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IIMI RESEARCH PAPER NO. 2
PROCEEDINGS FROM THE WORKSHOP ON
SELECTED IRRIGATION MANAGEMENT ISSUES

15-19 JULY, 1985
DIGANA VILLAGE, SRI LANKA



INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

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The International Irrigation Management Institute (IIMI) is an autonomous, non-profit international organization chartered in Sri Lanka in 1984 to conduct research, provide opportunities for professional development and communicate information about irrigation management. Through collaboration, IIMI seeks ways to strengthen independent national capacity to improve the management and performance of irrigation systems in developing countries.

The Institute's research program aims at deriving methodologies and conceptual understandings that result in better management of irrigation resources. Researchers seek to understand the ways in which local conditions - physical and social - affect the performance of irrigation systems. Attention is focused on the whole system through a multi-disciplinary approach.

IIMI's training program is designed to strengthen leadership and management skills among professionals responsible for planning and managing irrigation systems. This is accomplished through workshops and conferences, and support for graduate students and post-doctoral fellowships in innovative irrigation management.

IIMI's information program supports researchers and an international network of people interested in irrigation management. The Communication and Publication Office produces publications on irrigation management topics, provides documentation services through a computerized database, and maintains the Institute's library.

The Institute's headquarters is in Digana Village near Kandy, about 130 km east of Colombo and central to some of Sri Lanka's extensive irrigation projects.

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INTRODUCTION

The International Irrigation Management Institute (IIMI) held an international Workshop **on Selected Irrigation Management Issues** from 15-19 July 1985. Irrigation managers, planners, and researchers were invited to IIMI's Headquarters in Digana Village, Sri Lanka, to assess the present state **of** knowledge in several potential irrigation management research areas, and to help identify issues that IIMI might focus on in its research programs. Participants came from India, Indonesia, Morocco, Pakistan, Philippines, Sri Lanka, and Thailand, as well as from Britain, France, West Germany, Japan, and the United States.

One full day was spent on each of four topics:

Rapid Appraisal
Rehabilitation
Main System Management
Institutional Aspects.

A fifth day was devoted to wrap-up discussion and recommendations.

These topics grew out of a **small** planning workshop held at IIMI during December 1984 in cooperation with the Institute of Development Studies (Sussex) **and** Wye College, United Kingdom. Drs Robert Chambers, Ian Carruthers, and Mick Moore participated in that workshop and were instrumental in framing these four irrigation management issues.

A lead paper supported by case studies introduced each session. The objectives were to assess the state **of** knowledge **on** the topics, **to** identify priorities for research, and to consider IIMI's comparative advantage in addressing the issues. The wrap-up on the final day considered methodologies for approaching the selected issues, and planned research networks.

The presented papers and discussion have been summarized in these Proceedings. Summaries of *Managing the Rehabilitation Process* and *Managing Main System Water Distribution* were prepared **by** the authors. The other papers and the discussion were summarized by me. Copies of **the** original papers are available from the authors.

Grateful acknowledgement *is* given to the United Nations Development Program (UNDP) which provided a major part of the funding for the workshop, the many organizations which allowed the participants **to** join the workshop, and the participants themselves. IIMI's entire staff contributed to the success of the workshop, most notably **Ms** Jennifer Cramer and **Ms** Ranjini Molligoda.

Any comments on the topics raked in these proceedings are most welcome and may be addressed to the authors directly, **or** to IIMI on the **form** provided at the end of these Proceedings.

David Groenfeldt
Workshop Coordinator

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APPRAISAL TO IMPROVE CANAL IRRIGATION PERFORMANCE: IN SEARCH OF COST-EFFECTIVE METHODS

R. Chambers and I. Carruthers

The Purpose of Appraisal

To improve irrigation performance, governments and aid agencies are undertaking major investments in physical rehabilitation, canal lining, control structures, communication equipment, drainage, watercourse reconstruction, and on-farm improvements such as land levelling. In practice the choice of components, detail, and priority of these programs are based more on the general professional opinions of national and international experts than on extensive deliberate appraisal and analysis of particular irrigation systems. Ideas about what it *is* best to do vary according to so-called "state of the art" thinking, but surprisingly little attention has been paid to the processes which generate those ideas, or to methods of appraisal and analysis for identifying needed actions to improve irrigation systems. The purpose of this paper is to discuss methods, and contribute to their development and use.

Approaches to Appraisal

It will help to define our terms. Various words - *appraisal, diagnostic analysis, evaluation, investigation, observation, analysis, diagnosis, prescription* - have been used. In this paper, the term *appraisal* is synonymous with *diagnostic analysis* or *diagnosis and prescription* or *project identification, design and appraisal* (Fig.1).

SEQUENCE

		C T I O
Investigation	Analysis	
Diagnosis	Prescription	
Appraisal		

Fig. 1. Appraisal: Overlaps of word meanings.

Appraisals of canal irrigation systems are often "quick and dirty" as when a cursory visit is made to the project area resulting in a mistaken conception of the actual situation. Appraisals which are done over a long period of time, however, do not necessarily result in better decision-making. These "long and dirty" approaches may consist of long, drawn-out multidisciplinary research in which each discipline wanders off into the minutiae of its specialized by-ways, rendering more difficult the tight integrating analysis needed to generate clear recommendations for action. By the time research results are finally analyzed and reported, it is often too late to have any effect on policy decisions.

The term, **Rapid Rural Appraisal (RRA)**, refers to techniques which attempt to optimize cost-effectiveness with an emphasis on timeliness of report completion. RRA methods aim to produce fairly quick, relatively clean, research and recommendations. While there is a sizeable literature on RRA techniques in general, little work has been done to apply these techniques to the issues of canal irrigation, perhaps due to the sheer complexity of canal irrigation systems. Individual irrigation specialists who practice RRA follow implicit, personal methodologies which have yet to be systematized, tested, and reported.

The RRA approach advocated in this paper is integrally linked to action to improve irrigation performance and thus should be thought of as a type of action, as well as a type of research. The action orientation of RRA guards against over-refinement of technique in favor of practicality. In some situations RRA will involve active interventions which can be monitored and modified as the best way of learning about an irrigation system quickly. Learning from action may be of particular value in complex systems where predictions based on simulations require more investment than a simple "twe" experiment. The importance of action as an outcome of RRA or as part of the procedure itself is tied to the critical status of irrigation systems. We cannot afford to deliberate while the opportunity cost of not improving irrigation systems is constantly rising.

One major criticism of rapid methods of assessment is that they require a very scarce resource: high caliber and experienced professional expertise. In this paper we argue that all professionals, from the most junior to senior, will benefit from a reconsideration of their study methods, from avoiding biases and probing gaps. RRA techniques are basically a form of applied systems analysis. It is a way of thinking that attempts to use scarce resources in the most efficient manner.

The Complexity of Irrigation Systems

It has become conventional wisdom that canal irrigation systems should be analyzed as wholes. They have many connected parts, and leaving any of these out is liable to lead to only partial understanding and misleading diagnosis. Irrigation systems can be examined in terms of 1) domains, 2) dimensions, and 3) linkages.

Domains. The physical domain includes not just the main system down to the outlet, but also field channels, fields, and drains. The bio-economic domain includes the supply or purchase of inputs (including credit) before crop growth; all biological organisms (livestock, grass, trees, weeds, fish, perhaps birds); and the processes of husbandry, harvesting, storage, consumption, and sale. The human domain includes farm households and laborers on the one hand, and irrigation and other departmental staff on the other. The latter are organized in a hierarchy and spread out over the physical system, while the former are organized in village communities or hydrological groups. Any appraisal of the whole canal irrigation system should take account of all three domains and should consider problems of boundary definition for each domain. In practice, boundaries are seldom where they first appear to be: water leaks and drains; credit and inputs flow in and out; laborers migrate; families move; officials are transferred.

Dimensions. Canal irrigation systems are also complex in terms of space (the network of canals, branches, distributaries, minors, field channels) and time. While the spatial dimension is obvious, the time dimension is often neglected. The historical growth (construction, decay, rehabilitation) of the system, seasonal variations in irrigation conditions, irrigation cycles within seasons, and daily

¹ See Potten, David 1985 "Rapid Rural Appraisal Emergence of a methodology and its application to Irrigation," a bibliographic review presented at the International Workshop on Selected Irrigation Management Issues Digana Village, Sri Lanka IIMI

variations (e.g., night/day) need consideration when appraising an irrigation system; any given moment must be viewed in its proper context. Performance is a function of a long process proceeding through space and time, from capturing water to satisfying human needs.

Linkages. Another perspective on canal irrigation systems focuses on the linkages between domains and the elements within them. Some of these linkages are well understood (e.g., crop water requirements), while others have been largely neglected (e.g., management and incentives of irrigation staff; organization of farmers). The true complexity of canal irrigation systems has yet to be fully appreciated.

The Uses of Rapid Rural Appraisal

Rapid appraisals of canal irrigation systems have been conducted for a variety of purposes and in various contexts. A rough typology includes the following four categories:

1. Appraisals conducted as one aspect of standardized programs such as on-farm improvements, canal lining, or rotational schedules to determine how the program can be implemented in a given case; the question of whether the standardized program is appropriate is seldom asked.
2. Appraisals to develop diagnostic methods, which may have a training emphasis (as in USAID's Water Management Synthesis Project) or a monitoring and evaluation emphasis (e.g., Bottrall's 1981 World Bank report), and may concentrate below the outlet (USAIO) or include the main system (Bottrall).
3. Appraisals which yield recommendations that are never implemented for a variety of reasons, not least of which may be that they do not fit into an explicit operational plan.
4. Appraisals which result in action; this is the goal and seems to have been attained in India's National Water Management Project. At a local "do-it-yourself" level, some irrigation project managers have conducted informal appraisals of the systems under their control and made improvements they felt were needed.

Recent experience suggests that appraisals are most effective when 1) each irrigation system is viewed afresh as a unique case, 2) the entire system is considered, from the farm level to the main system, 3) there is an operational plan for reacting to the recommendations, and 4) there is continuity of staff involved in both appraisal and action.

Analytical Techniques for Appraisal

There is a wide range of approaches to rapid appraisal. One option is between thought and action: How much and what kind of research is necessary? Another is the necessary trade-off between ideal solutions and feasible recommendations. The best practical solution is one where everyone gains and no one loses, as when improved management alleviates waterlogging problems of head-end farmers while providing secure water supplies to tail-enders. A proposed solution based on sound engineering principles and logical economics will not succeed unless it also has political support.

Of the various options for ordering and analyzing information, five analytical approaches stand out: 1) Resource-based, top-down approaches which start with the water resource, its capture and storage, and then work downstream to the farm level; 2) performance-based, bottom-up which starts

from downstream symptoms of system ills (e.g., tail-end shortages or low yields) and works back upstream to determine the cause; 3) algorithms and other diagrams to express the logical linkages and interactions among the elements of an irrigation system; 4) menu maps which depict the overall set of functions, activities and responsibilities of the various departments and individual staff who manage the irrigation system; and 5) key questions and probes (e.g., How is water allocated during times of scarcity?) which aim at understanding linkages between parts of the system (e.g., head-tail, farmers-officials).

The Mechanics of Rapid Appraisal

Before a RRA begins, consideration must be given to the objectives of the irrigation system under study, as well as the objectives of the appraisal itself. The composition of the appraisal team should reflect both the technical and the social sciences, but should be kept as small as possible (perhaps 2-7). Narrow specialists can be a liability; the ideal are multidisciplinary individuals whose horizons are not limited by their formal training. The time required for an adequate "rapid" appraisal may be in the order of two weeks (though most so-called appraisals are often done in 2-4 days). Time is needed for reviewing background information, for identifying useful informants, and for meaningful discussions with farmers and officials.

One basic tool for eliciting information during the appraisal is the checklist, which can take many forms. Not everything needs to be known; the checklist serves as a guide to what is probably most important. The key to rapid appraisal is to move quickly and surely to the main problems, opportunities and actions, to consider alternatives and avoid obvious biases. The sources of information and insight that should be consulted include the following: 1) Key people (officials, farmers, laborers, specialists); 2) maps, photographs, or just a good hill-top view; and 3) documents (project appraisals, background reports, monitoring data, manuals and circulars, weather records).

RRA is only one of a series of preceding and subsequent activities for understanding and improving a canal irrigation system. The team must consider the history of the project and the people (e.g., local irrigation staff) who have been part of the system's history and will be part of its future. In addition to careful selection of the appraisal site, careful preparation must be made to explain the RRA objectives to project staff, and to seek their guidance, assistance, and collaboration. The pay-off to thorough preparation comes not only during the appraisal activities, but in the results of those activities. **Unless** project staff are involved in the appraisal, the recommendations are likely to be both ill-conceived and poorly received.

Recommendations should consider existing programs and budgets, and should include at least improvements that can be made immediately as a means of orienting the long-term agenda. Those **who** conduct appraisals rarely write about what they do or how they think. For programs of training and action, practical methods are needed. To this end, three activities are proposed:

1. Develop subroutines or modules to break the subject down into manageable units, allowing the gradual build-up of experience and its systematic testing;
2. Conduct empirical studies of appraisals so that the individuals who carry out RRAs can gain a better understanding of how **they** arrive at their recommendations;
3. Collect, sift, analyze and disseminate the experiences and techniques that have proven to be useful in rapid rural appraisal.

Those directly involved in project management and appraisal need to become more active in writing about their methods and experience. Their rules of thumb can be combined with more formal procedures to further advance our ability to appraise irrigation systems rapidly and effectively.

RAPID APPRAISAL DISCUSSION: A SUMMARY

The discussion began with a brief presentation by Berkhoff about India's Improved Water Management Plan and the role of rapid appraisal (RA). One issue was who should do appraisals: "Who tests **and** monitors *the system* to see if it's doing what it's supposed to **be** doing? You can't expect scheme operators to do that, although they may have perceptions of how it's working. Someone must have a sense of how the system as a whole fits into the environment as a whole and I don't see how that can come from anyone **but** planners." Berkhoff was referring to operational plans for an entire system, but what about the routine knowledge necessary to run part of that system? Carruthers noted that: "I was thinking of the executive engineer and managers in the field." Merrey addressed the **same** point: "Should a country like India be thinking about institutionalizing the capacity to send out RA teams constantly, **or** should we be thinking in terms of teaching existing managers to **do RA** themselves as a continuous process?"

One main issue centered around the question of how rapid is "rapid?" Coward suggested the term "sensible" appraisal as being more accurate. Chambers agreed: "The original idea was to call it *cost-effective* (giving recognition to the value of time). The main point is to have approaches and methods both in investigation and analysis to draw down from the shelf as part of the repertoire for **use** by people - managers, visiting teams, or whomever - who are trying to improve a particular system."

Not **all** participants were ready to drop the term "rapid." Rao cautioned that, while RA is useful for finding or correcting immediate problems, it cannot replace a thorough investigation of the whole system. Sundar noted that sometimes making no decision is worse than making a slightly wrong decision. When a decision **must** be made quickly, RA may be appropriate. Furthermore, we should remember that rapid appraisals are done **by** people having long experience. However, there **are** cases where RA may be ill-suited to the serious consequences of a wrong decision: "If you ask me to build a dam, I am not going to **assess** the hydrology on a rapid basis; I will take my time to assess that hydrology."

How does one do a rapid appraisal that can yield significant information? There **was** some doubt that it can **be** taught at all. "It's a losing proposition," said Wallach. "I think **RA** will remain the **province** of people who have a certain mental suppleness, curiosity, and energy. **We** need to observe how *these* people work and draw lessons from them. The **best** way to learn appraisal is to try doing it with people who know how to do it."

Carruthers responded that these lessons can be extracted, written down, and learned. "We're trying to accelerate the experience of others by recording it and giving some guidelines. We're **talking** about avoiding traps that have been spotted by people who have done it before. It's still an art form but we think there is some distilled experience that can be handed on." Lowdermilk noted, "It's a **process** of learning from experienced people who know their craft and then trying to do it better."

The concepts of "rules of thumb" and "tricks of the trade" were mentioned several times as fitting the level of detail that is desirable. To be rapid it has to be rough; corners must be cut: The **key** is to cut corners that are not very significant and focus on a few points that have special meaning. **As** Wade put it, "We're talking about ways to get a quick general sense about how a canal system is **performing** and the effectiveness of its management." **He** suggested several indicators that could **be** useful:

1. What is happening in the drains? How much water goes into them and how often are the escapes used?

3. What is the ratio of water diverted into the system to the area actually irrigated (e.g., land area per cubic meter of water)?
4. How many years have the senior managers been in their positions?
5. Who controls canal gauge readings: the irrigation staff upstream or downstream from the gauge? Is there incentive to falsify the readings?

The issue of performance indicators was taken up by several of the participants. Saldanha pointed out that once you decide on a set of indicators, it still remains to determine causality. "There is also a problem of linkage," Carruthers observed. "The same problem can be expressed in different ways. One can't simply assign weighted values to the indicators and add them; scoring systems don't work because of the complexity of interactions. This is why in the end it's an art form."

MANAGING THE REHABILITATION PROCESS

D. Hammond Murray-Rust

During recent years there has been a growing interest in the rehabilitation of existing irrigation systems. This interest has been stimulated in part by awareness of the diminishing land and water resources that support the construction of new systems, and in part by the increasing inability of many countries to finance major construction. At the same time research has demonstrated that existing **systems** perform much less efficiently than initially anticipated, and has suggested that there is considerable potential to increase productivity with relatively little capital expenditure.

An equally important aspect of rehabilitation is that countries become increasingly concerned with crop diversification as they approach or achieve self-sufficiency in rice production. Irrigation systems built primarily for rice irrigation may require modernization of physical and managerial capacity to meet these different demands. Experiences from a number of rehabilitation programs indicate the need to examine the rehabilitation process from planning through to implementation.

There has been a tendency **to** focus only on the physical works of system redesign and reconstruction at the expense of providing the appropriate and parallel support for system operation and management (**O&M**).

Definitions

The term rehabilitation includes a range of potential activities. The most general definition is that it involves some **form** of modification of an existing system as opposed to design and construction of a completely new system.

Rehabilitation is needed when existing facilities are under-utilized. A program may focus on restoring irrigation deliveries to a proportion of an existing system; it may involve expansion into adjacent non-irrigated areas; it may aim at alleviating specific technical deficiencies, halting or reversing development of adverse **environmental** impacts such as salinity or water-logging, or promoting changes in cropping patterns or cropping calendars.

If no change in the system objectives are envisaged rehabilitation is equivalent to deferred maintenance. However, the **term** is more properly applied to programs designed to lead to significant modifications in system operation or changed production strategies.

Physical Bias in Rehabilitation Programs

Most rehabilitation programs are biased toward improving physical infrastructure. This is largely a reflection of the legacy of many irrigation agencies which have emphasized design **and** construction rather than operations. Construction allows agencies and donor organizations the opportunity to quickly monitor progress, and facilitate large and rapid capital expenditure. As in any construction activity there may **be** opportunities for personal gain not normally present in routine operational activities.

Irrigation agencies and donor organizations have developed mutually beneficial linkages in construction programs. Linkages for operational activities are less common because they do not often fit into a convenient project framework. These factors contribute to a bias toward physically oriented projects with clearly defined life spans.

Many agencies are unfamiliar with alternative uses of existing systems. It is clearly easier to upgrade physical infrastructure than to redesign a system for a new purpose, particularly if crop diversification is involved. There is also considerable unfamiliarity among irrigation agencies on how to involve farmers in redesign. Farmer involvement in rehabilitation is clearly justified insofar as they have system experience that is not available to agency personnel. It is no doubt easier under these circumstances to opt for a traditional construction project than experiment with unfamiliar programs.

Distinguishing Between Operation and Maintenance

A weakness in many rehabilitation projects is that insufficient attention is paid to system operation. The view of rehabilitation as deferred maintenance tends to foster the impression that if the system is physically rehabilitated then its operation, and hence performance, will automatically improve. While this may be true in some cases it is by no means assured.

Maintenance activities are concerned with keeping physical infrastructure in good enough condition to facilitate conveyance and control of water according to original design criteria. Operational activities are concerned with the use of physical infrastructure to implement the planning decisions made in relation to water allocation and distribution. While there may be instances where deteriorated infrastructure makes it difficult to implement desired procedures, it is also true that in many cases physical infrastructure is under-utilized. In the latter case, improvement of infrastructure is likely to have little impact on system performance unless there is a parallel improvement in operations. It is important to ensure that within any rehabilitation activity the correct balance is obtained between the repair of physical infrastructure and the operational requirements of the system.

Planning and Defining Objectives

Because rehabilitation is concerned with existing irrigation systems, there is usually an accumulation of experience and knowledge of actual conditions. Identification of a system for rehabilitation implies that performance is below what was expected at the time of construction or that the system can no longer meet changed objectives. The facts, however, may be of insufficient detail to develop a full program of activities. A characteristic of rehabilitation programs, and linked to the physical bias described earlier, is that operational modifications are not thought out in as much detail as those of physical works. This seems in conflict with stated program objectives which emphasize increased agricultural output, employment, and income through more equitable and efficient water allocation and distribution.

A comprehensive knowledge of existing system management practices is essential to designing a rehabilitation program. If managerial capacity is limited prior to rehabilitation, then merely improving physical capacity will be an incomplete solution. Clearly some physical works are necessary but it is important to integrate the physical activities with realistic expectations for future system management. By analyzing prior managerial performance it may be possible to more clearly identify areas that need assistance. This approach can be regarded as operational rehabilitation.

A further aspect of rehabilitation programs is the extent to which it is desirable or feasible to recreate the original system. Irrigation systems evolve over time, with both farmers and irrigation agency adapting to unique local conditions. Past assumptions about physical, economic, and social conditions may no longer be and may never have been valid. There is a need to learn more about the system's attributes.

Unless the system is in a state of extreme disrepair physical rehabilitation may need to cover only a certain percentage of the total infrastructure. With financial constraints becoming more serious there is a growing interest in *pragmatic rehabilitation* where only the most essential structures and channels are improved. This strategy not only results in lower total costs but can provide a good opportunity for integrating operational improvements with physical repairs.

Evaluation of irrigation agency records is an important source of information on how the system has been managed. It will assist in determining what knowledge is available for the redesign process and indicate where there is need for additional information. However, this information is not always detailed and field investigations are almost always inevitable. It is in this respect that farmers have an important contribution to **make**.

Involving farmers in the redesign process is necessary in two respects. First, they can help in identification of specific problems at field level, such as deficiencies in the original design, problems of water delivery scheduling **and** location of areas of flooding, high topography, soil variability, and so forth. Second, they can advise on the practicality from their perspective of proposed changes to water scheduling, cropping patterns, and O&M responsibilities. Integrating farmers at this stage can strengthen linkages and communications that will last through implementation and subsequent operation. However, many irrigation agency **officials** are not **used to** dealing with farmers and it may be appropriate to involve some third party catalysts to foster farmer-agency communication.

Two other aspects of planning rehabilitation merit attention: existing agency regulations **and** the need for flexibility. Many systems irrigate areas that are not officially included in the command area. Similarly, farmers may have installed additional unsanctioned structures and channels. Rehabilitation can incorporate these changes whenever appropriate. This is only one type of flexibility that may be required. **As** more information becomes available concerning system conditions and performance, changes in the project will **be** inevitable. Flexibility is particularly desirable in rehabilitation programs since farmers' livelihoods are at stake if problems arise.

Program Implementation

Rehabilitation programs face unique problems of implementation because changes must be made within the framework of continued operation. Although it may be necessary to shut the system down for short periods, it is normally impractical to do so for long periods. Implementation of the program must be handled carefully to avoid antagonisms between farmers and the irrigation agency.

Construction activities may have to be scheduled to peak in periods when agricultural activities are at a minimum to avoid danger of damaging crops through water shortages or by machinery. There may also be access problems along minor channels due to encroachments on rights of way. Domestic water deliveries may also have to be maintained.

Many rehabilitation programs include opportunities for farmer involvement in construction activities. This not only provides some additional income opportunities but also offers the prospect of a greater sense of ownership or involvement in the system. However, farmer participation in Construction is only likely to result in longer term cooperation if farmers are also involved in the design and operation phases of the project. This implies that there must be agreement at an early stage between farmers and irrigation agencies on the scope of any future responsibilities.

Operational changes need to be implemented cautiously. It is not always possible to predict the system's actual behavior under different operational criteria, and it is essential that farmers' livelihoods are not threatened by modifications to existing practices. There are dangers inherent in unilateral imposition of new water delivery schedules by irrigation agencies.

Many irrigation agencies are structured so that there is a distinct division between design and construction on one hand and operation and management on the other. External personnel introduced for construction work may not, under these conditions, communicate fully with regular operational staff. This is particularly critical if design staff make assumptions on future system operation.

Evaluation

Despite the increasing number of rehabilitation projects there are few clear examples of objective evaluation of the project's actual impact. One major contribution of rehabilitation programs may be to strengthen the basic monitoring activities undertaken by irrigation agencies. Any evaluation depends on a reasonably continuous data base rather than a simplistic before-and-after approach. There is merit in establishing monitoring activities as soon as possible in the project life in order to assist subsequent evaluation, but also to provide opportunities for agencies to respond more effectively to short term difficulties experienced within the system.

In-depth evaluations of rehabilitation programs are needed. As in many projects there is a danger of over-optimistic assumptions during project formulation so as to arrive at favorable benefit-cost ratios.

Conclusions

While increasing attention is being paid to rehabilitation there is relatively little agreement on exactly what is involved and how it should be undertaken. To some extent, each project is unique in that it must accommodate local variability. At the same time some commonalties appear to exist. Five issues may be briefly summarized:

1. What and when to rehabilitate. There appears to be little consensus on when systems need rehabilitation and whether such activities should involve wholesale change or incremental improvement.

2. Integration of construction and management. Because rehabilitation occurs in existing systems there is need for greater integration of managerial activities (operation, planning, and maintenance) with design and construction. Unless there are specific technical constraints, it may be more appropriate to introduce some, if not all, of the managerial improvements before commencing physical work.

3. How and when to involve farmers. Rehabilitation provides an opportunity for a new start in strengthening agency-farmer relationships, not merely for construction but also for transfer of limited amounts of O&M responsibilities to farmer organizations.

4. Donor-contractor-irrigation agency relationships. Because rehabilitation programs need to be site specific, flexible, and self-sustaining, many of the existing donor-contractor-irrigation agency relationships require revision. Donor agencies must be less willing to accept cookbook solutions

based on generalized assumptions and more willing to support improvements in managerial capacity. They must also encourage irrigation agencies to be more flexible and innovative.

5. Evaluating the impact of rehabilitation programs. This assessment needs to be undertaken at two levels: a) benefits accruing from individual projects in terms not just of engineering and agriculture but also the full economic and social impacts, and b) if projects do not achieve a reasonable level of expectation, the evaluation should be extended to include the process undertaken in attempting to achieve these initial objectives. There is some evidence to suggest a mismatch between rehabilitation project objectives and the actual tasks undertaken.

Rehabilitation programs run the risk of being all encompassing: aspects of redesign, construction, operation, maintenance, and allocations may be present in a single project. While it is true that any or all of these activities could be improved, it may be inefficient to cope with all the changes simultaneously. A more effective approach may be to develop a process whereby key constraints are identified and remedied on a more frequent basis than is currently practiced.

REHABILITATION DISCUSSION: A SUMMARY

De Cock presented a short case study of the Uda Walawe Project in Sri Lanka, in which SOGREAH has been involved. Some of the problems addressed by rehabilitation include severe delivery inequities and wastage by those farmers receiving more water than they need. These problems can be traced to design and construction flaws, as well as organizational issues. Part of the rehabilitation effort will be directed to organizing farmers at the turnout level. Moore asked why such an effort is being made, given that turnout level groups have a poor track record elsewhere in Sri Lanka. Murray-Rust suggested that the primary function of farmer organization is at the D-channel (50-75 hectares) level, rather than at small turnouts of about 14 hectares.

One discussion issue focussed on the timing for rehabilitation and the prediction of rehabilitation benefits over time. Should rehabilitation be carried out when the **system** is still functioning fairly well but problems are anticipated, or should the system be allowed to deteriorate to a point where performance is severely curtailed? At what point along the curve should rehabilitation be carried out (Fig. 1)? What shape is the curve?

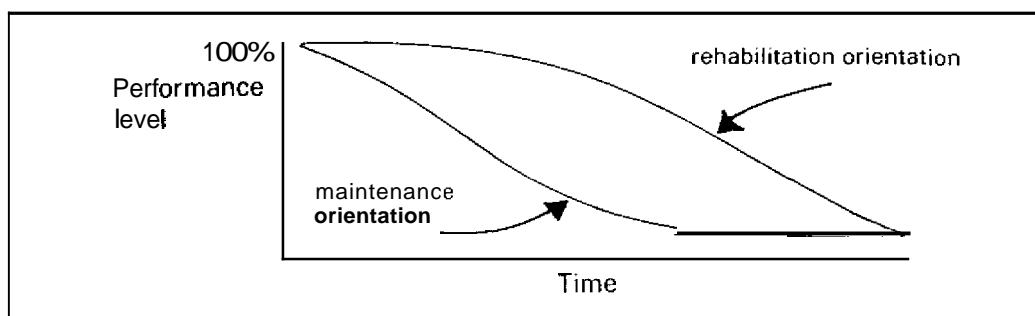


Fig. 1. Range of performance curve for suggesting when rehabilitation should begin.

After rehabilitation, what are the levels of increased performance that can reasonably be expected and for how long? Project appraisals generally indicate high benefits extending for a long period; the actual outcome is usually less beneficial for a shorter time. As Walter observed, "We refuse to admit that the design expectations, the project expectations at the beginning, are so unrealistic..." (Fig. 2).

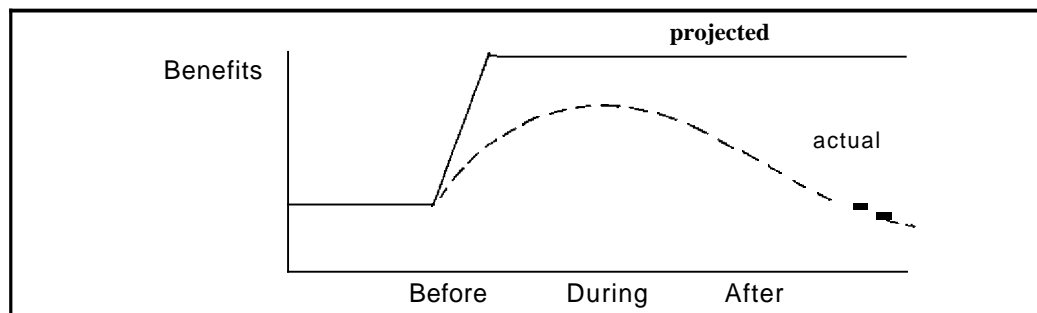


Fig. 2. Benefit curve for rehabilitation projects.

The trade-off between maintenance and rehabilitation received considerable attention from the participants. Tiffen suggested, "We have to distinguish between two types of rehabilitation: rehabilitation because of bad maintenance and because of bad design. The costs of regular maintenance have to be weighed against the cost of rehabilitation and its disruption to farmers." In practice, Murray-Rust pointed out, the two cannot be easily compared because "we're dealing in two separate currencies. When you do a major rehabilitation project, you get a major grant from outside; it doesn't cost the agency anything. When you're doing maintenance, it costs them everything. Therefore, from the agency's perspective it's cheaper to do nothing until rehabilitation is needed."

Several participants stressed the need for research into why maintenance is neglected (other than the reason just mentioned). Sundar asked, "Why does the problem arise? Is it possible not to make this irrigation system into a criminal so that he need not be rehabilitated?" This implies the need for close monitoring to identify maintenance problems before they get out of hand.

Questions of maintenance vs. rehabilitation and the role of donor agencies in the economic calculus facing irrigation departments "is an area that's just loaded with policy implications," noted Lowdermilk. We need comparative case studies as the first step in building a knowledge base that can be used to train managers and planners who must make these decisions.

The issues of what to rehabilitate and what should receive highest priority were also considered. Saldanha asked, "Are we talking about normal wear-related rehabilitation given an acceptable level of management or about rehabilitation aimed not so much at reconstruction but at bad management?"

How does one arrive at rehabilitation priorities? Wickham remarked, "I'm always impressed at the divergent views of the people on a mission as to what is required in particular rehabilitation projects. One person argues for watercourse improvement; another for cross-regulators. Everybody has his own key area. These points are seldom addressed on the basis of knowledge but on the basis of strength of persuasion on the team."

One guideline for focussing on the priority components of rehabilitation, suggested Nakamura, is the extent to which it would contribute to water savings or water re-use. Participants urged research attention on design issues as well as management. Prakash noted that there are still many design problems for which there is insufficient research available. Drainage was cited as a missing link in rehabilitation projects. Bandaragoda encouraged greater attention to this aspect. Carruthers pointed out that in non-rice growing areas especially, an integral part of irrigation is the removal of dissolved salts through proper drainage.

The organization and management aspects of rehabilitation were raised by Alwis, who reminded the participants that management capacity within irrigation agencies has an important bearing on the effectiveness of rehabilitation. This point was also raised by Groenfeldt who suggested that "we need to include the institutional aspects as something that deserves rehabilitation in itself. We might want to think about reform in the agency as well as reform to the physical system:"

Coward raised the issue of rehabilitating small-scale systems and systems which are logically distinct from large-scale systems as an area where design and management problems can be addressed simultaneously: "Many policy makers and program implementors are relatively uninformed about the experience others have with the same kinds of problems and issues." Research on small-scale systems is "clearly policy relevant and lends itself to cross-national comparisons. It provides an environment for dealing simultaneously with topics that cut across physical, economic, and institutional issues."

Sharing experiences and accessibility to information about rehabilitation was an issue which Wallach raised in reference to systems of all sizes. "If I want to find out about rehabilitation experiences in a particular country, what do I read?" For example, the participant from Indonesia did not know about Sri Lanka's experiences in rehabilitation and vice versa. Berkhoff noted that much relevant information is available in World Bank office libraries; Tiffen pointed out that contractors have documents relating to their projects. In neither case, however, is this information generally available: "Most of us don't have access to a great deal of information."

The information problem is one affecting not only policy makers and researchers but also consultants who design projects. As Tiffen noted, "Consultants need to know the operational difficulties with their designs. Designs will only be improved if the people responsible for them get some feedback on their performance."

MANAGING MAIN SYSTEM WATER DISTRIBUTION

P.S. Rao and A. Sundar

Introduction

"Main System" refers to the canal system from the headworks of a storage reservoir or diversion structure down to the outlet where water is delivered to the farmers. In large public irrigation systems, the canal network is complex and comprises the main canals, branch canals, distributaries, sub-distributaries, and minors. (The terminology of primary, secondary, and tertiary canals is also used). The operation of the canal system is governed by a set of rules for allocating and distributing water. The irrigation bureaucracy is responsible for operating and properly maintaining the canal system.

For over a decade, policy makers, planners and administrators in South and Southeast Asia have been concerned about the poor performance of irrigation systems. Although considerable irrigation potential is being created, there is a time lag before it can be utilized; the yields from irrigated agriculture are relatively low; the problems of waterlogging, salinity and alkalinity are increasing; and there are also other problems of organization and of on-farm development activities below the outlet. However, it soon became clear that improved and more equitable water distribution at the outlets was a prerequisite for increasing the agricultural productivity of the land. Thus, the focus has been shifting to the main system water distribution and improving its performance. Methodologies have been devised for monitoring the performance of large scale irrigation systems. There have also been some attempts by engineers and administrators to improve performance by effecting changes in the main system distribution.

This paper presents, first, a framework for understanding the main system water distribution in a systemic context and focussing on the problems, potentials, and opportunities for improvements. Some evidence is presented of improved performance from changes in main system distribution. Second, a practical typology and description of methods of main system water distribution is described. These are actually used or potentially usable in South Asian systems. And, third, we discuss research priorities for improved distribution in main systems.

Attributes of Characteristics of Main Systems

Input-output concept. The limited objective of the main conveyance and distribution system is to deliver water to the outlets. The water supplies at the outlets should be equitable, reliable, predictable, and reasonably adequate to meet the requirements of the farmers. The system (Fig. 1) has hardware and software components which have complex interactions in them and between them. Water from storage or diversion is the input into the system, and water at the outlets is the output. The system is embedded in and interacts with technological, social, economic, and political environments.

It is important to understand why a system has evolved the way it has and why certain methods of water distribution have become accepted. The design process of the main distribution system is based on a series of assumptions about crop-water requirements, irrigation requirements (which may be aggregated at some level), rugosity coefficients, conveyance losses, and discharge coefficients. A certain method of system operation is also assumed. In many cases, efforts are never made to test the assumptions and check the conformity between the expected operation as per the design and the actual operation. In the absence of effective feedback to improve the planning and design process, the same assumptions continue to be made.

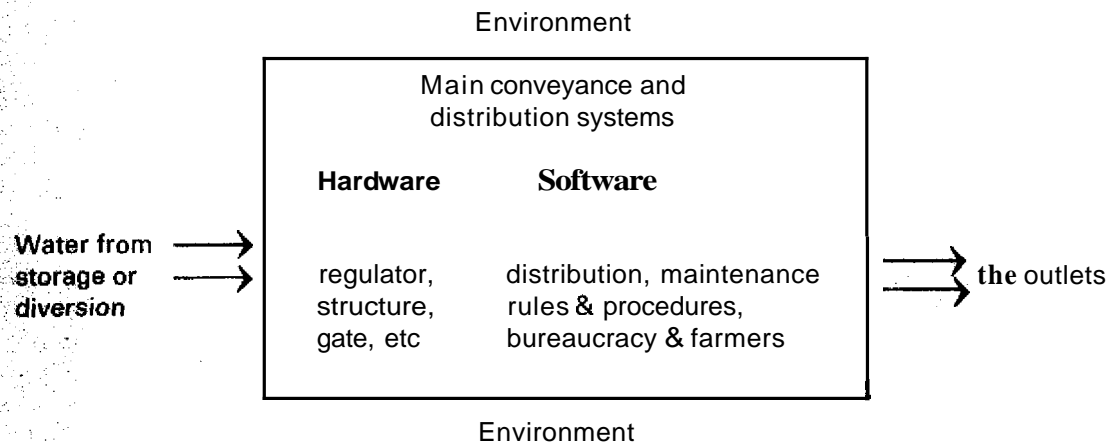


Fig. 1. An input-output concept for main irrigation systems

One way of understanding the complex process in the system *black* box is to investigate the validity of assumptions when the design is applied to real world systems, and to assess the impact on system performance of the errors caused by the assumptions.

Other attributes. The main distribution systems are large in terms of canal length, numbers of control structures, and numbers of people involved. The interactions among elements and with the environment are very complex. They are dynamic in that the demands on the system and its condition changes over time. There are uncertainties associated with the system, the foremost is the hydrologic uncertainty affecting the availability of water.

The allocation and distribution of a scarce and valuable resource like water is bound to generate competition, conflicts, and corruption. There are many decision makers operating at various levels from the outlet gate up to the headwork. Decisions are made and controls exercised by personnel of the irrigation bureaucracy and by farmers, formally or informally, legally or illegally. Each control represents a degree of freedom for whomever may exercise that freedom.

A Typology of Main Systems and Methods of Water Distribution

Main systems. The interactions among the elements of the system and between the system and the environment, and the problems arising in the system, can vary widely. Classifying the systems may help our understanding:

1. **Size of the systems:** major, medium, and minor.
2. **Climate:** humid, arid, and semi-arid.
3. **Crop:** paddy and non-paddy systems.
4. **Bureaucratically** administered and management-oriented (top-down), and participatory (bottom-up).
5. **Traditional communal** systems and government or public systems.
6. **Storage** and non-storage.

Methods **of water** distribution. Several distribution systems have evolved through practice or design to meet specific physical and/or social requirements. They may be broadly categorized as:

1. Rotational Water Distribution System (RWDS or "warabandi"). Warabandi is a rationing system used when water supply is insufficient to provide adequate irrigation to **all** the land served **by** the system. In the past, such systems, in north-western India and Pakistan, had no adequate storage and supplies to the canals were unpredictable. The principal objectives of warabandi systems are: a high degree of equity in water distribution, and high efficiency in **water** use by imposing scarcity on each user. Each farmer, based on his land holding, gets his share of water according to a schedule, The farmer is at liberty to decide on his own cropping pattern and how to use his share of the water.

Water from a river or a reservoir is conveyed by a main canal, which feeds two or more branch canals. These operate by rotation and function as the primary distribution system to provide a varying supply of water throughout the season. Branch canals supply water to many distributaries which must run full supply for eight day periods by rotation. This is the secondary distribution system. Distributaries supply water to watercourses through ungated outlets. The flow in water-courses is allocated among farmers by a time roster covering seven days (i.e., 168 hours). This is the tertiary distributary system. The water distribution from an outlet, and flowing into a watercourse, is managed by the farmers, while the flows in the system above the outlet are managed by the state. Each cultivator's right to a share of water in the water course is guaranteed by law and the Canal Act empowers the canal officer to enforce this right for any farmer who institutes a grievance procedure, Every other aspect of managing the system is up to the farmers.

2. Intermittent flow. Water delivery is fixed according to how much area is served and what crops are grown, but water is not delivered on a continuous basis; the entire system or a portion thereof is closed intermittently. Applications for water are received from farmers who state the crop they wish to grow and the area to be planted. Water is then sanctioned, according to the **crops** and the total demand on the system. The farmers can propose a proportionate reduction in irrigated area if the demand exceeds the available water. A schedule giving turns to different irrigators is prepared for each rotation, and farmers are informed in advance. The rotation interval depends on the watering interval for crops which need large amounts of water, and crops on the same outlets which need less water may receive it on alternate rotations.

The system works smoothly as long as the full area demanded by the irrigators for the different crops can be sanctioned. However, when the irrigated area is restricted, there is a tendency for farmers to take more water than authorized for irrigating the curtailed portion. Punishment by imposing penal water rates does not prove to be a deterrent.

3. Continuous flow. Canal systems from diversion structures or storage reservoirs run continuously during the crop season and serve concentrated areas of paddy-growing commands, The systems are designed on the concept of *duty*, that is, the area that can be irrigated by a unit discharge flowing continuously for the duration of the crop (base period). When the farmers are few and the supply is more than the demand (as in the rainy season), the system can be used efficiently if proper drainage at the farm level is ensured. In all continuous flow systems, there are problems of inequitable distribution of water to head and tail-enders.

4. Demand based. Water delivery to the farm is according to indents received from the farmer. Computer programs can use crop, soil, and climate data to identify the water requirements of a crop at different growth stages. Computer controlled irrigation can determine the individual watering

schedules of each farmer, This is perhaps the ideal. An issue to ponder is whether large-scale public irrigation systems, because of their inherent characteristics and limitations, are capable of reaching such goals.

Main System Water Distribution: Objectives, Criteria, Performance Standards

The objectives of irrigation management are comprehensively stated in terms of efficient use of resources, equitable distribution, environmental stability, and human welfare. The performance of an irrigation system may be evaluated according to these criteria.

Objectives of main system water distribution. Delivering irrigation water at various levels down to the outlet or turnout through minors, distributaries and canals, is the objective of the main system. The criteria for evaluating the performance of the main system should, therefore, concern the various measures of water delivery and compare the *actual performance* with *the performance expected as per the design*.

Measures of water delivery. Delivery measures include: quantity of water delivered, and frequency and reliability of supply. Performance indicators for a water distribution system can be formulated, measurements can be made on a sample basis, and performance can be evaluated at various levels.

Standards of performance. Currently there are no performance standards for various systems. Therefore, it is necessary to establish expected standards for a well-designed and well-maintained system operated according to some well-defined procedures in a given environment. This can be done only through extensive research on various systems.

Assessment of Problems in Main System Water Distribution

The management of main system water distribution is a relatively neglected research field and, at present, there are not many empirical studies of acceptable quality available for comparative analysis. There is need for studies of problems related to main system management, especially about the technical aspects of the physical system, including planning, design, operation and maintenance, and performance evaluation.

Problems arise in large public gravity systems from unclear objectives. Fundamental problems relate to the role of public systems, and the conflict between the goals of management and those of the private beneficiary farmer. To the system manager, water is generally the limited resource. He attempts to derive the maximum benefit from the limited and variable amounts available to a command area and served by the existing canal system. Thus, he is interested in attaining maximum benefit per unit of water carried in the system. To the farmer, on the other hand, land is usually the limited resource and, hence, each individual wants to maximize his benefit from the limited land he holds. His objective is to obtain maximum benefit per unit of land, and he attempts to get as much water as he can for irrigating his land.

The smooth operation of a large public system requires the elimination or reduction of this environment of conflict. This can be done by rejecting the concept of meeting the total crop water requirements for every farmer. Management's clearly stated objective must be to supply equitable, predictable, and reliable quantities of water at stated intervals to farmers. And the water allocated to

each farmer should be less than his full requirement so that he is induced to obtain maximum efficiency in its use. In this way, the objectives of the individual farmer and that of the system as a whole will coincide.

Problems arising at planning and design stages. Misunderstanding and lack of clarity also exist regarding localization and the desire to enforce cropping patterns by executive fiat. Another important assumption is that farmers will irrigate during the night as well as during the day,

Some other design deficiencies are: 1) outlets which are too small to supply the designed discharge, 2) outlets which are not located properly, 3) sluices or outlets which come directly from the distributary instead of from a minor, 4) the assumption that duties at the heads of all distributaries will be the same irrespective of channel length, 5) the assumption that seepage and operational losses will be lower than they actually are, and 6) not providing drainage facilities even where they are necessary.

Testing the system for acceptable performance in its ability to deliver water at various points as per the design is not a standard practice in many irrigation departments.

Problems arising from construction phasing. During early construction stages, storage facilities provide abundant water to the first reaches of canals that are complete. This often results in over irrigation in the head reaches. When the entire canal system is completed, there is insufficient water for tail-enders.

Problems of operation and maintenance (O&M). Operation and maintenance of irrigation systems is not given a high priority. There are no manuals for O&M. Adequate measurements are not made for effective monitoring and management. Communication systems are weak. There is no organized feedback from the beneficiaries to the management. Maintenance grants are very inadequate.

The situation is further compounded by the complex operations that involve many controls and many people - both farmers and irrigation agency personnel. The interactions of the water distribution system with the social and political environment also play a part in O&M.

Research Priorities

Potential for improvement. The potential for improving main system water distribution is widely accepted and convincingly demonstrated by actual interventions. (Some examples are given in the full text of the paper).

Issues for Research and Priorities.

1. Awareness and Commitment. How can we increase the awareness, desire, and commitment of national governments to improve the performance of irrigation systems and, therefore, of main water distribution systems?

2. Objectives, criteria, and indicators of performance. What objectives underlie planning, designing, and operating main water distribution systems? What criteria and indicators can be used to evaluate system' performance?

3. Design conformity. What operating policies and operational plans are assumed in designing a **water distribution** system? If the system is operated as designed, can it deliver the required **quantities** of water at distributary, minor, and outlet levels? If deficiencies exist, can they be **remedied** and the system improved to the standard assumed in the design, and at what cost?

4. Studies on operation of **the** system. Comparative studies should seek answers to questions like: **How** is the system actually operated in the field and during times of scarcity? Are the **operational plans** and procedures understood by farmers and officials? What measurements are made and **what information** collected for use in operating the system? Who really makes the operational **decisions at various** levels? What roles do farmers and officials play in system operation and **how** do they **formally** and informally interact? **How** does the socio-economic and political environment influence **system operation** and with what impact?

5. Studies on **maintenance** of **the** system. What criteria can be used to define the level of system maintenance? How can resources be raised for maintenance? What are the maintenance roles of farmers and officials? What conditions are conducive to obtaining good maintenance?

6. Others. Case studies, the role of communications and communication technologies, and research methodologies are **additional** areas for research.

MAIN SYSTEM MANAGEMENT DISCUSSION: A SUMMARY

De Cock's supporting paper on Water Management in **the** Office du Niger gave an account of significant water savings (20%) in the Sahel Canal system through a concept for controlling water releases that required no new construction. Constant demand-driven downstream volume was regulated manually by observers who communicated daily by radio or telephone. The large size of the **Sahel** Canal permitted adequate on-line storage; the only investment required was an initial topographic survey and a mathematical model. The impressive results of this example stimulated a lively discussion of the French *School*, and the pros and cons of demand-driven systems **in** general.

Do Asian engineers learn about French systems in their formal training? Are these systems rare in Asia because they are ill-suited to Asian conditions or because they are not widely **known**? Wade pointed out that downstream control is the rule in North Africa where it generally **applies** to the **main system**; at the local level it reverts to **upstream** control.

Several participants suggested that IIMI carry out research on the comparative advantages of **upstream vs.** downstream control under various environmental and political conditions. Downstream control using automatic gates is successful in countries with strong, authoritarian governments. **Could** these systems, which are easily tampered with, also work in South and Southeast Asia? Clearly there is an element of historical chance which determines the system adopted. **Bottrill** discussed India's Chambal Irrigation System which flows between the states of Rajasthan **and** Madhya Pradesh. Although the environmental conditions are identical in both states, each operates **according** to different distribution principles.

The warabandi system of India and Pakistan brought out several comments. Wade noted that warabandi systems are relatively simple to administer but are inherently inflexible. How serious a problem is **this** in terms of water wastage? Interest was expressed for comparative **research** on **regulation** technology. Planners need to know the options, observed Moore. "Engineers who design

the systems," noted Walter, "need to know the objectives: should they design for ease of management, for simplicity of maintenance, or for maximum performance?"

Ait Kadi noted that the greater capital investment required for downstream control must be weighed against the more intensive management required by some systems for upstream control. This raises the question of the relationship between system design and institutional arrangements. As Saldanha put it, "When we talk of system management, we cannot talk of management isolated from the bigger organization to which it belongs." Managers need incentives for accountability, and technical, financial, and manpower support. "And if the manager doesn't get that support from the bigger organization, what is the use of his trying to develop more creative and effective methods of distribution?" One approach to improved irrigation management, suggested Huppert, is to look outside irrigation at management approaches that could be applied to irrigation systems or agencies.

While all participants agreed on the need for comparative research studies, they debated the methodology for comparing one system with another. System performance means different things to different people; until performance is better defined, how can two systems be compared? Should performance be limited to physical measures, such as water loss efficiency or agricultural productivity? Rao suggested that performance evaluation must be tied to clearly defined objectives. The concept of production performance vs. management performance arose as a related issue: "We can't assume that because a canal performs well in terms of physical measures, its management also performs well." Moore noted, "a canal might be designed so well that it performs adequately in spite of poor management."

What then is meant by improving the performance of managers? Should Performance be limited to efficient use of water, or does it also include efficient personnel management? Groenfeldt suggested that so long as the marginal productivity of irrigation staff is not negative and the physical performance of the irrigation system is not adversely affected, the issue of superfluous staff should not be IMI's concern. Carruthers argued that inefficient management of people necessarily involves an opportunity cost which could in theory be applied elsewhere.

At what level are performance indicators needed? Do we want to compare the performance of irrigation sectors in different countries or different systems within a region? Saldhana suggested that our primary task is "to improve the management of specific irrigation systems and the capacity of managers and planners." Wade argued for a more macro-perspective: "We need to be able to measure effects if we're going to make prescriptions. If we're going to talk about performance above the system level, it means indicators that can compare the performance of whole irrigation sectors at the national level."

One of the key factors in improved system Performance is improved communications. Chambers cited the installation of a new communication system along the Nile. Radio signals will link solar-powered monitoring stations to computers in Cairo and Aswan to regulate the entire irrigation network from Aswan to the Mediterranean. Boonyok outlined some of Thailand's options for improved communications. A communications system, observed Rao, should be thought of "as a linkage between an information system which flows up and a control system which flows down."- Coward cautioned that communication technology is only useful if it is integrated into the management organization of an irrigation system.

INSTITUTIONAL ASPECTS OF IRRIGATION MANAGEMENT

Three papers were presented in the session on Institutional Aspects. The lead paper by Bret Wallach was entitled, "Grabbing the Bull by the Horns." Supporting papers were by David Groenfeldt ("Farmer Organization and Irrigation Management: A Reconsideration") and Mick Moore ("Social and Institutional Aspects of Irrigation Management"). These three papers and the discussion are summarized in this section.

GRABBING THE BULL BY THE HORNS

Bret Wallach

In 1900 the world had about 40 million hectares of irrigated land, an area about the size of Bangladesh. Most of the systems irrigating this land had been developed by farmers; there was little question about water rights. Social cohesion had sustained these systems generation after generation.

When colonial governments began constructing large-scale irrigation systems in the 19th century, a fundamental change took place in the nature of irrigated agriculture. Irrigation was taken out of the hands of farmers and placed under the jurisdiction of government agencies. Independence brought new governments, but the old irrigation management strategies persisted. One of the first schemes built by independent India, on the Tungabhadra River, was unable to irrigate more than two thirds the intended command area. Local officers explained that upstream farmers were taking more than their share. Farmers are generally the ones who are blamed for poorly performing irrigation systems. They steal water; they refuse to follow the recommended cropping pattern; they do not maintain their field channels.

In the Indus Basin system of Pakistan, the early British estimates had suggested that 20% of the irrigation water entering the outlets (*mogha*) was lost through seepage. This figure was lowered to 10% in some estimates made after independence. Measurements in the 1970s showed that water loss rates were 50% higher than previously realized. As part of Pakistan's current on-farm water management strategy, 5,000 water-user associations are being formed to build and maintain improved water courses. It is unclear how successful these associations will be in maintaining such channels; the provincial irrigation departments have left responsibility in the hands of the farmers and the agriculture department. Physical problems of siltation and social problems of factionalism have yet to be solved.

The Gezira scheme in Sudan, the world's largest and perhaps most autocratic irrigation system, provides a lesson in large-scale management problems. Born of a colonial vision of orderly, productive agriculture, the straight lines and 4 hectare plots took shape under a three-way partnership between government, a business syndicate, and tenants. The main canal, opened to irrigate government land in 1925, was managed by the syndicate and farmed by tenants. Enforced cropping patterns, planting dates, and cultivation practices freed farmers from any decision-making, and relegated them to the role of hired labor. Ironically, over half the tenants hire other laborers to farm their plots today. The original colonial paternalism has been retained in the form of the Gezira Board, while the infrastructure which allowed this vast system to function is steadily breaking down.

Examples of other colonial legacies reveal a similar story. The Dutch began constructing irrigation systems in Java near the end of the 19th century. Like the British, they built them to last and imposed cropping rules to limit the area of paddy, especially in the dry season. Unlike the British, they attempted to provide varying quantities of water to meet seasonal crop requirements. Irrigation districts were established on a river-basin basis controlled by the provincial administrations. They lacked a detailed knowledge of soils and water crop requirements, and the flexibility designed into the system could not be utilized to best advantage. Distribution below the government outlets was entirely in the hands of village officials.

Development funds for Java after independence focussed on irrigation, primarily in the outer islands. Projects, long ignored, required massive investments in the **1970s** for rehabilitation. Even after rehabilitation, however, operation and maintenance remained grossly inadequate. Efforts to strengthen the provincial departments finally began in **1983**, but efforts to create water-user associations have not been successful. Lines of authority are tangled. Power to allocate water is still held by village officers, while rotation rules are issued by the irrigation department.

Irrigation systems developed by French engineers in North Africa exhibit features which have been generally ignored by the English speaking world. Self-regulating **NEYRPIC** gates and proportional modules were introduced in Morocco in the 1930s and have since been adopted in many parts of the country. Morocco's major irrigation systems begin with land consolidation that wipes the existing cadastral pattern clean and replaces it with a rigid geometry of privately owned plots on which particular crops must be grown. An intricate network of semi-circular-elevated concrete flumes gives a misleading picture of successful management. **Broken** modules and unauthorized crops point to uncertain relations with the farmers. Fully volumetric sprinkler irrigation is one possible solution; a cheaper approach might be to promote active farmer organizations charged with local **level** irrigation management.

Irrigation development in Thailand's central plain was oriented to averting crop failures until **1957** when the barrage at Chai Nat was built across the Chao Phraya. In **1964**, upstream storage was added to permit double cropping in much of the command area. Another project, the Mae **Klong**, is still under construction on the western edge of the plain. The carefully constructed, highly regulated network of lined canals fitted with **Rominj** weirs belies the uncertain future of a project that may never be completed. New construction by the Royal Irrigation Department is in jeopardy because Thailand cannot find markets for the rice which the project produces. Diversified cropping has met with limited enthusiasm from both farmers and irrigation staff. Meanwhile the country's older systems **are** deteriorating.

The situation is far worse in Malaysia where, by some estimates, nearly half the peninsula's **300,000** hectares of irrigated paddy land are now abandoned. In Negeri Sembilan, near Kuala **Lumpur**, the irrigation department spent **M\$120** million on project rehabilitation only to see cropping intensity fall from **75% to 25%**. In **1932**, when the irrigation department **was** created, the country had **less** than **40,000** hectares of irrigated land. **Many** settlement schemes and much investment later, the country's agricultural sector must be heavily subsidized to keep it afloat. In the Muda scheme, lined tertiary channels have been constructed at government expense to avoid field to field irrigation. **At** the same time, group farming is encouraged and farmer cooperatives have been formed to handle subsidized agricultural inputs. in spite of these efforts, farmers continue to leave agriculture, and the government's target of **80%** self-sufficiency in rice remains a dream.

Irrigation departments rarely admit that farmers should do anything except **follow** orders; the Philippines, however, may provide an exception. Between **1966** and **1980**, massive investment pushed the area under government irrigation projects from **60,000** to more than **one** million hectares. **The** lack of maintenance responsibility, coupled with willful destruction of control structures, prompted the government to experiment with alternative management approaches that directly involved farmers.

Beginning with small communal systems which had received government assistance, community organizers assisted farmers in managing their expanded irrigation infrastructure through community participation. In large-scale **systems**, farmers were encouraged to take over management responsibility for part of the system (e.g., a **lateral**). **So** far over **92,000** hectares of small and **34,000** hectares of large national projects are involved in this program. The results seem impressive. Farmers are irrigating more land with the same amount of water, while the National Irrigation Administration (**NIA**) is recovering a higher proportion of its investment on some schemes. The question remains whether these organizations can endure after the novelty and the outside support are gone.

Farmer participation experiments **also** occur in Sri Lanka. where experience with modern irrigation systems are less glorious than the ancient irrigation traditions would suggest. Water was first issued to what was then the country's largest irrigation and settlement project, Gal Oya, in 1951; by 1978, it required massive rehabilitation. A USAID-financed scheme sought farmer involvement in constructing, operating, and maintaining the rehabilitated system. Since then, participation has become a major goal for the government. The potential for improvement is great as was evidenced by the Minipe scheme. In 1978, a combined effort of a Buddhist society, a few dynamic government officials, and farmers resulted in a dramatic increase of water to the tail end. Still, the question remains: will farmers generally be so cooperative?

The privatization of government-built deep tubewells in Bangladesh may add a note of caution to the panacea of farmer participation. CARE helped organize farmer cooperatives to rebuild the distribution system on 63 deep tubewells; the irrigated area was doubled as a result. Similar results were obtained from other projects where farmers were assisted from outside. But can farmers cope with management responsibilities when left to themselves?

The expansion of irrigation has been spectacular, but we have still not learned how to build systems that work the way we say they will. The problem is often planners and administrators who see farmers not as customers but as mules. Engineers complain that farmers are eager "to throw dust into the eyes of authority." Irrigation professionals refuse to admit that, with all their specialized knowledge, they need the active cooperation of the farmers who will use the system. All around us we see what happens when we rely on technology or impotent laws to impose our wishes on farmers,

Capitulation? Giving farmers whatever they want? Nonsense. So government policy limits the amount of water that a farmer is to get? Fine; the engineer can live with that. He tells the farmers that he can do nothing for them unless they can work out a way of enforcing the agreed-upon policy. If a solution can be reached or an institution created, fine: work goes ahead. If no settlement can be reached, too bad; either the policy should be changed or the project should not be attempted. Pretending that the problem does not exist and going ahead with construction only results in wasted money.

FARMER ORGANIZATIONS AND IRRIGATION MANAGEMENT: A RECONSIDERATION

D. Groenfeldt

Participatory development, whereby the targeted beneficiaries are encouraged to take an active role in shaping the development that will affect them, has become a popular theme among international donor agencies and private organizations. A generally accepted doctrine in the field of irrigation management says that farmers should play a more active role in local infrastructure management and water allocation, and that this should be accomplished by establishing formal irrigation associations. This policy has been developed with little research on the extent to which farmer Organizations are effective in improving the physical performance of irrigation systems. While cooperation among farmers is the *sine qua non* of efficient irrigation management, organizing farmers into formal associations is only one means of attaining the requisite cooperation. Alternative approaches involving government management and enforcement might give better results in some situations.

The Need for Cooperation

Managing limited irrigation water at optimal efficiency requires that individual farmers receive less water than they desire so that society as a whole can receive the highest possible returns to investment. With limited supplies, for example, total wheat production will be higher if water is spread thinly over the entire command area than when the same limited supply is concentrated in only part

of the area. The farmer's interest in wanting enough water for maximum yields is at odds with the interest of the collectivity of farmers, each of whom wants as much water as possible. In order that each farmer gets his fair share, some form of cooperation is necessary. An irrigation system with enough water to support maximum yields is actually an inefficient system. Full water supplies and satisfied farmers are not necessarily indicators of a successful project; they may be symptoms of poorly designed systems whose command areas should be expanded to spread existing supplies more thinly and productively.

Given a water supply at the outlet which is less than the water demand below the outlet, the question of equitable allocation becomes problematic. Farmers at the head reaches can increase their yields by using extra water but this will create serious water shortages for tail-enders, and over-all production within the service area will fall. How can farmers be induced to share a limited supply of water in an equitable fashion? In some cases, head-enders might voluntarily share water with tail-enders in spite of the economic cost involved (e.g., if they are related or recognize mutual social obligations). If voluntary measures are insufficient, coercion and/or legal sanctions might be necessary.

Organizational Alternatives to Promote Cooperation

The appropriate method for encouraging farmers to cooperate depends on the circumstances. In some cases, formal farmer associations may be beneficial but they should not be seen as a blanket solution. A critical factor in evaluating the potential for voluntary farmer cooperation is the history of the irrigation system and of the farmers themselves.

There are three historical situations to consider: first, indigenous irrigation systems built and operated by stable, traditional communities represent situations where farmers enjoy a long tradition of cooperation. While the allocation of irrigation water may not be equitable, farmers follow an accepted procedure and there is little or no need to establish new institutions to promote farmer cooperation. Second, new irrigation systems running through old established farming communities are another situation where pre-existing social and political relationships need consideration before any new organizations are introduced for irrigation management. And, third, farmers in new irrigation systems within new settlement schemes may be social strangers. The socio-economic bonds that link families in stable communities have not yet had time to develop and the level of farmer cooperation necessary for efficient irrigation management can be attained only through government supervision and/or by establishing formal irrigator associations.

Depending on the ability of farmers to cooperate among themselves (which in turn is dependent on their settlement history), one or more of the following approaches might be appropriate:

1. Indigenous organization. If existing social institutions are adequate for irrigation management, a "hands-off" policy is appropriate. Most indigenous systems, as well as some new systems built in stable community environments, would fall under this category.

2. Government management. If farmers cannot manage their irrigation supplies effectively, or can manage only a portion of the system, some government involvement would be required. Nearly all large-scale systems fall in this category, with the extent of government's optimal role depending on the ability of farmers to cooperate informally among themselves.

3. Induced organization. If farmers cannot manage their irrigation supplies effectively, the government may choose to encourage or "induce" their participation in lieu of direct government management. The popularity of this approach is growing, largely because of the experience of the National Irrigation Administration in the Philippines.

While cooperation among irrigators is an economic imperative, the magnitude of such cooperation depends on specific social and historical conditions. These conditions must be considered before proposing an organizational solution to improve local management of irrigation resources.

SOCIAL AND INSTITUTIONAL ASPECTS OF IRRIGATION MANAGEMENT

Mick Moore

The very existence of the International Irrigation Management Institute reflects a shift in the agenda of irrigation management issues over recent years. Originally set by irrigation engineers, the old agenda comprised three main sets of perceived problems: inadequate financial resources for O&M, perverse and destructive behavior on the part of farmers, and the need for discipline and political enforcement. Over the past decade, a new agenda has emerged which includes an interest in the social, institutional, and political factors that give rise to poor water management.

The management of irrigation systems appears to follow a "natural evolution." In the early stages, land and water are relatively abundant, while both labor and experience in irrigation management are scarce. As experience with irrigation accumulates and water becomes more scarce relative to land and labor, greater attention is paid to its distribution and use.

A sense of the historical trajectory is important in developing irrigation management practices in order to avoid promoting practices which are inappropriate for a particular situation. Certain general pressures operate gradually over time to produce management practices which become progressively more sensitive to farmers' irrigation requirements. These pressures include: 1) time and accumulation of experience by farmers and irrigation officials, 2) increases in population densities and changes in labor markets, 3) changes in the preferred cropping pattern, and 4) diminishing opportunities for irrigating new areas.

The process of irrigation evolution is characterized by stages of management: Stage 1 - an orientation to the capture and release of water; Stage 2 - a concern with equity of water access by all farmers within the command area; Stage 3 - an effort to fine-tune water distribution to respond to varying topography, soils, and seasonal fluctuations; Stage 4 - an attempt to meet the demands of individuals or groups of farmers for given quantities and timings of water. Cross-cutting this natural sequence of irrigation management are exogenous factors including new agricultural technology, and in particular tubewells and low-lift pumps, budgetary constraints for new projects, or the national economic climate.

Other factors which influence the evolutionary sequence of irrigation systems are: 1) administrative traditions (e.g., the British administrative style is centralized, hierarchical, and rule-bound); 2) the nature of the water sources (e.g., farmers in small diversion systems of Indonesia manage higher levels of the system than do farmers in a huge system such as the Indus Basin in Pakistan); and 3) the politics of bureaucratic change (e.g., irrigation agencies tend to resist change and some are more successful than others).

The core of present problems with irrigation management lies in "pork barrel" projects put in place either because politicians want them, because irrigation agencies have a vested interest in expansion, or because various interest groups stand to benefit from construction contracts. Those nominally intended to benefit - the farmers - have no incentive to press for "economic" decision-making in construction, and no means of enforcing efficiency in the use of the facility after construction.

The recent Philippine experience indicates that drastic change in the attitudes of both irrigation officials and farmers can be effected by introducing policies which directly expose the actors to the material consequences of the investment decisions and management performance. The policy decision that NIA will have to fund most of its operating and maintenance costs, and to repay foreign loans through irrigation fee collection, appears to have brought about a remarkable change in engineers' attitudes. They have been handing over their more costly-to-run small schemes to farmers, as well as sections of large national schemes. The introduction of "mutual financial responsibility" between irrigation agencies and farmers is a promising strategy for improving institutional performance.

Some Important **Social** and Institutional Issues

1. Efficiency and public intervention **on small scale schemes**. Asian countries are likely to pay increasing attention to construction and rehabilitation of small systems. The physical potential for constructing new large-scale schemes is diminishing, while there is growing concern to develop new economic opportunities in marginal, hilly regions (e.g., NE Thailand) where large irrigation systems are not feasible. This shift of attention gives grounds **for** concern. Irrigation agencies are attempting to do things which they are unfit to do or which are simply unnecessary: pour concrete where it is not required; re-build or build farm ditches which farmers are able to do it more cost-effectively; and persuade, train or organize farmers to distribute water according to externally-imposed programs. Excessive intervention at its worst can create physical reconstruction which farmers do not want, and promote water user associations in place of, and sometimes covering different groupings of farmers than, previous community organizations; this may reduce farmers' commitment to self-help and actually reduce standards of **O&M**.

2. **System** rehabilitation. Most of **Asia** is rapidly shifting to a situation where major irrigation investments are in system rehabilitation rather than in new construction. Large-scale rehabilitation is often financed through foreign aid, and tends to be biased towards capital-intensive methods, towards rapid completion in a limited time scale, and towards periodic total rehabilitation rather than towards expanded continuous maintenance and upgrading which might be more efficient. Rehabilitation efforts generally give too little consideration to the changes in physical configuration made by farmers, or that could be suggested by farmers, based on their operating experience. Organizing farmers to participate in planning, financing, and monitoring is inadequately exploited. Other institutional aspects of rehabilitation include: (a) investment decisions and financing, (b) the influence of aid donors, (c) the degree of conservatism of irrigation agencies in organizational reform **as well as** new design and technology, (d) the **willingness**, or lack of it, on the part of irrigation officials to consult with farmers, (e) **job** incentives within irrigation agencies, and (f) the role of farmer groups.

3. Irrigation bureaucracies **and** irrigation **management**. The factors which explain variations in the performance of different bureaucracies in managing irrigation water are not **well** understood. Two methodological problems in grappling with this issue are: **a)** the lack of an operational definition of the concept of "efficiency in water management," and **b)** even if a relationship could be established between "efficiency" and the nature of management systems, the nature of the causality would not necessarily be demonstrated. Factors associated with the responsiveness of management systems are **likely** to include: a) the level of resources (staff, finances, influence) available to managers, **b)** quality and knowledge of staff, **c)** incentive structure, **d)** accountability of staff for system performance, **e)** status of irrigation management work within the irrigation agency, **f)** isolation of managers from political manipulation, **g)** corruption, and **h)** grievance procedures and information **channels** for farmers.

Some Unimportant **Social** and Institutional Issues

1. Coordination **of** irrigation **and** agricultural agencies. While coordination problems are intrinsic to bureaucracies, there are ways of ameliorating them. Other things being equal, coordination is easier between departments in the same ministry than between agencies under different ministries. There may **be** a good case for the creation of temporary super-ordinate authorities directing the activities **of** both agriculture and irrigation under certain conditions (e.g., Integrated Agricultural Development Programs in Malaysia, Command Area Development in India), but a wide range of factors will affect the wisdom and feasibility of such actions in each case. The decision to "coordinate" **will** have **spill-over** effects on other parts of the public service which **may** suffer from staff

defections to a more glamorous new department or authority. Improved "coordination" between agriculture and irrigation would almost certainly take the form of more sharing of responsibility for irrigation O&M, thus exacerbating the problem by diffusing responsibility.

2. Farmer organization. There are significant analytic and policy problems relating to farmer organization, but before considering them two distinctions must be made: a) Is the purpose of farmer organization oriented around O&M activities (water allocation, conflict resolution, system maintenance) or new investment decision-making (e.g., new construction and rehabilitation)? On the whole, the latter role is more promising, and when farmers act collectively to plan and construct irrigation channels they develop a sense of commitment to making good use of the completed facilities. b) The different kinds of situation in which farmers voluntarily cooperate to share water may range from autonomous organizations such as the Balinese *subak*, minimalist organizations where groups of farmers adhere to a set of rules such as the case of *warabandi* systems in India and Pakistan, and situations where allocation procedures are introduced and perhaps maintained through outside intervention (e.g., community organizers in the Philippines). There may also be ecological factors which promote certain kinds of Organizational solutions in different regions. Another set of issues concerns the relationship of farmer O&M groups to the irrigation bureaucracy on large-scale schemes. In cases where farmers have been exploited by irrigation officials in the past, government efforts to organize farmer participation may encounter resistance.

INSTITUTIONAL ISSUES DISCUSSION: A SUMMARY

In addition to the three formal papers presented in Thursday's session, Wade outlined a World Bank research project in which he is currently involved. The study seeks to explain O & M practices and water allocation rules in terms of several independent variables, including: 1) the scarcity value of water (a function of population density and water supply, as well as the performance of the national economy), 2) construction rates of new irrigation schemes, 3) opportunities for rainfed agricultural intensification, and 4) various other factors. National statistics from several Southeast Asian countries (including Taiwan, Thailand, and Indonesia) form the data base from which the developmental trajectory of the variables is being traced. A working hypothesis guiding the analysis is that a more or less "natural" trajectory exists in the intensification of irrigated agriculture when viewed from a national perspective.

The wide-ranging discussion sparked by the main presentations covered the topics of farmer organizations, the management of irrigation agencies, and research methodologies. One very basic question that arose was the benefits of farmer organizations. Bottrall pointed to the importance of research to determine, "what are the returns, in terms of costs and benefits, to organizing farmers in different ways or for different purposes and in different contexts?" Another set of questions is the factors determining the kinds of organizations that develop under different conditions. For example, Taiwan and the Philippines are often cited as having strong farmer organizations. Saldanha noted that "very little seems to have been written from the farmers' side. What are the cultural factors that have influenced farmers' reactions to government efforts to organize them?"

In order to understand the success or failure of farmer organizations, and their benefits, we need to know what functions they perform, or have the potential of performing. In many irrigation systems, groups of farmers are actively involved in augmenting the supply of water they would normally receive, as well as allocating that supply among themselves. Organizations originally formed around irrigation can also expand to other functions such as acquiring fertilizer or bank credit. Chambers focused attention on farmers' management roles above the outlet, either in formal groups (which is rare) or in informal understandings among farmers of different turnouts. He noted a paradox that "the better the operation of the main system, the less likely the farmers are to want to take part in

this type of operation." This point was underscored by Prakash. Farmers in small, flexible systems are more likely to organize themselves for irrigation management than in the case of large rigid systems (e.g., *warabandi*) where there are few management decisions for the farmers to make.

Moore suggested that "the greatest scope for involving farmers to improve irrigation lies in organizing farmers to make intelligent input into the rehabilitation process" where their experience with the existing system can be applied to the new design, and their labor can be recruited for construction. Moore also argued that research on the irrigation benefits and functions of farmer organizations is best conducted in systems that are undergoing rehabilitation.

The degree to which improvements in irrigation performance can be effected through improvements in the management of the irrigation agency itself drew a mixed chorus of comments from the participants. Lowdermilk stressed the importance of management functions within the agency as a neglected topic in the minds of donor agencies, whose focus is largely construction. Bottralt expressed concern, however, at the image of outside experts telling irrigation agencies how to manage themselves. IIMI might follow the example of schools of management, suggested Coward, and conduct long-term management studies in close collaboration with an irrigation agency, so that both the researchers and the managers would learn together. Another way of conducting a management study, proposed by Farooq Akbar, would be to focus on a specific irrigation function such as maintenance.

A great interest was expressed in Comparative studies of management, as well as alternative approaches. Merrey raised the issue of whether public agencies have the potential for managing irrigation effectively: "There are real limits to how well a public agency or irrigation department can manage an irrigation system because most bureaucracies are very sensitive to pressures from above, whereas their services are to the people below." Alternatives to public agencies are found in the irrigation districts of the western United States; some type of public company or irrigation cooperative might be another approach. Huppert advocated closely controlled comparative studies to evaluate different management approaches.

While many irrigation systems are undergoing rehabilitation, many others are not. Carruthers pointed to the practical need for improved management in systems which are physically deteriorating. A related issue is the shifting management responsibilities taking place in the Philippines, as the government unloads some of its systems into the hands of farmers. Is this a portent of things to come in other countries? Bangladesh is also experiencing the constraints of limited budgets, reported Bottrall, and is looking to collective management solutions.

The question of how to conduct research on the human and institutional issues was raised several times. The vague boundaries of the topic caused discomfort among the technical scientists. Walter asked for a definition of the "social irrigation system" (none was forthcoming) and asked how we can talk about social alternatives to an undefined system. The separation of social issues from the technical issues of irrigation is neither necessary nor desirable, suggested Small; rather, they can be integrated into such topics as main system management and rehabilitation. Several participants, notably Moore, viewed rehabilitation as an umbrella topic within which institutional issues could be addressed. Farmer organizations can also function as an important aspect of main system management, observed Wickham, and from an irrigation agency's perspective, it would be preferable to treat the two in an integrated fashion.

SUMMARY OF "WRAP—UP" SESSION

During the wrap-up session on the final day of the workshop, participants were asked to consider which of the four selected issues IIMI should give priority and to suggest how a research network might be formed to address those issues. The network(s) would be a vehicle for undertaking research in several countries according to a coordinated set of objectives and methodologies, and in collaboration with the Institute.

The participants' consensus was to reshape the four workshop issues into a modified research agenda. Rapid Appraisal was judged important for continued research but not as the focus of an entire research program. Rehabilitation and Main System Management were accepted as central to IIMI's research mandate. Institutional Aspects was integrated into both Rehabilitation and Main System Management. Finally, a new topic was proposed: small-scale community managed systems, particularly with regard to the role of the government irrigation agencies in upgrading their physical and/or institutional infrastructure.

Discussion began with the participants' reaction to the proposed addition of small-scale systems as a separate topic. Moore suggested that small-scale systems should be separated from large-scale systems because they are usually under the jurisdiction of separate government agencies (with small-scale systems often part of the agriculture department). Prakash voiced the general consensus that there are enough different features between small and large systems to justify treating them separately. Berkhoff and Wade pointed to irrigation extension as a means of effecting improvements in community irrigation systems without altering the indigenous management structure.

Three groups were formed to consider each of the current topics (Rehabilitation, Main System Management, and Small Systems). Each group was asked to reach a consensus on the priority research issues, the methodology for addressing those issues, the countries where the research should be done, and the organizations which might work with IIMI in long-term research projects.

Rehabilitation

Six rehabilitation issues were identified: 1) trade-offs between maintenance and rehabilitation in terms of performance and/or cost-effectiveness; 2) information requirements for planning rehabilitation; 3) alternative irrigation technologies; 4) the roles of various agencies, including donors, consultants, and government irrigation agencies; 5) the role of farmers in planning, designing, and implementing rehabilitation; and 6) the economic and institutional impact of rehabilitation.

Available research sites could be very limited for detailed action research or extensive if completed rehabilitation projects were studied by a collaborating network of institutions in several countries. In either case, selection criteria should include: 1) the "lavishness" of the program (per unit cost); 2) the percentage of domestic financing; 3) type of donor and financial agreements; 4) characteristics of the irrigation agency; 5) the system's size; 6) the physical, agricultural, and social environment; 7) the proportion of the system undergoing rehabilitation. and 8) whether rehabilitation involved a modification of the original design objectives

The disciplines involved would be weighted towards engineering but would strongly emphasize institutional aspects. Outputs would help guide agencies in their approach to rehabilitation, but would not try to anticipate specific questions. Potential pitfalls and opportunities would be suggested.

Main System Management

The primary focus is **large-scale** gravity flow irrigation systems. System performance would be dealt with by evaluating actual physical performance against design specifications and identifying opportunities to improve that physical performance. This would present a range of hardware and software options. Any research on design and management interactions would require the cooperation and collaboration of the irrigation agencies concerned.

Issues include: 1) operation and maintenance options, 2) regulation technologies, 3) scheduling and methods of water allocation, 4) operational plans, and 5) communications and information management. The selection of research sites would determine the feasibility of studying specific features such as conjunctive use, intensive vs. extensive irrigation, and upstream vs. downstream control. Two different but simultaneous strategies could be pursued. First, relatively rapid case studies of improved management Performance could yield short-term payoffs with limited effort. This strategy would involve documenting cases that are already known to be successful. Second, detailed studies of systems in several countries would be investigated through a collaborative network of local scientists and/or agencies. Long-term research objectives would focus on **generalizable** lessons. Countries included in such a network might be Indonesia, the Philippines, Sri Lanka, Thailand, India, Pakistan, Morocco, and Sudan.

Efficiency of Small-Scale Systems

Small-scale systems are defined according to size (which varies from country to country) and farmer management or with a clear potential for farmer management. **Small-scale** systems research should begin by surveying selected countries to identify the current situation and establish research network contacts. Such a network would enable **international** and regional comparisons, which are of concern to IIMI. However, the linkages within a country (e.g., between academic institutions and government agencies) are outside IIMI's direct role. Because small-scale systems research involves a strong **social** science component, questions were raised about the institutional capacity of irrigation agencies to provide expertise. Prakash advocated a component of institution building as part of the larger research effort.

A few general research issues were discussed. Among them were alternatives to government intervention, and the hardware and software needs implied. Site selection criteria should include new government-built small systems that have potential for farmer management, as well as indigenous systems that have always been managed by farmers. In either case the focus **would be** on the role that the government does, should, or should not play in managing some part of small-scale irrigation systems.

General Discussion

The issue of performance indicators was raised at various times during the week and was brought up again in the wrap-up discussion. Wade suggested that universal measures are not needed in order to improve performance in specific cases. While a conceptual understanding of the range of factors that can bear on performance is important, absolute measurements are not feasible. The indicators selected to evaluate performance require new thinking. Noted Subasinghe, "We must consider social indicators as well as physical ones." Berthery proposed that performance be assessed in terms of specific criteria for identifying opportunities for management improvements. Merrey commented that a good general orientation for evaluating performance is the system's responsiveness to farmers' irrigation needs.

Many participants expressed interest in the interaction of the physical design and system management. Wade mentioned a recent study of the variety of designs proposed by four consulting firms competing for a project in the Tarai. What factors account for the choice of a given technology and to what extent is it simply a function of engineering traditions? Small asked for research into the underlying principles and necessary conditions associated with different operational procedures such as *warabandi* and indenting

By concentrating on three main topics, many interesting small issues were necessarily omitted. Chambers itemized a number of these "gap" topics to bring them to the attention of the group:

1. **Rapid** appraisal. We need a field manual on rapid appraisal techniques for irrigation management. This might be along the lines of Rhoades (1982).¹
2. **Action** research methodology. This might grow out of IIMI's proposed research networks.
3. **Irrigation and farming** systems. This should emphasize labor constraints.
4. **Social benefits and costs** and the indirect impacts of irrigation schemes.
6. The "donor black box". How do donors arrive at investment decisions and what effect do they have on national irrigation policies?
6. **Farmers' role** in main system management.
7. **The experience** of practicing engineers. Practitioners should be encouraged to record their experiences.
8. **Global** irrigation statistics. There appears to be no centralized and accessible database for basic irrigation information (e.g., the amount of new irrigation construction in a given year).
9. **Conceptual categories** for analyzing irrigation development. There is no agreement about a typology for irrigation systems.
10. **Drainage**. This "other side" of irrigation is not given adequate attention.

¹ Rhoades, R. 1982. "The art of the informal agricultural survey." Social Science Dept., International Potato Center (CIP), Lima, Peru. Training document 1982-2.40p.

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