management options.

It makes system's operation rather complex and performance evaluation problematic.

METHODOLOGICAL APPROACH

The farmer's approach shows two performance measurement levels: the plot level and the whole system level.

Plot level

The plot is the level managed by individuals with specific goals and constraints. The management of any individual plot depends on the importance of these activities in the whole farming system. It depends also on family resources such as capital and labor.

For instance, in the case of Thiagar the socioeconomic surveys showed three categories of farmers:

* Those who have more parcels outside the perimeter.
* Those who have all their parcels in the perimeter.
* Those who have all their parcels in the perimeter but perform nonagricultural activities as well.

At the plot level, the methodology may be a threefold approach:

1) The identification of cropping activities under farmers' supervision.
2) Interviews of a sample of farmers' groups before cropping activities. The survey may be oriented by questions such as:
    * What did the farmer plan to do?
    * How does he plan to manage the cropping agenda?
    * What does he expect from his cropping activities?
3) Observing and monitoring of the cropping campaign at the plot level in order to compare actual results to planned goals.

In the Thiagar case, activities which have been identified as the farmer's responsibilities are:

* Drainage;
* Seeding; and
* Pest control.

Perimeter level

Large-scale perimeter management is essentially water management including infrastructure maintenance and conflict management. This level deals with organizational problems and sociopolitical factors. The management procedures are determined by the perimeter technical conception.

In order to evaluate management performance at this level, one has to distinguish internal performance from external performance. By external performance we mean activities which depend on external services such as the credit system, the input market, etc. Internal performance on the other hand, is related to the ability of farmer's organizations to manage efficiently all the tasks which had been defined during the goal-setting process including the relationship between the organization and its components.

The methodological approach used in the plot level is also appropriate to investigate the performance indicators at the large-scale perimeter management level.

First stage. This step deals with the identification of socio-organizational groups which are targeted in the study. For instance, in the Thiagar large-scale perimeter case, three groups of farmers have been identified. The first group represents farmers from the village of Thiagar where there are more farmers than the other groups but which lacks land.

The second group is composed of farmers from the villages of **Ndietene** and **KHOR** who traditionally own land rights. And the last group from the villages of **Thienel Doki** and **Loug Demis** is composed of farmers who are also livestock breeders.

The perimeter is 870 hectares with one electric pumping station. This technical conception implies a centralized management structure of the 55 irrigation units.

In every irrigation unit, farmers are organized in Economic Interest Groups (EIG). In order to well-manage the centralized structure the EIG's formed the Economic Interest Group's Union (EIGU) which is in charge of the pumping station, the water distribution and the whole-scale maintenance. The EIGU in other perimeters may also be responsible for machinery management, land preparation, and harvesting and post-harvest operations. But in the Thiagar case, these responsibilities rest with organizations at the village level.

Second stage. Group discussions are organized with the EIGU in order to find out the plans in terms of activities, expectations with regards to partners, and, finally, the rules and principles under which these things are to be done.

Third stage. This last step deals with observation and monitoring in order to identify conflicts and technical problems that may occur during the campaign.

The analysis of EIGU planned goals and actual results is done in order to evaluate management performance of the structure.

RESULTS

In the Thiagar case, we can conclude, at this points of time, that at the plot level most of the planned activities were achieved. Some problems occurred in the cropping operations due to the lack of fertilizer in the input market. At the large-scale level, we observed a low performance due to external relations with partners. For example, when there was a failure in electrical power, the EIGU was not able to solve the problem efficiently with the National Electric Company and most of the time SAED had to intervene. Farmers' EIGU is not strong enough to face national companies.

On the other hand, while the formal scheme extended only to 870 hectares, the EIGU increased it up to 1,520 hectares. The difference in the area of cultivated land went to small-scale perimeters around the main scheme, although SAED did not authorize such extension.

The maintenance program did not reach a very high level of performance. Frequency of conflict occurrence related to water distribution was very low.

If we compare total production expected from 870 hectares with production obtained from the 1,520 hectares with a very low investment, we can conclude there is a high performance of FMIS which integrate these social objectives.

The following Table summarizes the methodological results obtained from the study. These results are only indicative. They are not those of a comparative analysis between FMIS and AMIS but indicate how, with this monitoring procedure, one can identify where FMIS needs to be improved. It is also realistic about FMIS in terms of constrains.

CONCLUSION

Expressed in economic indicators, the concept of performance is a static one. It assumes only productivity and homogeneous objectives. However, it does not deal with sociopolitical and environmental aspects of disengagement problematics.

Without a conceptual framework and a holistic approach one cannot draw conclusions on FMIS performance. An interdisciplinary approach is necessary to link quantitative data from financial and economic analyses with qualitative ones from sociocultural approaches.

Table 1. Performance evaluation of Thiagar's FMIS.

Level	Socio-organization unit	Responsibilities	Performance	
			Internal	External
Plot	Farmer/EIG	Seeding	High	–
		Drainage	High	–
		Pest control	High	Low
		Harvesting	Low	High
Perimeter	EIGU	Irrigation	High	Low
		Maintenance	High	High
		Land preparation	Low	High
		Conflict settling	High	

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Impact Analysis of the Agricultural Sector Crisis on the Performance of Water Users' Associations in the Province of Mendoza, Argentina

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ABSTRACT

THIS PAPER DEALS with the impact of the crisis of Mendoza's agriculture sector on the performance of users' associations since the early 1980s.

First, a general economic analysis at provincial level is performed. Then a plot-level examination is made of the different economic situations and conditions of two users' associations located in two different irrigation areas. The second analysis is based on the study of farm models carried out through field surveys.

The farm-level information reveals that the different impacts borne by agricultural producers is a function of their farm size and of their managerial skills. The worsening economic situation of the individual farmer has caused a weakening in the capacity of the associations to deal with the management and upgrading of the system.

INTRODUCTION

Mendoza is a province in the west of the Argentine Republic (33^0 South latitude) and is bordered by Chile on the west. Its total area (150,839 km^2) is arid. Water is obtained from snowmelt from the Andes Mountain Range. There are 360,000 irrigated hectares in five irrigation districts. The total registered area for agricultural use is 594,792 ha. This area covers barely 3 percent of the total provincial area. Average annual rainfall is 192 mm. Mendoza is traversed by five major rivers, none of which has an annual module of more than 50m^3/sec.

These conditions have resulted in the formation of five cultivated oases with an irrigation infrastructure consisting of 8,000 km of canals, of which 500 km are lined. There are 1,800 km of drainage collectors in the lower lying areas of the irrigated systems.

Groundwater use is also important and there are over 18,000 wells. Some 80,000 ha are irrigated exclusively with groundwater, while about 30,000 ha are irrigated with both surface water and groundwater.

43 General Irrigation Department, Mendoza, Argentina (1991).

Water is managed and distributed by an autonomous agency — the General Irrigation Department (DGI) — together with 366 water users' associations (WUA) or Canal Inspections, each of which administers irrigated areas of 300 ha or more.

Mendoza's economy is based mainly on the cultivation of grapes, vegetables and fruits, on their associated industries (wine-making and fruit and vegetable canning), and on oil extraction and distillation.

A general economic analysis of the province cannot be undertaken without reference to the national and international contexts.

A common denominator of all irrigation systems in the world is the high investments required to keep the systems working. When the economic returns to agriculture do not suffice to make these investments, a crisis is inevitable.

This is what occurred in Mendoza in the 1980s. The economy, strongly dependent on grape production, was faced with the problem of producing final products with no market value. To this may be added a national policy with a marked anti-export bias, underrated US dollar, high tariffs, red tape, etc. On the other hand, imports affected the local industry. As a result of high interest rates savings were diverted to the financial system and speculation replaced production.

The decline of the productive sector is evinced in the share of agro-industries in the Gross Provincial Product (GPP). The GPP is about US$3,600 million, which is roughly equivalent to 4 percent of the total gross national product.

An analysis of the GPP reveals that agriculture represents 12 percent of the total. This is an improvement as, after reaching 18 percent in the 1970s, agriculture fell to only 3 percent in the early 1980s.

These figures clearly reveal the crisis the sector has undergone. Low profitability was due to a fall in the prices of agricultural products, to deficiencies in the irrigation system, and to deterioration of soils. The hydrologically rich years of the 1980s brought about drainage problems and waterlogging.

The reduction in profits and investment capacity affected the WUA too. In this case, the situation was marked by a decrease in participation, modernization, maintenance, and investments in new works.

Two important parameters should be mentioned in this context: the cost of water and the cost of the land. For the former, irrigation water rates have ranged from US$16.35/ha/year to US$54.63/ha/year. The provincial average, weighted according to the area of each irrigation district, is US$18.82/ha/ year. In other words, water costs US$0.18/m^3 as the DGI delivers an average of 10,000 m^3/ha/year at the intake of secondary canals.

Water may then be said to be a cheap input since, when expressed as a percentage, it represents 1 to 4 percent of the production costs of the various crops.

The cost of the land varies, but a hectare of cultivated land with irrigation rights may be estimated at about US$3,000.

Due to the different production and marketing conditions in the different regions of Mendoza, they were affected by the crisis in different ways.

The two WUAs under study reacted differently to the crisis. The WUA of the "Constitucion" Main Canal — better organized, closer to urban markets, and with better transportation and means of communications — was able to face the crisis and is now in a position to make the necessary investments. The "Real del Padre" WUA does not satisfy those conditions and, unless it receives outside aid, will be unable to recover from the crisis.

OBJECTIVE

The objective of this paper is to evaluate the influence of the farmers' economic and financial situation and their productive strategy upon the general performance of two WUAs in the province of Mendoza, Argentina.

METHODOLOGY

Two WUAs similar in size and irrigation infrastructure, were selected for analysis. Each is considered representative of its respective geographical region. The "Constitucion" WUA is located in the northern oasis of the province and the second, "Real del Padre," is located in the southern oasis.

Information was drawn from the existing landownership registers, irrigation registers and from interviews with farmers. The survey furnished information on land tenure, available technology, type of irrigation and cropping patterns. This made it possible to stratify the irrigated plots according to area, and to identify the "standard" farms at each stratum with the "farm modeling" methodology.

The information was supplemented with data on marketing, regional markets, agricultural and social characteristics of the command area of each WUA, service systems, etc.

The characteristics of the associations under study are given below.

The "Real del Padre" Canal Inspection

This canal inspection (WUA) is situated in the Real del Padre District in the Department of San Rafael. It is within the Atuel River Irrigation System, from which water is diverted through a direct intake with good infrastructure. The Atuel is regulated by the Nihuil-Valle Grande interconnected dams.

The WUA serves the Real del Padre agricultural community. The irrigation network comprises the main canal and six secondary and tertiary canals which irrigate 11,525 ha with irrigation rights. The irrigation register records 1,254 users. The inspection authorities are the inspector and five delegates.

Table 1. Cropping pattern (%) in the WUA command area.

	Real del Padre	Constitucion
Grapes	29.1	55
Fruit trees	16.1	11
Annual crops	6.7	6
Others	5.4	–
Fallow	42.8	28

Soils are sandy-loam to slimy-loam, but they are impaired by waterlogging and salinity. According to the Riverside soil classification, they are in the second and third categories. Almost 52.4 percent of the area has a salinity over 5,000 umhos. The rehabilitation project for this irrigation district concerns its physical aspects in view of the declining productivity arising from drainage problems.

The "Constitucion" Canal Inspection

This WUA, in the area managed by the Lower Tunuyan River Subdelegation, diverts water from the Tunuyan River, which is regulated by the "El Carrizal" Dam. A diversion dam downstream branches off into a main canal which, in turn, flows into the Constitucion Canal.

The Constitucion Main Canal is located in the center of the area irrigated by the Lower Tunuyan River. The canal authorities are the inspector and five delegates. The irrigation network is made up of three secondary canals and fourteen tertiary canals. There are 10,573 ha with irrigation rights and 1,352 registered users engaged in agricultural activities (see Table 1 above for the cropping pattern).

In general, soils are sandy-loam to loam; i.e., in the first category. However, there are large waterlogged areas due to infiltration and seepage from the irrigation canals.

DEVELOPMENT

To compare both WUAs, the existing cadastral data and the DGI's users' register were used. With the farm modeling methodology, each association was stratified according to the irrigated plot sizes, disregarding those of less than one hectare.

A calculation was made of the share of each stratum in the total number of farms, as well as the represented area. The cropping pattern of each stratum was determined on the basis of information provided by the Cadastral Data Bank and ratified or rectified through field surveys. On the basis of this data, the standard farm for each stratum was determined.

The information was complemented with questions on:

* Production and yields.
* Possibilities of expansion.
* Family composition, tenure systems and their influence on productivity levels.
* Current and potential financial situation.
* Capacity and willingness to pay the irrigation water rates.

With this information, four production models were developed according to the relevant variables in each area: "minifundia," small family holdings, family holdings with capital investments, and entrepreneurial concern.

The economic analysis of each of the proposed models started with a budget of expenditures, investments and income, which made it possible to compare different situations in the different areas.

The economic indicators of each model are:

1. Total income: obtained from the sale of the total production.
2. Gross margin: difference between total income and direct expenditures.
3. Operational results: difference between gross margin and indirect expenditures.
4. Gross benefits: difference between operational results and amortizations.
5. Instant profitability: gross benefit/ total capital.

The results made it possible to make an economic diagnosis of the farm models corresponding to the associations under study.

Tables 2 and 3 contain some of the indicators described for the two WUAs. An analysis of Tables 2 and 3 reveals the following.

Model A. This model represents an important number of small farmers. The instant profitability indicators show that the Atuel River irrigators are better off, but that the Constitucion Canal users have higher incomes per hectare. The gross margin per hectare is greater at Real del Padre because direct expenditures are higher in the Constitucion command area. This could be explained by a higher technological level of these farms, especially taking into account the greater capitalization per hectare in the latter WUA.

Model B. The farms in this model do not show significantly different indicators between the two WUAs. In both cases, profitability is positive but there is not much margin for economic improvement.

Table 2. Description of the water users' associations.

Association	Model	Area (ha)	Stratum (ha)	Area (%)	Farms (%)
Real del Padre	A	4.7	1.1 – 5.0	30.6	10.6
	B	9.1	5.1 – 10.0	34.3	23.0
	C	14.7	10.1 – 20.0	19.8	21.5
	D	24.5	20.0 – 30.1	4.4	25.0
Constitucion	A	3.0	1.1 – 6.0	43.0	17.0
	B	8.2	6.1 – 12.0	20.0	20.0
	C	15.2	12.1 – 22.0	8.0	15.0
	D	60.0	+ 22.0	9.0	46.0

References: A: Minifundia
B: Small family holding
C: Family holding with capital investments
D: Entrepreneurial concern

Table 3. Economic indicators (US$, May 1990).

Association		Income		Cross margin		Capital		Instant profitability
		Total	p/ha	Total	p/ha	Total	p/ha	%
Real del Padre	A	2116.1	450.2	1147.1	244.1	11681.2	2485.5	3.1
	B	4110.2	451.8	2285.9	251.2	18096.9	1988.6	2.9
	C	7470.4	508.2	4566.1	310.6	22954.7	1561.6	10.1
	D	12249.6	500.0	3878.0	158.2	53516.5	2184.3	-4.3
Constitucion	A	1597.6	532.5	528.4	176.1	8470.9	2823.7	-5.0
	B	4992.7	624.1	1792.3	224.1	13312.3	1623.5	4.0
	C	11481.9	755.5	5240.8	344.7	29230.0	1922.9	2.5
	D	57199.0	953.3	31195.6	520.0	90520.0	1508.6	21.4

References: A: Minifundia
B: Small family holding
C: Family holding with capital investments
D: Entrepreneurial concern

Model C. In this case, the instant profitability indicator is higher in Real del Padre, while income and gross margin are greater in Constitucion. Although gross benefit is smaller in Constitucion, it should be pointed out that this is due to larger amortization shares, which stem from the users' larger capital.

Model D. In this model there are marked differences between the two WUAs. Both in the number of users and in the represented area, Constitucion shows much higher values. The per-hectare income at Constitucion is almost double that of Real del Padre; its gross margin is three times as large, and its operational results are five times larger. The differences are more evident when analyzing gross benefit and profitability because both these items yield negative values for Real del Padre. On the other hand, when other parameters are compared, it can be seen that:

* Marketing centers are better organized and closer to the command area of the Constitucion Canal, which gives it an edge over Real del Padre.

* Proximity to the larger urban centers makes it possible for the Constitucion farmer to live on his farm and, thus, manage it better.

* The Constitucion farmers use more technology and have a greater capitalization. This allows them to have a better economic structure than that of Real del Padre. This situation is described in model D, where the Constitucion users are better off than the Real del Padre farmers in all economic indicators.

To complete the economic analysis of the areas under study, the average income per hectare was calculated and weighted according to the relative importance of each stratum.

Average Income Per Hectare

Real del Padre

$$IP = 450.2*0.106 + 451.8*0.23 + 508.2*0.215 + 500.0*0.25 = 385.90 \text{ (US\$/ha)}.$$

Constitucion

$$IP = 532.5*0.17 + 624.1*0.20 + 755.5*0.15 + 953.3*0.46 = 767.2 \text{ (US\$/ha)}.$$

The difference in income is reflected in the different capacity to pay for the irrigation service during the 1985/90 period. This is shown in the following Tables.

Table 4. Annual irrigation rates collected in two canal inspections, 1985/90.

Constitucion Main Canal - 10,573 ha					
	Irrigation rates billed		Amounts collected		
	US$/ha	Total(US$)	US$/ha	Total(US$)	% Collected
1985	8.80	93,042.40	3.91	41,357.14	44.45
1986	10.89	115,139.97	4.79	50,681.95	44.92
1987	12.78	135,122.94	4.60	48,666.59	36.02
1988	7.76	82,046.48	3.18	33,666,53	41.03
1989	6.19	65,446.87	3.71	39,302.78	60.05
1990	16.56	175,088.88	6.62	70,074.95	40.02
Real del Padre Main Canal - 11,525 ha					
	Irrigation rates billed		Amounts collected		
	US$/ha	Total(US$)	US$/ha	Total(US$)	% Collected
1985	7.25	83,556.25	1.23	14,216.56	17.01
1986	11.09	127,812.25	1.66	19,174.44	15.00
1987	10.01	115,365.25	1.80	20,784.33	18.02
1988	5.51	63,502.75	1.65	19,058.41	30.01
1989	5.19	59,814.75	1.25	14,375.53	24.03
1990	14.37	165,614.25	2.30	26,502.72	16.00

The average irrigation water rate collected in the period under consideration is 44.23 percent for the Constitucion and 20.05 percent for the Real del Padre Canals.

The different investment capacity in physical improvements of the two WUAs according to their respective average incomes, may be seen in the following Table.

Table 5. Physical investments in the two associations (in US$).

Year	Constitucion Total investment (10,573 ha)	Investment per ha	Real del Padre Total Investment (11,525 ha)	Investment per ha
1987	11,684.75	1.01	2,561.21	0.21
1989	1,055.13	0.09	248.59	0.02
1990	5,868.45	0.51	1,510.15	0.12

CONCLUSIONS

The impact of the agriculture sector crisis on two representative users' associations was analyzed in this paper. Through the analysis of simple economic-financial indicators, a marked difference may be observed between them during the period 1985/90.

Although the two associations are similar in size and irrigation infrastructure, their entrepreneurial structure strongly affected their economic-financial performance.

Differences in profits affect their payment and investment capacity, as shown in Tables 4 and 5. A low payment and investment capacity leads to a passive attitude on the part of the users, which eventually results in the obsolescence of both the administrative system and of the irrigation infrastructure.

With respect to the DGI projects which include canal lining and the installation of drainage systems, from this analysis it may be seen that one of the associations is in a position to carry them out and the other is not.

In the case of the Constitucion Main Canal WUA, the proposal consists of lining 11,200 m of one of the secondary canals and in the construction of different works, such as the rehabilitation of the drainage collector network. It is expected that water use efficiency will increase and that the processes of soil salinization and waterlogging will be reversed.

The Real del Padre Project includes the construction of a main collector and secondary drainage works in order to counteract worse deterioration processes than those of Constitucion.

Although the economic analysis of both projects renders positive results, the capacity of the associations to bear the costs is different. As a result, the financial feasibility of the Constitucion Canal is positive, while that of Real del Padre is negative.

The importance of the productive structures and the income levels of the users' associations as performance indicators, is also evinced by this analysis. The different economic development of the two command areas accounts for their different technical and administrative skills. The performance of the associations will always reflect their socioeconomic situations.

Programs designed to strengthen users' associations in order to help prevent the deterioration of their systems, should be closely connected to improving the economic situation of the agriculture sector and should monitor the indicators herein proposed.

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Analysis of the Consolidation Process of Users' Associations of the Lower Tunuyan River, Mendoza, Argentina

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ABSTRACT

THIS PAPER AIMS at describing the transformation process that users' associations of the Lower Tunuyan River Irrigation System have undergone since their consolidation.

Conditions prevailing at the time the changes took place and the actions taken by the General Irrigation Department are described in this paper. Mention should be made of the importance that the election of canal inspectors with managerial skills had on the process — a key factor in interpreting the users' proposals and in implementing a policy consistent with their needs.

Finally, the advantages and disadvantages of the new consolidated associations are discussed and some considerations on their future activities are made.

INTRODUCTION

The General Irrigation Department (DGI) is the agency responsible for all matters pertaining to irrigation in the Mendoza Province.

Its present organization consists of the headquarters office, which is the seat of the Superintendence and the Advisory Council, and the Water Subdelegations, which are responsible for managing each of the provincial rivers on whose waters irrigation rights have been granted.

The irrigation system of the Lower Tunuyan River comprises 94,000 hectares in the northeastern region of the province.

Water is managed at two levels. At the first level, the DGI through its Water Subdelegations, controls dams and primary canals; at the second level, the users' associations, distribute water to the individual farm intakes.

By 1984, there were 194 canal inspections in the Lower Tunuyan River System with serious administrative and operational difficulties. Based on a new philosophy that would lead to a decentralized management, the DGI undertook heir consolidation in 1985.

44 General Irrigation Department, Mendoza, Argentina (1991).

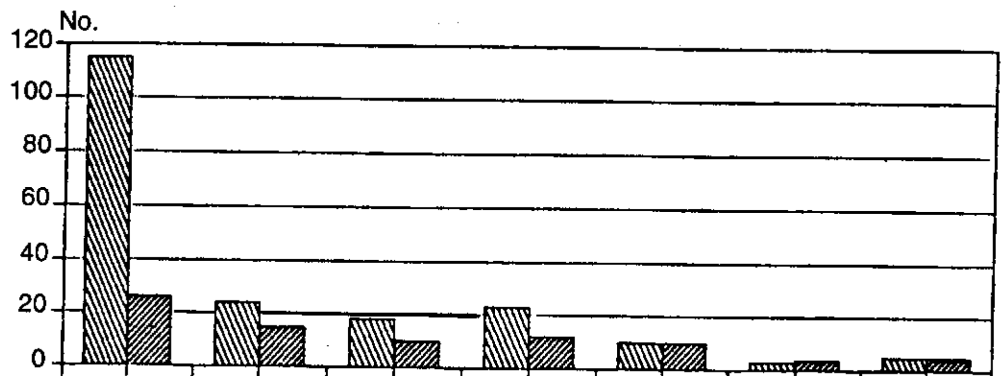
THE TRADITIONAL MODEL

Figure 1 shows the 194 canal inspections existing in 1984 in the Lower Tunuyan River command area, classified according to size.

It might appear that the large number of small canal inspections could be explained by the users' interest in managing their own organizations. This, however, was not the case. The excessive atomization of the inspections left little decision-making authority to the administrators.

Often a farmer accepted the responsibility of heading a users' association merely because of tradition and because of the incentive of additional benefits accruing from his authority to decide on water distribution.

Figure 1. Variation in the number of canal inspections between 1984 and 1991.



	(0-400)	400-800	800-1500	1500-3000	3000-7000	7000-10000	de 10000
1984	115	24	18	23	10	3	5
1991	26	15	10	12	10	4	5

1984 1991

Furthermore, the regular meetings summoned by the DGI for the discussion of matters pertaining to the operation of the associations were often attended by as few as 10 percent of the inspectors.

The inspections were in a permanent state of isolation. In many cases, nobody knew who the inspector was. The DGI did not know how inspections were being administratively or operationally managed. As the inspections were unable to solve the users' problems, their demands were submitted to the DGI.

It was impossible to work on or to improve the irrigation system either because of the large payments a small number of beneficiaries would have to make, or because the small users' associations did not have the technical capacity to undertake such works.

The lack of participation and the prevailing disorganization impaired the accounting and financial condition of the inspections' accounts, which was made worse by the failure to collect irrigation water rates from defaulting debtors.

The above problems, inherent in small users' associations, called for a change in the size of the traditional canal inspections.

THE NEW MODEL

A new structure of users' associations was devised in 1985. Chambouleyron (1985) proposed a transformation of the traditional inspections into irrigation companies, with command areas ranging between 10,000 and 15,000 ha instead of the traditional 100 to 500 ha.

The organizational structure would be similar; i.e., they would be autonomous, they would prepare their own budgets and they would issue their own regulations in accordance with the powers granted them by the Water Law.

These companies would be headed by a "manager," who would be the highest authority in the users' association, assisted by an accountant, some employees and the gate operators who are in charge of distributing water.

Management responsibilities could be assigned to a company, e.g., an electric, fruit-growing or viticultural cooperative, which — apart from being a canal user — was organized in such a way as to be able to discharge the duties of a manager.

It was considered most important that the manager be a person with management training so that he could cope with the complex tasks assigned to him, such as:

* To administer the area under his control; establish water delivery turns, supervise the irrigation network, organize canal maintenance and determine which works should be executed.

* To undertake afforestation along the canals in order to obtain the highest possible returns from the timber, maximizing income and thus permitting the setting of low irrigation water rates.

* To purchase or rent the machinery needed for irrigation and drainage system maintenance. Alternatively, machines could be borrowed from the DGI.

* To set up workshops and purchase tools to keep the machinery in working order.

* To purchase vehicles, two-way radios, and any other technical equipment needed for the efficient management of the facilities.

* To bill users and to collect the irrigation water rates by checking the list of debtors, reporting abandoned farms, visiting and sending reminders to users who are in arrears of payment, and reporting annual variations in irrigated area to the DGI.

* Since the manager is a paid person, he would have to be in close contact with the DGI to implement the most appropriate water policies.

* To actively participate in cooperative movements and to organize meetings in irrig: tors' communities in order to accumulate experience on water management ar administration.

This, in brief, was the new structure devised for the users' associations.

IMPLEMENTING THE UNIFICATION OF CANAL INSPECTIONS

The activities performed by the DGI to unify users' associations were of two types: a) promotion and b) implementation. Promotion activities were carried out at headquarters by an interdisciplinary team that provided logistic support through the organization of meetings addressed to the technicians of the Water Subdelegations. Policies and objectives were discussed and methodologies were suggested. Training courses on different techniques, such as group dynamics, were also held.

An evaluation of the results obtained in the course of promotion was performed by this promoting group, who always saw to the requirements of the Water Subdelegations.

The second group of activities, i.e., implementation, was carried out by the Water Subdelegations themselves. In the case of the Lower Tunuyan River, it was deemed necessary to hire a professional — as a facilitator — to speed up activities and to avoid delays in the unification process.

In order to define the areas comprising the new canal inspections, the area irrigated by the secondary canal was the factor considered.

The first attempt was carried out on the "Reduccion" Main Canal, where the twelve existing associations were consolidated into one inspection. The traditional associations all suffered similar problems despite the large area (some 14,000 ha) over which they were spread. The methodology applied consisted in explaining the proposal at a general irrigators' assembly.

It was necessary to hold several meetings. The original proposal improved with suggestions put forward by the users themselves, who began to realize the importance of the new opportunity they were given to manage their own organization. Finally, the incorporation papers of the new inspection were signed and approved by all the inspectors.

A new list of authorities was submitted for approval to the DGI by the resigning inspectors, who were organized into an advisory committee.

Curiously enough, the main obstacle to the reorganization of the canal inspections was the organization of the DGI itself, whose legal and administrative requirements made it difficult to achieve the objective.

In January 1986, the inspection of the "Reduccion" Main Canal was set up — a milestone in the process of reorganization.

CONSOLIDATION OF THE NEW ADMINISTRATION

The "Reduccion" Main Canal Inspection was the first to be unified in the Mendoza Province. The first steps of the new administration were firm and unflagging. One of its most significant achievements was the fact that there was money in its bank account from the transfer of funds of the former associations. This made it possible to allocate funds to meet the most urgent requirements in the area served by the new inspection. In the past, the funds remained idle and isolated in each small inspection.

After a short time, the new administration hired an agricultural engineer to advise the users on irrigation matters, to organize and improve water distribution and to identify the required works.

The gate operators' work areas were reorganized on a more rational basis and a reduction in labor costs was attained. Later on, two jeeps were purchased to drive along the service roads close to the canals.

A contract was signed in which the Water Subdelegation lent a pick-up to the inspection, which undertook to repair the vehicle in order to use it in matters pertaining to the management of the users' associations. Soon after, the service rendered to users improved substantially.

The disappearance of complaints presented to the Water Subdelegation is evidence of the improved service, as all problems were sent to and solved by the inspection itself.

Another important activity was the reforestation of the margins of earthen canals in the area served by the association. More than 8,000 poplars were planted, which increased the economic potential (timber use) of the association in the area.

The annual canal cleaning was organized more efficiently. The inspection hired a crew of workers to desilt the canals and to restore them to their original shape, paint the sluice gates with antioxidant, and repair their mechanisms.

The example set by this new users' association soon aroused the interest of neighboring organizations. Despite some doubts and fears, they became enthusiastic about the innovations introduced, which brought about concrete and real improvements.

The consolidation of the "Constitucion" Main Canal (command area: 10,000 ha) a few months later came as no surprise. Soon after there followed the consolidations of the Montecaseros Canal inspections and of the Middle Section Canals, with command areas of 9,000 and 10,000 ha, respectively.

Three additional associations in the Lower Tunuyan River have recently been consolidated: the San Martin Canal, the Norte Alto Verde Canal and the Sur Alto Verde Canal. The objective pursued is to have this irrigated area managed by no more than 15 or 20 users' associations.

GROWTH SYMPTOMS OF THE NEW INSPECTIONS

The principle of equality before the law took root in the inspections. They launched an aggressive campaign to collect irrigation water rates with the intention of rewarding the farmers who pay on time and of collecting old debts. Up to that time, it had not been possible to cutoff the water supply to overdue users because the system was not properly organized. The new associations have cutoff the water supply to defaulters. This procedure is still in force and has proved to be highly effective.

Another important activity carried out by the new associations was the construction of works. Upon the request of the Lower Tunuyan River inspections, works have been constructed with the technical assistance of the Water Subdelegation. This type of small constructions, with individual costs under US$10,000 are undertaken by the inspections themselves, which purchase the materials and hire the necessary labor.

In the last two years, it has been possible to construct an important number of minor works, such as gauging stations, sluice gates, dividers, lining, etc., at a cost lower than if public tenders had been invited.

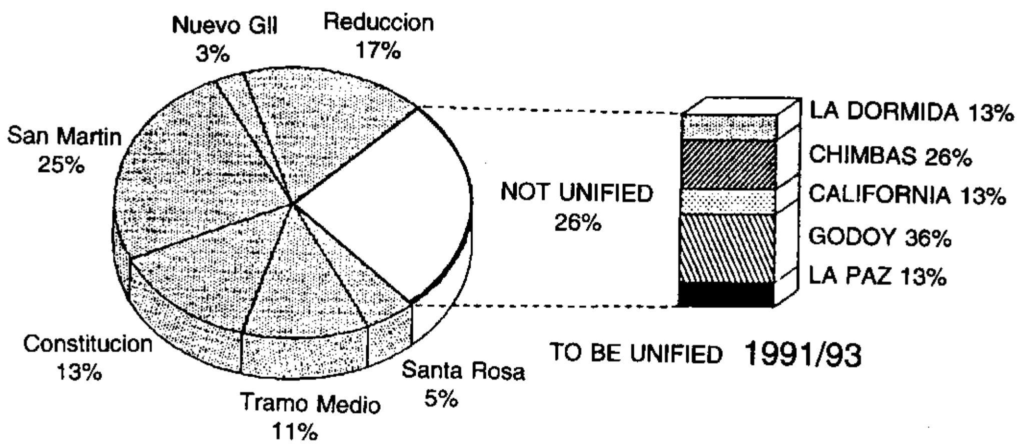
The adoption of opportune measures, such as switching from permanent flow in the main canals to the rotation system became possible thanks to the new structure. This is what happened in 1990 when water was very scarce. The decision, endorsed by the inspectors, represented a change that had not been made in thirty years. This would not have been possible with the traditional associations.

The percentage of DGI funds lent to the former Lower Tunuyan River inspections, which paid them back from the collection of irrigation water rates, used to be in the order of 22 percent. Pressure exerted by the new associations increased that percentage to 28 percent which, in relative terms, represents an increase of 27 percent in fund availability.

WHAT REMAINS TO BE DONE

At present there are two types of structures on the Lower Tunuyan River: consolidated canal inspections and traditional canal inspections. Figure 2 below describes the situation at present.

Figure 2. The process of unification of the inspections.



The objective is to complete the consolidation of inspections in two years' time. With this consolidation it will be possible to have an integrated and rational river management with no more than 20 organized inspections.

The progress made in the reorganization of canal inspections is irreversible, but it is evident that changes in the organization of the DGI itself are required for the consolidated inspections to have more economic and operational autonomy.

Often, an important fact is the great distance between the area where irrigation service is rendered and the seat of the DGI. An effective economic decentralization will help strengthen users' management.

Up to now, the administration of funds has been centralized in the Superintendence, which deposits the corresponding funds in the inspections' accounts. The associations of the Lower Tunuyan River have requested that their funds be automatically credited to their accounts by the banks as soon as the irrigation rates are collected. This would ensure a secure and real flow of money and would encourage overdue users to pay their debts.

Another aspect that should be promoted is the construction of works. The consolidated inspections have proved to be effective in performing this task with local skilled labor.

The growth of both users' associations and Water Subdelegations should be accompanied by a reduction in the central organization. If such a reduction is to be achieved, it will be necessary to transfer human and material resources to avoid overlapping structures.

The role of each organizational level must be defined. At the users' level — the first level — the inspection should operate the system with all the necessary human and material resources that help to ensure a direct and prompt service. At the second level, the Water Subdelegations would advise the inspections under their jurisdiction on technical and accounting matters. To this end, they should have a staff consisting of engineers, accountants, land surveyors, water gauging employees, etc., with modern means of communication and computers.

At the third level, the Superintendence would be responsible for the general management of all Water Subdelegations. It would perform permanent administrative, technical and accounting evaluations and controls of the Subdelegations. It would also devise the overall water policy in keeping with the provincial policy.

CONCLUSIONS

The authors of Mendoza's Water Law were wise men. The norms drafted 107 years ago are still relevant. Furthermore, it can be said that it is necessary to "return to the original sources" and adhere to the original philosophy of the law — albeit with the logical modifications that physical, social, environmental and technical changes demand.

The users' organizations of the Lower Tunuyan River accept the challenge, and what is more, they demand it. They realize that the significance of the activities carried out so far cannot be ignored and that the policy devised should be followed; otherwise, a state of anarchy would arise that would lead to the loss of the system and to an inevitable deterioration of the irrigation network.

The Lower Tunuyan River System has a capital represented by its users' associations. The implementation of the measures set forth in this paper — increase the number of consolidated inspections and achieve an economic and operational decentralization — will improve their performance and will make it possible to lay the foundations for a new General Irrigation Department.

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Performance Measurement of FMIS in Soil Conservation and Reclamation

Carlos Mirábile and Ricardo Bagini[45]

ABSTRACT

THIS PAPER IS the result of a research carried out at two users' associations located in the Central oasis (Arroyo Claro) and in the Northern Oasis (Tulumaya) of Mendoza Province. Through a knowledge of the factors that cause soil degradation in irrigated areas, attempts have been made to assess the level of participation and efficiency with which the associations deal with these factors. Soil characteristics within each of the associations were analyzed and a survey was prepared with a view to collecting the data needed to quantify and qualify their performance in soil conservation and reclamation.

Eighty-five percent of the farmers belonging to each association were surveyed (14 from Arroyo Claro and 9 from Tulumaya). The results yield different degrees of participation and performance, Arroyo Claro holding the higher ones.

The parameters involved in soil degradation and conservation were correlated. The different performance and participation indexes obtained make it possible to assess the users' attitude towards the problems under consideration.

INTRODUCTION

Mendoza Province is located in the central-western region of Argentina and has a long tradition in irrigation dating from pre-Columbian times. In spite of having only 13 percent of the national water resources, it comprises 360,000 hectares under irrigation, which is equivalent to 30 percent of the total irrigated area in the country.

There are five main rivers originating in the Andes Mountain Range and fed by snowmelt. The use of this resource has given rise to the formation of five irrigated oases.

In 1978, abundant snowfall in the Andes Range led to a rich hydrological cycle. It has resulted in rising water tables and soil salinity problems produced — inter alia — by a high aquifer recharge in river faults, canal seepage and infiltration (90% of the network is made up of earthen canals), and by low irrigation efficiencies because of the important water supply and little groundwater extraction.

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The economic crisis of the viticultural sector, the main agricultural activity in the province, and the fluctuations in the fruit and vegetable growing sectors further aggravate the soil degradation and reclamation problems.

In view of these problems, both the national and provincial governments have supported the agriculture sector by granting subsidies for soil reclamation to farmers who organized themselves into associations, rehabilitating a large network of zonal drainage canals, and by granting canal inspections a higher degree of autonomy (participation in irrigation management). All this led to the setting up of more than 15 users' associations which have carried out soil reclamation activities.

This is why it was necessary to measure the performance of these associations in soil reclamation and improvement, especially because water resources in the province are fully allotted and water rights are appurtenant to the land. Thus, it is imperative for productivity levels of those lands to be maintained.

BACKGROUND INFORMATION

Several authors have dealt with this subject lately. FAO's report on South America focuses on the causes of soil degradation and on the corrective actions required, but it does not take into account the performance of users' associations.

Smedema (1990) points out that the quantification of waterlogging and soil salinity can be used as users' performance indicators in an irrigated area.

M. Bos (1990) analyzes the importance of evaluating water distribution in irrigated areas. Water distribution has a considerable incidence on the degradation of heavy soils or soils with limiting layers due to drainage problems. Bos and Walker (1990) also point out the importance of assessing irrigation efficiency, another factor contributing to soil degradation due to drainage problems.

At FAO's Workshop (1989) on "Soil degradation mechanisms in Latin America," the main causes of the process were identified. These are: accumulation of salts on the profile due to inefficient water use, high water tables because of drainage problems, and the use of inadequate irrigation techniques. A series of recommendations were issued to offset the causes and to further extension activities for the farmers' technical training.

METHODOLOGY

Two users' associations have been selected to evaluate their participation in soil conservation and reclamation. The selected associations are Arroyo Claro (Central Oasis) and Tulumaya (Northern Oasis).

There are 16 farmers (390 ha) in Arroyo Claro and 11 farmers (147 ha) in Tulumaya. After analyzing soil degradation processes in both areas, a questionnaire was prepared containing 25 items dealing with the actions required to combat soil degradation causes and the number of drainage works constructed. The objective pursued was to assess farmers' participation and performance.

Eighty-five percent of the farmers' in each association were interviewed. Both associations share high water table and salinity problems; both have been granted subsidies by the national government to construct soil conservation and reclamation works.

The surveys having been analyzed, average values for each of the parameters were calculated. This information made it possible to relate and weigh the most important parameters and to generate participation and performance indexes.

RESULTS

A preliminary analysis of both areas showed that the main problem of the cultivated soils was the rising water tables due to rich hydrological cycles, low irrigation efficiencies, seepage and infiltration in the distribution system (earthen canals), and the discharge of industrial effluents with high salt contents in the irrigation system (Tulumaya). These problems of water table salinization and soil degradation have been further aggravated by a failure to maintain the existing zonal drainage canals and the insufficient number of secondary and farm drainage works. The parameters examined aim at quantifying and qualifying farmers' attitudes towards them (Table 1).

Table 1 shows that Arroyo Claro had more difficulties because — before farmers joined in an association — the water table was at 0.50 m. But the association was able to lower the water table 1.18 m and it has washed a higher percentage of soils affected by salinity. At present (5 years after the association was set up), there is a smaller percentage of soils affected by high water tables (30%) and salinization problems.

This was achieved through greater participation in combatting against the elements which produce soil degradation. This is shown in the results obtained for other parameters: a higher percentage of farmers cleaning the zonal drainage canals (93%), shorter cleaning intervals (1.7 year), a higher percentage (100%) of farmers constructing secondary drainage canals (7,630 m total) and plot drains (100% = 16,670 m).

Table 1. Basic parameters for measuring participation and performance of users' associations.

Parameter	Average value	
	Ao. Claro	Tulumaya
1. Total area (hectares)	390	147
2. Cultivated area (%)	75	69
3. Condition of crops (very good, good, fair, bad)	Good	Fair
4. Water table depth before setting up the association (meters)	0.50	0.67
5. Present water table depth (m)	1.68	1.67
6. Area with water table problems (%)	30	59
7. Salinity problems (slight, normal, serious, excessive, uncultivable)	Normal to Serious	Serious

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Parameter	Average value	
	Ao. Claro	Tulumaya
8. Area with salinity problems (%)	21	25
9. Farmers who clean the zonal drainage canals (%) and cleaning intervals (years)	93 1.7	25 5
10. Reasons why the zonal drainage canals were not cleaned i. economic problems; ii. should be done by the General Irrigation Department [DGI])	i	ii
11. Farmers who have dug secondary drainage canals % and total meters per association	100 % 7,630 m	100 % 2,604 m
12. Farmers who have dug plot drains (%) and total meters per association	100 % 16,670 m	35 % 2,180 m
13. Meters of plot drains per hectare affected by high water tables	142	25
14. Reasons why plot drains were not dug i. unnecessary; ii. economic problems	–	i (45%) ii (20%)
15. Farmers who clean plot drains (%) and cleaning intervals (years)	79% 1.7 year	35 % 1 year
16. Lowering of water table (meters)	1.18	1.00
17. Farmers who washed soils affected by salinity (%)	50 %	43 %
18. Washed saline soils (%)	90 %	80 %
19. Canal seepage and infiltration according to farmers (%)	1–5 %	5–10 %
20. Irrigation method (S: furrow; M: basin; cd: with runoff; sd: no runoff)	S and M sd	S and M sd (50%) cd (50%)
21. Irrigation water quality according to farmers (excellent, good, fair, bad, excessively saline)	Good to Fair	Fair to bad
22. Farmers' opinion of their irrigation: i. insufficient; ii. well; iii. in excess	i and ii	ii
23. Field water application efficiency (measured)	43 %	43 %
24. Number of meetings of users' associations during the year	12	1
25. Members' attendance at the meetings (%)	70 %	40 %

The results show an important difference in favor of the Arroyo Claro Association (142 m) as regards meters of drains dug per affected hectare. Another important parameter is the number of meetings held by each association and the number of farmers attending them. The Arroyo Claro Association had an average attendance of 70 percent and a monthly meeting, while Tulumaya had one yearly meeting and a 40 percent attendance.

Although the parameters give a clear idea of the associations' participation and performance in soil conservation and reclamation, the most important ones were related and weighed according to their incidence upon the problems analyzed. The following indexes were obtained:

Performance Index

D1 = (% hectares affected by salinity problems that were washed x 0.4) + (water table lowering attained (m) x 0.2) + (meters of plot drains per ha affected by rising water tables x 0.4)

D2 = (% hectares affected by salinity problems that were washed x 0.4) + (meters of plot drains per ha affected by high water tables x 0.6)

D3 = (application efficiency x 0.4) + (external conveyance efficiency x 0.2) + ((100/cleaning interval of the zonal drainage canal - in years) x 0.4)

Participation Index

P1 = (Farmers (%) who washed soils affected by salinity x 0.35) +
+ (farmers (%) who cleaned zonal drainage canals x 0.2) +
+ (farmers (%) who dug plot drainage canals x 0.45)

P2 = ((Farmers (%) who cleaned zonal drainage canals / cleaning interval) x 0.3) +
((farmers (%) who cleaned secondary drainage canals / cleaning interval) x 0.35) +
((farmers (%) who cleaned tertiary drainage canals / cleaning interval) x 0.35)

P3 = (Condition of crops x 0.2) + (cultivated area (%) x 0.2) +
+ ((1/area affected by salinity problems (%)) x 0.3) +
+ (1/area affected by rising water tables (%)) x 0.3)

P4 = Number of annual meetings x (average attendance per meeting/100). The parameters involved in each index were then analyzed. This was done to quantify the possible maximum and acceptable minimum values for each of them according to the problems and characteristics of the area. The maximum and minimum acceptable values for each of the indexes are the following:

Performance

Max = (100 x 0.4) + (1.5 x 0.2) + (100 x 0.4) = 80.3
D1
Min = (50 x 0.4) + (0.75 x 0.2) + (50 x 0.4) = 40.1

Max = (100 x 0.4) + (100 x 0.6) = 80
D2
Min = (50 x 0.4) + (50 x 0.6) = 50

Max = (90 x 0.4) + (100 x 0.2) + ((100/1) x 0.4 = 96
D3
Min = (75 x 0.4) + (85 x 0.2) + ((100/2) x 0.4) = 67

Participation

Max = (100 x 0.35) + (100 x 0.2) + (100 x 0.45) = 100
P1
Min = (50 x 0.35) + (50 x 0.2) + (50 x 0.45) = 50

Max = ((100/1)x0.3)+((100/1)x0.35)+((100/1)x0.35) = 100
P2
Min = ((50/1)x0.3)+((50/1)x0.35)+((50/2)x0.35) = 41

Max = (4 x 0.2) + 100 x 0.2) + ((1/0)x 0.3) + ((1/0)x0.3) = 20.8
P3
Min = (3 x 0.2) + (80 x 0.2) + ((1/20)x0.3) + ((1/20)x0.3) = 16.6

Max = 12 x (100/100) = 12
P4
Min = 1 x (60/100) = 0.6

As may be observed, for index D1, the percentage of hectares affected by salinity problems yields a maximum value of 100 percent and an acceptable minimum of 50 percent.

It has been determined that the optimum lowering of the water table is 1.5 m in view of the fact the water table levels, prior to the implementation of reclamation activities, were at 0.50–0.70 m. By lowering the water table to a depth of 2–2.20 m, the crops will not be affected. As regards index D3, the application efficiency parameter has been assigned a maximum value of 90 percent and an acceptable minimum of 75 percent.

The external conveyance index has a maximum value of 100 percent and an acceptable minimum of 85 percent. The annual zonal drainage canal cleaning parameter ranges between an optimum of once a year (as recommended) and an acceptable minimum of once every two years.

The percentage of farmers participating in different activities has been included among the participation indexes. The maximum has been set at 100 percent and the acceptable minimum at 50 percent, with the exception of index P4 (attendance at meetings parameter) which has been assigned a minimum value of 60 percent.

For index P2, both the maximum and minimum values of the cleaning interval parameter for the different drainage canals is 1 year. This is so because the farmers are unable to clean the canals more frequently, and because experience shows that a longer interval results in the deterioration of the canals.

As regards index P3, the parameter concerning crop condition was rated as follows: 4 — very good; 3 — good; 2 — fair; 1 — bad. The maximum is 4 and the acceptable minimum is 3. With respect to soils with rising water tables and salinity problems, the optimum value is 0% and the acceptable minimum is 20%.

Once the optimum or maximum and acceptable minimum values had been determined, the indexes for both associations were quantified by calculating the different indexes with the average values obtained from field surveys.

The calculations and results are given in Table 2.

Table 2. Performance and participation quantification in the users' associations under study.

Association: Arroyo Claro
Indexes : Performance (D)
D1 (90x0.4) + (1.18x0.2) + (142x0.4) = 93
D2 (90x0.4) + (142x0.6) = 121
D3 (43x0.4) + (95x0.2) + ((100/1.7)x0.4) = 59
Subtotal: 273
Participation (P)
P1 (50x0.35) + (93x0.2) + (100x0.45) = 81
P2 ((93/1.7)x0.3) + ((100/1)x0.35) + ((79/1.7)x0.35) = 67
P3 (3x0.2) + (75x0.2) + ((1/21)x0.3) + ((1/30)x0.3) = 16
P4 11 x (70/100) = 8
Subtotal: 172
Association: Tulumaya
Indexes: Performance (D)
D1 (80x0.4) + (1x0.2) + (25x0.4) = 42
D2 (80x0.4) + (25x0.6) = 47
D3 (43x0.4) + (90x0.2) + ((100/5)x0.4) = 43
Subtotal: 132
Participation (P)
P1 (43x0.35) + (20x0.2) + (35x0.45) = 30
P2 ((35/5)x0.3) + ((60/2)x0.35) + ((35/1)x0.35) = 25
P3 (2x0.2) + (69x0.2) + ((1/25)x0.3) + ((1/59)x0.3) = 14
P4 1 x (40/100) = 0.4
Subtotal: 69

With respect to performance indexes, the Arroyo Claro association exceeds the maximum values for D1 and D2, which results from the digging of a certain length of drains necessary to lower the water table and wash the salts in the soil. On the other hand, D3 yields values below the minimum. This shows that, although zonal drainage canal cleaning intervals and external conveyance efficiency can be considered adequate, it is the low application efficiency on the irrigation unit which affects the index. The Tulumaya performance indexes are below the minimum, with the exception of D1, which is slightly above minimum (42 points versus 40 points).

The analysis of participation indexes reveals that the values of the Arroyo Claro association are above the minimum, with the exception of P3, which is slightly below minimum (16.6 points versus 15.6 points). This is due to the fact that the soils are being reclaimed and improved. It is expected that these values will exceed the minimum once soil reclamation has been completed.

With these indexes it is possible to classify the performance and participation of soil conservation and reclamation associations. The objective is to compare them and identify the causes that lead to such a classification by means of each of the parameters that defines the different indexes.

By adding up the minimum and maximum values of D1, D2 and D3, and P1, P2, P3, and P4, the following rating system was established:

Index Score Rating	–157 Bad 157–170 Fair
Performance (D)	171–210 Good 211–256 Very Good 111–160 Fair –111 Bad
Participation (P)	161–180 Good 181–232 Very Good

According to this rating system, the Arroyo Claro association's performance is "very good" as regards soil conservation and reclamation operations (273 points) while participation is "good" in problem-solving (171 points). On the other hand, performance and participation at the Tulumaya association are rated as "bad" (132 points — 69 points, respectively).

CONCLUSIONS

The results obtained show that good performance depends on good participation. The Arroyo Claro association is a good example as it combines a good physical management of the problem with the members' interest in solving it.

As regards the Tulumaya association, its performance can be expected to improve if greater users' participation in soil reclamation and conservation activities is achieved.

This paper can be considered as a starting point to evaluate the performance and participation of users' associations in soil conservation and reclamation. Further analyses of a larger number of associations will help to correct the methodology and turn it into an effective tool.

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A Diagnosis of Farmer-Managed Irrigation Systems' Performance in Mendoza, Argentina

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ABSTRACT

This paper deals with the water management system in Mendoza, Argentina, with special reference to users' participation in water administration and management.

Mention is made of the legal and administrative aspects on which the current participatory administrative system is based and which has been in operation for over a century. The system comprises 90,000 users who use water for multiple purposes, in three oases that cover an area of 360,000 hectares. A brief socioeconomic description of the agricultural and industrial activities conducted in the command areas of the users' associations is also made.

The diagnosis of the performance of users' associations was carried out through a survey. The characteristics described are location, number of hectares, number of users, infrastructure managed and level of organization attained. Water costs are discussed in relation to organizational level and size of the administered area. Finally, a description is given of their present operation and of the perspectives for improvement.

BACKGROUND INFORMATION

Water Administration in Mendoza

The Mendoza Province has a long tradition of irrigated agriculture. The colonization process in the region began with the arrival of the Spaniards by the end of the 16th century. The Indian communities in the area learned irrigation management techniques from the Incas: they had built diversion and conveyance works from the Mendoza River on which their subsistence irrigated agriculture was dependent.

The ensuing conquest of territories and the blend of cultures gave rise to one of the most remarkable transformation processes of desert areas in Argentina. This rugged region with scarce rainfall, water resources drawn from low flow rivers of marked seasonal variations and difficult to regulate, was shortly transformed into an important economic and political settlement.

The numerous immigrations from Spain, Italy and France during the 19th and 20th centuries gave shape to an agricultural culture characterized by hard work and a vast experience in water management and administration. An economic model — similar to the one prevailing in the

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Mediterranean Basin — based on the intensive cultivation of vineyards, fruit trees and vegetables and their associated industries was developed. Three main oases were developed on an irrigated area of 359,523 hectares.

One of the most relevant aspects of this process is the way in which farmers shaped the structures necessary to administer as scarce a resource as water. Thus, a system was set up in which the farmers themselves assume responsibility for building and maintaining the irrigation works as well as for the administration and equitable distribution of the water. Records show that during the 18th and 19th centuries there were users' associations headed by a democratically elected Tertiary Canal Judge (Juez de Hijuela). A General Water Judge was in charge of administering the provincial water resources with the collaboration of delegates from each association.

The General Irrigation Department

Law 322 of 1905 defines the structure of the General Irrigation Department (DGI) as a decentralized and autarchic agency in charge of administering water for irrigation and other uses. The DGI is headed by a Superintendent, who is assisted by a Council composed of five members. Both the Superintendent and the members of the Council are appointed by the Provincial Executive with the approval of the Senate and remain in office for a five-year period. The Superintendent is the highest executive authority and is responsible for all matters pertaining to the management of provincial water resources and their protection from harmful effects. The Appeals Council is a collegiate body with jurisdictional powers and is considered an administrative Court of last resort in matters related to water use and distribution. There is also an Administrative Tribunal made up of the Members of the Council and presided over by the Superintendent. The Tribunal has "legislative" powers: it approves the DGI's annual budget, determines the irrigation water rates and approves the election procedures of the Users' Associations. It may also issue regulations for the operation of the DGI itself as well as regulations to be complied with by all irrigators in the province.

The DGI administers the resource at basin level through Subdelegates, who are responsible for managing the rivers on behalf of the Superintendent. At present there is one Water Subdelegation for each of the main rivers (Mendoza, Lower Tunuyán, Upper Tunuyán, Diamante and Atuel) and Area Headquarters for both the Tupungato and Malargue Rivers. The Subdelegations carry out O&M activities in the dams and distribution systems up to primary canal level. At secondary canal level the water is managed by the users' associations. The DGI has a staff of 640 and its annual budget is in the order of US$6,000,000.

Users' Associations

The 1894 Provincial Constitution ratified the canal users' right to elect their authorities and administer their income. The users' active participation in water management was finally adopted in the 1916 Provincial Constitution and in the General Water Law.

Users of the same canal have both the right and the obligation to participate in water management and distribution and in the maintenance of the irrigation system. The setting up of the users' associations, known as Canal Inspections, is a right recognized by law; i.e., a user belongs to an association by virtue of the water rights he holds in a given canal.

Canal inspections enjoy a considerable degree of independence, which enables them to elect their own authorities, draw up and administer their own budget, perform maintenance activities and organize their water distribution schedule. Until 1949 they also collected the irrigation water rates, part of which was allotted to the operation of the primary infrastructure and the DGI. Since 1949, it is the DGI itself that collects the irrigation water rates and allocates the funds required by the Canal Inspections.

The users' association is managed by one of its members, the Canal Inspector, an unpaid official who is elected by the users for a three-year period. He is assisted by a Board of Delegates and a Users' Advisory Commission. The organization structure described is a case of "dual decentralization," the DGI being autonomous from the Provincial Government and the Canal Inspections being autonomous from the DGI.

DEVELOPMENT

Users' associations in Mendoza are examined here by means of performance indicators:

Geographical Distribution

There are 366 Canal Inspections in Mendoza. Their distribution is not proportional to the area they irrigate. The northern oasis covering the Lower Tunuyán and Mendoza Rivers, represents 46.4 percent of the area. It is administered by Canal Inspections in the province and contains 77.3 percent of the associations (see Table 1, columns 2 and 4).

Size of the Canal Inspections

Since water is delivered according to registered area, the unit for water concessions is the hectare. For administrative reasons, the hectare is the unit used even when calculating flows for nonagricultural uses. This of course, is done after performing the respective conversion.

The total registered rights, including nonagricultural uses, amounts to 783,780 ha. Registered irrigation water rights for 1991 are equivalent to 594,792 ha. Of these, 438,915 ha are administered by Canal Inspections. Table 1, column 3 shows the area in each of the seven districts. Greater land subdivision along the Mendoza and Lower Tunuyán River basins account for the large number of users and small size of users' associations.

Table 2 classifies the canal inspections according to area and irrigation districts. The columns contain the number of inspections in each area stratum for each irrigation district. The last column shows the total inspections for each area stratum.

There are 182 associations, i.e., 50 percent of the total number of associations, that administer less than 400 ha each. Of these, 94 percent are to be found in the northern oasis (columns 1 and 2). However, the area administered by this first group is 25,873 ha, which represents only 5.9 percent of the total.

Table 1. Area (ha) administered by canal inspections per subdelegation (number of inspections, average area and number of users).

District	Number	%	Area	%	Average area	Users	Area/user
Mendoza	171	46.7	124,987	28.5	731	21,694	5.8
Tunuyán Lower	112	30.6	78,514	17.9	701	16,075	4.9
Tunuyán Upper	17	4.6	33,291	7.6	1,009	3,338	10.0
Tupungato	8	2.2	4,183	0.9	523	678	8.0
Diamante	33	9.0	78,993	18.0	2,394	10,904	7.2
Malargue	1	0.3	5,386	1.2	5,386	136	
Atuel	24	6.6	113,561	25.9	4,732	9,676	11.7
Total	366	100%	438,915	100%	1,199	62,501	7.02

Table 2. Number of inspections per area stratum on each of the main rivers.

Area range (ha)	Mza.	TLow.	TUp.	Tup.	Dia.	Mal.	Atu.	Total
0 – 400	91	80	3	4	1	–	3	182
400 – 800	32	10	5	1	5	–	1	54
800 – 1,500	18	6	3	3	9	1	3	43
1,500 – 3,000	11	4	3	–	8	–	5	31
3,000 – 6,000	15	5	1	–	4	–	6	31
6,000 – 12,000	4	5	2	–	6	–	4	21
+ 12,000	–	2	–	–	–	–	2	4
	171	112	17	8	33	1	22	366
%	46.9	30.8	4.7	2.2	9.1	0.3	6.0	100

Within the 0–400 ha range, there are canal inspections that administer tertiary or quaternary canals. In general, these associations are dependent on larger inspections. This occurs in 119 associations, which represents 65 percent of the inspections in this stratum.

Thesse inspections can be classified into:

* First degree inspections: receive water directly from the DGI.
* Second degree inspections: receive water from first degree inspections.
* Third degree inspections: receive water from second degree inspections.

Table 3 shows the number of different degree inspections for each of the main rivers and the area they administer.

Table 3. Different degree canal inspections.

District	Total number	Degree			Area per degree			Area (ha)
		1°	2°	3°	1°	2°	3°	
Mendoza	171	70	91	10	82,026	34,984	7,977	124,987
Tunuyan Lower	112	38	40	34	38,396	32,146	7,972	78,514
Tunuyan Upper	17	17	–	–	32,290	–	–	33,291
Tupungato	8	8	–	–	4,183	–	–	4,183
Diamante	33	25	8	–	66,269	12,724	–	78,993
Malargue	1	1	–	–	5,386	–	–	5,386
Atuel	24	23	1	–	112,416	1,145	–	113,561
Total	366	182	140	44	340,966	80,999	15,949	438,915

The small number of inspections in the last five districts makes it easier to coordinate activities, schedule canal maintenance, discuss expenditures, etc.

Users

There are 62,501 users under the Canal Inspections Management Organization. Users of private waters for hydroelectric and drinking water supply purposes are not included.

This is shown in Table 1, columns 6 and 7. Reference here is made to the area with irrigation rights and not to the total area. Users owning more than one farm within a given inspection are counted only once.

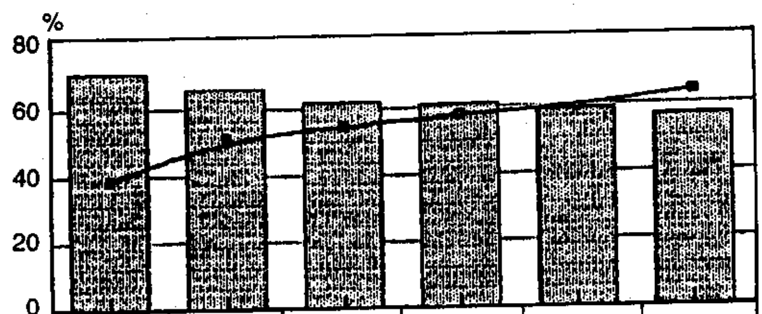
Users' Participation

The participation of canal inspections in the decision-making process varies among the Subdelegations. Only a few inspections with more than 3,000 ha on the Mendoza River participate in monthly meetings and regular discussions. On the Lower Tunuyán River, the consolidated inspections of over 4,000 ha have an active participation and they even demand innovations and improvements from the Subdelegation. Participation levels on the Upper Tunuyán and Diamante Rivers coincide with the mean levels, but participation is somewhat tutored. In the case of the Tupungato River, with a considerable administrative structure and small inspections, the Area Headquarters (DGI) carries out the activities of the Inspection. On the Atuel River, inspectors do participate, but as their level of education is usually lower, there is little that they can contribute to management.

Users' participation in management of the Inspection is usually limited to canal cleaning and maintenance. Few of the users feel that they belong to the inspection: their main concern is a reliable supply of water.

In December 1990, users elected their present authorities. Figure 1 shows the relationship between inspection size and the degree of user participation in the elections. Each column gives the values for each area stratum. The first row shows the percentage of votes cast at each area stratum. The data show it decreases (from 71 to 57 percent) as the size of the inspection increases. At the same time, the percentage of inspections that held elections (fourth row) increased with the size of the inspection (from 38.5 to 64 percent). Only in a few of the smaller inspections was there a higher percentage of votes. On the other hand, the larger the area the better the organization and the greater the capacity to hold elections.

Figure 1. Election of authorities users' participation.



	0-400	400-800	800-1500	1500-3000	3000-5000	de 6000
Votes (%)	71	66,1	62,3	61	59,1	56,9
No. canal Inspections	70	28	23	18	19	16
Total Inspections	182	54	42	31	32	25
Elections (%)	38,5	51,8	54,76	58,06	59,38	64

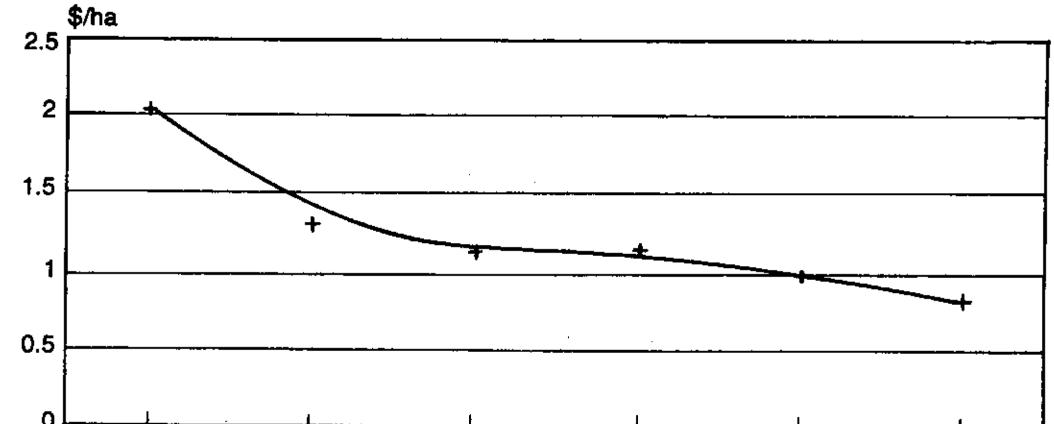
Irrigation Water Rates

Eighty-five percent of the inspections prepare a budget. Inspection budgets are submitted to the DGI which includes them in its annual budget. The budget is financed by the rates paid by the users in six annual installments. The DGI allots funds to the inspections according to their budgets. The share of the irrigation water rate corresponding to the inspection is called the "canal prorate." Inspections that do not prepare a budget are usually very small, with a mean area of 248 ha.

The canal prorate may be divided among the different Inspections. Second and third degree inspection users pay their rates to the corresponding higher level inspection. Figure 2 shows the average canal prorate for different degree and different size inspections. It may be observed that the prorate decreases as the area increases and when the inspections are of the first or the second degree.

Besides reducing the prorate, the degree of the inspections complicates the operation, organization and coordination of activities.

Figure 2. Inspections water costs variation.



	0-400	0-400	400-800	800-1500	1500-3000	3000-6000
$/ha	2,04	1.3	1.14	1.14	0.97	0.81
Grade	3	2	2	1	1	1

CONCLUSIONS

The participatory management system in the Mendoza Province has been described. The use of some simple performance indicators is proposed to account for the different behavior of users' associations. The decentralized administration and the large number of associations restrict the scope and depth of this analysis.

The size and degree of the inspections affect their performance. Small inspections lack the financial capacity and have both higher costs and greater difficulty in attaining user participation in management activities as well as in the election of authorities.

In the older irrigation areas situated near urban centers, the inspections are smaller in size. They represent 50 percent of the total and most of the DGI's efforts are directed towards them. There are more inspections depending upon higher level ones (second and third degree inspections), their water costs are higher and the quality of service is poorer.

The monitoring system for a large number of users' associations' performance could be improved by a closer relationship with DGI's accounting system. This would make it possible to carry out historical analyses for better administrative policy planning and to improve productivity.

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Study on Measurement and Evaluation of Performance of Farmer-Managed Irrigation Systems in China

Mao Zhi[47]

ABSTRACT

IN CHINA, ABOUT one half of the total irrigated farmland in the country is completely managed by the farmers themselves. Moreover, all the irrigation systems under branch canals in China are managed by the farmers. There is therefore an urgent need to study methods of measurement and evaluation of performance of Farmer-Managed Irrigation Systems (FMIS) in order to improve the performance and raise the management level of Chinese FMIS. This paper proposes a method of quantitative evaluation of FMIS performance, by scoring according to an index system consisting of sixteen techno-economical factors. The methods of measurement and calculating the mark of each index and the weighted average mark (WAM) and evaluating the FMIS performance on the basis of the WAM are presented. Finally, based on the results of the application of the abovementioned methods in a typical FMIS in South China, the methods of measurement and calculation of each index and the WAM, and the method of evaluating FMIS performance are illustrated.

INTRODUCTION

In China, small-scale irrigation systems which irrigate areas of less than 667 hectares (ha), or whose total reservoir capacity, as the main water source is less than one million m^3, are managed by the farmers themselves and are thus farmer-managed irrigation systems (FMIS). Large-scale and medium-scale systems are managed by government agencies (GMIS). According to the official statistics in 1990, the total irrigated farmland in China is 48 million ha. About half of this area is controlled by FMIS. Moreover, the management responsibility of government agencies in GMIS is limited to managing the main and branch canals and the major facilities, while most of the activities connected with the lower-level canals and field channels are carried out by farmers themselves. Accordingly, all the irrigation systems in China below the branch canals, may be considered FMIS. Therefore, studies to improve the performance of FMIS in China are an urgent need in order to conserve irrigation water and increase crop yields.

To better understand present performance and problems and to develop a plan for improving FMIS performance, research on performance measurement and evaluation have already begun and a method for evaluating the performance has been tested in some typical FMIS in South China.

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Based on an analysis of the results of the research and experiments in a typical FMIS in South China by the author, and in light of the special characteristics of FMIS, a method of quantitative measurement and evaluation of performance by scoring and calculating the weighted average mark (WAM) has been developed. The method and its application are described and discussed below.

AN INDEX SYSTEM FOR EVALUATING FMIS PERFORMANCE AND FOR THE MEASUREMENT AND CALCULATION OF THE INDICES

According to the national unified index system (on trial, 1982) and in light of the specific conditions of FMIS in South China, the following index system is used. It consists of sixteen techno-economical indices for analyzing the performance of FMIS, organized into four groups. The methods of measurement and calculation of the indices are as follows:

(1) **Group 1. Indices of irrigation water utilization**

The four indices used are

1) Efficiency of irrigation water supply, S, (%).

$$S = \frac{W}{W_r} * 100$$

where W and W_r are the actual and required annual quantity of irrigation water diverted from the water sources in the same years (m^3/year). W can be obtained by measuring the discharge from headworks of the various water sources. W_r can be calculated using the water balance method, in which the crop water requirements may be obtained from the irrigation experimental station in the vicinity or from a nearby region, or may be read from the provincial maps of isolines of crop water requirements and water quotas, which have been prepared for most provinces in China.

2) Efficiency of utilizing local water resources within the irrigation district, U, (%)

$$U = \frac{Ww}{Wwr} * 100$$

where W_w and W_{wr} are the actual and required (in the same hydrologic years) annual quantity of irrigation water supply from the water sources within the irrigation district (m^3/year).

3) Irrigation application efficiency, E.

$$E = \frac{W_f}{W}$$

where W_f is the total quantity of irrigation water delivered to the fields (m^3/year); E can be calculated by:

$$E = \pi_{i=1}^{n} E_i * E_f$$

where E_1 is the application efficiency of irrigation canals of i-th rank, n is the total numbers of ranks of canals, E_i is calculated from the water loss in irrigation canals, which can be measured either by the static or dynamic test methods in one or two typical canals of each rank; E_f is the water application efficiency in the field. In South China, for rice fields, $E_f = 1$.

4) Gross annual irrigation water quota, M, (m^3/ha/year) and the percentage of standard irrigation quota, P_m, (%)

$$M = \frac{W}{A}$$

$$P_m = \frac{M * E + 300}{M_n + 300} * 100$$

where A is the actual irrigated area in ha; M_n is the standard net annual irrigation water quota (m^3/ha/year). This can be obtained from irrigation experimental stations or read from the provincial maps of isolines of irrigation water quotas.

(2) **Group 2. Indices of irrigation area and engineering aspects of the system**

Three indices are used:

5) Percentage of actual irrigated area, F, (%)

$$F = \frac{A}{Ap} * 100$$

where A_p is the planned irrigated area in ha in the same year.

6) Percentage of area provided with field irrigation and drainage systems, D, (%)

$$D = \frac{A_f}{A_{fd}} * 100$$

where A_f and A_{fd} are the actual and design area provided with the field irrigation and drainage systems (ha).

7) Percentage of facilities in good condition, G, (%)

$$G = \frac{N_g}{N}$$

where N is the total number of facilities for irrigation or drainage in a particular category; N_g is the number of the facilities in good condition (safe, integrated, functioning normally and attaining the design standard).

(3) **Group 3. Indices of yield and economic benefit**

The six indices used are

8) Yield per unit area, Y, (t/ha/year) (t=ton) and the percentage of the highest yield per unit area, P_ya, (%).

$$Y_a = \frac{Y}{A}$$

$$P_ya = \frac{Y_a}{Y_ah} * 100$$

where Y is the total annual yield (t/year) of crops in A (ha); Y_ah is the historical highest annual yield per unit area (t/ha/year).

9) Yield per unit quantity of irrigation water, Y_w, (t/m^3) and the percentage of the highest yield per unit quantity of irrigation water, P_yw, (%).

$$Y_w = \frac{Y}{W}$$

$$P_{yw} = \frac{Y_w}{Y_{wh}} * 100$$

where Y_{wh} is the historical highest annual yield per unit quantity of irrigation water (t/m^3).

10) Percentage of the highest total yield, P_y, (%)

$$P_y = \frac{Y}{Y_h} * 100$$

where Y_h is the historical highest total annual yield in the whole irrigation district (t/year).

11) Efficiency of collection of irrigation water charges, P_i, (%)

$$P_i = \frac{lw}{lwr} * 100$$

where lw and lwr are the actual and required total annual income from irrigation water charges in the whole irrigation district (yuan/year) (Yuan is the Chinese unit of currency. In 1991, one yuan = US$0.192); lw should be calculated on the basis of the collection of water charges from the total irrigated area and using the unified price of water which is set by the local government.

12) Irrigation benefit per unit area, b, (yuan/ha/year) and percentage of the highest benefit, P_B, (%)

$$b = (y - y_o)c + (y' - y_o')\,c' - h'$$

$$P_B = \frac{b * A}{B_h' * 100}$$

where y and y_o are the annual yields of crops per unit area (t/ha/year) with and without irrigation, respectively; y' and y_o are the annual quantities of by-products per unit area with and without irrigation (t/ha/year); c and c' are the costs of agricultural product and by-product (yuan/t); h is annual expenditure per unit area for irrigation (yuan/ha/year); B_h is the historical highest total annual irrigation benefit in the whole irrigation district (yuan/year).

13) Percentage of financial self-sufficiency, B, (%)

$$B = \frac{I}{H} * 100$$

where I is the total annual income of the FMIS, which is obtained from water charge and several other revenue (yuan/year); H is the total annual expenditures for irrigation management which includes the current expenditures and the payment to the peasant managerial personnel and irrigators (yuan/year).

(4) Group 4. Indices of land melioration and environmental impact

Three indices are used:

14) Rate of change of groundwater table, R, (%)

$$R = \frac{D_1 - D_t}{D} * 100$$

where D_1 and D_t are the annual average depth of groundwater table last year and this year (m); D is the mean annual depth of groundwater table (m).

15) Percentage of the melioration of low-yield land, Z, (%)

$$Z = \frac{A_{Lm}}{A_L} * 100$$

where A_L is the total area of original low-yield land in which the crop yields are lower than one fourth of normal yields (ha); A_{Lm} is the area of low-yield land which has been improved by measures of drainage and irrigation, and the crop yields have been raised over one half of the normal yields (ha).

If there is no low-yield land ($A_1 = 0$) in this irrigated district, $Z = 90$.

16) Percentage of afforestation of canals, J, (%)

$$J = \frac{L_t}{L} * 100$$

where L is the total length of conveyance canals (km)); L_t is the length of conveyance canals along which the trees have been planted (km).

CALCULATION OF THE WAM OF THE INDEX SYSTEM

The performance of FMIS can be quantitatively evaluated by the weighted average mark (WAM) of index system. The higher the WAM, the better the performance. The basis for calculating WAM is the values of mark and the weight of each index. The methods for determining these values will be introduced in the following:

Determination of the Mark and Weight of Each Index

Based on the results of application of the WAM method to evaluate the performance of some typical FMIS in South China and the suggestions of the peasant personnel, the methods for determining the mark and weight of each index are as given in Table 1.

Method of Calculating the Weighted Average Mark of the Index System

For a given FMIS, the WAM is calculated by

$$WAM \ \sum_{i=i}^{16} (ID_i * WT_i) + \blacktriangle MK_1 + \blacktriangle MK_2 + \blacktriangle MK_3 + \blacktriangle MK^1$$

where ID_i and WT_i are the values of i-th index and its weight; $\blacktriangle MK_1$, $\blacktriangle MK_2$ and $\blacktriangle MK_3$ are the additional marks. If the management organization is sound and the great majority of peasant management personnel have been trained properly,

$$\blacktriangle MK_1 = 4$$

If the records, tables and charts of management are complete,

$$\blacktriangle MK_2 = 2$$

If the advanced technique has been applied and proved to be effective,

$$\blacktriangle MK_3 = 4$$

If it does not accord with the above respective demands, $\blacktriangle MK_1$, $\blacktriangle MK_2$ and $\blacktriangle MK_3$ are equal to zero.

Table 1. Methods of calculating the marks and weights of indices.

No.	Names, symbols and units of indices	Methods of calculating mark (MK=mark)	Values of weight (WT=weight)	
1	Efficiency of irrigation water supply, S, (%)	$MK=S$	0.03	0.20
2	Efficiency of utilizing local water resource within the irrigation district, U, (%)	$MK=U$	0.06	
3	Irrigation application efficiency, E	$MK=100E * K$ $K=1.3$ ($A<200$ ha) $K=1.4$ ($A=200 \sim 1000$ ha) $K=1.5$ ($A>1000$ ha)	0.08	
4	Percentage of standard irrigation water quota, P_m, (%)	$MK=50+0.5P_m$ $(P_m \leq 100)$ $MK=150\text{-}0.5P_m$ $(P_m>100)$	0.03	
5	Percentage of actual irrigated area, F, (%)	$MK=2F\text{-}100$	0.08	0.20
6	Percentage of area provided with field irrigation and drainage systems, D, (%)	$MK=D$	0.04	
7	Percentage of facilities in good condition, G, (%)	$MK=2G\text{-}100$	0.08	
8	Percentage of the highest yield per unit area, P_{ya}, (%)	$MK=2P_{ya}\text{-}100$	0.05	0.35
9	Percentage of the highest yield per unit quantity of irrigation water, P_{yw}, (%)	$MK=2P_{yw}\text{-}100$	0.05	
10	Percentage of the highest total yield, P_y, (%)	$MK=2P_y\text{-}100$	0.10	
11	Efficiency of collection of irrigation water charges, P_1	$MK=P_1$	0.05	
12	Percentage of the highest benefit, P_B, (%)	$MK=P_B$	0.05	
13	Percentage of financial self-sufficiency, B, (%)	$MK=B$ $(B \leq 100)$ $MK=100$ $(B>100)$	0.05	
14	Rate of change of groundwater table, R, (%)	$MK=2.5\,(40\text{-}\lvert R \rvert)$	0.05	0.15
15	Percentage of the melioration of low-yield land, Z, (%)	$MK=Z$ $(A_L>0)$ $MK=90$ $(A_L=0)$	0.08	
16	Percentage of afforestation of canals, J, (%)	$MR=J$	0.02	

$\blacktriangle MK'$ is the deduction of marks due to an accident arising from the negligence of management personnel. The values of $\blacktriangle MK'$ are as follows:

For ordinary accident:

$\blacktriangle MK' = 2.0$	(A <100 ha)
$\blacktriangle MK' = 1.5$	(A = 100 ~ 1000 ha)
$\blacktriangle MK' = 1.0$	(A > 1000 ha)

For serious accident:

$\blacktriangle MK' = 10.0$	(A <100 ha)
$\blacktriangle MK' = 7.5$	(A = 100 ~ 1000 ha)
$\blacktriangle MK' = 5.0$	(A > 1000 ha)

In China, the standards of ordinary and serious accidents have been fixed by the government.

In Table 1, the sum of the weight of 16 indices is 0.90. Therefore, in general, the full mark of WAM of 16 indices is 90 and the full mark of WAM of an FMIS is 100. In Hubei Province, the standard for evaluating the performance in FMIS is:

$WAM \geq 90$	excellent
$WAM = 80 \sim 80.9$	good
$WAM = 70 \sim 70.9$	fair
$WAM = 60 \sim 60.9$	bare
$WAM < 60$	poor

APPLICATION OF THE PERFORMANCE EVALUATION METHOD IN A TYPICAL FMIS

The above mentioned method has been applied in some FMIS in Hubei Province in South China. As an example, the application of this method in Fushui Irrigation System (FIS) in Hubei Province is described below.

General Features of the Fushui Irrigation System

Fushui Irrigation District (FID) is situated in the central part of Hubei Province, North of the Changjiang (Yangtze) River. It was constructed in 1960. FIS is one of the FMIS in the hilly regions typical in South China, both in terms of its natural and social conditions and its performance and management level. The irrigated area of FID is 370 ha, of which about two-thirds lies in the hilly regions and one-third in the plain area. The soils of the area are mostly clay and loam. The main crops are rice and wheat. Rice is planted over 89 percent of FID and wheat is planted on 68 percent of the rice fields after harvest. The average annual evaporative capacity is 1,298.5 mm and rainfall is 1,033.1 mm, which is distributed in a highly irregular pattern both within and between years. Irrigation of rice is indispensable in both dry and wet years, and the irrigation periods are from

May to August. Irrigation is not necessary for wheat in any year. The annual yields of rice in FID was 6.1–7.3 t/ha during the 1980s.

The irrigation water of FIS is diverted mainly from the main canal of Xujiahe Irrigation System (XIS) which is a large-scale irrigation system of the Hubei Province. The main canal of FIS is one of the branch canals of XIS. There are one main canal and 51 branch canals of two ranks in FIS. The length of the main canal of FIS is 6.30 km and the capacity of this canal is 1.1 m^3/s. There are 407 ponds with a total capacity of 781 thousand m^3 which can provide 20 percent (in dry years) to 45 percent (in medium years) of the total irrigation water. It is thus clear that the ponds are a very important supplementary water source in FIS.

The management organization of this system was established in 1963. There is a management committee which is composed of the chairman, vice-chairman and three full-time members. All the members are village heads and farmers. Under the committee, there are seven management groups which are composed of 34 peasant management personnel and about 100 peasant irrigators. The responsibility of the organization and its members is to manage the irrigation structures, canals and ponds and to engage in water management and fields irrigation.

Evaluation of the Performance of the Fushui Irrigation System

Based on the material gathered, investigated and measured in FIS in 1988 (a median dry year), the performance of FIS in 1988 was evaluated by the method of WAM. The processes and results of calculating WAM of index system of FIS in 1988 are shown in Table 2.

Because the peasant management personnel had not been well-trained, the records, tables and charts of operation were not complete and the advanced technique had not been applied in FIS in 1988.

$$\blacktriangle MK_1 = \blacktriangle MK_2 = \blacktriangle MK_3 = 0$$

Because no accident occurred in 1988 due to the management personnel's negligence,

$$\blacktriangle MK' = 0$$

Thus, for FIS in 1988,

$$WAM = 75.0$$

his means that the grade of the performance of FIS in 1988 belongs to "fair." This grade is low for the historical conditions of FIS.

The causes of the unsatisfactory performance of FIS in 1988 can be found in Table 2. First, *MK* of No. 2 is too low. The reason is that the quantity of water supplied by the local water source ponds is much less than required. In the 1960s, the average annual quantity of water supplied by ponds in FIS was about 2,250 m^3/ha. But in the 1980s, it was only about 1,200 m^3/ha because the farmers abandoned the ponds and transformed them into rice fields to make up for the loss of farmland, which was occupied by local industry. Second, MK of No. 7 is low because there were six irrigation structures (water gates) which did not function normally. Third, MK of No. 9 and 10 are low because the total yield in 1988 lagged far behind the historical highest in 1984. Besides, an important additional mark $-\blacktriangle MK_1$ — is equal to zero because the peasant management personnel have not been trained, although the management organization was sound.

Table 2. Process and results of calculating WAM of index system of FIS in 1988.

No	Names, symbols and units of indices	Processes and results of calculating indices	Processes and results of calculating marks (*MK*=mark)	Values of weight (*WT*= weight)	*MK* * *WT*
1	Efficiency of irrigation water supply, *S*, (%)	$S=\frac{2.06*10^6}{2.456*10^6}*100=84.0$	*MK*=84.0	0.03	2.52
2	Efficiency of utilizing local water resource within the irrigation district, *U*, (%)	$U=\frac{0.320}{0.616}*100=51.9$	*MK*=51.9	0.06	3.11
3	Irrigation application efficiency, *E*	$E=0.84*0.83*0.87*1.00=0.607$	*MK*=100 * 0.607 * 1.4 =84.9	0.08	6.79
4	Percentage of actual irrigation water quota, *Pm*, (%)	$Pm=\frac{6100*0.607+300}{4200+300}*100=89.0$	*MK*=50+0.5 * 89.0 =94.5	0.03	2.84
5	Percentage of actual irrigated area, *F*, (%)	$F=\frac{338}{365}*100=92.6$	*MK*=2 * 92.6-100=85.2	0.08	6.82
6	Percentage of area provided with field irrigation and drainage systems, *D*, (%)	$D=\frac{320}{365}*100=87.7$	*MK*=87.7	0.04	3.51
7	Percentage of facilities in good condition, *G*, (%)	$G=\frac{45}{51}*100=95.1$	*MK*=2 * 88.2-100=76.4	0.08	6.11
8	Percentage of the highest yield per unit area, *Pya*, (%)	$Pya=\frac{7.18}{7.55}*100=95.1$	*MK*=2 * 95.1-100=90.2	0.05	4.51
9	Percentage of the highest yield per unit quantity of irrigation water, *Pym*, (%)	$Pym=\frac{0.001177}{0.001358}*100=86.7$	*MK*=2 * 86.7-100 =73.4	0.05	3.[illegible]
10	Percentage of the highest total yield, *Py*, (%)	$Py=\frac{2427}{2800}*100=87.6$	*MK*=2 * 86.7-100 =73.4	0.10	7.34
11	Efficiency of collection of irrigation water charges, *P1*, (%)	$P1=\frac{9010}{1000}*100=90.1$	*MK*=90.1	0.05	4.51
12	Percentage of the highest benefit, *PB*, (%)	$PB=\frac{177.5*10^3}{213.0*10^3}*100=83.3$	*MK*=83.3	0.05	4.17
13	Percentage of financial self-sufficiency, *B*, (%)	$B=\frac{16.30*10^3}{12.14*10^3}*100=131$	*MK*=100.0	0.05	5.00
14	Rate of change of groundwater table (*R*%)	$R=0$	*MK*=2.5(40-0)=100.0	0.05	5.00

continued on p.219

No	Names, symbols and units of indices	Processes and results of calculating indices	Processes and results of calculating marks (*MK*=mark)	Values of weight (*WT*= weight)	*MK* * *WT*
15	Percentage of the melioration of low-yield land, *Z*, (%)	$A_L = 0$	*MK*=90.0 0.08	7.20	
16	Percentage of afforestation of canals, *J*, (%)	$J = \frac{6.00}{6.30} * 100 = 95.2$	*MK*=95.2	0.02	1.90
	$WAM = \sum_{i=1}^{16} (MK_i * WT_i)$			$\Sigma = 0.90$	$\Sigma = 75$

CONCLUSION

Measurement and evaluation of performance of FMIS in China are urgently required to improve their performance and to raise their management level. The performance of FMIS can be measured and evaluated by a method of quantitative analysis with the weighted average mark of an index system which consists of sixteen techno-economical indices of an FMIS. The present level of performance of FMIS, the major problems and their main causes can be clarified and the main measures for resolving the problems and improving the performance can be identified by applying the abovementioned method. The evaluation of the performance of a typical FMIS in South China has demonstrated the application of the method described. This type of evaluation can help to improve the performance, increase the crops yields and save on irrigation water in FMIS.

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Performance Measurement in Farmer-Managed Irrigation Systems: Case Studies of Tubewells in a Selected Area of Bangladesh

M.A. Hakim and D.E. Parker[48]

ABSTRACT

THE PERFORMANCE OF farmer-managed tubewells (TW) is of great importance to Bangladesh given the country's preponderance of groundwater technologies among its irrigation systems and given the pace of turnover of agency wells to farmer groups. This study examines farmer-management involvement in performance measurement in a sample of deep tubewells (DTW) in the Rajshahi Region of western Bangladesh. DTWs were found to be often underutilized in relation to reasonable expectations of command area and service to farmers. If farmer managers of DTW FMIS are to be able to effectively manage their wells and improve their performance, they must have access to relevant measures of output, impact and management process attainments. While FMIS managers in the study do keep some basic records they are aware that there is scope for the use of a number of additional types of measures. Further, there is some confusion as to what might constitute appropriate standards of performance for various measurement indicators. Irrigation agencies (or other organizations) could usefully contribute to the performance of farmer-managed TWs by providing training and information in regard to various performance measures and standards. In addition, agencies could collect and disseminate information on some types of technical indicators (evapo-transpiration, water table changes, etc.) that would be difficult for farmer-managers to acquire on their own.

INTRODUCTION

Bangladesh, with a very high land/man ratio estimated at 766 persons per square kilometer in 1989, is among the ten most densely populated countries in the world. The most pressing development problems of the country include a) chronic food shortage, b) massive unemployment and under-employment, c) widespread and severe poverty and d) inequity in the distribution of assets and incomes. The Government of Bangladesh has identified the creation and expansion of irrigation facilities as a key strategy in dealing with these problems and irrigation now covers about 25 percent of the total cultivable land in the country. Of the total irrigated area about 90 percent is

48 Authors are respectively, Researcher and Head of Bangladesh Field Operations in IIMI's Bangladesh office. Field information reflected in this study is an offshoot of data gathered in a project on irrigation management in rice-based farming systems funded by the Rockefeller Foundation through IIMI.

covered by modern methods and the rest by traditional technologies. The irrigation sector is dominated by small-scale irrigation systems, which include primarily shallow tubewells (STWs), deep tubewells (DTWs), and low lift pumps (LLPs).

Farmer-Managed Irrigation Systems (FMIS) in Bangladesh

Although in Bangladesh farmer-managed modern irrigation systems were introduced in the late sixties, the country has a very long history of farmers managing irrigation with traditional methods. The traditional methods include individually owned one-farm *dhones* (pivoted boat-like devices discharging 0.04 cusec), and swing baskets (discharging up to .06 cusec) which use surface water and dug-wells capable of irrigating 0.2 to 0.3 acres of rice. More modern small-scale methods such as DTWs and LLPs were initiated and installed by the government and then handed over to farmers for their use and management under various arrangements — rent, sale or (with more agency involvement) for a fee. The present government policy is to turn over to the private sector all tubewells (TW) and pumps. The rental system is still prevalent, however, particularly for DTWs.

FMIS include both government-developed modern methods as well as traditional technologies of minor irrigation. Such systems irrigate 2.23 million hectares which is over 90 percent of the total irrigated area in the country. These systems are managed variously by farmer cooperatives, informal groups of farmers, and individuals. Compared with surface irrigation FMIS in other countries, farmer-managed TW and LLP irrigation systems in Bangladesh are smaller in scale, more cash-oriented and enjoy a greater degree of control over the source of their water (Parker 1991). As with major agency-operated irrigation projects, however, there is a growing concern in the country over the performance of these farmer-managed systems. Irrigated command area is often small in relation to technical capacity and water access by tenants and small farmers is seldom secure.

Issues in Performance Measurement

To address the issue of performance of these farmer-managed pump irrigation systems, it is necessary to examine the bases of performance concepts for FMIS and the constraints of performance measurements. Against whose goals is performance to be measured? Are they the goals of the tenant cultivator(?), the large farmer(?), the system manager(?), an irrigation agency(?), a donor(?) Or are they to be a composite of the goals of all of these parties? Performance measurement indicators may well differ by these differing perceptions of performance. Related to these issues of goals and measurements is that of the standards against which indicators are to be compared in performance measurement. Are standards used by researchers based on some theory, notion or experience with which the users of a farmer-managed system are unfamiliar? Do farmers agree with these standards? As farmers are the primary actors in these systems such agreement is essential if progress is to be made in attaining given standards of performance.

Another measurement issue concerns the availability and usability of data with which to assess performance. If irrigation performance measures are to be useful tools for farmer managers, the supporting information or data must be easily gathered and easily understood. How can the use of such data be promoted among farmers and others concerned? Are the farmers convinced of the need of the data and of the indicators supported by the data?

Objectives of the Paper

The broad objective of this paper is to contribute to the development of an approach to performance measurement that is appropriate to the attainment of the goals of FMIS. The specific objectives are to address some of the issues mentioned above, particularly in the context of samples of DTWs located in the western part of Bangladesh falling under three categorizations of group management/ownership. These categorizations include: a) private groups owning wells; b) groups renting TWs from a government agency; and c) groups managing wells in an agency project. The specific objectives may be detailed as: i) to identify the goals of farmer-managed irrigation systems (under varying situations) as distinct from the goals of agency-managed systems; ii) to determine and categorize a set of relevant indicators to measure FMIS performance; iii) to identify standards against which some of the indicators may be compared; and iv) to examine farmer-manager use of performance measures and to explore ways to promote the use of relevant indicators among farmers and others.

The objectives of the paper were pursued mainly through case studies of groups of farmer-managed DTWs distributed among the three categories of management/ownership noted above. These types of tubewell management form a significant portion of the FMIS in Bangladesh, covering 0.56 million hectares. Three groups of 15 DTWs (private, rental and agency-coordinated fee-based) were chosen for study in the Rajshahi area of western Bangladesh. In each group of 15, three were chosen for interviews with farmers and managers while information on irrigation coverage, costs, yield, etc., was gathered from all of the wells. The data generated from the case studies were supplemented by information from various sources such as agency reports, project documents, evaluation reports, field studies and monographs, and farmer records.

DISCUSSION AND FINDINGS

Objectives of Tubewell FMIS in Bangladesh

FMIS using motor-driven pumps in Bangladesh were originally introduced (and generally installed) by such government agencies as the Bangladesh Agricultural Development Corporation (BADC) and the Bangladesh Water Development Board (BWDB). In the initial years of rental FMIS, the agencies provided repair and maintenance services. This is also true in the present agency-coordinated fee-based systems. In its present policy of turning over (selling) DTWs to private groups for ownership and management, the government is providing a fairly substantial level of subsidy. Given these government inputs as well as the government's general development aims, one view of appropriate FMIS objectives might be that such goals should be the same as those of government-managed irrigation systems — which seem generally to be subscribed to by international development agencies. Broadly, these objectives include a) increasing farm production, especially of food grains, b) increasing incomes of all categories of farmers, c) creating additional employment opportunities for farmers and landless laborers, and d) reducing, or at least arresting, inequity in the distribution of income and assets. These impact objectives are expected to be achieved through the realization of such output objectives as increasing the technical efficiency of the systems as reflected in increased irrigated area, ensuring water supplies in sufficient quantities in a timely and predictable manner, and ensuring equity through the provision of access to irrigation water to all categories of farms.

The farmers who are managers and owners of the DTWs under study would seem to be in general agreement with these broad objectives. Among the 9 TWs (under 3 types of farmer management) surveyed, the managers stated that with the help of irrigation they would like to increase their farm production as well as the incomes and employment of their fellow farmers in the village. In respect to equity, the managers also declared that every farmer should get equal access to water as long as he paid his irrigation fee/charge. There is, of course, skepticism in Bangladesh (and elsewhere) about the motivations of larger and more influential farmers in respect to their less-advantaged neighbors, and the statements of the tubewell managers on equity goals might be open to some doubt. The 3 owner-managers in the sample, however, identified maximization of the return on their investment as one of their important management objectives and noted that irrigation investment return-maximization requires providing efficient irrigation services to the maximum number of farmers and irrigated area. In many areas the development of water markets seems to act as a deterrent to the monopoly pricing of water. As a result, area coverage increases are the remaining route to increased returns. Where returns to the manager's system (as opposed to the manager's own farm or influence) is not the prime concern, of course, the equity goals of managers may differ from those stated here. Such a difference might be expected in some surface systems but is less likely for farmer-managed TWs in which some level of financial return (after O&M costs) can be extracted from users.

A sample of 70 cultivators in the study TWs were also interviewed in regard to their views of irrigation system objectives. Again, their objectives seemed compatible with those of the government and the tubewell managers. In other words, for the types of pump-irrigated FMIS examined in this study, there is a fairly high degree of agreement on irrigation goals between users, managers, government agencies and aid donors.

Indicators of Performance

Performance indicators might be classified as measuring progress toward: a) output objectives (directly related to the provision of irrigation); b) impact objectives (related more to irrigation's longer-term or indirect results); and c) process objectives (dealing with management processes). Irrigation agencies and outside researchers have interests in all three types of performance indicators — both to rate the progress of an irrigation project and to identify ways to improve the system. Farmer-managers would appear to be more interested in the attainment (through whatever means) of their direct output objectives rather than in the more diffuse impact types of objectives. The performance of tubewell FMIS in Bangladesh has, in the past, been evaluated primarily by international aid agencies and government departments through sponsored research by consultants, universities or institutes. The emphasis would seem to have been on project performance rather than on the use of performance measures by farmer-managers. As a result, there has been little focus on making performance indicators user-friendly at the FMIS management level. Farmer-managers have seldom been consulted when measures were selected nor have they usually been instructed in the use of the indicators as the measurements have been seen as evaluative tools rather than management ones.

Even as primarily project evaluation tools many of the performance indicators utilized in studies of tubewell irrigation in Bangladesh have had a number of problems of design, coverage, quality of data and lack of comparability, etc. (Bottrall 1983, Sadeque and Hakim 1989). There has, at times, been confusion between measures of output, impact and process attainments and a lack of explicit linkages between these various types of measures. Measures have sometimes been inappropriate and others have not been clearly defined. For example, a measure of area irrigated is not useful unless there is some definition of what constitutes an irrigated crop. A crop receiving one irrigation turn (when more turns are needed) is in a very different category than a crop which receives water when required. Yet area-irrigated measures have seldom made that distinction.

From the literature already cited some performance indicators might be listed that have been identified as being particularly appropriate for the analysis and/or management of pump FMIS in Bangladesh.

Output indicators:

* Area irrigated effectively.
* Total volume of water made available in a particular season.
* Attainment of start-up time best suited to a chosen cropping pattern.
* Adequacy of water in relation to crop water needs.
* Equity of water supply by field location and farm category.
* Reliability of water supply.
* Participating farmers as a proportion of potential command area irrigators.
* Return on irrigation system investment by farmers.

Impact indicators:

* Yield increments due to the irrigation provided.
* Cropping intensity increases due to irrigation.
* Cropping pattern changes due to irrigation.
* Changes in costs of cultivation due to the provision of irrigation.
* Impacts on local employment, particularly of women and disadvantaged groups such as landless labor.
* Sustainability of yield, income and employment increases due to irrigation.
* Impacts on the environment and on social systems.
* Irrigation-related crop income gaps of farms by field location, farm size and tenurial class.
* Levels of technical efficiency of input use.
* Return on outside (i.e., government or donor) investments in pump FMIS.

Process indicators:

* Nature of farmer organization in FMIS
* Nature of organization of irrigation management functions.
* Nature and practice of irrigation planning.
* Adequacy of irrigation budgeting.
* Adequacy of accounting system.
* Degree of mobilization of farmer participants for repair, construction, and maintenance of irrigation channels.

* Regularity of repair and maintenance functions (pump and channels).
* Costs of operation and maintenance per hectare.
* Irrigation fee collection efficiency.
* Loan repayment rates if institutional credit is used.
* Nature of contacts with government irrigation and agricultural support agencies.
* Quality of monitoring systems.

Standards and Performance

Performance measures become useful as management tools when employed in relation to some standard of attainment. Where past records exist, comparisons with previous performance can be made. For tubewell FMIS comparison with other TWs is useful for the creation of realistic expectations of performance. In Bangladesh, there is little agreement on standards for key performance variables for tubewell systems of similar technology. Of course, there are regional differences in agro-ecological conditions and in the socioeconomic contexts within which pump FMIS operate. Even on a regional basis, however, the definition of such a basic measure as potential irrigable area for DTWs has been termed an "elusive quality" (Murshid 1985) by at least one researcher.

This lack of agreement is not just on the part of researchers. From interviews and discussions with officials, tubewell managers and farmers in the study area there would appear to be wide differences in expectations. In Table 1 it can be seen that standards for irrigated area and rice yield vary markedly by category of respondent.

An attempt was made, using data from research area TWs, to calculate a few possible standards for irrigated area, number of farmers served and rice yield during the irrigated boro rice season. These figures are shown in Table 2 along with average actual attainments per tubewell. It can be seen that actual performance in regard to irrigated area is somewhat below the rather moderate calculated potential for rental and private wells and is roughly half the potential for the agency FMIS TWs. At least part of the area shortfall is due to operating hours. While it is technically feasible to run the pumps for much longer periods, the sample wells operated an average of 8.8 (agency FMIS), 9.5 (private) and 10.4 (rental) hours per day during the boro rice season. For the agency FMIS wells it would also appear that much more water was utilized per hectare than would seem necessary given characteristics of rainfall, evapotranspiration, seepage and percolation. Some of that extra water could have been used to irrigate an additional acreage.

Table 1. Stated standards of irrigated area and boro rice yield by agency officials and by DTW FMIS farmers and managers.

Type of FMIS	Irrigable hectares per cusec			Yield in tons per hectare		
	Farmer stated	Manager stated	Official stated	Farmer stated	Manager stated	Official stated
Rental	15.7	20.2	12.2	6.9	6.1	4.6
Private	15.8	24.1	12.2	6.9	6.1	4.6
Agency FMIS	9.7	10.4	12.2	5.5	7.1	5.5

Table 2. Selected indicators for case study DTWs[1].

Type of FMIS	Irrigated area (ha)		No. Farmers (per TW)		Yield (ha),	
	Potential[2]	Actual	Potential[3]	Actual	Potential[4]	Actual[5]
Rental	19.9	15.6	116	91	6.0	4.6
Private	20.2	17.9	118	105	6.0	5.6
Agency FMIS	16.6	8.4	55	28	6.0	4.6

1 Information derived from 45 DTWs — 15 in each category.

2 Potential irrigated area calculated from average measured TWs discharge, an assumption of 12 hours per day pump operation, 67 operating days for rental and private wells and 82 days for agency wells (due to a different rice variety), and 1991 irrigation needs for boro rice based on measured evapotranspiration, seepage/percolation and rainfall.

3 Potential farmers are based on the number of farmers per hectare for actual irrigated area extrapolated to the potential irrigated area.

4 Yield is assumed to be 6 tons per hectare when using prescribed amounts of inputs including adequate irrigation water.

5 Actual yield estimates are based on crop cuts.

Operating and maintenance costs, fee revenue, net tubewell returns and farmer returns are shown in Table 3. Calculated standards have not been determined for these items as significant parts of O&M costs cannot be expected to be linearly related to hectares irrigated. Some economies of scale might occur as irrigated acreage expands. This would indicate that net returns to the sample TWs are substantially below their attainable level if the calculated potential irrigation coverage were to be achieved.

Table 3. Returns for case study DTWs.[1]

Type OF fmis	O&M[2]		Fee Revenue		Net TW Return[3]		Farmer Return[4] ha
	TW	ha	TW	ha	TW	ha	
Rental	51,592	3,307	62,564	4,011	10,972	704	12,262
Private	62,534	3,494	119,244	6,662	56,710	3,108	15,454
Agency FMIS	41,050	4,887	60,944	7,255	19,894	2,368	9,739

1 Information derived from 45 DTWs — 15 in each category.

2 O&M costs include all repair and maintenance to pumps and channels, all salaries and honoraria, fuel and miscellaneous expenditures.

3 Net TW returns are net of O&M costs but not capital costs.

4 Farmer returns are calculated after all costs of production including irrigation fees.

Use of Performance Measures by DTW FMIS

As noted earlier, most studies of TWs in Bangladesh have been made from the perspective of the outside evaluator (researcher or agency official). The intent has generally been to analyze performance so as to recommend irrigation agency or NGO (nongovernmental organization) solutions to identified problems. A variety of performance indicators and standards have been used for this purpose. But what of the farmer managers in DTW FMIS? They, too, have needs for performance measures and standards for use as direct management tools. What measures do they use and how might additional useful measures be made more accessible to farmer managers?

The focus of farmer-managers in tubewell FMIS might be expected to be on only a subset of the issues identified earlier under output, impact and process indicators. Among the sample TWs in this study, the FMIS managers make records of a limited number of items: a) area irrigated; b) the number of farmers getting irrigation water; c) operation and maintenance costs; d) collection of irrigation fees; and e) return over O&M costs. Where fees are collected in kind, some record of yield is also maintained. These fall primarily under the output indicator category but also include some process measures. The methods of recordkeeping are fairly crude. While area irrigated and the names of farmer-irrigators are generally registered in a log book, other information is kept in rough note books or loose sheets of paper. These notes are generally discarded after their immediate seasonal purpose is served and, as a result, changes over time are difficult to trace.

There is an awareness among farmers and tubewell farmer-managers that various additional measures would be useful. For example, among other items, managers identified a need for knowing whether they were supplying a sufficient amount of water to the crops. They also wanted to know more about changes in the water table. Farmers wanted to be able to compare the performance of their tubewells with that of other wells with the intent to find ways to improve the working of their own DTWs. Farmers' interest in the profit or loss of their wells would indicate a concern for the accountability of the tubewell managers. They were also interested in the level of farmer participation in irrigation affairs in comparison with other systems.

While some additional useful measures may be known to farmers and farmer-managers, others are not. In addition, the collection or interpretation of certain types of information may be difficult for the managers of FMIS. For example, water table monitoring and the efficier satisfaction of crop water needs require measurements and technical knowledge that are possi'y beyond the means or expertise of most farmer-managers. There is scope for irrigation agenc' to make available to farmer-managers localized information on water table performance, rainfall, evapotranspiration, seepage/percolation of certain types of soils, etc.

In addition, farmer-managers could be trained usefully in the making of various types of measurements and in the use of additional performance indicators in their management functions. When interviewed, farmer-managers mentioned the need for brochures or other information on various performance measures and standards as well as a need for suitable recordkeeping forms. Again, irrigation agencies or other rural development groups could provide training or otherwise disseminate information or measurement aids. To allow farmer-managers and their clients to compare performance with other wells, the compilation and distribution of regional tubewell performance records and suggested standards could also be useful to farmers.

CONCLUSIONS

The performance of farmer-managed TWs is of great importance to Bangladesh given the country's preponderance of groundwater technologies among its irrigation systems and given the pace of turnover of agency wells to farmer groups. DTWs are often underutilized in relation to reasonable expectations of command area and service to farmers. If farmer-managers of DTW FMIS are to be able to effectively manage their wells and improve their performance, they must have access to relevant measures of output, impact and management process attainments. While FMIS managers do keep some basic records there is scope for the use of a number of additional types of measures. Further, there is some confusion as to what might constitute appropriate standards of performance for various measurement indicators. Irrigation agencies (or other organizations) could usefully contribute to the performance of farmer-managed TWs by providing training and information in regard to various performance measures and standards. In addition, agencies could collect and disseminate information on some types of the technical indicators (evapotranspiration, water table changes, etc.) that would be difficult for farmer-managers to acquire on their own.

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Irrigation Efficiency and Users' Performance in Water Management

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ABSTRACT

THIS PAPER IS the result of research conducted in Mendoza Province, Argentina. An attempt has been made to determine performance parameters for irrigation management users' associations in order to rate water use efficiency. To this end, 130 farms and 14 users' associations were surveyed in an 85,000 hectare oasis. Data were interpreted by means of multiple regression, and the effectiveness of the parameters to evaluate Application Efficiency (EAP) in an irrigated area was verified. To this end, the values were calculated for a set of 10 farms and high performance values were found to coincide with high EAP values. Likewise, low performance values coincided with low EAP values. Although the result is encouraging, further case studies will have to be examined to evaluate the performance indexes obtained.

INTRODUCTION

Mendoza Province in Argentina is an arid region where the irrigated area has expanded most rapidly in recent years. Some authors point out that the causes of this expansion were the timely selection of an agricultural development model that has easily responded to the country's food requirements, and an evolution in the demand for agricultural products.

The increase in land use brought about a greater demand for water. Thus, in the 1950s, the province's total surface water rights were transferred to the farmers and 360,000 ha were cultivated with an annual regional flow of 5,600 hm3. It was in this period of intensive land and water use that a water management agency was set up, which — unlike similar agencies in arid provinces — is basically decentralized and participatory.

The participation of users in the water management agency brought about an improvement in water use, and a regional efficiency of 39 percent was attained in Mendoza's five oases.

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Water was administered through users' associations in charge of managing all the irrigation systems in the province. Now, there are over 370 canal associations that manage irrigation water at secondary canal level.

Modern lifestyles and ever-increasing industrial activities brought about a higher regional demand for water. It has been estimated that by the year 2000 urban and industrial water demand will be over 500 hm^3. Therefore, if agriculture is to continue expanding, greater water use efficiency will have to be attained.

This paper focuses on the activities of farmers and users' associations in relation to application efficiency (EAP) and defines water use numerical indexes. Performance parameters were derived from these indexes to evaluate water use efficiency and individual and collective participation.

BACKGROUND

Several authors have dealt with this topic, and lately a good number of papers have been written to explain what the parameters are, why they are measured, and how to proceed with their evaluation.

In this regard, it is important to mention Wolter and Bos's contribution (1990). They stress the importance of measuring efficiency as a performance parameter in irrigation water use, and they point to the variations between these values and rainfall. Clemmens and Bos (1990) also stress the importance of evaluating water distribution in an irrigated area as a performance parameter of efficient water use.

Smedema (1990) considers that waterlogging and salinity should be measured as performance parameters of water use in an irrigated area.

Plusquellec et al. (1990) make an interesting review of irrigation system performance with respect to initial objectives.

Finally, mention should be made of the contributions of Small and Svendsen (1990) concerning the conditions under which performance parameters should be measured in an irrigated area.

Some of these important concepts and methodologies are included in this paper.

METHODOLOGY

As stated above, this paper aims at determining which are the main performance parameters affecting water EAP in irrigated agriculture in the province. To this end, water use was examined in one of the oases in Mendoza Province, with 85,000 cultivated hectares irrigated by the Lower Tunuyán River.

Work was divided into three stages. Through 130 field surveys, the first stage determined the on-farm EAP, which yielded water use values from the farm intake to the irrigated plot.

In addition to measuring efficiency, a personal survey was conducted which aimed at measuring the farmers' training and participation level in irrigation water management.

Two aspects were taken into account in the surveys: quantitative and qualitative aspects. The quantitative aspect was used to calculate efficiency values applying the technique of Merriam and Keller (1978).

The qualitative aspect of the survey was divided into three parts: 1) mechanization, i.e., whether or not machinery is used in land farming; 2) irrigation infrastructure, to evaluate water delivery to the farm (earthen, mixed material or concrete pipes); and 3) users' training (literacy, agricultural know-how, participation in water management at canal level, and managerial skills).

For interpretation purposes, the farms were divided into two groups: those using surface water and those using groundwater, the latter being subdivided according to the irrigated crop — vegetables or deep root crops. Each of the above elements was duly assessed in order to identify which is the one that affects farm irrigation efficiency the most. The second stage of the research dealt with users' associations to define performance parameters beyond the farm boundaries.

The irrigated area under study is broken down into 14 large canal "inspections" (associations) that manage water for the whole area. Not all the associations manage water with the same level of efficiency. In general, each of the large associations has administrative limits that coincide with the physical area irrigated by a secondary canal. The General Irrigation Department (DGI) usually delivers monthly varying flows of water at the secondary canal intake. To obtain the delivered depth, the instant flow delivered to the system is multiplied by the number of seconds/month, and divided by the area with water rights. As the areas with water rights are larger than the actually irrigated ones, and since they are not the same for all canals, different depths are derived along the irrigation system. The depth derived at the secondary canal intakes on the Lower Tunuyán River varies from 9,000 to 12,000 m^3/ha/year. This is a most important parameter in EAP evaluations, especially if different water requirements (deep root crops and vegetables) are taken into consideration.

In this second stage, canal inspectors were interviewed. The surveys included questions that would help reveal the farmers' level of participation; for example, interest in the solution of problems,

participation (or not) in the operation and maintenance of the irrigation system, and relationship with the General Irrigation Department.

The third stage consisted of a general evaluation of the total irrigated area. On the basis of the above aspects, which were correlated to indicate greater or lesser efficiency, each of them was rated and weighted in order to interpret project efficiency for the whole irrigated oasis with due consideration of the elements that exert a greater influence.

The multiple regression method was applied to interpret the data collected in the three stages of the surveys as it permits an accurate interpretation of the importance of each parameter in EAP.

RESULTS

As already stated, 130 field surveys were evaluated with reference to both quantitative and qualitative parameters. For the quantitative analysis, the results were divided into deep-root crops (fruit trees, vineyards, alfalfa, forest trees) and vegetables. Each crop type, in turn, was divided into sandy (low storage capacity) or sandy-loam (greater water storage capacity) according to soil type. Finally, a separation was made between efficiency values in farms that use surface water for irrigation and efficiency values in farms that use groundwater.

The calculated efficiencies were compared with the depths applied on the irrigation plots, in order to establish performance parameters that rate water management at farm level. The results obtained are summarized in Table 1. EAP values above and below 70 percent are also included.

The applied surface water depths are usually in excess of 100 mm and variations in soil texture are not taken into account. Thus, for deep-root crops in compact soils, the EAP is higher than in sandy soils. Water is distributed according to the registered area of the canal and not according to soil type or crop requirements. When the depth is reduced, the soil's storage capacity remaining constant, efficiency increases as shown in the second part of Table 1.

The characteristics of surface water use have been transferred to groundwater use and the same problems have arisen: no variations in depth according to soil and crop types. It may be concluded that the farmers' knowledge and control of the applied water depth, using both, surface water and groundwater, is an excellent performance parameter of water use efficiency.

Table 1. Physical performance parameters: Applied depths and efficiency according to soil type.

Soil type	Sandy				Loam			
Source	S.W.*	G.W.**	S.W.*	G.W.**	S.W.*	G.W.**	S.W.*	G.W.**
EAP 70% Applied depth (mm)	60	96	160	166	121	86	147	133
EAP %	51	38	35	48	25	27	41	37
EAP 70% Applied depth (mm)	86	84	88	86	–	65	107	107
EAP %	80	80	80	80	–	73	88	88

* Surface Water
** Groundwater

The qualitative analysis of the first stage of this paper yielded the results given in Table 2.

The results in Table 2 were interpreted applying multiple regression techniques. Crop types (vegetables or deep root crops), mechanization, irrigation infrastructure (earthen or concrete ditches, or reinforced concrete pipes), users' training in agricultural and irrigation activities were correlated. The results show that, at the individual level, crop type is the most significant parameter as it increases efficiency by 19 percent, while the use of machinery yields a 9 percent increase in efficiency, and reinforced concrete pipes lead to a 7 percent increase.

Although training is an important parameter, it does not raise efficiency as much as the other qualitative elements. It raises efficiency by only 5 percent, which is not statistically significant.

From the analysis of Tables 1 and 2 it may be concluded that water depth is the most significant physical performance parameter for EAP at user level whereas for the qualitative aspects, crop characteristics, mechanization and irrigation infrastructure are the most important.

Table 2. Qualitative performance and efficiency parameters.

	Application efficiency		EAP increment	
	Low	Medium	High	(%)
1. Crop type				
vegetables	33	–		
deep root			53	19%
2. Mechanization				
no tractor	36	–		
tractor			51	9%
3. Infrastructure				
earthen	36			
mixed		47		
lined			50	7%
4. Training				
low	34			
medium		41		
high			47	5%

Four variables were analyzed at canal inspection level. Since they cover the full range of water use, they must be added to what has already been obtained at farm level (Table 3).

These variables were identified as participation, operation, management and relationship with the General Irrigation Department.

The participation variable was obtained from the answers to seven questions related to canal cleaning, attendance to meetings, money or labor contributions to canal repairs, interest in the election of authorities, etc.

The operation variable was obtained from the answers to five questions on: number of owners and farm size per canal, legal problems, pressures to change irrigation turns, trends in water demand, etc.

The management variable shows from the user's own point of view, what he knows of the factors affecting irrigation efficiency. It was obtained from the answers to eight questions on: size of water depths and flows, knowledge of soils and crops, adequacy of water depths to soils and crops, use of groundwater, etc.

Finally, the relationship with the General Irrigation Department variable summarizes in eight questions the relationship between all levels of the water management agency and the users, including an appraisal of the agency's performance.

The inspectors of the 14 users' associations in the area were interviewed. They answered 36 questions with three possible answers each — from affirmative to negative. The results are given in Table 3, together with the indexes for each variable (Ip: participation index; Io: operation index; Im: management index; and Ir: relationship with the General Irrigation Department). In each case, the indexes are defined as a number of positive answers divided by the number of negative answers. The average value per inspection as well as the maximum and minimum values for each parameter are given so as to facilitate performance evaluation.

Table 3. Indexes of participation, operation, management and relationship between users' associations and the General Irrigation Department.

Association	Indexes					
	(Ip)	(Io)	(Im)	(Ir)	Registered ha	Irrigated ha (%)
1	1.00	0.50	0.50	–	13,900	60
2	0.67	1.00	0.33	–	10,500	70
3	3.00	0.67	0.50	5.00	9,800	71
4	0.40	0.67	0.67	1.00	22,000	50
5	–	1.50	0.25	3.00	10,800	70
6	0.17	1.50	4.00	6.00	3,000	76
7	0.50	3.00	0.33	–	4,500	82
8	0.25	4.00	2.00	5.00	600	75
9	2.00	4.00	2.00	7.00	4,000	100
10	0.50	1.50	1.50	3.00	4,950	100
11	0.25	0.50	3.00	–	3,400	100
12	0.20	0.33	0.67	6.00	11,000	90
13	0.40	1.50	0.20	–	2,100	76
14	0.50	2.00	1.00	2,50	5,520	90
Average	0,46	1.26	0.83	6,23	–	–
Maximum	6.00	4.00	7.00	7.00		
Minimum	0.17	0.25	0.14	0.14	106,070	83,795

* Ratios between positive and negative replies.

Table 3 also shows the registered and actually irrigated areas to indicate the real use of water distributed in each canal association. The sum total of hectares is an indication of the representativeness of the sample under study; effective water use is 79 percent. It may be observed that the "participation" variable has an average index of 0.46 (24 affirmative answers/52 negative answers), which is quite low as compared to the maximum value (6.0). Only 2 out of the 14 associations (No. 3 and No.9) have a medium-level index. The absence of values in the case of association Nó. 5 indicates a very high level of participation (0/6).

The operation variable shows a higher average index (1.26) which, in turn, reveals that there are 20 percent more users interested in participating in the operation of the distribution system. In this case, the number of associations with medium- to high-level indexes is greater, 8 out of 14.

The management variable indicates, through its average index (0.83), that most farmers do not know what "efficient" irrigation means; only 33 percent of the farmers seem to have some idea.

Only four associations have medium-level management indexes, and they coincide with relatively small areas (an average of 2,750 ha).

With the "relationship with the DGI" variable the situation is completely different. The average index is a relatively high value (6.23) and only two associations have very low values. The absence of IR values in all cases indicates a very high value (7/0).

After each of the elements in the different research stages was analyzed, they were assembled and duly weighted according to their greater or smaller influence on overall water use efficiency.

In order to evaluate users' or a users' association performance in water use efficiency, an evaluation mechanism has been devised which does not require any prior physical measurement.

Table 4 groups the different physical, qualitative and management parameters for the study area. Each parameter has been rated as low, medium or high. In the case of quantitative parameters, numerical values and units are given, whereas for qualitative parameters, only estimates are provided.

The rating has been devised in such a way as to assign the "high" category a value that coincides with the weighting percentage of each parameter in relation to the total weight (100 percent). Then, the "medium" and "low" categories were assigned the corresponding values so that the maximum potential rating for each category is 23, 49 and 100 for a low, medium and high performance evaluation, respectively.

Table 4 also contains estimates of two well-known associations, the "Constitución" Main Canal (No. 12) and the "Montecaseros" Canal (No. 3).

To test the strength of the proposed rating mechanism, five farms on each association's canal were randomly selected. The EAP was field-measured (73 percent for No. 12 and 64 percent for No. 3) and each of the parameters was evaluated. The score obtained through this rating makes it possible to estimate performance values which coincide with the measured efficiency values (71 points and 73 percent EAP and 54 points and 64 percent EAP).

In view of the above, it can be said that the EAP of an irrigated area can be rated by measuring or evaluating physical and qualitative aspects that weight or take into account the degree of users' participation in irrigation water management. With these values, performance may be rated "excellent" (above 80 points), "good" (between 60 and 79 points), or "fair" (below 60 points).

It is worth noting that this rating mechanism serves two important purposes: to ascertain whether performance, in general, is efficient or not; and, once parameters (physical, qualitative, participation) have been analyzed in groups and checked against the possible maximum values, to detect which aspect or aspects have more serious drawbacks and correct them.

Table 4. Performance parameter evaluation in users' associations of the Lower Tunuyán River.

Parameters	Weighting (%)	Evaluation (points)			Examples (associations)	
		Low	Medium	High	(n^o12)	(n^o3)
1. Physical						
Depth at intake (mm/ha.year) (-1000, 1000, +1000)	15	3	7	15	3	3
Surface water/groundwater (%) (-40, 40, +40)	13	2	6	13	13	10
Crop type (vegetables, both deep root)	12	2	6	12	13	6
Irrigated area v. registered area (smaller, same, greater)	10	2	5	10	10	5
2. Qualitative						
Mechanization (no tractor; horses/rents tractor; with tractor)	15	3	7	15	14	13
Farm conveyance infrastructure (earthen, minor works, concrete pipes)	9	2	4	9	3	4
Farmer training (no, scarce, yes)	6	2	3	6	5	3
3. Management						
Of participation (low, medium, high)	6	2	3	6	2	3
Of operation (good, fair, bad)	5	2	3	5	2	3
Of irrigation (good, fair, bad)	4	1	2	4	1	1
Relationship with the DGI (good, fair, bad).	5	2	3	5	5	3
Total:	100	23	49	100	71	54

CONCLUSIONS

This paper seeks to define parameters that will make it possible to rate on-farm EAP through the performance of users' associations in the Mendoza Province, with the aid of qualitative values observed in situ and evaluated by means of a field survey. The results obtained after assessing 130 farms and 14 associations ("inspections") show that there is a relationship between physical aspects, such as distributed water depth, and aspects related to area operation and users' participation in determining water application efficiency. As this paper is the result of field surveys carried out to establish performance parameters, further evaluations will have to be carried out in other areas so as to confirm the correlation between these performance parameters and irrigation efficiency.

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Performance of FMIS Improved Under NGO Assistance: The Case of the National Development Foundation in Sri Lanka

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ABSTRACT

SIX KEY INDICATORS were used to evaluate the performance of a pilot project implemented in Kurunegala District located in the Northwestern Province of Sri Lanka. These indicators which can be used in other assistance programs as well are: Area Increase, Production Increase, Profitability, Resource Mobilization, Institutional Effectiveness, and System Sustainability. The first three indicators were quantitative measurements by which tangible achievements were assessed, while the other three were intangible achievements which could not be readily quantified. The impact of these indicators could be identified by assets and/or attributes created by the system performance. The qualitative indicators were more critical than the quantitative ones since those indicators were vital to sustainable system management and assured self-management. As collectively shown by these indicators, the performance of the National Development Foundation (NDF) contrasts with other assistance programs which have not proven to be sustainable for a longer time since they have not been successful in relieving the people of the "dependency trap." The performance of NDF-assisted FMIS seems to be positive as their approach and strategy have helped farmers to gradually become self-managed as a result of making farmers the owners of the systems improved.

INTRODUCTION

Of the nongovernment organizations (NGOs) operational in Sri Lanka, only a few are directly involved in irrigation rehabilitation or their improvement process. These NGOs offer assistance programs with minor irrigation improvements as one of their development activities, classified under the broad field of rural development. The National Development Foundation (NDF) is one of the two major NGOs having a fairly large assistance program for minor tank improvement. The largest organization which has an island-wide minor-irrigation assistance program is a Statutory Board, the Sri Lanka National Freedom From Hunger Campaign Board (FFHC), which follows an NGO approach in carrying out its assistance strategy.

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National Development Foundation

The National Development Foundation was established in 1979 as a nonprofit, nonpolitical, voluntary organization, registered under the Societies Ordinance of Sri Lanka. In a sense, it is an improved variant of FFHC, as it has introduced some innovative elements to the NGO-assisted rural development in Sri Lanka.

The NDF has several objectives for its rural development exercise. As stated by the NDF (Magedaragamage 1990), these objectives are: 1) Build up people's self-confidence to handle their economic, social, cultural, religious and political affairs by themselves; 2) Help and facilitate people to identify their resources and to mobilize them for their advantage with the least external help; 3) Assist people to initiate and develop their strength and power, so they are able to know their rights and demand them; 4) Initiate a suitable village-based people's institution, to effect proper coordination between the farmers and government officials; and 5) Train a team of youths from their own communities to carry out their initiatives for the purpose of attaining self-reliance.

Tank Renovation Program of the NDF

The NDF has carried out six major rural development projects which include a series of activities aiming at the enhancement of the livelihood and the socioeconomic status of the rural communities. Of these projects, renovation of minor tanks in Kurunegala and Puttalam districts (located in the Northwestern Province of Sri Lanka) was an important project implemented during the mid 1980s. Phase I of the project was carried out in Kurunegala District from 1984 to 1987 when work on 10 tank communities was completed. Phase II of the project is presently in progress in Kurunegala and Puttalam districts, with an improved capacity based on the experience of the implementation of Phase I. The completed Phase I of the project had several planned activities. They were: 1) Renovating village tanks with the beneficiary participation; 2) Initiating and developing a suitable institutional arrangement for effective coordination between the farmers and the officers; 3) Introducing modern agricultural techniques to small farmer groups; 4) Training selected local youth as change agents of agricultural development; and 5) Paving the way to organize informal educational programs for farmers.

The selection criteria for tank renovation as stated by NDF included the capacity of the tank; economic background of the community which depended on the tank; farmers' desire for external help to improve their irrigation system; lack of help from any other source to renovate the tank; and the landownership pattern under the tank.

Phase I of the Tank Renovation Project was carried out as a pilot exercise in Kurunegala District. For this phase, 10 out of 16 planned small tanks were renovated with the active participation of beneficiary farmers. These village tanks were in a state of disrepair before NDF's intervention which is well-documented as a systematic participatory process with the involvement of farmers and competent officers. Several assessment studies have been carried out on NDF's tank renovation project which has extended its assistance program to transform some semi-abandoned village tanks into real farmer-managed irrigation systems. These studies include: NDF's own assessments (Magedaragamage 1990 and 1991), an appraisal by an outside consultant (Perera 1988), a comparative study with another NGO intervention (Vimaladharma 1990), and two of IIMI's recent studies (Dayaratne 1991). This paper is generally based on the findings of the above studies and particularly on IIMI's recent study on "Sustainability Aspects."

PERFORMANCE

The performance of 10 renovated tank systems in Kurunegala District, since the inception of NDF's assistance program, and more particularly since the completion of renovation activities, is evaluated in this paper using a set of selected indicators.

Performance Indicators

Six indicators have been used as performance measurements to evaluate the small tank renovation-cum-water management program of NDF: a) Area Increase; b) Production Increase; c) Profitability of the Assistance Program; d) Resource Mobilization; e) Institutional Effectiveness; and f) System Sustainability.

Area Increase

All the renovated tanks were formerly working tanks which had fallen into a state of disrepair thus limiting the possibility for incremental command area. The cultivable area, however, could be increased with renovation since the storage capacity and thus the water duty could be increased. This was possible in NDF-assisted tanks located mainly in the Intermediate Zone where seasonal rains are more reliable than in the Dry Zone. Table 1 shows the area increase under the improved systems.

Table 1. Area increase due to renovation of tanks.

Tank name	No. of Farmers	Command area				Increase		
		Before		After				
		acres	(ha)	acres	(ha)	acres	(ha)	%
Aralugaswewa	34	22	(9.0)	25	(10.7)	3	(1.1)	14
Dalupothuwewa	14	18	(7.3)	18	(7.3)	0		20
Habawewa	18	18	(7.3)	25	(10.1)	7	(2.8)	38
Mawathagama Wewa	18	24	(9.7)	33	(13.4)	9	(3.7)	37.5
Nabadathenge Wewa	15	15	(6.1)	15	(6.1)	0		0
Pannala-Aluthwewa	13	16	(6.5)	20	(8.1)	4	(1.6)	25
Uswewa	22	24	(9.7)	24	(9.7)	0		0
Wegollagama Wewa	7	7	(2.8)	7	(2.8)	0		0
Weliagara Wewa	17	14.5	(5.9)	19.5	(7.9)	5	(2.0)	34.5
Yakadapotha Wewa	18	27	(10.9)	36	(14.6)	9	(3.7)	33.3
Total	176	185.5	(75.2)	222.5	(90.1)	37	(14.9)	20

Source: Field Survey 1990 and NDF files.

The total command area of the 10 tanks has been increased by 20 percent on average. The command area has not changed in four tanks owning to the unavailability of land and to physical constraints for capacity increase. The absolute area increase, varies from 1.1 ha (3 acres) to 3.7 ha (9 acres) in the remaining 6 tanks. This indicator shows that the physical performance of the systems is positive since more lands have been brought under cultivation as a direct impact of NDF's assistance. This is particularly important as the available land for physical area increase, in most cases, is limited under working tank conditions.

The tank duty, however, is below the required volume for the Intermediate Zone, (2.5 acre feet per acre) resulting in limited or no *yala* (dry season) cultivation. Nonetheless, the pre-project cultivated area was mostly limited to the head-end area of the tank command areas even during *maha* (wet season) owing to the reduced tank capacity over the years. The cropping intensity of these tanks was, thus, between 50 and 80 percent before the project. Cultivation in one tank was totally abandoned, with a zero cropping intensity. With the cultivation of rice and other field crops (OFCs) during maha and a limited OFC cultivation during yala, the cropping intensity under the post-project condition has increased up to between 90 and 140 percent in most of the systems studied. The increased command area has, therefore, not only enhanced cultivation during the maha season, but has caused diversification of the cropping pattern, especially in yala, showing increased cropping intensities, and in turn showing positive system performance.

Production Increase

Minor irrigation systems in Sri Lanka function as integrated systems which depend partly on irrigated agriculture and partly on rain-fed upland farming and off-farm activities. Therefore, production increase may not directly affect the economic condition or income level of the tank communities. Compared to the pre-project condition, NDF-assisted tank systems show a considerable production increase. As indicated in Table 2, over 50 percent of the tanks had yields below 40 bushels of unhusked rice per acre (2,570 kgs per ha) and another 20 percent between 40 and 60 bushels of unhusked rice per acre (2,570 to 3,800 kg per ha), under the pre-project conditions. With the project, production has increased over 100 percent in most cases. Sixty percent of tanks have received 80 to 120 bushels of unhusked rice per acre (5,000 kg to 7,700 kg per ha).

Table 2. Unhusked rice yield under irrigated agriculture (N=10).

Yield level kg/ha	Before project No. of tanks	After project No. of tanks
Below 1,900	01	–
1,900 – 2,570	04	–
2,570 – 3,800	01	01
3,800 – 5,000	04	03
5,000 – 7,700	–	03
Over 7,700	–	03

Source: Field Survey 1990.

Production has increased from a negligible and below-subsistence level (in most cases) under pre-project condition to an above-subsistence and surplus production level, with project condition, because of a number of inputs provided by the assistance program. These inputs included: 1) Improvements to the physical system for restoration of the tank capacity; 2) Motivation of farmers for new innovations such as cultivation of short-term rice varieties, cultivation of other field crops (OFCs), and the use of fertilizer and agro-chemicals; and 3) NDF's intervention to provide facilities such as rice-seed sprayers and other agro-inputs on a soft loan basis.

The production increase in the village tanks, as mentioned above, has contributed to increase their overall income which consists of irrigated agriculture, non-irrigated agricultural and off-farm activities. The production increase has resulted in increased consumption by the farmers and in reduced purchase of rice for consumption from outside, thereby inducing some savings. These savings plus motivation by NDF have enabled the establishment of a tank fund for system maintenance.

Profitability

The third indicator by which the performance of the NDF assistance program is evaluated is its economic profitability. This is calculated in simple terms by using the benefit/cost analysis method. Total project costs plus production costs and average income under 10 tanks for 5 years of project implementation are used in the calculations. Project costs and benefits over 5 years are summarized below.

Project costs	a) Farmers' contribution in cash	Rs	78,000
	in kind		20,000
	b) Estimated government contribution	Rs	300,000
	c) NDF's contribution	Rs	1,216,500
	Subtotal	Rs	1,614,500
	d) Cost of production per year (at Rs 7,410 per ha)	Rs	667,500
	Total cost	Rs	2,282,000
Project benefits	(Average yield/income for maha of 5 years/seasons)		
	a) Average production per ha=5,335 kg (80 bushels/acre)		
	b) Total production of 90 ha=480,150 kg		
	c) Total value of production at guaranteed price (1985–88 prices)= Rs 80/bushels (Rs 2.96/kg) (a * b * c) = total benefits	Rs	1,421,244

The benefit/cost ratio at the end of the first year [Rs 1,421, 244 / Rs 2,282,000] is 0.62; this will rise to more than one at gross calculations only after the third year, giving a value of 1.18. These calculations are made without applying any discounting factor for the 5-year period. Therefore, gross profit margins are calculated using a discounting factor of 15 percent as shown in Table 3. According to these calculations too, project benefits become positive only by the end of the third year. The gross profit margin by the end of the fifth year is 1.24.

As mentioned earlier, the importance of irrigated agriculture in a minor system (with each individual owning between 0.2 and 0.6 ha of land on average) is marginal since the farmers' main cash incomes are derived from other agricultural and non-agricultural sources. But with the assistance program the system performance has been enhanced from a below-subsistence level to at least subsistence level and/or above-subsistence level in most cases, showing some savings. The fact that a project reaches a break-even point within three years of an assistance program and then becomes profitable is an encouraging fact, for FMIS.

Table 3. Benefit/cost ratio: Gross margin calculation (in Sri Lanka Rs.)

Year	Cost	Benefits	Present Value at 15% DF		
			Cost (1)	Benefits (2)	2–1
0 (1984)	1,614,500	–	1,614,500	–	-1,614,500
1 (1985)	667,500	1,421,250	580,725	1,236,488	655,763
2 (1986)	667,500	1,421,250	504,630	1,074,465	569,835
3 (1987)	667,500	1,421,250	439,215	935,183	495,968
4 (1988)	667,500	1,421,250	381,810	812,955	431,145
5 (1989)	667,500	1,421,250	331,748	706,361	374,613
5 years	4,952,000	7,106,250	3,852,628	4,765,452	912,824
US$	(198,080)	(284,250)	(154,105)	(190,618)	(36,513)

(1) = Total project cost. (2) = Cost of production per year/season.
DF = Discount Factor.
US$1.00 = Rs. 25 (at 1985 prices) is used for conversion.

Resource Mobilization

The NDF has adopted a "non-regimented intervention style" to ensure successful community participation and self-management (Vimaladharma 1990). A group of farmers under each of these tank systems was mobilized to fully utilize their physical, financial and human resources for their own benefits. The mobilization of human resources is of vital importance, since it has 1) led farmers to organize into their own associations; b) encouraged them to adopt new innovations such as integrated farming systems and other income-generating activities; and c) resulted in effective use of community labor for physical construction.

The NDF has mobilized farmers mainly to increase the productivity of lands already cultivated under the renovated tank, by their own initiative. The added extent brought under the plow as a result of increased tank capacity has been efficiently used to increase the productivity by mobilizing farmers to conserve irrigation water, to cultivate OFCs during yala, and to have constant community interaction for better participation in system management.

The major components improved under NDF assistance included consolidation of the tank bund with full or partial manual labor, and construction of sluices, spills and the channel system. Machinery has been used only to supplement manual labor, where heavy works were involved. There too, farmers were mobilized to contribute for fuel purchase out of their tank fund. With a farmer mobilization process throughout the assistance program, it has been easier to get positive contributions from the farmers. This has not been common under other assistance strategies, particularly under government agencies. The total financial contribution of the farmers exceeds Rs 75,000 (US$3,000) and the value of their labor should be the highest of all contributions. The farmer's organizations, plus the farmer federation created for sustained system performance have been effective, from project completion to the present post-project condition, where self-management of systems is evident in most of the systems studied. The communities were not only organized into coherent groups for project-related activities, but were also motivated to carry out successful water management programs, O&M activities, and conflict management by themselves during the post-project conditions.

Institutional Effectiveness

Three main institutions were introduced and developed by NDF's assistance program. They are a) the Field Coordinator (FC); b) the Farmers' Organization (FO); and c) the Small Farmers' Federation (SFF).

The FC is NDF's field-level facilitator who acts as a change agent. He works full time and each has passed the GCE (Advance Level) examination. The FCs are resident in the project area and possess sufficient knowledge of the society, culture and development needs of the farmers of the area in general and of the ten renovated tanks in particular. The FC's role was more important during the initial period of intervention when people were motivated to discuss their problems and organized into groups to plan and implement an integrated farming system based primarily on the village tank. The FC also helped train volunteers in community work aimed at sustainable system management. Further, he acted as mediator between farmers and government agencies for mobilization of available resources and services. Motivation of farmers during the initial period and during project implementation was the main responsibility of the FC who visited the farmers very frequently to achieve this purpose. These visits became less frequent after the project, since the trained volunteers could take over the FC's activities in the latter part of the project. Although they approached the communities with tank renovation in mind, their service in motivating people and mobilizing resources in general has been quite effective even at the post-project level. The FC has also played the role of a liaison officer to obtain the services of the relevant government officers such as Technical Officers, Managers of the Agricultural Development Authority, Divisional Officers of the Department of Agrarian Services (DAS) and Assistant Government Agents (AGAs).

The FOs were formed under each tank community as the main bodies for management of development activities throughout the assistance program and thereafter. Prior to renovation of tanks, farmers rarely gathered to discuss their problems. *Kanna* (seasonal cultivation) meeting was the only forum at which they could discuss their problems with government officials. With the formation of FOs, farmers' participation in project activities increased, starting from planning through construction work to post-rehabilitation O&M of tanks. These project-related tasks became more systematic and meaningful as the farmers organized themselves into FOs and established their group fund and appointed several subcommittees for various functions such as water management (Perera 1988). The motivated FOs were effective enough to elect their leaders, enact a constitution of the group, open a group bank account and negotiate with NDF and other agencies on their needs and problems. The responsibility for O&M of the tanks rests with the FOs as a group. They used the group fund for annual repairs to channel systems and cleaning of the bund. Through group activities farmers have realized the importance of irrigation water management and of contributions of money and labor to renovate and continue regular maintenance of the tank. These farmers' groups were further effective in realizing an integrated farming system based on the tank, for the benefit of the entire community. The FOs, thus, provide a powerful mechanism to organize and direct farmers to work together.

The third institution created under the NDF strategy is the Small Farmers' Federation (SFF) formed as the umbrella organization for all the farmer groups under the hitherto improved tank systems. Logically, SFF was to have a membership of all 176 farm families in the 10 tank communities, but in fact, the farmer leaders represented these families in SFF's activities. The main stated activities of SFF are: 1) Coordination of intervillage level farmer activities; 2) Agricultural planning and decision making on crop diversification in a given season; 3) Linking individual village-level farmer groups with external agencies such as DAS and the banks; 4) Providing financial support to individual farmer groups when the need arises. The progress of the 10 renovated tanks has been subjected to a consolidation process which has been attempted through strengthening the financial position of SFF by channeling various grants to it by NDF; for example, OXFAM's seed rice grant has been made available for the tank communities. The SFF has started a program of integrated farming mainly as a survival strategy for rice-biased farmers to diversify their economy. According to recent field studies, however, effectiveness of SFF appears to be limited as an institution as its importance has not been recognized by farmer groups. This is due mainly to the haphazard manner in which SFF activities have been carried out by its representatives. Farmers have not been correctly educated in federating the relevant activities. Some farmers were not even aware of the existence and the functions of the SFF. Of the three main institutions introduced by NDF, SFF is the least effective, making the performance of that institution rather negative. The roles of social organizer (FC) and the FO have been more effective in relation to project implementation and in system management afterwards, showing positive system performance.

System Sustainability

The collective effect of the inputs provided by an assistance strategy should lead to long-term system sustainability. The NDF-assisted tank systems in Kurunegala District have been in operation only for about five years since the completion of the improvements, which may be sufficient to judge the sustainability aspects.

Although sustainability could be a valid indicator to assess a rehabilitated system, it is difficult to apply it directly for renovated tanks which were in working condition even prior to renovation. Nine out of the ten tanks renovated by NDF were in working condition prior to the assistance. For physical sustainability, regular operation and maintenance are required. These aspects, over the post-project five years, have been sufficiently looked after by the farmer groups, but in a few tanks they were not adequate for long-term physical sustainability (Dayaratne 1991).

Since the majority of the farmers depend more on upland agriculture and other activities than on irrigated agriculture, economic sustainability must be measured as a collective impact on the integrated agricultural system in which the tank irrigation system is only one element. Therefore, economic sustainability of the system has been enhanced by the assistance program as the communities now have diverse economic means for their survival.

Of the institutions introduced by NDF, most effective for sustainability are the social organizers (Volunteers and FCs) and FOs that have played vital roles in system sustainability. All the improvements achieved could be sustained thus far, owing mainly to the continuous operation of these institutions. A recent IIMI study (Dayaratne 1991) revealed that the farmers have most positively accepted the leadership and the functions of the FOs in relation to sustainable system performance.

It was found that NDF's assistance program has not given any attention to ecological sustainability which is most important in long-term sustainability. Although physical and economic sustainability should go hand in hand with environmental stability, the assistance program has not introduced a specific program including catchment management and soil and water conservation. The recent NDF supplementary program for "Integrated Farming System" can be effective only if these environmental aspects are contemplated.

CONCLUSIONS

Small irrigation systems in Sri Lanka have been traditionally farmer-managed. However, with the agrarian change from subsistence to commercial agriculture in the last century, and a dependency syndrome created by various assistance programs in more recent times, these systems have become jointly managed since the government appears to hold responsibility for O&M activities. The government's efforts at present are to reverse this trend and make all irrigation systems farmer-managed. The achievements of NGOs such as NDF, in this regard, are highly encouraging, as the performance of the assistance program has been positive.

The performance of small irrigation systems may be effectively measured by the indicators used in this paper. Of the six indicators developed, three are quantitative measurements by which tangible achievements were assessed, while the other three are intangible or abstract achievements which cannot be readily quantified. The impact of these indicators too, however, could be identified by assets and/or attributes created by the system performance. The qualitative indicators are more critical than the quantitative ones since these indicators are vital to sustainable system management and assured self-management.

As collectively indicated by these indicators, the performance of NDF contrasts with other assistance programs which have not proved to be sustainable for a longer time since they have not been successful in relieving the people of the "dependency trap." The performance of FMIS under NDF-assisted programs appears to be positive as their approach and strategy have helped farmers to gradually become self-managed or farmer-managed resulting from a process of "putting the farmer first."

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ABSTRACTS

Abstract No. 3

A Comparison of Farmer-Managed and Agency-Managed Minor Irrigation Projects in the Thakurgaon District of Bangladesh

M. T. H. Miah

THIS STUDY EXAMINES the performances of farmer-managed shallow tubewell (STW) and agency-managed deep tubewell (DTW) minor irrigation projects of Thakurgaon District in Bangladesh. In total, 40 tubewells comprising 10 DTWs and 30 STWs, were randomly selected for the study. Questionnaires were prepared to collect relevant primary data from the owners/managers of the selected tubewells. Three principal discounting measures such as benefit-cost ratio, net present value, and internal rate of return together with an equivalent annuity criterion were employed to determine the comparative performances of the projects. The average lives of DTW and STW projects were set at 15 and 10 years, respectively. Only a 16-percent discount rate was chosen for financial analyses of the projects. The major findings of the study are that the field level performances of farmer-managed STWs are far better than those of the agency-managed DTW projects. In some cases, agency-managed DTWs are incurring a heavy loss. The study, therefore, suggests that the farmer-managed STW projects be encouraged for the betterment of farmers elsewhere in Bangladesh as well.

Abstract No. 8

For a System Analytic Approach

Nirmal Sengupta

AS ONE MOVES from areas of high to low surface water availability, the objectives of FMIS change. From this perspective a topology of FMIS has been made. Through a comparison of the goal-ecology interaction it has been shown that the objectives of FMIS are wider than and partly different from those of the government-managed systems. It follows that performance standards need to be defined so as to accommodate this distinction. In particular, multipurpose uses of FMIS structures and their environmental impacts need to be given due regard.

It has been shown that off-site impacts of FMIS may be considerable demanding multi-level evaluations. In accordance with the farming system perspective used here participatory evaluation is recommended. Because of greater involvement of agencies than in farming system evaluations an inbuilt negotiation procedures has been thought desirable. An evaluation procedure consisting of exploration, negotiation and evaluation proper would be the most appropriate. Participatory Rural Appraisal (PRA), Stakeholder-based Evaluation (SBE) and Participatory Assessment, Monitoring and Evaluation (PAME) approaches have been recommended. Finally, certain problems of measurement have been discussed.

Abstract No. 12

Performance Measurement in Farmer-Managed Irrigation Systems from the Israeli Experience

Moshe Sne

SCARCITY OF WATER and cultivable land in Israel triggered high awareness among farmers and manufacturers of irrigation equipment regarding the efficiency of water utilization in agriculture. The development of irrigation in the last four decades was followed by extensive performance measurement of irrigation systems. This activity was collaborated by farmers, water associations, research and extension, the Water Commission and the manufacturers. The scope of performance measurement ranged from the individual accessory to the whole system. The consecutive activity contributed no doubt to the development of innovative irrigation equipment as well as to the impressive achievements in the efficiency of water utilization. It had influence on the policy of funding irrigation projects and the rehabilitation of supply and irrigation networks. The collaboration in performance measurement induced an atmosphere of confidence and cooperation between farmers, producers and the supporting bodies.

In Israel, in general, irrigation is operated and managed by farmers or farmers' associations. So, performance measurement actually means Performance Measurement in Farmers-Managed Irrigation Systems.

Abstract No. 27

The Mexican Experience in the Transfer of Responsibility of Irrigation Districts to their Users

Enrique Palacios-Velez[53]

ALTHOUGH FOR MANY years the users of irrigation districts have tried to be responsible for their operation and maintenance, (as it happened with the users of small irrigation works) for different reasons, it has not been possible to definitely transfer such responsibility; furthermore, the 1971 Water Federal Law does not consider this procedure as legal; however, the new government policies to reduce its administrative involvement in many kinds of enterprise, with the purpose of improving their administration, are now in favor of transferring the operation, maintenance and administration of the irrigation and drainage infrastructure to users' associations, which is showing very favorable results, presenting significant changes in the administration of the water resource, with an increased productivity and maintaining the work in better operational conditions.

To favor the privatization of the infrastructure administration, operation and maintenance there have been changes in the fiscal legislation and there will also be changes, in the near future, to the Water Federal Law. This experience in a country like Mexico, where irrigation is vital for

53 Coordinator, Technology of Irrigation and Drainage, IMTA.

its economy, can serve as an example to other countries with similar physical and socioeconomic conditions, for setting criteria in defining policies.

Abstract No. 30

Interventions in a FMIS in Bolivia: The Hidden Logic in Local Irrigation Water Management

Hans Bleumink, Piet Sijbrandij, Jacques Slabbers[54]

IT IS WIDELY recognized that, generally, the performance of modernized farmer-managed irrigation systems, does not match the expectations. Local practices in irrigation water management should be integrated into the design, to resolve the problems of inappropriate functioning of these modernization projects. This paper argues that the integration of certain elements of local irrigation practices alone does not guarantee appropriate functioning of the modernized system. More attention should be paid to the logic in local irrigation water management. It is our opinion that the understanding of local irrigation practices should be an integrated part of the design process. This paper describes a farmer-managed irrigation system in the Valle Alto of Cochabamba, Bolivia. The logic in local irrigation water management is outlined. From this point of view, the modernization of the irrigation system is analyzed, and "irrational" farmer behavior during the execution of the modernization is re-interpreted.

Abstract No. 35

Performance Measurement in FMIS: The Case of Sri Lanka

IJsbrand H. de Jong[55]

IN EVALUATING IRRIGATION performance, the identification of the goals against which the performance is assessed is of crucial importance (Small and Svendsen 1990). However, goals remain mostly implicit at the level of the irrigators while government goals are usually comparatively readily accessible in official reports and policy papers. The evaluation of irrigation performance is thus at risk of becoming a single-sided and a normative undertaking. Future interventions, based on those assessments, run the risk of being founded on unjustified presumptions about the ex ante situation.

The case presented in this paper touches upon the question of the goals that form the basis of any performance assessment. From a perspective of the water-use efficiency, the top-end part of the command area of a tank system in Sri Lanka is compared with the tail end. It is shown that farmers and government officers embraced mutually opposing objectives and hence perceived the

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55 The author is presently Agricultural Engineer for the International Labor Organization, Abidjan, Ivory Coast. The paper summarizes the main findings of a field research conducted in Sri Lanka in 1990–1991. The author is indebted to the International Irrigation Management Institute (IIMI) and the Netherlands Foundation for the Advancement of Tropical Research (WOTRO).

performance of the system in a different way. Whereas the farmers had established an ingenious system to divert the water to the tail end, the government did its best to supply water to the top end only. While conclusions are drawn regarding the character of the farmers' objectives, ways to ensure their incorporation in performance assessments are recommended.

Abstract No. 38

Survival — Not Productivity: Criteria to Evaluate FMIS in a Drought-Prone Region

S. T. Somashekhara Reddy[56]

IN DROUGHT-PRONE Regions(DPR) the role of FMIS in tank irrigated areas is to extend a chance for the community to survive through the drought which demands continuous prediction of when drought sets in and estimation of probable impact of such drought on the community. In India, these are normally carried out through an indigenous calendar of rainfall. Once the drought is predicted, FMIS had to amplify the chances to produce food for survival by resorting to various ways of accumulating water, as for example, its allocation by adopting different measures to appropriate and to conserve. The performance of FMIS depends largely on how the entire community is made to acquire the ability to survive the impact of drought.

In India, an area is declared as a drought-prone region (DPR) "... in which the probability of a drought year is greater than 20%..." (Suresh K. Sinha etal. 1987). A drought year is one in which the rainfall is less than 75 percent of the normal rainfall. In such DPRs the role of Farmer-Managed Irrigation Systems (FMIS) is the provision to grow food crops for subsistence, by taking into consideration prevalent food stocks and the performance of rainfall. FMIS need not replenish the entire stock lost due to drought, but should help tide over the situation.

An attempt is made in this paper to identify certain generic types followed by various FMIS in tank- irrigated areas so as to develop criteria to evaluate the performance of FMIS in DPRs. The data for this paper, apart from studies conducted by others, and much of the details are from my own studies, my discussions and observations and above all from the personal experience I had as a member of the farming community. Whenever the studies conducted by others do have a point of reference to which the text indicates, they are acknowledged.

Nearly 72 per cent of the Indian geographical area is located within the rainfall range of zero to 1,250 mm, of which, nearly 50 percent of the area is below 750 mm of rainfall and the duration of rainfall in this region ranges from one month to two months. In this region of low rainfall, the traditional form of irrigation is from surface reservoirs called 'Tanks' (Jasbir Singh 1984). These tanks are always regarded as common property resources (Nirmal Sengupta 1985). In most of the areas irrigated by tanks, FMIS are prevalent.

56 Research Fellow, Indian Institute of Management, Bangalore, India.

Abstract No. 42

Performance Measurement of Farmer-Managed Irrigation Systems

Washington Teran Caceres and Jorge Sotomayor Valarezo[57]

THIS PAPER AIMS to analyze and compare state and private organizations in public and private irrigation systems management in Ecuador. The Ecuadorian water law system is analyzed, with special reference to the Water Law and its Regulations containing special provisions by which the Ecuadorian Institute for Water Resources (INERHI) is empowered to set up private and public law agencies devoted to water resources management.

The technical and social characteristics of the systems management are also analyzed, with special emphasis on the aspects listed below:

* Infrastructure for irrigation water use: characteristics of the primary, secondary and farm-level canals systems; irrigation water measurement and distribution structures.

* Organization of irrigation systems' operation and maintenance. Their technical and administrative structure.

* Water rates system: reimbursements for investments made and for the system's operation and maintenance costs, in accordance with legal regulations in force.

* Social structures in public and private water management systems: Users' Boards; Water Boards; Irrigation and Drainage Commissions.

* Technical assistance services to system users.

* Research and training programs on irrigated agriculture.

This paper includes an analysis of the problems of public and private administration, with special emphasis on the legal, technical and operational aspects. Current private water management structures for operation and maintenance optimization and for agricultural production improvement are also analyzed.

It is hoped that this study will contribute to meet the participation requirements of a modern system that optimizes farmer-managed irrigation systems and that frees the State from the responsibility for managing the systems.

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57 Ecuadorian Institute for Water Resources (INERHI).

Abstract No. 45

Developing a Social Learning Framework of Performance Indicators System: A Study for Effective Irrigation Management at Pulangui River Irrigation System (PRIS), Valencia, Bukidnon, the Philippines

Josefino M. Magallanes

SYSTEMATIZING A FRAMEWORK of indicators system involves the adoption of a theoretical model, the identification of priority programs, the measurement of both the performance and process indicators, and the empirical testing of statistics in an operational context. It is based on the systemic, social learning theory which formulates two basic propositions: First, performance indicators align closely with each other under the three major areas of concern and second, the process variables influence the levels and rates of change occurring in the performance variables.

The identification and appraisal of prioritized programs commence with the portrayal of a short-term scenario wherein the agency practices participatory approaches; where the technical area initiates the development of a strong farmers' organization, and wherein the community has irrigators developing self-reliance. It proceeds with the appraisal of programs using social cost benefit analysis.

The development of measures and their empirical testing were operationalized in Division 4, PRIS, Valencia, Bukidnon, the Philippines. Analyses show that results partially confirmed the assumptions. Actual performance of the system was evaluated as moderate against potential performance. While the statistical analyses show weak supporting evidence, the process of formulating a framework of performance indicators show strong feasibility for attaining effective management in a farmer-managed irrigation system.

Abstract No. 63

Performance Parameters for Irrigation Water Users' Associations in Catamarca, Argentina

Carlina Beatriz Jedliczka de Hansen[58]

THE OBJECTIVE PURSUED is to measure the performance of irrigation water users' associations in order to determine the causes restricting users' participation.

Surveys were conducted in two irrigation districts with different characteristics as regards users' lack of knowledge of the system and of the level of participation they are granted by the Law.

Index values were obtained in order to establish performance parameters in the irrigation districts.

58 Lawyer, Professor at the School of Agricultural Sciences, National University of Catamarca.

Abstract No. 68

The Organization of Irrigation in Peru: Four Case Studies in Paruro

Jesus S. Mora[59]

THIS PAPER DESCRIBES the different ways in which farmers have organized themselves to manage their irrigation systems since the setting up of the Special Project for Rural Development in Microregions (PRODERM). To this end, reference is made to the irrigation systems in four farming communities, where the infrastructures have been improved.

Farmers' organization, water distribution and irrigation management are described and compared in each of the four communities with a view to identifying and recording the changes produced after the implementation by PRODERM of technical and organizational changes since the improvement of the infrastructures.

As regards the organizational aspects, Irrigators Committees, enforcement of Irrigation Regulations, and water rates are discussed. With respect to the technical-productive aspects, the farmers' response to simultaneous irrigation, parcel irrigation, and fixed flows are analyzed. The effects on the economy (second harvest, crop rotation) are also discussed.

In summary, the objective of this paper is to determine the relationship between the institutional proposals and the way farmers' organizations respond, whether it be by adopting, incorporating or modifying the new technology according to their specific needs and interests.

Finally, some ideas which should help irrigation projects reach their objectives are put forward, with due regard to the existing restrictions, at both institutional and farmers' level.

Abstract No. 70

The "El Carmen" Irrigation Subdelegation (Province of Jujuy): Transfer to the Private Sector

Hugo A. Mattiello[60]

THE PRINCIPLE OF users' participation in irrigation water management is an organizational one in water policy, which forms part of a broader one: administrative decentralization.

In spite of the theoretical advantages of the principle, and despite its almost universal acceptance by different legal systems, its implementation and performance of farmer-managed irrigation system are far from reaching the objectives sought and adequately fulfilling the functions stipulated in the regulations governing their constitution.

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60 Lawyer, Specialist in Water Law and Management. Former Professor at the Law School of the University of Mendoza.

The Province of Jujuy, in accordance with National Law 23696 of State Reform, has decided to decentralize and transfer the management of the irrigation system known as the "El Carmen" Subdelegation, with a command area of more than 20,000 hectares.

The study deals with the applicable law, the choice of privatization methods, the transfer processes, the relationship between Central Public Administration and users, and with the institutional, economic and technical criteria involved in this FMIS.

The tariff system and the different types of administrative transfer of services and public works to the private sector are particularly relevant. This is due to the fact that both aim to insure an increase in service efficiency and the self-financing of their administrative organization.

Abstract No. 72

Evolution of the Prospects for Users' Participation in Water Management in Mendoza, Argentina

Pedro Luis Marchevsky[61]

THIS PAPER DESCRIBES the experience gained in the organization of Consolidated Water Users' Associations in the Lower and Middle Tunuyan River Subdelegation (General Irrigation Department — DGI, Mendoza, Argentina).

The "Reduction" Main Canal and Diversion Channels Association has been selected to illustrate this experience. Reference is made to its objectives, background, current performance and to the works constructed by users' associations as well as their improvements in irrigation management.

An analysis is made of the objectives and advantages of the new Consolidated Associations.

Abstract No. 75

FMIS Performance and Pollution: The Case of Campo Espejo[62]

Graciela Fasciolo[63], *P. Scardia*[64], *O. Zoia*[65] *and J. Hernandez*[66]

THIS IS A case analysis of an agricultural area using domestic effluences from Greater Mendoza for irrigation. This situation results in a clandestine use and an "informal" irrigation management as effluent reuse has not been regulated. The socioeconomic characteristics of the study area as well as the attitudes and opinions the users and of the families living in the area are described. A proposal

61 Agricultural Engineer, Inspector of the "Reduction" Main Canal and Diversion Channels.

62 The authors wish to thank Ms. Santa Salatino, Agricultural Engineer and Mr. Amilcar Moyano, Lawyer, for their cooperation.

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65 "Licenciado" in Business Administration, Department of Water Systems and the Environment, CELA, INCYTH.

66 Agricultural Engineer — Researcher, Groundwater Regional Center.

is made for participatory management concerned with the people's interests and public health. A monitoring system for public health objectives is recommended and a number of quantitative measurements are specified for their evaluation.

Abstract No. 77

Performance Indicators for Large Irrigation Systems in the Coastal Valleys of Peru

Jan Hendriks[67]

THE USERS BOARDS of the Irrigation Districts in Peru have been the formal administrators of irrigation systems since 1989 when they were charged with the operation and maintenance of these systems through the promulgation of Supreme Decree 037/89/AG. Thus, there was established in Peru a type of systems similar to that of Farmer-Managed Irrigation Systems (FMIS), covering vast and complex areas of irrigated land.

Experience in recent years has shown that passing a law is not sufficient to convert the users' organizations into effective FMIS. Government policy is required to promote the technical and social functioning of these organizations, through concrete action, promotion and advisory measures. In the first place, this policy demands a proper institutional framework, which does not exist at present and, in the second, it would be advisable to develop a system of performance indicators having two principal objectives: one, to obtain reliable discernment and judgment elements for dialogue between users, the organization and the authorities; two, to evaluate and guide policies and actions for making stronger Users Boards, in order to procure technically rational, socially just and economically viable management of irrigation water.

Provisionally, in order to develop these performance indicators, six variables should be considered: hydraulic infrastructure, the environment, availability of and access to irrigation water, agricultural/livestock production, users' participation and institutional management of the FMIS.

Abstract No. 78

Hydro-Economic Indicators for the Evaluation of the Performance of Irrigation Systems in Farming Communities in the Southern Andean Region of Peru. An Effort to Measure the Efficiency, Equity and Sufficiency

Carlos de la Torre P. and Carlos Pereyra[68]

WE PRESENT A group of basic indicators to measure the efficiency, equity and sufficiency of irrigation systems handled by Andean farming communities. These three criteria facilitate an integral evaluation of the performance of an irrigation system.

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68 The authors are members for the Irrigation Programme of Intermediate Technology Development Group (ITDG). Carlos de la Torre P., Economist, Manager of Cusco Project. Carlos Pereyra M., Agricultural Engineer, in charge of the hydrical items of Cusco and Ica projects.

Efficiency, conceived as the optimum use of the resources involved in the process is analyzed under organizational and technical focuses. Sufficiency is understood as being the degree to which the irrigation systems satisfy its users. Equity refers to the degree to which the benefits originating from the use of the system are equally accessible to the rural families who use the same system.

Some of these indicators are of a hydric character and others of an economic character. The first refers to the measuring of the efficiency of conduction, distribution and application of the irrigation water. The second group attempts to measure the efficiency of the administration of the irrigation systems and the degree of access to the water.

The basic concern is to respond, with field measurements, to the question: to what extent the communal organization fulfills the abovementioned criteria as regards the management of irrigation water, in order to satisfy the needs of the community members, on a stable basis.

Given the diversity of the farming communities, this present proposal considers a basic typology on nine kinds of community, based on the way of managing the irrigation and the actual type of irrigation system used.

Abstract No. 90

Assessing the Cultural Factors that Effect Water Use Efficiency

Jorge Tacchini[69] *and Kiyoe Hiramatsu de Carballo*[70]

THIS PAPER EXAMINES the relationship between water use efficiency and the users' cultural level. The basic characteristics of the farmer's personality in consecutive development stages have been identified. Parameters obtained through field work make it possible to assess the farmer's aptitude. In all cases high correlations between aptitude for irrigation and irrigation efficiency have been found. The difference between attitude and aptitude stems from the incoherence that exists between the objectives and the rules that govern behavior.

The results can be used to evaluate the possibility of success of extension programs. Technical knowledge alone does not suffice.

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70 Assistant Professor of Agricultural Economics and Law, School of Agricultural Sciences, National University of Cuyo, Mendoza, Argentina.

Abstract No. 91

Performance Measurement of Farmer-Managed Irrigation Systems in the Province of Tucuman, Argentina

Juan Taboada[71] *and Anibal Comba*[72]

THE OBJECTIVE OF this paper is to measure, through one or more appropriate indicators, the performance of two Boards of Irrigators having different behaviors and attitudes towards their irrigation system management. In this way, it will be possible to draw conclusions not only in diagnosis but also in formulating recommendations and reconsidering the State-User-System relationship.

Both the users' organizations are examined and analyzed, and a diagnosis is made of each situation for the comparison of attitudes and behavior concerning their agroclimatic and social circumstances. A compilation of written papers and interviews with farmers and managers of different water users, over the last fifteen years, is included.

The following parameters are examined: a) relative annual users' investments in system management and maintenance as compared with Government contributions; b) annual time devoted to discussions, meetings and organization of the system's routine management; c) annual services rendered by the system in relation to irrigated area; and d) volumes of water derived for industry and cattle raising.

One or more applicable performance measurement indicators that can be defined on the basis of information acceptable for the users are investigated. These indicators, when applied to each organization, will show how it is operating and will make it possible to compare different organizations.

Abstract No. 94

Irrigation Systems Performance in Venezuela's Andean Region

C. Grassi,[73] *L. Razuri Ramirez and J. Perez Roas*[74]

THE IRRIGATION SYSTEMS in Venezuela's Andean region — the states of Merida, Tachira and Trujillo — are good examples of users' participation in water management. In this region of steep slopes, the irrigation areas comprise farms (5 to 300 hectares) which produce vegetable crops and use sprinkler systems. Because of the abundant rainfall, irrigation is supplementary. There has been either total or partial users' participation in the construction of the irrigation works. This

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72 Water Resources Engineer. General Irrigation Department. Tucuman, Argentina.

73 CIDIAT Professor.

74 CIDIAT Adjunct Professor.

situation is completely different from that in other systems constructed by Venezuela's public sector.

In order to identify performance parameters for water management, this paper analyzes the impact that irrigation and farmers' management have had upon this region.

To this end, a general diagnosis was made and representative systems were selected according to the following criteria: location, irrigated area, number of beneficiaries, prevailing crops, infrastructure, etc. Technical, economic, environmental, institutional and social indicators were used to compare initial and final conditions, with and without irrigation. Different types of indicators — socioeconomic, production risks, conservation practices, technical training, health, infrastructure, production, etc. — were quantified for a comparative analysis of the irrigation systems.

The results show that users' management had a positive impact. Evidence of this is: a) the farmers' growing participation in natural resources management; b) the expansion of the area under irrigation; c) the new production techniques; d) the support given to production activities; e) an end to the rural exodus; and f) greater production.

Through this research, it has been possible to detect problems in the following sectors: technical assistance, applied research, soil and water conservation, and information on markets and merchandizing.

Abstract No. 98

The Functioning of Peasants' Managed Irrigation in the Northern Ecuadorian Andes (Mira Watershed)

Patrick le Goulven[75] *and Thierry Ruf*[76]

IN THE ECUADORIAN Andes, between 75 and 80 percent of the land is supplied with irrigation water by hydraulic systems managed by farmers organized in to Water Councils. After noting their specific characteristics, the authors describe the role of this particular type of irrigation in the national economy, its historical evolution, and the productivities obtained for the main crops. The low productions observed are mostly justified by the dysfunctions in the chain of water mobilization (water supply, transport, allocation between areas, distribution and application in the parcels). Analysis is based on precise multidisciplinary studies in representative zones, and studies completed by a systematic inventory (localization, organization and characteristics of each system) elaborated on watersheds. The presented results are issued form the study on the Mira Catchment (3,500 km^2) situated in the northern part of the country.

75 ORSTOM Hydrologist, AA 6596 CCI, Quito, Ecuador.

76 ORSTOM Agro-economist, AA 6596 CCI, Quito, Ecuador.

Abstract No. 105

Causes and Indicators of Poor Performance in Traditional Irrigation Schemes

C. K. Chiza[77] *and R. L. Daluti*[78]

THIS PAPER EXAMINES the causes of poor performance in traditional irrigation schemes developed about 40–50 years ago on the slopes and foots of mountains in Tanzania. Poor performance has been attributed to increasing population pressure in higher areas which forces people to cultivate land in the lowlands where rainfall is erratic and unreliable and irrigation facilities are inadequate; and to poor construction, operation, maintenance and management at scheme and farm levels.

The paper discusses performance of traditional irrigation schemes in the light of their output and impact objectives. The need for measuring the general performance of traditional irrigation systems by attaching performance monitoring systems has been compounded by a suggested agricultural monitoring system drawn from typical traditional systems.

The level of government intervention and its resultant effects on the performance of traditional schemes has been cited with a view to indicating how social considerations and people's awareness can contribute to the performance of traditional irrigation systems.

The paper also highlights on how performance measurement and indicators set up can be useful in the formulation of rehabilitation projects with a view to achieving sustainable farmer-managed irrigation systems.

Abstract No. 121

Water Management and Self-Managed Projects in the Andean Region

Fransh Medina Durand[79]

THIS PAPER DESCRIBES agricultural practices in different Andean regions in Peru: Arequipa, Valle del Colca and Lari. It aims at showing the goals attained and the impact of an external development agent on a shared-management project. The objective of this paper is to help strengthen the productive activities in Lari by means of an alternative irrigation and production design.

The activities proposed are based on a previous diagnosis of Lari's agricultural and peasant conditions. There exists an important potential, namely, the capacity of the users' associations for organization and work, which has made it possible to provide material resources to the Irrigators' Commission with a view to improving water resources management by means of a shared-management project (with technical assistance from Center for the Assistance and Promotion of Agricultural Development, Peru (CAPRODA).

77 National Project Director, Rehabilitation of Traditional Irrigation Project, Kilimanjaro, Tanzania.

78 Zonal Irrigation Engineer, Kilimanjaro, Tanzania.

79 CAPRODA, Center for the Assistance and Promotion of Agricultural Development, Peru.

From the technical point of view, the project consisted in constructing a concrete dam (with a valve) to store rain water, which would then be conveyed to the most critical agricultural sectors. Other objectives are to enlarge the pond's water surface from 4 to 6 ha, and to correct infiltration problems.

The impact of this pilot project will be observed in the medium and long term.