

Expanding the Frontiers of Irrigation Management Research

*Results of Research and Development at the
International Irrigation Management Institute,
1984 to 1995*

Douglas J. Merrey



IIMI

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

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Cover photograph, by M.S. Shafique, shows researchers measuring the discharge of a river-lift pump (along the White Nile) located near El Dueim in Sudan.

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Foreword

In 1995, the International Irrigation Management Institute (IIMI) celebrated its tenth anniversary. This was also the year in which IIMI made significant changes in its program priorities. The most important change was to correct an imbalance that had developed between IIMI's development and research mandates: its development work had advanced more rapidly than its research capacity. Therefore, IIMI has now reemphasized the importance of strengthening its research program to provide intellectual leadership in the field of water resource management and irrigated agriculture. This is being done while continuing IIMI's program of capacity building through collaborative research with national scientists.

To provide a good foundation for this shift in emphasis, we felt that a thorough review of the findings and results of IIMI's research during its first decade would be useful. The present document is the result. Many readers may be pleasantly surprised to find that IIMI has already produced a lot of interesting and useful research results. The author of this book does not shrink from pointing out weaknesses and lost opportunities, but also brings out what IIMI has achieved. One important reason why IIMI's research results are not better known is that so many are reported in unpublished project reports and workshop papers; this book is designed to make these results more accessible.

The book has multiple audiences: researchers (including IIMI's own staff), policy makers, water resource managers, donors, consultants, and students. It therefore has all the strengths and weaknesses implied in an attempt to write for multiple audiences: researchers may wish to know more, while others may feel there is too much detail. But I hope that reading this volume will whet the appetite of researchers and students to seek out the original sources for more details and to carry out further research to confirm, refute, or replace the reported findings. The long summary, detailed table of contents, and index will make it easier for those with particular interests to look these up quickly and conveniently.

None of the research reported here could have been carried out without the active cooperation and collaboration of many people and institutions. They are too numerous to name but, particularly, include the various irrigation management agencies and research institutions in the countries where IIMI has worked. IIMI is grateful for their cooperation and acknowledges that none of its work would be possible without this.

The author, Douglas J. Merrey, has been a staff member at IIMI since 1985 (he left IIMI briefly in 1995 and returned in 1996). He has written this report based on his comprehensive knowledge of IIMI's work and the intellectual context within which it was done. We are grateful to Doug for accomplishing this heroic task so quickly and well.

David Seckler

Director General

International Irrigation Management Institute

Acknowledgments

The idea for preparing this book came from IIMI's Director General, David Seckler, who felt that an earlier overview of IIMI's research results and impacts should be updated. He read the early drafts of the first two chapters and suggested improvements; and encouraged me to continue at a level of detail that is far greater than that of the original paper. What started as an exercise to "update" that earlier report, therefore, turned into a much larger project, but hopefully one that is more valuable in substantive terms.

Randy Barker read the early chapters and pointed out that I had often taken too much for granted and failed both to explain clearly some points and to use the figures and tables in a way that fully supports the argument. Chris Perry was in overall charge administratively and was very supportive and helpful in more ways than he may realize. Other IIMI staff provided me with papers and documents, and summaries of work that are presently underway, for which I thank them.

I offer special thanks to Charles Abernethy, who undertook to read a draft of the book and offered detailed comments, corrections and suggestions. Charles has been associated with IIMI for the same period as I have, making his suggestions particularly valuable. I have not been able to use all of his suggestions, but have used most of them.

I owe a debt of gratitude to the IIMI Information Office and Library Staff. Jim Lenahan, head of the office, helped me to update my list of IIMI research papers, helped me out with computer problems several times, and responded immediately whenever I appeared at his door with another "urgent" request. David Van Eyck, in charge of distribution of IIMI publications, shared his holdings with me. The library staff, especially Ramya, Shanthi, and N. U. Yapa, were extremely patient and helped immensely in tracking down reports and publications. This report could not have been completed without their professional assistance.

Finally, many sections of this book were written in the Jakarta office of Gaia International Management Inc., my "home" from January to July 1996. I thank the Managing Director, Jan Gerards, for unstintingly providing me a computer, printer, a place to work, office supplies, and his genial and stimulating company. These thanks to him are also on IIMI's behalf as these services and facilities were provided without charge.

I return to thanking David Seckler for giving me the opportunity to prepare this book. I found it very interesting and personally rewarding; and I feel gratified that IIMI has produced so much more useful work than is generally realized. With all this assistance, I remain responsible for any errors or omissions.

Douglas J. Merrey

Abbreviations

ADB	Asian Development Bank
ADRC	Associated Development Research Consultants (Sri Lanka)
APM	Adjustable proportional module (Pakistan)
ASEAN	Association of South East Asian Nations
BAU	Bangladesh Agricultural University
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economic Cooperation and Development, Germany)
B/C	benefit/cost
cumec	cubic meters per second
CBP	Columbia Basin Project (USA)
CCA	Culturable Command Area
CEMAGREF	Centre National du Machinisme Agricole, du Genie Rural, des Eaux et des Forêts (France)
CGIAR	Consultative Group on International Agricultural Research
CRBC	Chashma Right Bank Canal (Pakistan)
CRWS	Cumulative Relative Water Supply
CTL	Critical Tolerance Level
dS/m	decisiemens/meter
DID	Department of Irrigation and Drainage (Malaysia)
DPR	Delivery Performance Ratio
DSE	Deutsche Stiftung für Internationale Entwicklung (German Foundation for International Development, Germany)
DSS	Decision Support System
DTMO	Tenants' organization (Sudan)
DTW	deep tubewell (Bangladesh)

EC	Electrical Conductivity
ECL	Engineering Consultants Ltd. (Sri Lanka)
EDI	Economic Development Institute (of the World Bank)
ERR	Economic Rate of Return
ET	Evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
FIO	Farmer Irrigator Organizer (Philippines)
FMIS	Farmer-Managed Irrigation System
FSD	Full Supply Discharge
GKF	Grameen Krishi Foundation (Bangladesh)
GMP	Mutual Production Unit (Niger)
GNP	Gross National Product
GPV	Gross Product Value
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
HIMAT	Institute of Hydrology, Meteorology and Land Development (Colombia)
HJRBDA	Hadejia-Jama'are River Basin Authority (Nigeria)
HR	Hydraulics Research (Wallingford)
IA	Irrigation Association (Philippines)
IAAS	Institute for Agricultural and Animal Sciences, Tribhuvan University (Nepal)
ICID	International Commission for Irrigation and Drainage
IEE	Initial Environmental Evaluation
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IHE	International Institute for Hydraulic and Environmental Engineering (Netherlands)
IIED	International Institute for Environment and Development (Britain)
IIMA	Indian Institute of Management, Ahmedabad (India)
IIMI	International Irrigation Management Institute
ILRI	International Institute for Land Reclamation and Improvement (Netherlands)
IMCD	Research Network on Irrigation Management for Crop Diversification in Rice-Based Systems

IMIS	Irrigation Management Information System
IMPISA	Irrigation Management Policy Support Activity (Sri Lanka)
IMTI	Irrigation Management Training Institute (Tamil Nadu)
INCA	Irrigation Network Canal Assessment (HR/Wallingford)
INMAS	Integrated Management of Major Irrigation Schemes (Sri Lanka)
IRMA	Institute for Rural Management, Anand (India)
IRMU	Irrigation Research Management Unit (Sri Lanka)
IRR	Internal Rate of Return
ISF	Irrigation Service Fee
ISMP	Irrigation Systems Management Project (Sri Lanka)
ISNAR	International Service for National Agricultural Research
ISPAN	Irrigation Support Project for Asia and the Near East (USAID)
ITIS	Information Techniques for Irrigation Systems
KRIP	Kano River Irrigation Project (Nigeria)
LCC	Lower Chenab Canal (Pakistan)
LLP	Low Lift Pump (Bangladesh)
LSC	Lower Swat Canal (Pakistan)
mcm	million cubic meters
M&E	Monitoring and Evaluation
MADA	Muda Agricultural Development Authority (Malaysia)
MANIS	Management of Irrigation Systems (Sri Lanka)
MDR	Management Delivery Ratio (Sudan)
MIRP	Major Irrigation Rehabilitation Project (Sri Lanka)
MIS	Management Information System
MPWWR	Ministry of Public Works and Water Resources (Egypt)
MTP	Medium Term Plan
NARS	National Agricultural Research Systems
NCP	North Central Province (Sri Lanka)
NGO	Nongovernment Organization
NIA	National Irrigation Administration (Philippines)
NIMI	National Irrigation Management Institute

NR	Nepali rupee
NWFP	North-West Frontier Province, Pakistan
NWMP	National Water Management Project (India)
NWRC	National Water Research Center (Egypt)
O&M	Operation and Maintenance
ODA	Overseas Development Administration (Britain)
ODI	Overseas Development Institute (Britain)
ONAHA	Office National des Amenagements Hydro-Agricoles (Niger)
PAR	Participatory Action Research
PEEM	WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control
PIO	Provincial Irrigation Office (Philippines)
PICA	Performance Improvement Capacity Audit
PMC	Project Management Committee (Sri Lanka)
PMI-BF	Irrigation Management Project (Burkina Faso)
PRA	Participatory Rural Appraisal
R&M	Rehabilitation and Modernization
RBDA	River Basin Development Authority (Nigeria)
Rp	Rupiah (Indonesia)
RUG	Resource User Group (Sri Lanka)
RUO	Resource User Organization (Sri Lanka)
RWS	Relative Water Supply
SAR	Sodium Adsorption Ratio
SCOR	Shared Control of Natural Resources Project (Sri Lanka)
SCRB	Separable Costs Remaining Benefits
SIC	Simulation of Irrigation Canals
SIAM	Shijiazhuang Institute of Agricultural Modernization (China)
SIR	Supply Indent Ratios (Sudan)
STW	shallow tubewell (Bangladesh)
TAC	Technical Advisory Committee of the CGIAR
TC	Training Center (Egypt)

TIMP	Tank Irrigation Modernization Project (Sri Lanka)
TNA	Training Needs Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
USA	United States of America
USAID	United States Agency for International Development
USBR	United States Bureau of Reclamation (USA)
VASFA	Vaishalli Area Small Farmers Association (India)
VIMG	Village Irrigation Management Group (China)
WALMI	Water and Land Management Institute (India)
WAPCOS	Water and Power Consultants, India
WARDA	West Africa Rice Development Authority
WECS	Water and Energy Commission Secretariat (Nepal)
WHO	World Health Organization
WIIP	Walawe Irrigation Improvement Project (Sri Lanka)
WMP	Water Management Project (Sri Lanka)
WNASA	White Nile Agricultural Schemes Administration (Sudan parastatal)
WNHC	White Nile Holdings Company (Sudan private firm)
WRMT	Watershed Resource Management Team (Sri Lanka)
VSFA	Vaishalli Area Small Farmers Association (India)
WUA	Water Users Association
WUHEE	Wuhan University of Hydraulic and Electrical Engineering (China)

Summary

Introduction (Chapter 1)

The purpose of this book is to consolidate into one accessible document an overview of IIMI's research results during its first decade, i.e., from 1984 to the end of 1995. The book is organized around IIMI's revised program structure to enable the reader to understand how the past research leads directly to the present and future research programs. The book also reviews several of IIMI's major institutional strengthening activities. The intended audience is primarily water resource and irrigation researchers and other professionals interested in understanding what IIMI and its partners have contributed to irrigation management research; but policy makers and irrigation managers may also find the book useful. It focuses almost entirely on IIMI's own results and refers to others' research only to place IIMI's work into a broader context. It makes use of a wide variety of published and unpublished papers and documents. Some of these are informal and scattered—true “gray literature”—and are therefore difficult to find outside IIMI's library and the files of a few staff members.

Performance Assessment (Chapter 2)

Assessment of irrigation performance has always been at the heart of IIMI's program. The work is discussed under three headings: conceptual frameworks for assessing performance, quantitative measures of performance, and applications of performance assessment methodologies for both comparative analysis and analysis of impacts of interventions.

Conceptual Frameworks

The International Food Policy Research Institute (IFPRI) and IIMI collaborated to develop a widely used “nested framework.” This nested framework places the management of irrigation water into increasingly broad contexts, moving from irrigated agriculture to higher levels such as the agricultural economic system. It thereby clarifies responsibilities and relationships among the complex activities that constitute irrigated agriculture. The nested system has been complemented by another framework that emphasizes the dynamic nature of the management process, particularly at the level of irrigation system managers, and introduces the important dis-

inction between operational performance (“Am I doing things right?”) and strategic performance (“Am I doing the right thing?”).

A third conceptual framework has been developed to assist in answering a different question: what is the capacity of a given irrigation system to improve its performance? This *performance improvement capacity audit* provides five basic questions that can be used to assess quickly what kinds of interventions are likely to be successful in a given irrigation system. A related approach distinguishes between *functional* and *dysfunctional* systems: functional systems have defined water rights, infrastructure capable of delivering the service embodied in water rights, and assigned responsibilities for all aspects of system operations; dysfunctional systems lack one or more of these features.

Performance Indicators

IIMI has published the only available major review of the range of irrigation performance indicators available, and how they have been used. In addition, its staff and partners have developed several specific quantitative measures of performance, some of which continue to be used by staff members and other researchers. These include measures of delivery performance based on targets (Delivery Performance Ratio), measures of equity, and measures of adequacy (for example, Cumulative Relative Water Supply). More recently, IIMI staff have begun testing a “minimum set of indicators” for irrigation performance, which puts particular emphasis on the economic value of water.

Comparative and Impact Studies

IIMI has carried out several comparative studies of irrigation systems, as well as studies of the impact of investment projects or specific innovations. Two comparative studies found that very few managers have clear objectives or interests in assessing system performance; one of the studies documented the absence of indicators for environmental trends, and showed that systems with simple designs tend to have better performance than more complex systems.

A study comparing the actual field impacts of full desilting, targeted desilting, and lining of canals in Pakistan showed the latter is the least cost-effective and, in the case studied, actually had a negative impact on performance because of institutional problems affecting implementation. Both targeted and periodic full desilting have high positive returns.

Conclusion

Some of the indicators and frameworks developed have not yet been adequately tested in a sufficient number of countries. IIMI is now shifting its attention from the development of indicators to the application of the minimum set. It is also adopting a wider *water basin* perspective, within which it examines irrigation performance, including increasing competition among different users for scarce water supplies; and is paying more attention to system outputs than to management processes. It is also making more use of new technologies including geographic information systems and remote sensing.

Design and Operation of Irrigation Systems (Chapter 3)

Improved operation and maintenance of irrigation systems are central to achieving higher production from irrigated agriculture. This program seeks ways to improve the hydraulic and agricultural performance of canal irrigation systems, conjunctive use of canal water and groundwater, environmental sustainability with special reference to waterlogging and salinity, and the management of maintenance and modernization of irrigation systems, especially through the use of management information and decision support tools.

Management of Rice-Based Irrigation Systems for Other Crops

During its first 5 years, IIMI focused much attention on the management of rice-based irrigation systems to support diversified cropping, particularly higher-value crops that can be grown in the dry season in Asia. Other crops are often more profitable but rice farmers are often reluctant to grow them. There are several reasons for this, but one relates to water delivery on irrigation systems. Irrigating non-rice crops requires more intensive management to deliver smaller quantities of water at regular intervals, better communications between managers and irrigators, and high reliability of water supplies. Work in Sri Lanka, the Philippines, Indonesia, and Bangladesh showed the potential for doing this and demonstrated what kinds of management changes would support the cultivation of higher-value crops.

Canal Irrigation: Pakistan

IIMI and a variety of collaborators have been working on the performance of canal irrigation in Pakistan's very large irrigation systems in three sites (two in Punjab, one in the North-West Frontier Province). Most of Pakistan's systems are classic supply-based systems whose objective is to distribute a scarce water supply equitably; farmers are then expected to adjust their cropping patterns to this fixed but predictable water supply. IIMI's research has demonstrated the very wide gap between design assumptions and reality. Distribution of water among outlets on distributaries is highly inequitable and unreliable. As a result, there is also a wide gap within watercourses between the theory of *warabandi* (fixed rotations based on a period of water flow proportional to area) and the reality. The causes relate to changed hydraulic conditions in canals because of poor maintenance, widespread tampering with outlet sizes, and the operation of canals at very low heads. Frequent interventions by gate operators lead to increasingly large disturbances in water supplies to tail ends. The systems are *dysfunctional* in that the infrastructure is no longer capable of delivering the service embodied in the water rights.

Research was done on two systems which are experiments with *crop-based* designs as an alternative to the supply-based design of *warabandi* systems. These systems have higher water duties and can be operated more flexibly to meet the peak demands of a specified cropping pattern; they are thus partial demand-based systems. The research, however, showed these systems are operated as if they were supply-based, leading to high variance and a tendency to oversupply water. Farmers respond through a "refusal" system—turning off water when it

is not needed, and growing more high water-consuming crops than originally planned. As currently implemented, these systems are also dysfunctional: the institutional capacity to manage the infrastructure based on modified water rights is lacking.

Other Irrigation Systems: Sudan and West Africa

Research on large irrigation systems in Sudan found similar problems as in Pakistan: dependability and equity are low, there is a consistent pattern of over-indenting and oversupply; and as in Pakistan, yields are quite low compared to their potential. Research on small systems in West Africa found high levels of yield and cropping intensity, but low productivity of the most scarce resource—water. Basic data on these systems are either not available or unreliable. Reducing design duty and designing systems for an “optimum” area-reservoir capacity relationship can significantly reduce construction costs and increase the productivity of water.

Conjunctive Use of Groundwater and Surface Water

IIMI has carried out research on conjunctive use of groundwater and surface water in Pakistan and Bihar, India. In Pakistan, over 60 percent of the water used for irrigation now comes from groundwater, and extraction exceeds recharge in many places. Dependence on groundwater for irrigation increases as a percentage of total supply from head towards the tails of canals; but there is no relationship between location on a canal and density of tubewells. The more surface water is used, the more groundwater is also used in absolute quantities (but not percentage), leading to higher cropping intensities and yields at the heads of canals.

Water markets are becoming increasingly important in Pakistan. Tubewell owners tend to be larger farmers. Availability of tubewell water stabilizes supplies where surface water is unreliable. There is a high rate of water sales by tubewell owners, and also high rates of exchange of warabandi turns (though this is technically illegal). Researchers have expressed concern about the long-term implications of closing deep public tubewells in favor of shallower private tubewells; this may lower the quality of water used in irrigation, overload the already overstretched electric supply system, and reduce equity of access to water. Government energy policies have a very significant impact on farmers' decisions regarding the installation and use of tubewells.

In Bihar, IIMI collaborated with several partners in a large canal system characterized by low production and incomes, with very unreliable water supplies at the tail. Groundwater is shallow and of good quality, but operational costs of tubewells tend to be high, especially given current profitability of crops. There is a market for water, but tubewell owners charge kinfolk and members of the same caste low rates, and charge high rates to low-caste cultivators. The research suggests repairing the canals, improving the institutional environment for canal operations, and reducing tubewell operating costs would significantly raise production.

Waterlogging and Salinity in Pakistan

A basic conclusion of the work on waterlogging and salinity in Pakistan is that while waterlogging is no longer a serious threat, *rising salinity and sodicity balances are an increasingly*

serious threat to Pakistan's agriculture. The sodicity trend is particularly serious; its buildup is slow, but once established its solution is difficult. Use of poor quality groundwater, especially in the tail ends, combined with inadequate leaching using surface water is leading to serious secondary salinization of soils. In principle, the solution is reducing the amount of groundwater used and increasing surface water deliveries, but there is not sufficient surface water to do this. The ratio of surface water to groundwater is central, and as the supply of surface water cannot be increased, the solution may be to reduce either the area cultivated or cropping intensity, or both; such a reduction is already occurring at the tail ends of the system in an unplanned manner, but will have profound social, economic, and political repercussions. The research has also shown the institutional roots of the problem, which make solutions problematic; both data collection systems and management agencies are fragmented and ineffective.

Irrigation Management Information Systems

IIMI has worked with national and international partners to develop and test management information and decision support systems for canal managers. A generic process for identifying problems, and generic Irrigation Management Information Systems (IMIS) that can be adapted for use in a wide variety of contexts have been tested in two countries (Sri Lanka and Pakistan). They emphasize collecting key data, communication of the data to managers, and the use of computers to convert the data into useful decision tools. IIMI has also worked with system managers in Gujarat, India to adapt an existing data collection system to make it more user-friendly, and computerize its outputs as a management tool.

Management of Maintenance and Modernization

Research on management of maintenance has shown that it tends to be *administered, not managed*. As a result, it is not done cost-effectively. Improvements in management of scarce maintenance funds should precede allocation of additional funds for maintenance. A comparative analysis of different strategies for rehabilitation and modernization of systems in Sri Lanka found that more attention to institutional strengthening, more involvement of users in planning and implementing improvements, and "pragmatic" rather than full-scale rehabilitation make such projects far more cost-effective.

Design Processes

The design process on both small farmer-managed irrigation systems and larger irrigation systems is best conceived as a *socio-technical* rather than a purely technical process. It should be based on a dialogue with users and designs that are simple to maintain and operate, should use low-cost materials, and should be driven by local demands, while improvements should be phased over time to be effective.

Conclusion

Most of the work on design and operation of irrigation systems has assumed a particular design and has asked how it could be made to work better. Relatively little work has been done on alternative designs; for example "structured" supply-based designs versus more complex designs intended to achieve flexibility to meet changing demand. This is likely to change in future as IIMI places more emphasis on technical engineering features of irrigation systems. Much of the work to date has been on individual cases, with little comparative analysis; this is also likely to change, with more emphasis on comparative analysis to confirm what works and what does not under particular circumstances. IIMI will continue and expand its work on management information systems, conjunctive use, salinity, and improved operations.

A consistent theme in all the work on system management is the weakness of institutions at all levels. This is the topic of the next program.

Policy, Institutions, and Management (Chapter 4)

IIMI has worked on a wide variety of issues related to policy and institutions since its inception. This program consolidates a diverse set of activities that add up historically to the area having the most output.

Cost Recovery and Institutional Performance

One of the earliest multi-country comparative studies examined the question of what is the relationship between how irrigation services are financed, and the level of service. *The major finding is that where financially autonomous irrigation agencies obtain a fair portion of the financing of service costs through irrigation fees, performance tends to be higher.* This finding is now an accepted assumption in many donor documents.

A more recent study in Egypt used a model of the agricultural system developed by IFPRI to examine the likely impact on agricultural production of alternative modes of charging for irrigation services. Comparing flat area fees, crop-based area fees (where the fee is higher for crops using more water), and pure volumetric fees, it found that the latter two modes would at best have modest impacts on farmers' decision making and thus on water use efficiency; the costs of infrastructure and institutional arrangements required for these two options would be high, making such an approach infeasible.

A related question is, can small farmers in poor countries afford to pay for O&M? Results of research in Sri Lanka and more recently in Egypt show that O&M costs amount to no more than 4-6 percent of net farm incomes; only if all capital costs are included do the amounts get very high. Studies in the USA, Colombia, China, Bangladesh, and Nepal come to similar conclusions.

Sector Policies

A detailed study of investment trends in Sri Lanka shows that up to about 1980, construction of new systems was a good investment, as improved technology raised productivity faster than the increase in construction costs. Since that time the costs of new construction have risen above the economic benefits; but the study demonstrated that investment in rehabilitation projects with strong institutional strengthening gives very high returns.

IIMI attempted to develop a method for analyzing the goals that countries have for their irrigation investments, using Pakistan as a case study. The study found that there are a large number of formal goals as stated in official documents, and these are often contradictory. Many goals are implicit and not stated clearly, in a way that could be analyzed by policy makers to decide their priorities.

Another interest was how to assist countries to develop and achieve broad agreement on policies and implementation strategies. IIMI helped facilitate a 2-year project in Sri Lanka ("IMPSA") that used a highly participatory and interactive approach; its outcomes remain the basic guidelines for the country. An attempt to use a similar approach in Egypt had less success, for a variety of reasons.

Institutional Determinants of Performance

A number of different studies in Sri Lanka, Pakistan, and Egypt in particular, have demonstrated the weak performance orientation in irrigation management agencies, lack of focus on providing services to customers, and slow rates of innovation. These problems are deeply rooted in these agencies' institutional structures. In Pakistan, a set of "informal institutions" has developed parallel to, and in conflict with, the formal institutional structures; and both are no longer adequate to address modern issues and problems. In Sri Lanka, a major irrigation development and management agency continues to have a rigid paternalistic top-down bureaucratic culture that inhibits the effectiveness of its attempts to encourage farmers' organizations. The Ministry in charge of water in Egypt is also highly centralized, fragmented into many programs and units among which there is often duplication of functions, is not accountable to its customers in a systematic manner, and has human resource policies that do not motivate its staff to perform at a high level. In these countries, *irrigation is administered, not managed, as is the case for many such irrigation agencies around the world.*

In two case studies in Sri Lanka, research documented the weaknesses in accountability and responsibility of both the government agency and the donor in projects whose performance was very disappointing. In one of these cases, a long-term collaborative intervention program based on participatory action research was able to bring about improvements, largely by creating an agreed technical basis for seasonal water allocations on a water-short system, and a legitimate forum for discussion of issues and arriving at decisions.

On another Sri Lankan irrigation system during a serious drought, IIMI documented the success of a policy that followed a rigid administered approach for water allocations at a macro level, and a flexible entrepreneurial approach at lower levels to try to satisfy varying demands from users. Unfortunately, the agency did not fully recognize the legitimacy of the flexible arrangements at the lower levels.

Irrigation Management Transfer

IIMI defines irrigation management transfer as a shift in responsibility and authority for managing irrigated agriculture from government to nongovernment entities. It has carried out case studies in North America, South America, Africa, and Asia, has worked with several countries implementing management transfer, and has sponsored or participated in numerous workshops on this topic. It is probably the single topic on which IIMI has done the most research. The discussion of the cases is in terms of four topics: the management transfer process, the supporting conditions for management transfer, organizational models, and an assessment of the outcomes or performance impacts.

Irrigation Management Transfer: Case Studies

The Columbia Basin Project (USA) and irrigation districts transferred in Colombia are relatively successful cases: there was demand from the farmers concerned, the supporting conditions were positive, and the organizational models appropriate and legally supported. The Niger case, on the other hand, exhibits institutional and financial weaknesses because of inadequacies in the supporting conditions and organizational model, while the case of a river basin authority in Nigeria undergoing "commercialization" is at too early a stage to evaluate. The latter is an attempt to transfer a transfer process and organizational model from South Asia to a new situation; early results were promising.

IIMI has been closely associated for 10 years with the "participatory management policy" of the Government of Sri Lanka. Based on a case study of a system perceived as "successful," and on a comparative analysis of a large sample of "turned over" subsystems on jointly managed systems, it appears that the outcomes so far are, at best, mixed. The supporting conditions are not conducive to farmers taking full responsibility for system management, as farmer organizations remain dependent on the government for contracts and support, and have no financial responsibilities for system O&M. The comparative study found that water distribution may be better on systems managed by farmer organizations, but there is no apparent change in the maintenance quality or cropping intensity and yields. Many farmer organizations are in other agricultural businesses that get more attention than does irrigation management. Sri Lanka may be a "false failure" as there is no real transfer of authority and responsibility from government to nongovernment entities.

A recently completed comparative analysis of policies and examples of transfer in six states in India shows that there is much variation among these states, and the record is mixed; transfer is limited at best, and as in Sri Lanka, not linked to financial incentives. There are positive signs of impact, and the study predicts some states may succeed in their policy objectives of transferring responsibilities to farmer organizations.

The Philippines is a pioneer of irrigation management transfer. But a case study supported and published by IIMI raises questions about the effectiveness and commitment of both the irrigation associations studied, and the staff of the National Irrigation Administration. An important observation is that there is an inverse relationship between the physical condition of systems and the "viability index," the ratio of income and expenditures. This suggests the possibility that maintenance is being deferred to maintain a positive viability index.

Finally, IIMI worked with national collaborators to study two systems in north-central China, one relatively water-short, the other with an adequate water supply. Supporting conditions for local management of irrigation are very strong. Water rights, and linkages between these rights and financial responsibility are clear. An interesting observation is the importance of "sideline enterprises," businesses run by the irrigation management agency to raise funds used to keep irrigation fees down, improve the system, and pay attractive salaries to staff. This characterized the water-short system whose water was relatively more expensive as some had to be purchased from outside the system.

Irrigation Management Transfer: General Lessons and Observations

IIMI has recently begun moving from case studies to comparative analyses and drawing of conclusions from the experiences of various countries. This has been facilitated by the results of a major international conference on irrigation management transfer, co-sponsored by IIMI and held in Wuhan, China, in 1994. *It is clear from results in many countries that an important precondition for success is the political will to increase irrigation fees to the level of real O&M costs: countries that continue to heavily subsidize these costs are not able to achieve full transfer of responsibilities. Clear water rights, legal and political recognition of user organizations, benefits that exceed the costs, and a firm long-term political commitment to transfer are also necessary conditions.*

On small systems, direct management by farmers or their elected representatives is effective; but larger systems are more effectively governed through irrigation districts in which an elected board hires staff to manage the systems, with federations of organizations on particularly large systems. There is evidence to suggest that irrigation systems managed by an organization dedicated to that system, and that is financially and organizationally autonomous from the government, will perform better than systems managed by agencies that operate multiple systems, particularly if these agencies are dependent on the government.

A review of literature on management transfer suggests that the impact on O&M is either neutral or positive, but cropping intensity, area cultivated, and yields often increase; there is a reduction in the number of operational staff and costs for farmers increase over what they had been paying (but government costs are reduced); and farmer organizations often diversify their income sources beyond service fees (China being the most extreme example).

In future, IIMI's research on irrigation management transfer will put more emphasis on systematic comparative analysis of impacts; more attention will be paid to the economic implications of transfer; transfer will be studied in the context of broader policy and institutional reforms; and with the recent initiation of a program in Mexico, more attention will be paid to post-turnover "second generation" questions.

Farmer-Managed Irrigation Systems (FMIS)

Especially through its programs in Nepal and Sri Lanka, IIMI since its inception, has been studying FMIS. Most of its research conclusions confirm other findings, but have helped focus attention on how FMIS can be supported and improved in a way that strengthens rather than undermines self-reliance. In Chitral, Pakistan, IIMI and its collaborators found that though

systems lack formal organization, they have no debilitating conflicts, water rights are clear, O&M are effective, and the systems achieve high cropping intensities and yields and thus compare favorably to the large government-managed systems in the plains.

In Nepal, IIMI has studied a 150-year-old 3,500 ha system built and managed entirely by farmers. It has continuously evolved and changed over time. Its organization is effective in system O&M, its crop yields and intensities are high, and the returns to irrigation are high compared to the costs. Although there is a gap between formal rules and actual water delivery and a high degree of inequity in water deliveries, the responsiveness to farmer complaints ensures these have no significant impact on production or the credibility of the management.

Early work on support services for FMIS also confirmed previous findings of others. A detailed study on Nepal and Sri Lanka concludes that coordination of different FMIS support programs, integration of different support packages, decentralized implementation, private sector provision of commercial services, and legal and institutional support to farmer organizations are important conditions for improving FMIS performance.

Privatization of Pumps for Irrigation

IIMI has carried out research on the contrasting situations in Sudan and Bangladesh related to pump irrigation. In Sudan, the government is privatizing agricultural services to farmers on its large pump schemes, but is not transferring irrigation facilities. Six schemes were studied, two each managed by a parastatal, the tenants' organization, and a private firm. The services provided by the parastatal were rated highest by tenants compared to the others, and the net revenues of tenants were highest. The private firm invested to improve the irrigation services, but the costs of its services were high, reducing farmers' incomes. The study concludes Sudan's privatization policy is flawed and should be implemented slowly as many preconditions are currently missing.

Bangladesh, on the other hand, has seen a rapid increase in irrigated area under small shallow tubewells as a result of private investment. There are competitive water markets in many places, lowering the costs and improving efficiencies. Small farmers and male and female laborers have shared in the benefits of this remarkable increase.

Economic Impacts and Food Security Issues

The impact of irrigation on economic development, poverty, and food security is an area to which IIMI has only begun to contribute. A study that attempts to project the future contribution of irrigated agriculture to global food production finds that West Asia, North Africa, and sub-Saharan Africa face serious food shortages in future; while the West Asian and North African countries may be able to export other goods to purchase food, sub-Saharan Africa will face serious problems. The future of food production in China is the greatest source of uncertainty in such projections; and the slow rate of expansion of irrigated area worldwide means that it will be necessary to improve irrigation efficiency to meet future demands. There is little scope for expansion in Asia, where pressures will be highest and where efficiency improvements will be particularly important.

Gender Issues

Research on gender issues has involved literature reviews to define problems and issues, and case studies in a few countries. Gender is a key structural principle in all societies, which structures access to resources, perceptions and evaluations of these resources, and the impacts of resource management. Wrong assumptions about gender relations in societies have led to failures of irrigation investment in Africa, and to unanticipated social and economic consequences in many areas.

A case study carried out in a Nepal FMIS found that women are very highly involved in agriculture, and increasingly carry out tasks previously done by men. In the head end of this system, women in richer households manage the farm, while in middle-class farms women do much of the labor; 80 percent of the head-end households are managed by women as men have taken off-farm employment. Women are not formally involved in or members of the organization running the system. However, this was found to be an advantage, not a disadvantage, as women are basically free riders, getting benefits (and stealing water) without having to pay the full costs.

In Sri Lanka and Bangladesh too women were found to be more heavily involved in agriculture than assumed based on the traditional division of labor. But they rarely participate in meetings or farmer organizations, though in Sri Lanka at least they are involved in other community organizations. No serious consequences of this exclusion were found, but the researchers suggest that a shift to water pricing according to market forces, and management by local (male-dominated) user organizations may lead to the exclusion and marginalization of women.

In a case study in Burkina Faso, it was found that while the productivity of women's irrigated plots do not differ significantly from that of men's plots, in households where both men and women have their own plots, labor productivity on *both* is more than twice what it is when only men have a plot (on which women also work). In households where women also have a plot, women are able to contribute much more to the household income, and their bargaining positions and well-being are thereby enhanced.

Conclusion

Organizational and policy reforms are at the heart of the Policy, Institutions and Management program. The water resource sector is changing rapidly in many countries, albeit often lagging behind other sectors. A strong theme of IIMI's work has been the positive results of participation of users, and using participatory approaches to achieve organizational and policy change, and indeed in research methodologies. In future, the program will place greater emphasis on global policy issues such as food security than it has in the past, and will focus on systematic objective analysis of the results of changes like irrigation management transfer. It is likely to examine a wider range of institutional options, going beyond those which primarily address the role of the irrigator (such as irrigation management transfer). It will also focus attention on a few key issues related to institutional change, poverty, women and water, and food security.

Health and Environment (Chapter 5)

The Program on Health and Environment is IIMI's newest, and research is still at an early stage. One major environmental issue—waterlogging and salinity—is addressed under the Program on Design and Operation of Irrigation Systems. The Health and Environment Program to date has focused primarily on watershed management and water-related diseases.

Watershed Management

IIMI is currently implementing a large participatory research and development project on watershed management in Sri Lanka ("SCOR"). This project aims to integrate conservation of natural resources and improved production based on these resources, thereby raising incomes. It is doing so by testing improved technologies, better management of natural resources, and local institutional development, using an action research mode. Implementation is on two watersheds, one wet and the other dry, and is focused on selected micro-watersheds.

An experiment to develop institutional linkages between irrigators below a reservoir and people who are pumping water out of a feeder canal supplying water to that reservoir, and to improve management of the scarce water supply, has shown that the downstream irrigators were able to use water very efficiently in the wet season, enabling them to use the saved water for a dry season soybean crop. Cultivators along the feeder canal also improved their production but at the end of the first season there was no evidence of their reducing water consumption to increase supplies to the downstream farmers.

Researchers have also developed a methodology for selecting and improving small reservoirs that are linked as "cascades" on micro-watersheds in Sri Lanka. Previously, small reservoir systems have been rehabilitated without regard to their interactions with other reservoirs in the same cascade. This has reduced the impacts and economic returns of these projects. A program has been designed for donor funding that would combine the integrated participatory development approach of the SCOR project with the use of new methodologies for selecting reservoirs and identifying appropriate interventions to improve the productivity of water.

Water-Related Diseases

The research on water-related vector-borne diseases is at a very early stage, and to date has been confined to Sri Lanka and Pakistan. Sri Lankan rural people were found to be very knowledgeable about malaria, take preventive measures, and seek treatment promptly from western-style health care providers, mostly government centers. This is in contrast with Pakistan, where people are more apt to seek other forms of treatment. But malaria infection has very high costs for households in Sri Lanka, both in terms of treatment costs, and lost labor.

In a small tank associated with the feeder canal mentioned above, it was found that pools along the canal, in the tank bed, and in drainage areas were a major breeding ground for mosquitoes carrying malaria. The following year, when the feeder canal experiment mentioned above led to higher water levels and less pooling, the incidence of malaria was reduced significantly. This suggests the possibilities for management interventions to control the incidence of malaria.

Conclusion

Irrigation-related environmental issues can be classified into several types based on the degree of control of the irrigation community and the extent to which the irrigation community will benefit from amending a process. Some issues are entirely internal to the system in terms of both control and benefits from interventions, such as salinity; these are addressed in the Design and Operations Program. Some environment-irrigation interactions involve processes outside the control of irrigators, but amendments would benefit them. An example is erosion of upper catchment areas. Some processes are controlled by irrigators but they have no motive to make changes; pollution of downstream water by agricultural chemicals is an example. Vector-borne diseases represent yet another type, in which irrigators may have some control, but the benefits of making changes are not directly agricultural. These kinds of issues—in which there is discontinuity between who controls and who benefits from making changes—are most problematic to address, but will be the major focus of the Health and Environment Program in the future.

Training and Institutional Strengthening (Chapter 6)

IIMI's research is mostly carried out in collaboration with national institutions in irrigation systems of particular countries, usually funded from bilateral sources. Therefore, institutional strengthening is often the dominant objective of country-level research programs; and research and institutional strengthening are closely linked. Some of the activities discussed in the chapters on research results could have been easily discussed instead in this chapter, which briefly describes just a few specific institutional strengthening activities that have been important.

Strengthening Research Capacity

Aside from producing research results, strengthening both national research capacity and implementation of better irrigation management have been important IIMI goals. In regard to strengthening national research capacity, IIMI has had at best a modest impact in a few countries. In Pakistan a 2-year project tried to improve the coordination among research organizations and the quality of their work, while in India IIMI worked with research and implementation organizations in four states to promote multidisciplinary research on irrigation management issues. The results in both cases were not remarkable.

In Sri Lanka, IIMI has worked with the Irrigation Department to strengthen its capacity for identifying research issues, managing research, and making use of research results through an "Irrigation Research Management Unit." This project has shown some results, but their long-term sustainability is not clear. *A conclusion from all these activities is that the institutional frameworks of both research organizations and implementation agencies are not conducive to supporting and using research results.*

Integrated Approach to Institutional Strengthening

In Malaysia, IIMI was involved in a multiyear integrated institutional strengthening program with the Department of Irrigation and Drainage. It began by assisting the department to carry out a training needs assessment using interactive processes, and proceeded through various stages of curriculum design, training of trainers, implementation of training, and evaluating its results. A notable feature was assisting the technical staff to understand the distinction between technical tasks and managerial tasks and the different skills required for each.

In subsequent activities, IIMI assisted the Department of Irrigation and Drainage in a strategic planning exercise, and in an activity designed to improve research capacities, especially the department's capacity to make better use of research. The impact of this program was evaluated very positively by the department, and is a source of lessons for carrying out similar programs in the future.

In Egypt, IIMI evaluated a major new training center in the Ministry of Public Works and Water Resources. Although the center has excellent facilities and is offering a large number of courses for which there is demand, several issues emerged: the financial sustainability of the center is questionable; there are opportunities for responding to demand for training by other units of the ministry; its linkages with the research unit of the ministry should be strengthened and formalized; and the center should offer more courses on specific management skills, which are in high demand.

Regional Program for Institutional Strengthening and Exchanges

Finally, IIMI collaborated with the German Foundation for International Development (DSE) in a series of workshops and training programs for four Southeast Asian countries. This program focused much attention on the different policy and institutional contexts in the four countries, and the increasingly complex challenges they face. It was clear that the participants, who included senior policy makers, greatly appreciated this program. One outcome was a proposal to establish an ASEAN Water Resources Council.

Conclusion

IIMI has two types of clients for its institutional strengthening activities: national research organizations, and national irrigation implementation and policy making agencies. Most countries do not have specialized irrigation management research organizations equivalent to national agricultural research systems (NARS) on the agriculture side, which complicates IIMI's task. In future, however, it will increase its attention to strengthening national research organizations that do irrigation management research.

The institutional strengthening program to date has lacked a clear vision and strategy, and a way of providing systemic support to, and evaluating, its country and regional programs. Each country program has been a semi-independent "franchise." The integrated program in Malaysia provides a model for working with countries to strengthen both irrigation management, and the linkages of research to management organizations. The program in Southeast Asia provides a model for regional activities in the future. But two questions need to be ad-

dressed: How will IIMI improve the effectiveness of its institutional strengthening programs, especially with its increased emphasis on global research? And how will it evaluate the impacts of its activities?

Conclusion (Chapter 7)

The final chapter considers some of the limitations in the research outputs to date, as a basis for suggesting improvements in the future. It discusses the implications of the basic research conclusions for the future, and makes some suggestions regarding future research and institutional strengthening.

In its first 10 years, IIMI emphasized development and institutional strengthening over global strategic research. This was a function of its dependence on bilateral funding in partner countries, but the management and staff enhanced this developmental focus. Even after joining the CGIAR, this emphasis continued. Therefore, judging IIMI in terms of its scientific output is to use a criterion that was not a high priority in its first decade. The weaknesses in research design and analysis in some research outputs are real; and despite its emphasis on institutional strengthening, IIMI has not measured its impacts in this area effectively.

Nevertheless, IIMI has made important contributions to global understanding of irrigated agriculture and water management problems. It has

- documented the large “performance gap” in irrigation systems
- documented the negative and alarming trends affecting the sustainability of Pakistan’s mega-irrigation systems
- documented management turnover experiences and the serious governance and policy problems affecting irrigated agriculture
- demonstrated the use of participatory research and policy analysis techniques

IIMI’s (and others’) research makes very clear that the underlying causes of these problems are institutional and political in nature.

IIMI’s new management is making important changes to strengthen the quality and quantity of research outputs. But three important questions remain:

- 1 Will donors now support a research program on global water issues? They have not done so previously, and the available funds in the CGIAR system are at best static.
- 2 Will IIMI be able to do credible research on, and influence, the underlying institutional and political causes of water resource and irrigation management problems? IIMI seems to be veering toward strengthening its capacities in research on technical issues but needs simultaneously to improve its capacity to address these more fundamental questions.

- 3 How can IIMI reconcile its strong emphasis on research with an effective institutional strengthening program? These two objectives are not incompatible, but IIMI needs to develop an explicit strategy and vision, and seek support to strengthen its program in this area.

By 2006, will IIMI be regarded as the key intellectual resource for identifying the real nature of water resource and irrigation problems and their solutions? It will if it succeeds in producing quality research results on both the technical and institutional dimensions of these problems, communicating its results to other researchers and to policy makers, donors and politicians, and makes a serious contribution to strengthening national and regional capacities to address water resource and irrigation management problems.

CHAPTER 1

Introduction

1.1 Purpose and Audience

IN 1993 IIMI prepared a paper documenting its achievements and impacts in both research and institutional strengthening from 1984 to 1993 (IIMI 1993). The primary audience of that paper was IIMI's Board of Governors and the External Review team.

This book is based on that earlier draft, but very substantially revised, expanded, and updated. Its purpose is to pull together into one place an overview of the research results of IIMI and its partners organized according to the new program structure. It therefore has a narrower purpose than the earlier paper. The audience is primarily researchers interested in IIMI's research results, including IIMI's own staff and fellows, its collaborators throughout the world, and other professional water resource specialists who are themselves researchers, or are interested in making use of the results of research on water resource management issues. Policy makers and water resource managers may also find much in this report of interest—they could use the table of contents and the index to look up particular topics.

The book emphasizes the results of IIMI's own work. It relates this work to that done by others to some extent, but not comprehensively. It is based on a wide variety of research reports, published and unpublished, formal and informal. Since its inception, IIMI has produced a large variety of its own publications; IIMI staff (or in some cases consultants) have written papers for presentation at conferences, and for review by other colleagues. Some, but not all, of these papers have been published. Because of this scattered and often informal reporting, it is difficult to evaluate the quality and contributions of IIMI's work, and the extent to which it represents a cumulative effort to enhance understanding of irrigation management issues. This book draws on the entire corpus of such writings by IIMI staff, published and unpublished.¹

1.2 IIMI: New Directions

During IIMI's first 6 years, it was not a member of the Consultative Group on International Agricultural Research (CGIAR). Most of its funding came from bilateral sources, for applied

¹All writings by IIMI staff are listed in the *Literature Cited* section, and are available through IIMI's library. This report does not draw on reports written by others but published by IIMI, on the premise that these do not represent IIMI's own research.

research and institutional strengthening activities in particular countries. Therefore, development and institutional strengthening received a higher priority than global research. After joining the CGIAR in January 1991, the priorities shifted to give more weight to strategic research. But its new strategy and draft Medium Term Plan, prepared in 1992, still placed considerable emphasis on development. Funding for strategic research remained constrained and strategic research as an organized activity is still at an early stage.

During this same period, IIMI's mission has evolved from "improving the management of irrigation systems" before joining the CGIAR, to "increasing the productivity of irrigated agriculture." More recently, this mission has come to be seen in the context of water basins where rising demand for water from other sectors as well for agriculture makes it imperative to improve the *productivity of water used in agriculture*.

Today, while IIMI remains both a research and a development organization, it is focusing on strengthening its research program. The present report, by documenting research results during IIMI's first decade, sets the stage for its second decade. As will be clear, IIMI has been able to produce interesting and useful research results during its first decade of work.

The foundation for much of the research reported here lies in field work. IIMI's "laboratories" are existing irrigation systems in the countries where it works. Its research in this sense is closer to the natural sciences than to the experimental sciences: it is based on careful documentation and analysis of ongoing natural (including social) processes. In such research, there is limited potential to control variables and analyze the interactions among a few variables to test hypotheses, but the results of the work represent the complex reality of systems in a way that laboratory results cannot do.

Because IIMI's work is carried out in existing systems, it must develop cooperative relationships with a variety of collaborators, including irrigation system managers and farmers, supported by senior management and policy makers. This often involves overcoming a considerable degree of skepticism if not resistance. The imperative to do the research collaboratively, combined with the bilateral funding of much of its work, makes it necessary to focus attention on solving problems identified by national collaborators. In many cases, there is a congruence between these local priorities and IIMI's generic interests, but in some cases IIMI has had to balance competing interests in extracting generic findings while contributing to solving local problems. The research is often deliberately carried out in a manner that also contributes to institutional strengthening, for example, by directly involving managers and farmers in "action" research.

Nevertheless, in addition to the site-specific knowledge coming out of its field work, IIMI and its collaborators have also contributed to the generation of generic knowledge on irrigation management. In its work on specific irrigation systems, it has developed and tested a variety of methodologies, operational procedures and other management innovations, and hypotheses about the factors affecting irrigation performance, which can be used or adapted to solve similar problems elsewhere. IIMI has also done comparative studies, using both its own and others' data, to test hypotheses regarding determinants of performance; for example on the relationship between financial autonomy of an irrigation management agency and its performance.

Most of the early research results came from those countries where IIMI has had a long-term presence. These countries include Sri Lanka and Pakistan, its two most mature national programs, as well as Indonesia, Nepal, Bangladesh, the Philippines, Niger, Burkina Faso, and

Sudan. Increasingly, however, IIMI has been able to carry out research on specific issues in a variety of other countries, usually by working closely with national collaborators. These countries include China, India, and Colombia.

1.3 IIMI's Program Structure: Past and Present

IIMI has always faced a fundamental management problem: how to integrate its global and national programs. Until recently, its national programs were dominant because this is where most of the staff and financial resources were located; but it was difficult to integrate these national activities into coherent global programs. This problem continued even after joining the CGIAR, largely because core funding available for research continues to be limited. IIMI expanded rapidly during its first 5 years, but much of this occurred through adding country programs.

In 1986, three global programs were established: Systems Management, System Rehabilitation and Improvement, and Farmer-Managed Irrigation Systems. These programs had some staff and funds, but were primarily concentrated in Headquarters.

The first "Strategy Paper" in 1988 identified seven programs (Box 1.1). But funding constraints made it difficult to operationalize these programs. In 1992, after joining the CGIAR, IIMI prepared a draft Medium Term Plan (MTP) to cover the period 1994 to 1998 (IIMI 1992). This first MTP included five broad programs and four "crosscutting themes." Between 1993 and 1995, IIMI attempted to operationalize these programs and themes, by appointing program leaders and allocating funds and staff to them. This MTP was, however, based on funding assumptions that could not be met; therefore, while some programs and themes (e.g., Performance Assessment, Local Management, and Gender) became operational, others did not.

In 1995, the new Director General consolidated the research program under four new global programs and a smaller number of national programs. The four global programs are:

- Performance Assessment
- Design and Operation of Irrigation Systems
- Policy, Institutions, and Management
- Health and Environment

The Performance Assessment Program crosscuts and supports the other three programs, introducing state-of-the-art methods for analyzing system performance and the results of interventions. The Design and Operation of Irrigation Systems Program examines opportunities for direct interventions to improve system performance, for example, through the use of modern management tools. The Policy, Institutions and Management Program examines the policy and institutional requirements for introducing and sustaining improved management, and also pays special attention to gender issues. The Health and Environment Program addresses watershed management issues, and management options for controlling vector-borne diseases like malaria and schistosomiasis. All four programs are implemented in the context

Box 1.1. Evolution of IIMI's global programs.

In its 1986 *Annual Report*, IIMI reported its research results under the following programs and "project areas" (country activities were discussed under the program headings):

- ◆ Systems Management
 - Irrigation Management for Crop Diversification
 - Resource Mobilization
 - Performance Monitoring and Evaluation (M&E)
 - System Management in Pakistan
- ◆ System Rehabilitation and Improvement
 - Rehabilitation Processes
 - Design and Management Interactions
- ◆ Farmer-Managed Irrigation Systems
 - Farmer-Managed Irrigation Systems in Sri Lanka
 - Farmer-Managed Irrigation Systems in Nepal
 - Farmer-Managed Irrigation Systems Research Network

In 1988, IIMI's new Strategy Paper (IIMI 1989a) proposed seven new research themes:

- ◆ Institutions for Irrigation Management
- ◆ Management of Water Resources for Irrigation
- ◆ Management of Financial Resources for System Sustainability
- ◆ Management of Irrigation Facilities
- ◆ Management of Irrigation Organizations
- ◆ Management of Irrigation Support Services for Farmers
- ◆ Management of Change in the Institutions for Irrigation

The Medium Term Plan for 1994-1998 (IIMI 1992) proposed five research programs and four crosscutting themes. These were:

Programs

- ◆ Assessing and Improving the Performance of Irrigated Agriculture
- ◆ Sector-Level Management of Irrigated Agriculture*
- ◆ Improving Public Irrigation Organizations*
- ◆ Toward the Local Management of Irrigation Systems
- ◆ Sustainable Management of Water Delivery and Disposal

* These two programs were managed as one, for financial reasons.

Crosscutting Themes

- ◆ Environment and Health
- ◆ Gender Issues
- ◆ Choice and Use of Technology
- ◆ Improving the Global Database on Irrigated Agriculture

of *water basins*. The term *water basin* refers to the upper and lower areas of a basin, including its groundwater, and includes the basin's socio-technical, economic, cultural, and human dimensions in a systems perspective.

There is a very high degree of continuity in research themes since 1985 that continues as the program structure evolves. This report is organized in terms of the four current programs, which constitute a consolidation of the 1994 to 1998 "five plus four" set. Chapters 2 through 5 report IIMI's research results to date under these headings. Chapter 6 reports on several major collaborative activities related to institutional strengthening and training. Chapter 7 discusses the strengths and weaknesses of IIMI's research to date and relates it to IIMI's future directions.

CHAPTER 2

Research Results: Performance Assessment

2.1 Introduction: Evolution of the Program

Imagine a business with no system for collecting information on its output performance, no explicit objectives, no quantitative criteria for evaluating how it is doing, and no performance measures relating to its income, expenses, and cost-effectiveness. Imagine an airline having no printed schedule of the destinations and timing of its flights, or whose actual flights bear no obvious relationship to the printed schedule. Imagine a factory with no production targets, no information on what was actually achieved, and no information on the profits and losses from its production. All of these are difficult to imagine and, if they existed, would not be sustainable. Yet this is the reality for many irrigation systems. Some irrigation departments have annual budgets in hundreds of millions of dollars and their systems contribute a significant portion of the total national agricultural production. But they do not have even the simplest accurate data on their performance, and often seem uninterested in obtaining and using such information (Murray-Rust and Merrey 1994).

Irrigation management researchers have been developing and applying a variety of performance indicators for decades. But it has been difficult for researchers to agree on a universal set of indicators and standards for judging levels of performance. From its inception, IIMI and its collaborators have worked on developing and applying performance assessment methodologies useful for research, policy, and system management. A review of IIMI's *Annual Reports* since 1985 clearly shows its central concern with performance issues.

Nevertheless, a few years ago, the Board of Governors and management recognized that a much greater effort is required in performance assessment. The existence of IIMI is based on the premise that there is a gap between the present and potential performance of irrigated agriculture. But unlike businesses or airlines, there are no agreed-upon methodologies for quantifying the presumed performance gap and making cross-system comparisons, no agreed criteria for judging whether performance is good or not, and few guidelines to irrigation managers on what indicators they should use.

This chapter therefore reviews the contributions of IIMI and its partners to the science of assessing the performance of irrigation. It addresses three broad topics: performance assessment frameworks; methods and indicators for quantitative measurement of performance; and selected applications for comparative analysis and for assessing impacts of innovations. Much of the work on performance, until recently, addressed questions at irrigation system level. Therefore, the results reported here are closely related to those reported in the following chapter on design and management of irrigation systems. But performance issues are central to *all* of IIMI's programs, and the Performance Assessment Program is now shifting to a more explicit

role of supporting the other programs to develop and apply quantitative methods for assessing performance.

Irrigation performance is a topic in which many other researchers and institutions have had a long-standing interest. The International Commission on Irrigation and Drainage (ICID), for example, has a special Working Group on this issue, and the International Institute for Land Reclamation and Improvement (ILRI) in the Netherlands has played an important role, along with ICID, in developing and disseminating performance indicators (e.g., Bos and Nugteren 1974). There is a large academic literature on performance assessment methodologies (reviewed in Rao 1993). However, this literature has not had much impact on the management or performance of irrigation. IIMI's work has attempted to make use of the methodologies reported in the literature, and in some cases to modify and adapt them for use by irrigation managers in improving system performance.

2.2 Analytical Frameworks for Assessing Performance

IIMI and its collaborators have been struggling with the development of conceptual frameworks for assessing irrigation performance since 1985. The issue is important both for research on performance—how it should be defined and measured, and what are its determinants—and for improving the performance of particular systems through the adoption of cost-effective methodologies managers can actually use. In September 1986, IIMI staff held a workshop on performance, which revealed the complexity of the issues involved, and substantial differences of opinion on the subject. Some staff concluded that no overall framework could be developed that would be broadly acceptable. Nevertheless, over the years IIMI and its collaborators have proposed and used a number of types of performance assessment frameworks.

2.2.1 *Nested Systems Framework*

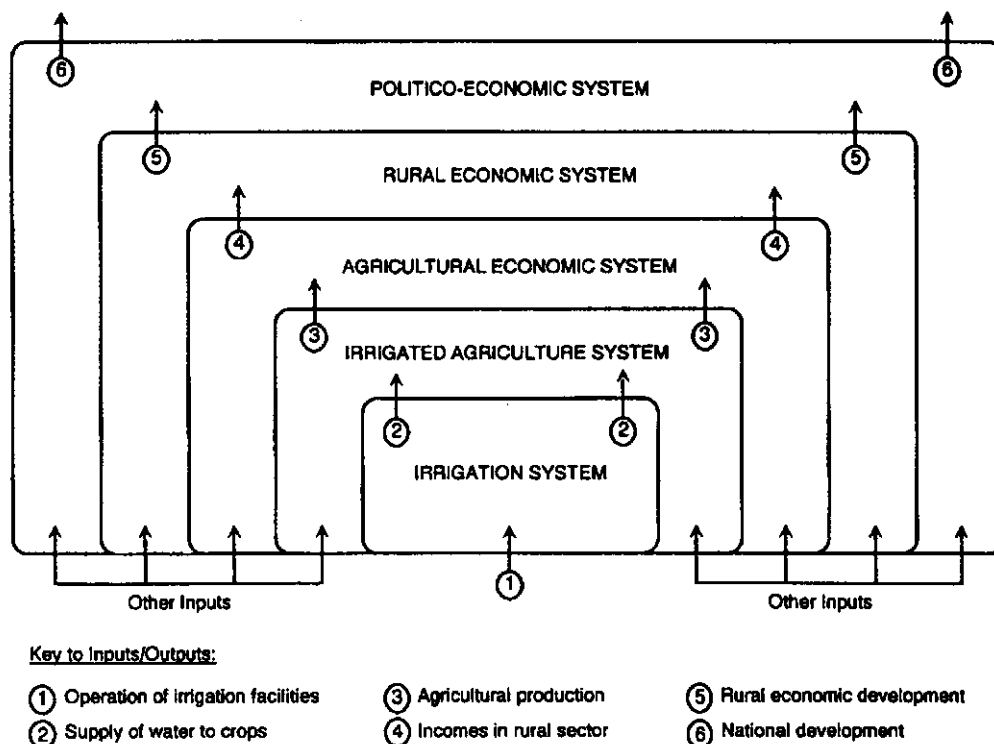
IIMI began collaborating with the International Food Policy Research Institute (IFPRI) on this topic in 1987. The major outcome of this collaboration has been the publication and wide dissemination of a “nested systems framework” (Figure 2.1; Small and Svendsen 1992²). This framework describes irrigation as a set of nested systems, each of which has its own particular set of objectives. The primary linkage between these systems is that the outputs from one system (say, the irrigation [water delivery] system) become part of the inputs into the next system (say, the irrigated agriculture system). This nested framework thus allows the actions of a manager or organization at one level to be placed in the context of the next higher level, and avoids confusing the objectives of managers at different levels.

The other useful contribution of Small and Svendsen's work is the distinction among three types of performance measures: *process measures*, which refer to the processes internal to a system; *output measures*, which describe the quality and quantity of outputs at a point where

²An earlier version was published in *Irrigation and Drainage Systems* 4 (4), 1990.

they become inputs to the next higher system; and *impact measures*, which refer to the impact of these outputs on the wider environment. The nested systems framework has been used in a number of IIMI's studies (see, for example, Sections 4.2.1 and 4.2.4).

Figure 2.1. Inputs and outputs: Irrigation in the context of nested systems.



Source: Small and Svendsen (1992:6, Figure 2).

2.2.2 Framework for Diagnosing Operational and Strategic Performance

A rather different but complementary approach was taken in a comparative analysis of the performance of 15 irrigation systems by Murray-Rust and Snellen (1993) as part of a collaborative project with the International Institute for Land Reclamation and Improvement (ILRI) and the International Institute for Hydraulic and Environmental Engineering (IHE). This work draws on selected business and organizational performance literature and attempts to identify a cyclical set of tasks that enables managers to review past performance and to make appropriate improvements for the next cycle. This management process has four components:

1. *Planning*, the process of setting objectives and targets
2. *Implementation* of the agreed plan

3. *Monitoring* of implementation to see that operational management is being carried out and to develop sufficient information for the 4th component
4. *Evaluation* of whether the broader objectives are being met (the results feed back to the next planning stage)

Murray-Rust and Snellen distinguish three levels of organization: system, agency, and sector; and, like Small and Svendsen, expect the objectives for each level will be different. Nevertheless, a common definition of performance is proposed, with two elements:

- the degree to which an organization's products and services respond to the needs of its customers or users
- the efficiency with which the organization uses its resources

A distinction is made between *operational performance*—routine implementation of plans—and *strategic performance*—the extent to which resources are being used efficiently to achieve the targets, and whether by achieving these targets the organization is achieving the broader set of objectives. The process of performance assessment involves two simple questions related to these two types of performance:

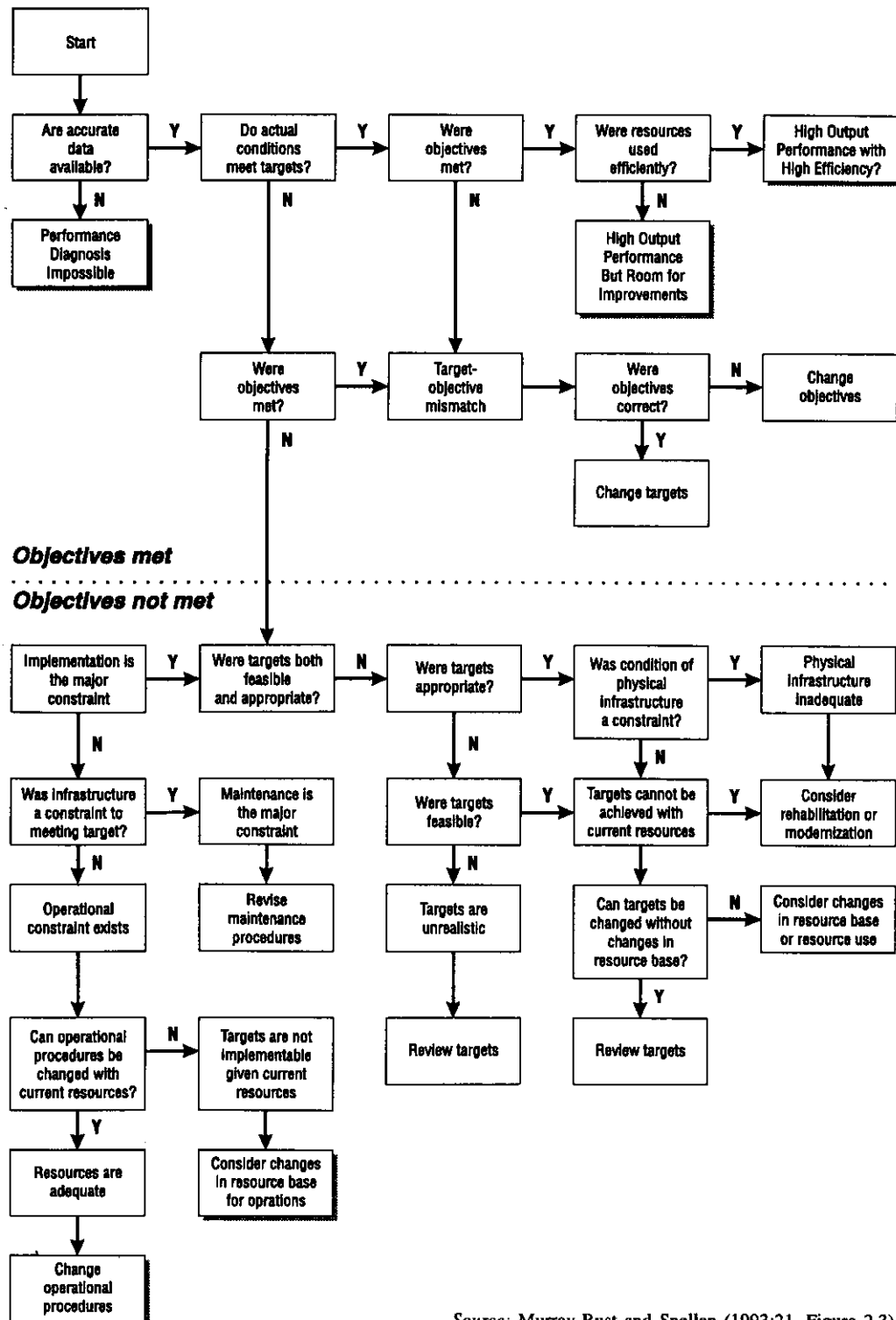
- *Am I doing things right?* (that is, are the operational targets being met?)
- *Am I doing the right thing?* (that is, are the wider objectives being fulfilled, and fulfilled efficiently?)

In the nested systems framework, answers to the first question from the perspective of an irrigation system manager lie within the irrigation system ("process measure") and at its boundary with the irrigated agricultural system ("output measure"); answers to the second question require analysis of whether meeting the water delivery targets contributed optimally to the broader objectives of the irrigated agriculture, agricultural economics, etc., of subsystems. Figure 2.2 depicts the general process of performance assessment and diagnosis as suggested by Murray-Rust and Snellen. The authors apply this framework to evaluate the performance of 15 irrigation systems (see Section 2.4.1).

2.2.3 Performance Assessment Framework for Irrigation Managers

In 1993, IIMI staff, in continuing collaboration with ILRI and IHE, built on the above two frameworks for assessing irrigation performance to propose a framework and a set of specific indicators that can be used both by managers of canal systems, and also by researchers and policy makers (Bos et al. 1994). Managers need a framework to use data for assessing performance. The authors draw on the nested framework of Small and Svendsen, which allows the actions of managers at one level to be placed in a larger context; the distinctions drawn by Small and Svendsen among process, output, and impact measures; and the management cycle and distinction between operational and strategic performance proposed by Murray-Rust and

Figure 2.2. Flowchart to show process of performance assessment and diagnosis.



Source: Murray-Rust and Snellen (1993:21, Figure 2.3).

Snellen. A key value of the proposed performance assessment framework is that it can be used to identify clearly who is responsible for what task, and to assess what happened and why things happened as they did.

Performance indicators include both actual values and targets, which are linked to broader objectives. The indicators proposed are all therefore in the form of ratios. They are grouped into three types:

- *Water Supply Performance* (which comprise both “process” and “output” measures in terms of Small and Svendsen)
- *Agricultural Performance* (“direct outcome” or output measures in terms of Small and Svendsen)
- *Economic, Social and Environmental Performance* (which deals with impacts on both physical and socioeconomic sustainability—“effects” or impact measures in terms of Small and Svendsen)

For each of these categories, the paper recommends specific indicators irrigation managers can use for assessing performance. The sequence is deliberate: it proceeds from aspects which system managers directly control, to direct outcomes, to less tangible and more subjective (but important) impacts. The first category helps answer the operational question, “Am I doing things right?” The second and third categories help answer the strategic question, “Am I doing the right things?”³

2.2.4 Performance Improvement Capacity Audit

The frameworks discussed above are useful for assessing *actual performance* of irrigation systems. Another type of assessment would identify the “potential performance” that can be expected from a system—an important but difficult concept. A third element of performance assessment that has been neglected in the past is *the capacity of managers to improve performance* beyond existing levels. A system whose actual performance is poor relative to its potential may therefore have a high *potential* for improvement; but its managers may have a low capacity to actually do so; similarly, a system that performs reasonably well may have a smaller gap between actual and potential performance, but its managers may have the capacity to adopt useful improvements which will help it reach its potential performance. Therefore, “performance improvement capacity” may vary independently from both actual and potential performance.

Merrey et al. (1995) present an easy-to-use generic methodology called “Performance Improvement Capacity Audit” (PICA). PICA poses five questions to enable a rapid assessment of the capacity of the managers of an irrigation system to improve performance and to guide the development of an improvement strategy. These five questions are built around five “determinants” of system performance:

³In a modified form, this performance assessment framework is presently being used by IIMI, ILRI, and IHE as the conceptual framework for a multi-country performance study.

1. *System design.* Is the physical infrastructure capable of being managed to meet the overall system objectives?
2. *System operation.* Are the planning, operational and maintenance inputs adequate to achieve a water delivery pattern that supports fulfillment of the overall objectives?
3. *Data collection.* Are sufficient data being collected to determine whether targets and objectives are being met?
4. *Management framework.* Are available data used as part of a systematic process of control for operational performance and evaluation to assess outcomes and impacts?
5. *The will to manage.* Is the organization, and are individual managers, sufficiently motivated to improve system performance?

The authors suggest a scoring system using the answers to these five questions. The total score indicates the relative ease or difficulty of improving performance; the combination of high and low scores for each question can be used to guide the planning of appropriate interventions; and the changes in scores after interventions can be used to evaluate the *sustainability* of improvements. PICA can be used in conjunction with programs to measure actual performance, to choose systems where interventions are likely to lead to improvements, and to choose the type and sequence of interventions. Systems with low scores overall are likely to require long-term multipronged interventions; systems with higher scores will be amenable to specific targeted interventions which can lead to improvements in the short term. Mixed scores will suggest areas needing more attention. The validity of PICA is tested by applying it retrospectively to five systems in three countries in which IIMI has worked (see Section 2.4.3).

2.2.5 *Determinants of Function and Dysfunction*

In a paper published simultaneously with the PICA paper, Perry (1995) defines three basic elements of successful irrigation, and suggests the match of these three elements can be used to distinguish “functional” and “dysfunctional” systems. The three elements are:

- defined water rights
- infrastructure capable of providing the service embodied in the water rights
- assigned responsibilities for all aspects of system operation

Perry argues that all other common issues (e.g., good maintenance, sound institutions) are really either a subset or a combination of these three basic elements. Water rights, infrastructure, and responsibilities interact and are interdependent: change in one will lead to changes in the other elements. The quality and interaction of these three elements can be used to distinguish between *functional* and *dysfunctional* systems, a distinction that Perry argues is of fundamental importance in formulating interventions.

To illustrate this distinction, Perry contrasts “dysfunctional” *shejpali* and “localization” systems of western and southern India with *warabandi* systems of North India. In the former

systems, the infrastructure is inadequate to provide the specified water rights, and the responsibilities assigned to the operating agency are not feasible. The result is dysfunctional systems in which interventions are doomed to failure. The north Indian warabandi system is described as functional—there is a good fit among the water right, the infrastructure, and the assignment of responsibilities. On the other hand, precisely the same water rights and assignment of responsibility govern the systems in Punjab, Pakistan, but these systems have become dysfunctional because of progressive deterioration of the physical infrastructure (see Section 3.2.3).

Perry's approach has some similarities to PICA. "Functional" systems are ones likely to score well on the PICA system, and which therefore have some capability to improve performance by adopting interventions; as Perry notes, functionality will normally be a precondition for improving performance. In dysfunctional systems—those with low PICA scores—assessment of performance is problematic, and interventions will have to address basic issues through a long-term multidisciplinary approach. Perry argues that changing infrastructure and assignment of responsibilities are relatively easy. Resolution of water rights issues will be the determining factor but it is also the most difficult to implement, as there will be strong reactions from losers.

2.3 Quantitative Measurement of Performance

While IIMI uses performance assessment methodologies and indicators derived from the literature, it has also contributed to the development of new methodologies. Under the IIMI-IFPRI collaboration on performance, a review of the literature on performance indicators was commissioned and later published (Rao 1993). This review provides the only organized discussion of the major types of performance indicators currently available to irrigation managers and researchers. It is an important foundation for the work of IIMI and others, as it makes it easier to ensure that research on performance assessment indicators builds on previous work. The remainder of this section briefly reviews several performance assessment methodologies and indicators developed by IIMI and its partners.

2.3.1 *Delivery Performance Ratio (DPR)*

Indonesian irrigation managers use a detailed and complex process for planning water deliveries. As part of its work there, IIMI developed a simple but powerful hydraulic performance indicator called "Management Performance Ratio" or as it is called in more recent work, "Delivery Performance Ratio" (IIMI 1987, 1989b; Kelly and Johnson 1991). This is the ratio of actual discharge to the target discharge at a given location and time; it allows for instantaneous checking of whether discharges are more or less as intended. This indicator is now commonly used in a variety of contexts—and is reported to have been adopted in some Indonesian systems by system managers (IIMI 1989c:8). Kelly and Johnson have more recently suggested ways in which this ratio can be adapted to evaluate the water delivery planning and implementation processes more precisely. IIMI staff routinely use the Delivery Performance Ratio (DPR) for evaluating performance of canals in Pakistan (e.g., Murray-Rust and Snellen

1993; Murray-Rust and Vander Velde 1994a; Bhutta and Vander Velde 1992a, 1992b), India (Sakthivadivel et al. 1995), and Sri Lanka (e.g., IIMI 1995a).⁴ Figures 2.3 and 2.4 illustrate the use of DPR. The vertical axis is the DPR: 1.0 means actual discharge is equal to planned discharge. The figures show the variation in DPR (i.e., the achievement of targets) for different discharge levels and for distance from the head of canals.

2.3.2 Measuring Equity of Water Supply: “Equivalent Distance” and “Relative Equity Ratio”

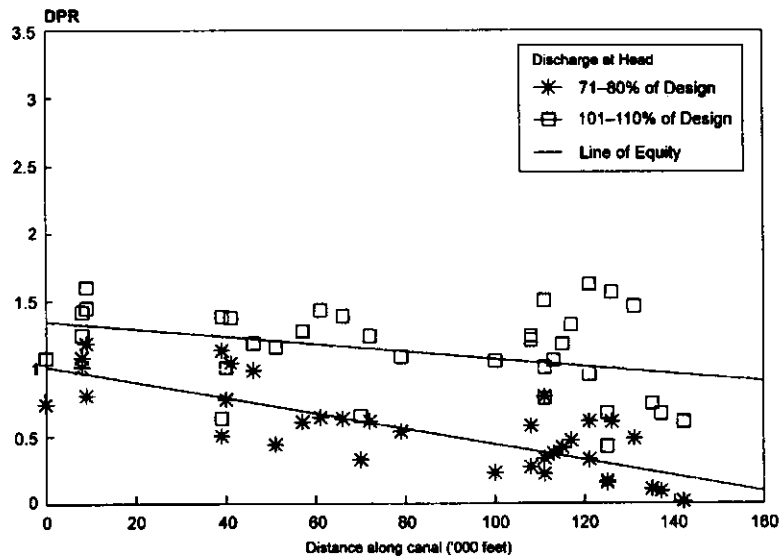
Longitudinal inequity, i.e., lesser water supplies to users at tail ends of canals compared to head-end users, is an important and commonly reported problem of larger irrigation systems. But the problem is not as straightforward as it appears. Existing methods of assessing equity of water supply generally rely on the assumption that linear distance from the head of a channel or system is a major determinant of access to water; that is, water supply from “head” to “tail” varies directly with distance. However, observations in Pakistan showed this not to be the case: linear distance is not a good predictor of water supply. Therefore, a methodology called “equivalent distance” was developed and has been tested and used in Pakistan.

This methodology combines hydraulic factors with distance: if there is a high ratio between discharge upstream of a structure and discharge into offtaking channels, then the offtaking channel will be less vulnerable to changes in upstream discharge than at locations where the ratio is low (Murray-Rust 1987; Colmey 1988). Figure 2.5 is an example of its use in Pakistan. Figure 2.5A shows the relationship between DPR and linear distance from the head as a measure of equity; Figure 2.5B converts the same data on distance into “equivalent distance”—combining “actual distance and the locational opportunity of an outlet vis-à-vis channel discharge”—to show that the difference between actual and design conditions is very strongly related to an outlet’s location along the channel (Bhutta and Vander Velde 1992a:240).

Another approach to assessing equity of water supply also takes as its starting point the observation that water supply does not necessarily correlate with distance from the head. Called “Relative Equity Ratio” (Rao 1987), this methodology defines “head” and “tail” of an irrigation system in terms of whether offtakes receive more or less than their “due share” (based on area served), rather than in terms of location along a canal. Using a form of the Lorenz curve, and arranging command areas served by each offtake in rank order from the most undersupplied to the most oversupplied, a parameter for the extent of inequity of water distribution is calculated. In the Sri Lankan canal used to test the methodology, it was found that distributaries located near the tail received their due share while those located in the middle were undersupplied.

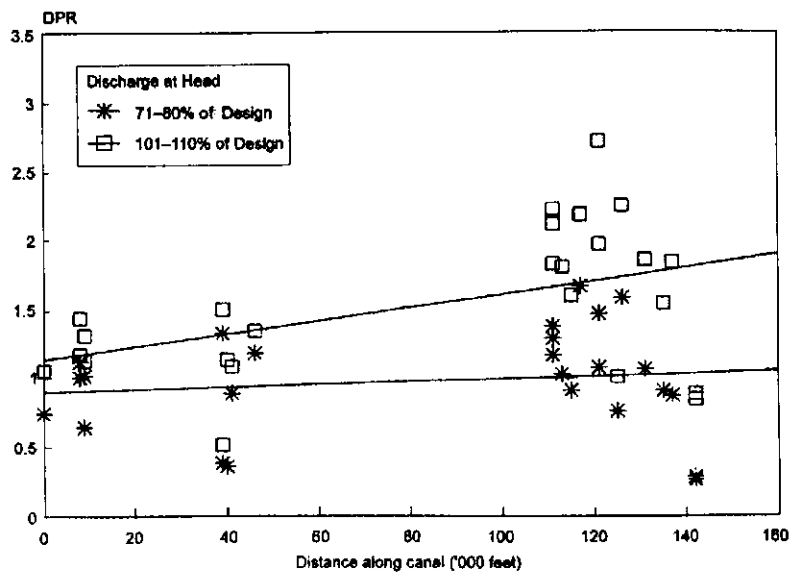
⁴Over a longer period of time it is useful to change discharges to volumes, resulting in an indicator called “Water Delivery Performance;” see Bos et al. (1994:244) and Clemmens and Bos (1990). Some authors have used the latter indicator but, confusingly, call it Delivery Performance Ratio, for example, Fernando, Hemakumara, and Ariyaratna (1995).

Figure 2.3. Delivery performance ratio, Khikhi Distributary, Pakistan, after lining.



Source: Vander Velde and Murray-Rust (1992:86, Figure 4.3).

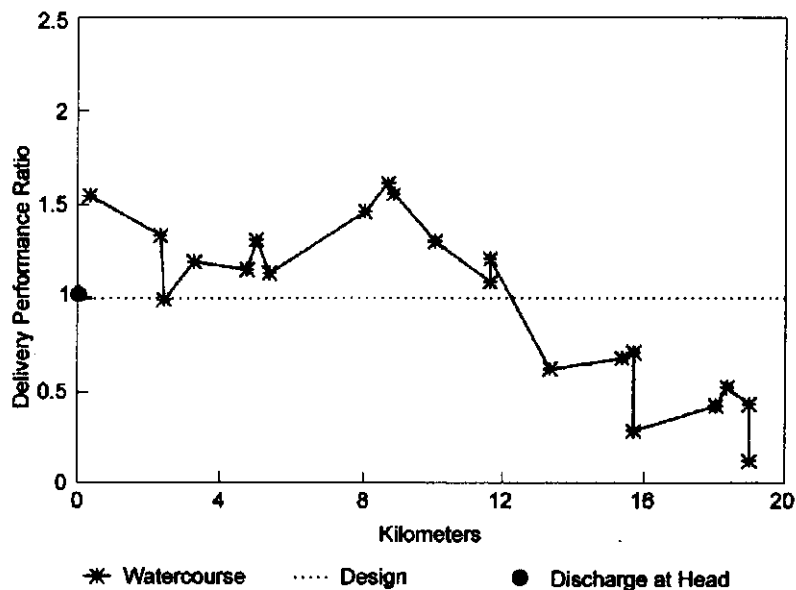
Figure 2.4. Delivery performance ratio, Khikhi Distributary, Pakistan, before lining.



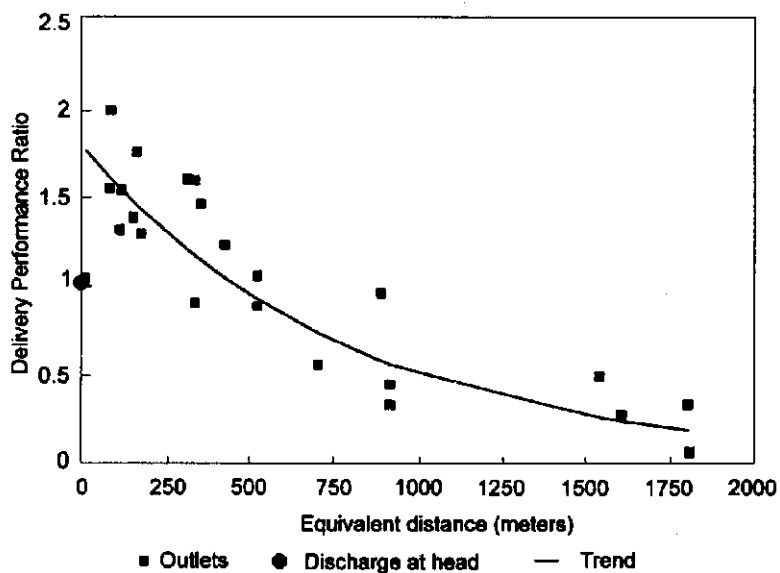
Source: Vander Velde and Murray-Rust (1992:85, Figure 4.2).

Figure 2.5. DPR and water distribution equity: Linear and equivalent distance.

A. Lagar Distributary, Pakistan: Water distribution equity.



B. Lagar Distributary, Pakistan: DPR and equivalent distance.



Source: Bhutta and Vander Velde (1992a:241-242, Figures 11.3, 11.5).

2.3.3 *Measuring Adequacy and Equity of Water Distribution in Lowland Rice Systems*

In its early years, an IIMI postdoctoral fellow developed and tested a simple low-cost methodology for measuring the adequacy and equity of water distribution in lowland rice systems. The method consists of measuring the inflow and outflow of water from the irrigation and command area, and installing perforated PVC tubes to monitor the fluctuations of the perched water level in rice fields. The author used the concept of *Critical Tolerance Level* (CTL) of water supply in rice paddies, defined as a threshold at which farmers will “tolerate” more water above it, but not below. CTL becomes the standard for measuring water adequacy. Through simulation, a “true” CTL can be calculated for any given situation—but the author notes this true CTL is site-specific, not general. Indices for measuring the frequency, duration, and intensity of water shortage (i.e., water levels below CTL, termed reliability, resiliency, and vulnerability, respectively) were developed. These proved to correlate very well with crop yield on sample irrigation systems in Indonesia, Sri Lanka, and the Philippines. The author argues that the methodology is feasible on a larger scale (Ng 1988).

2.3.4 *Cumulative Relative Water Supply*

The concept of “Relative Water Supply” (RWS) has been used by researchers to evaluate irrigation performance for more than a decade (Levine 1982; Rao 1993). This is the ratio of the water supplied to the water demand in a specific command, given specific crops and cultural practices. Based on work in Sri Lanka, Sakthivadivel, Merrey, and Fernando (1993) developed a complementary methodology called “Cumulative Relative Water Supply” (CRWS) which unlike RWS, takes into consideration the accumulation of the total supply of water from all sources over time. RWS is useful to evaluate the ratio of supply to demand at a given point in time—but it does not take into account such things as rainfall occurring soon after a measurement is taken. For example, assume the water requirement for a rice field in week 1 is 100 mm, and this amount of irrigation is given. Suddenly right after the irrigation, there is 100 mm of rainfall—changing the RWS from 1 to 2. The following week it does not rain, and no irrigation is needed or given; the RWS is therefore zero while actually the field does not need water. CRWS overcomes this anomaly by building time into the ratio, and it can be used by system managers to monitor water delivery performance on a continuous basis during the season and to make necessary adjustments as the season progresses. The actual CRWS curve can be matched with a theoretical CRWS (giving upper and lower bounds) to evaluate the quality of water supply quickly and easily. This indicator has been used in several projects in Sri Lanka (e.g., IIMI 1990a; Fernando, Hemakumara, and Ariyaratna 1995); its application is illustrated in Section 5.3.2 (see Figures 5.1, 5.2).

2.3.5 *Measuring Performance along Canal Reaches Versus at Control Points*

Measurements of hydraulic performance are usually taken at specific control points along a canal. On large canal systems, this often entails taking measurements at a few points to cap-

ture “head,” “middle,” and “tail” differences. In Sudan, IIMI has compared the results of this normal approach with those obtained by measuring water supply along a “reach” of a canal, that is, the stretch between two consecutive control points (Shafique 1993-1994, 1993, 1994). The portion of a canal between two control points—the “reach”—often has several offtakes (Figure 2.6). The total water requirement (or total water requested) and total actually received can be calculated to enable assessment of the ratio of actual and target deliveries. Measurements are converted into indicators (ratios) of actual compared to target deliveries, reliability, and adequacy.

Shafique found that applying performance indicators at control points alone leads to averaging of deviations, and hides problems at reach level. Data from two large irrigation schemes in Sudan (Gezira and Rahad) show that analysis of performance in terms of canal reaches is often more revealing about water delivery problems than is analysis at a few control points, as illustrated by Figure 2.7. Figure 2.7A shows supply indent ratios (SIR) at key control points on a Rahad canal; except for one point, all fall within a narrow range of 0.52-0.66. Figures 2.7B and C, however, show the large variations by *reach* in SIR (from 0.35 to 2.43) and management delivery ratios (ratio of actual delivery to requirement) on specific reaches, and can be used to identify specific over- and under-supplied areas, even in systems having good average performance (see Section 3.2.4, below, on Sudan).

Figure 2.6. Diagram illustrating the meaning of canal “reach.”

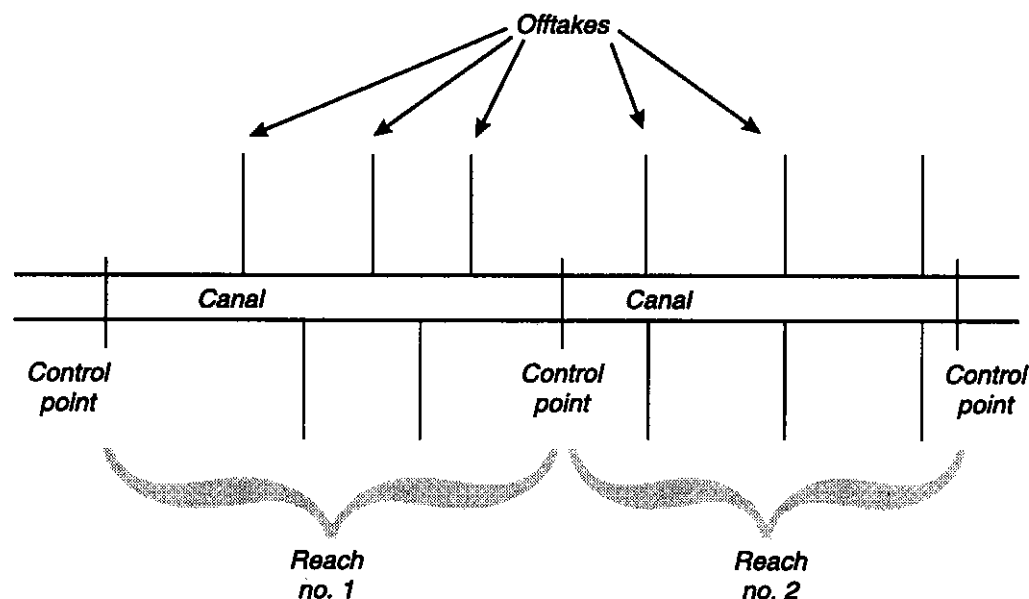
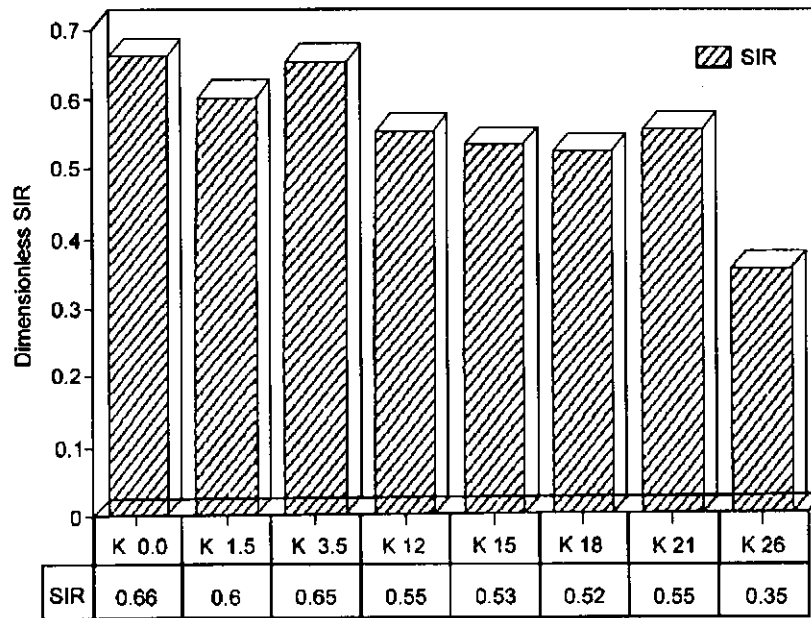


Figure 2.7. Contrasting results of performance assessment in Sudan: Control points and reach-wise.

A. SIR at control points.



B. Actual reach-wise SIR for major canal.

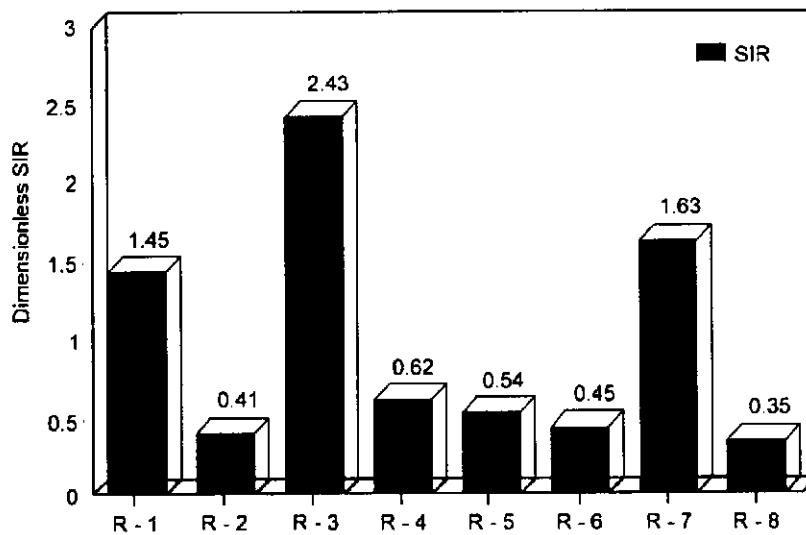
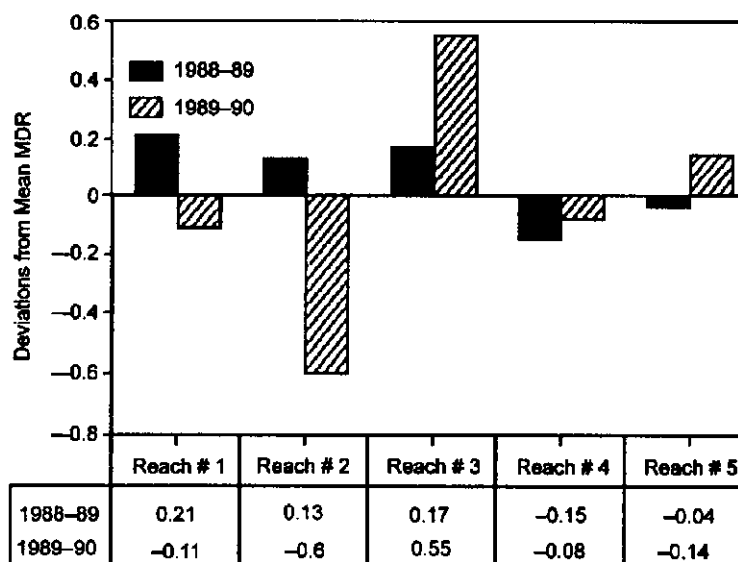


Figure 2.7. Continued.

C. Water distribution according to reaches: Nonuniform water distribution on reach basis.



Source: A and B from Rahad Scheme (Shafique 1993-1994: vol. 6, p.21). C from Gezira Scheme (Shafique 1993-1994: vol. 5).

Note: SIR = supply indent ratio ("indent" means request). MDR = management + delivery ratio.

2.3.6 Quantification of a Minimum Set of Performance Indicators

It is clear from the previous sections that over the years IIMI and its partners have developed a number of performance indicators (all related to water delivery performance); and they have also used a wide variety of existing indicators in their work. But because there has never been an agreed set of standard indicators, comparative analysis of performance using existing data sets is difficult. In 1995, the Performance Assessment Program finalized a standard approach to quantifying and measuring irrigation system performance using an agreed minimum set of indicators (Perry 1996a).

In the terms used above, the indicators are essentially external, or measures of inputs and outputs; the set does not include the kinds of internal indicators suggested by Bos et al. (1994) for example; and indicators for social and environmental impacts are "suggested" but are not part of the "agreed minimum set."⁵

The objective of using the minimum set of indicators is to assess the performance of alternative

- ways of allocating water (e.g., rationing, water markets, on-demand)
- organizations (e.g., farmer management, agency management)
- infrastructures (e.g., proportional delivery, variable or fixed flows)

⁵Rao (1993:63-64) also proposes a minimum set of indicators for screening problem systems.

These three “alternatives” correspond to the three “basic elements of successful irrigation” proposed by Perry (1995) in his discussion of “functional” and “dysfunctional” systems (Section 2.2.5). Objective comparative analysis across irrigation systems is the major objective—and not necessarily providing management tools for system managers, which had received emphasis earlier. Perry (1996a) defines a limited set of data requirements, and how the data are to be collected or estimated, to enable standardization and therefore comparative analysis. The minimum set of indicators is given in Box 2.1. The single “external” indicator that is most crucial as water becomes a limiting factor is:

What is the additional economic value of irrigated agricultural production per unit of water consumed from the hydrological cycle?

Box 2.1. IIMI's minimum set of performance indicators.

Output/unit land	$\frac{\text{Standardized gross value of output (\$/ha)}}{\text{Area irrigated}}$
Output/unit irrigation supply	$\frac{\text{Standardized gross value of output (\$/ha)}}{\text{Irrigation delivered}}$
Output/unit water consumed	$\frac{\text{Standardized gross value of output (\$/m}^3\text{)}}{\text{All water consumed (ET, nonbeneficial ET, losses to sinks)}}$
Gross return on investment	$\frac{\text{Standardized gross value of output}}{\text{Cost of distribution system}}$
Financial self-sufficiency	$\frac{\text{Water charges}}{\text{Cost of O\&M}}$
Relative water supply	$\frac{\text{Total water supply at field}}{\text{Crop demand (consumptive use, nonbeneficial ET, losses to drains and net flow to groundwater)}}$
Relative irrigation supply	$\frac{\text{Irrigation supply at field}}{\text{Irrigation demand at field (crop demand as above, less-effective rainfall)}}$
Water delivery capacity	$\frac{\text{Capacity to delivery at (sub) system head}}{\text{Peak consumptive demand}}$

All values are *annual* unless otherwise specified.

Source: Perry (1996a).

This emphasis on the economic value of water is clearly a reflection of IIMI's revised mandate, to "increase the productivity of water used in agriculture."

2.4 Applications: Comparative Analysis of Performance of Systems

IIMI's work on comparative analysis is at an early stage. Several of the assessment frameworks discussed in Section 2.2 have however been used for comparative analysis of systems. This section summarizes the results of some of these studies.

2.4.1 Diagnosing Operational and Strategic Performance

Murray-Rust and Snellen (1993) analyze quantitative data on the water delivery performance of 15 irrigation schemes around the world using the framework discussed in Section 2.2.2. The cases were categorized into two types based on their design: "fixed division systems" (five cases); and "gated division systems" (ten cases), with several variants identified for each. The analysis shows that:

- System managers rarely measure performance systematically.
- There is a wide gap between quantified operational targets and actual conditions.
- Simplicity in system design and operations more often leads to better performance than does complexity.

Those systems having a higher density of structures—which should enable better performance—rarely achieve their potential. The key variable is *management*, as is shown by cases of dramatic improvements as a result of management interventions. A common thread in the cases studied was irrigation managers' minimal concern for long-term sustainability, or indeed, for assessing and improving performance.

Based on their findings, Murray-Rust and Snellen offer a detailed set of "propositions for improving performance." These fall under the headings of objective setting, operational management, information feedback and management control, and institutional conditions.

2.4.2 Main System Management in Five Large South Asian Irrigation Systems

Sakthivadivel and Brewer (1993) use data from five large canal irrigation systems in India and Sri Lanka, in an attempt to define some of the common characteristics of large South Asian canal systems, and to identify possible relationships between management effectiveness, system performance, and the physical and institutional features of the systems. They use a model of main system management processes derived from Murray-Rust and Snellen (1993) and Bos et al. (1994).

The authors identify seven factors they expect would affect performance: size, water supply and demand, system controls, physical condition of the system, management resources, farmer involvement, and system database. The five irrigation systems studied are:

- Eastern Gandak, Bihar (see Section 3.3.2, below)
- Mahi Kadana, Gujarat (see Sections 2.4.3, 3.5.3, below)
- Tamiravaruni, Tamil Nadu⁶
- Uda Walawe, Sri Lanka (see Section 4.3.3 and Box 4.4, below)
- Kirindi Oya, Sri Lanka (see Sections 2.4.3, 2.5.3, 3.5.2, 4.3.3, and Box 4.4, below)

The data used are primarily qualitative, not quantitative; the authors are interested in the *quality* of management processes and the implications for performance. The main findings are:

1. The primary objective in all five systems is set in terms of irrigating a particular area; the managers do not consider equity, adequacy, or reliability to be major objectives. In the Sri Lankan but not the Indian systems, farmers are involved in setting the irrigated area.
2. While detailed schedules and targets are used in all the systems, the basic system data are not adequate to permit setting targets for each channel or portion of the system; Kirindi Oya is an exception as a result of IIMI's work with the management agency (see Sections 2.5.3; 3.5.2).
3. Operations are generally carried out with little regard for targets; rather, managers are concerned with solving daily problems, and balancing supply and demand to conserve water to ensure completion of the season (Eastern Gandak is an exception).
4. Flow measurements are confined to upper levels of the system; and the Indian systems do not gather or use agricultural performance data. All systems produce some measure of seasonal performance, but few have procedures to incorporate lessons learned into future operations.

The authors conclude that the recognition throughout South Asia of the principle of "management by objectives," however vague, forms a basis for management improvement; but suggest external pressures, or pressures from users in water-short systems, are necessary to motivate such improvements.

2.4.3 Application of "Performance Improvement Capacity Audit" (PICA)

The basic elements of PICA as an approach for assessing the capacity of an irrigation system to adopt changes and therefore improve performance have been summarized in Section 2.2.4

⁶IIMI recently published a paper on the work in this system. See Brewer, Sakthivadivel and Raju (1997).

(Merrey et al. 1995). PICA is applied retrospectively to five irrigation schemes in Sri Lanka, Pakistan and India; two systems are audited before and after innovations. The systems are given scores ranging from 0 (low capacity for performance improvement) to 2 (high capacity) for each of the five questions on design, operations, data collection, management framework, and willpower. The maximum total score is therefore 10. The results are shown in Table 2.1.

For four of the five systems, at the time of the intervention, the PICA scores were low (1–4); the exception is Mahi Kadana, Gujarat, with a score of 6. In this system, the management agency was assisted to introduce a more sophisticated management information system, with excellent results (Murray-Rust et al. 1994; see Section 3.5.3, below). In Ingini-mitiya, Sri Lanka (score = 3), a similar attempt to introduce a management information system had dismal results (IIMI and HR/Wallingford 1994; see Box 3.8, below).

Table 2.1. Performance improvement capacity audit in five selected schemes.

	Gal Oya (1981)	Gal Oya (1993)	Mahi Kadana (1993)	Kirindi Oya (1989)	Kirindi Oya (1993)	Ingini- mitiya (1992)	Chashma Right Bank (1993)
Design	1	2	2	1	1.5	1	1
Operations	1	2	1	1	1.5	1	0
Data Collection	1	2	1	1	2	1	0
Management Framework	0	1	1	0	2	0	0
Willpower	0	1	1	1	1	0	0
Total	3	8	6	4	8	3	1

Notes: 0 = Low capacity for performance improvement;
1 = Moderate capacity for performance improvement;
2 = High capacity for performance improvement.

IIMI's activities in Kirindi Oya started in 1986. At that time willpower was assessed at 0, and the overall score at 3.

Source: Merrey et al. (1995:17, Table 1).

Gal Oya and Kirindi Oya, both in Sri Lanka, had low scores before the interventions. In both systems, long-term multidisciplinary interventions led not only to improved performance, but to improved performance improvement *capacity*, as both emphasized institutional strengthening (see Section 3.5.2 for Kirindi Oya). The evidence given in the paper suggests the methodology is useful for evaluating the capacity for improvement, and for identifying the kinds of interventions likely to succeed.

2.4.4 Does Assessing Performance Make a Difference?

The work on performance assessment methodologies and frameworks by Murray-Rust and Snellen (1993), Bos et al. (1994), and Merrey et al. (1995) asserts that the use of a systematic

management cycle incorporating appropriate performance assessment procedures—or its absence—affects the actual performance of irrigation systems. Merrey, Valera, and Dassenaïke (1994) examine this relationship through a comparative analysis of data from three canal irrigation systems in Nepal, the Philippines, and Sri Lanka. They use the framework for performance assessment of Bos et al. (1994) described above in Section 2.2.3. This framework includes a four-element management cycle (planning, implementation, monitoring, evaluation) and three categories of performance indicators: water supply, agriculture, and socioeconomic environment. The authors hypothesize that institutional conditions which provide effective incentives to managers for good performance, the presence of an effective management cycle, and regular assessment of performance under the three categories suggested by Bos et al. are necessary for achieving and sustaining good performance.

The authors document which indicators are used by managers of each of the three systems, and the level of performance achieved based on available data. They also evaluate the presence and quality of the management cycle in the three systems, using a simple scoring system ranging from 0 (absent) to 2 (effective). Table 2.2 presents the scores for the three systems. The Philippines system's score is twice that of the other two systems. This system also has a superior performance assessment system (though with some gaps), and is the only one of the three in which the personal performance assessment and incentives of engineers are based on the objective performance of the irrigation system. The performance of the Philippines system in terms of cropping intensity, yields, farmer satisfaction, and adequacy of maintenance is also superior to that of the other two.

The paper suggests that while all three factors (management cycle, performance assessment system, institutional conditions) are important, having a supportive institutional framework is a prerequisite for the other two factors.

2.5 Applications: Analysis of Impact of Innovations

This section presents a few selected cases in which IIMI staff have documented the impact of specific innovations. It is not comprehensive. Studies of the impact of management transfer are discussed in Section 4.4. Much of the work has involved testing of management innovations, but not all of these have included rigorous quantitative assessment of impacts.

2.5.1 *Impact and Cost-Effectiveness of Lining and Desilting: Pakistan*

Although canal lining is often promoted as a long-term solution to water conveyance problems, there are few systematic evaluations of lining under field conditions. Murray-Rust and Vander Velde (1994a) report the results of a study comparing the costs and hydraulic performance impacts of four alternative interventions on four secondary canals in Punjab, Pakistan.⁷

⁷See Sections 3.2.3, 3.3, below, for related research findings.

Table 2.2. Presence and quality of the management cycle on three irrigation systems.

Management Cycle	System		
	Nayom-Bayto, Philippines	Pathraiya, Nepal	Inginimitiya, Sri Lanka
Planning			
Clear objectives	2	1	1
Specific targets	2	1	1
Consultation with farmers	2	1	2
Use results of previous seasons systematically	2	0	0
Implementation			
Follow plan	2	2	1
Flexible implementation (responsive to rain, etc.)	2	2	1
Communicate changes to farmers	2	2	1
Monitoring			
Regular data collection	1	0	1
Indicators: compare <i>actual</i> target	2	1*	1
Use indicators to adjust ("Doing things right?")	2	0	0
Evaluation			
Use data to analyze results ("Doing right thing?")	2	0	0
Total score	21	10	9
Percent of possible score	95	45	41

*Field staff in Pathraiya compare actual deliveries to the scheduled time of delivery.

Notes: Scoring: 0 = absent; 1 = present but flawed or ineffective; 2 = present, effective.

Two of the coauthors separately carried out the scoring, and then resolved their (minor) differences, while the third author evaluated the rankings done by the others and suggested two minor changes which had no impact on the overall scores. Although the subjectivity may mean that different observers would differ on details, the overall ranking would undoubtedly remain the same.

Source: Merrey, Valera, and Dassenaik (1994:285, Table 2).

- extensive lining (lower 75% of canal)
- partial lining (lower third of canal)
- major desilting
- selective desilting (using simulation results to select areas)

These interventions are ranked from most to least expensive. The research was carried out over a period of about 5 years. Equity and reliability of water delivery performance are

measured using DPR, "delivery performance ratio" (Section 2.3.1), and coefficient of variation in discharge, respectively.

The results are surprising. Both DPR and reliability *worsened* as a result of the lining, a function of quality control and implementation problems (Figure 2.3, above). Both types of desilting had significantly better positive impacts on hydraulic performance. The costs per ha of lining, major desilting, and selective desilting were US\$37.88, \$2.54, and \$0.55, respectively. The authors examine the conditions under which these costs can be justified. Justifying lining costs requires heroic assumptions about the life of the lining, water savings, willingness of farmers to pay enhanced irrigation fees (*abiana*), and impact on irrigation intensities. The institutional factors affecting Pakistan's capacity to carry out effective construction and maintenance are reported in detail in chapters 3 and 4. The authors conclude that under the existing conditions in Punjab, good selective maintenance on an annual basis, or periodic major desilting, is most cost-effective (see also Vander Velde and Murray-Rust 1992).

2.5.2 Evaluation of the Impact of the National Water Management Project (India) on Two Schemes

IIMI was requested by the World Bank and the Government of India to evaluate the impacts of the National Water Management Project (NWMP) on two large irrigation systems:

- Bhadra Project, Karnataka State
- Sathanur Reservoir Project, Tamil Nadu State

The results are reported by Sakthivadivel et al. (1995). As part of the evaluation of the Bhadra Project, IIMI worked with the National Remote Sensing Agency to use satellite remote sensing techniques to monitor and evaluate irrigation performance (de Silva 1995).

The NWMP strategy includes two components: strengthening institutional capacity to plan, implement, and monitor improved O&M practices; and low-cost infrastructural improvement to support an improved operational plan. The formulation and implementation of a specific operational plan were intended to constitute the key activity, underlying all others.

The study found that the NWMP concepts, particularly the importance of and methods for preparing operational plans, had not been fully understood and internalized by the implementing agencies. This was shown by the absence of scheme-level management committees, lack of organized farmer participation, nonestablishment of O&M cells, and inadequate monitoring and evaluation arrangements.

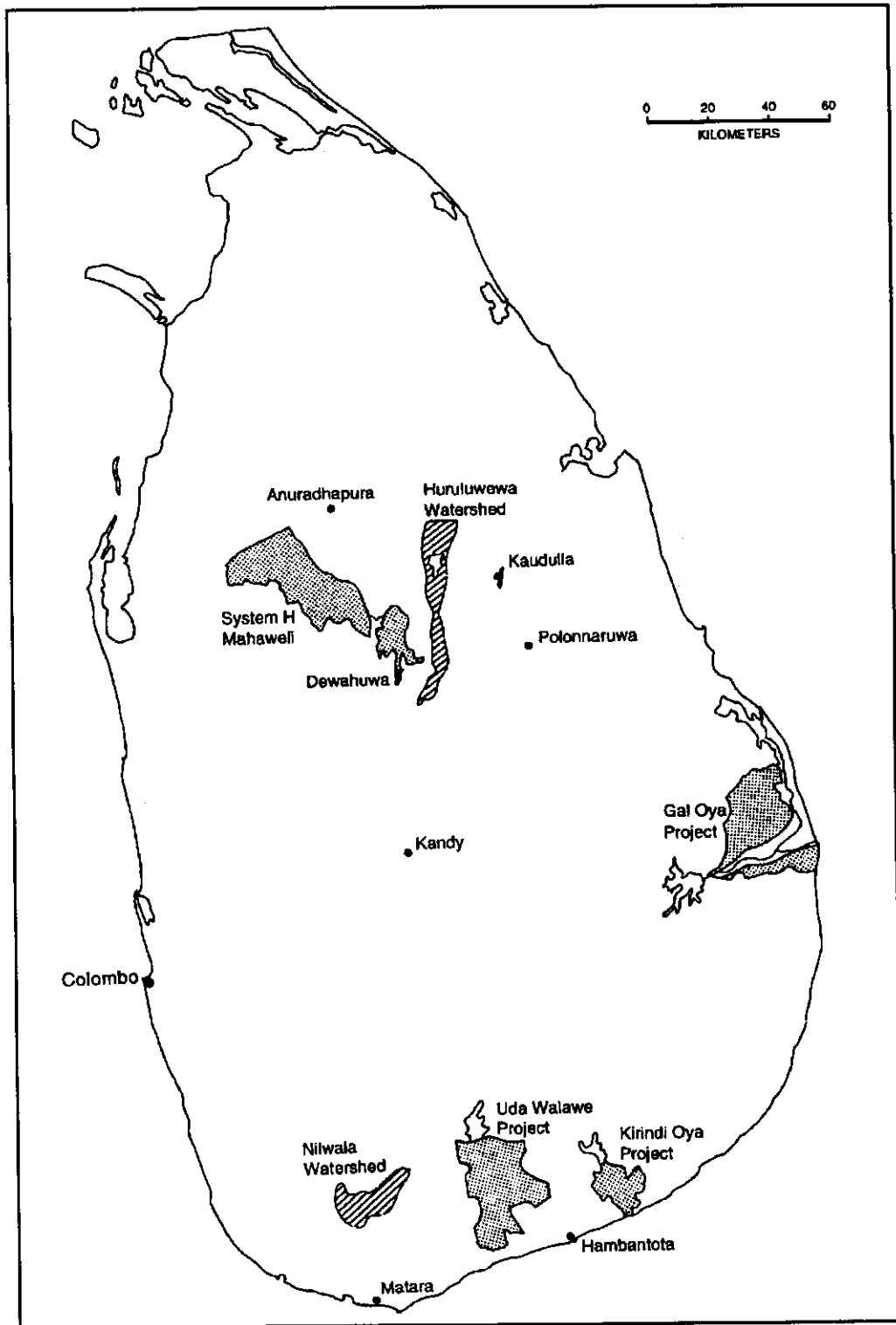
Nevertheless, the study found significant improvements in equity of water distribution in both systems, and modest improvements in predictability and reliability. There were also positive improvements in agricultural performance in both systems, though some of these changes may be related to factors other than the NWMP. The report documents its findings in detail, and makes specific recommendations for inclusion in a follow-on project (Sakthivadivel et al. 1995).

2.5.3 Evaluation of the Kirindi Oya Irrigation and Settlement Project, Sri Lanka

The Kirindi Oya Irrigation and Settlement Project is a recently completed multifaceted development project, involving construction of a large reservoir and canals to serve 8,400 ha of new lands, rehabilitation of existing irrigation facilities in an area of 3,675 ha, settlement of about 8,300 families, and development of community facilities and agricultural support facilities. IIMI has been carrying out research and development activities in Kirindi Oya since 1986 in collaboration with the Irrigation Department and other agencies (see Sections 2.4.2, 2.4.3, 3.5.2, 4.3.3, and Box 4.4). Figure 2.8 shows the locations of Kirindi Oya and other systems in Sri Lanka that are referred to in this book. IIMI was requested to carry out a comprehensive evaluation of the impact of the project, in association with the Agrarian Research and Training Institute of Sri Lanka. IIMI (1995b) provides a comprehensive detailed report on the results of this evaluation. The data were gathered through direct field measurements, published and unpublished reports, interviews with various officials, minutes of meetings and other official records, and a large-scale survey of farmers. This section highlights a few of the irrigation-related findings.

- The average rainfall in the past 20 years is one-third lower than the long-term average; because of this and changes in the catchment area, inflows into the reservoir were low, and releases over the past 8 years were 60 percent of the plan. This led to a reduction in the total area developed, and lower than expected cropping intensities (133% versus the planned 170%). Further, there is a very large gap between the design assumptions and the reality, in terms of water requirements, seepage and percolation, and time required to complete irrigations.
- The overall irrigation efficiency, defined as the percentage of irrigable area developed for irrigation multiplied by the percentage irrigation intensity, over 6 years is 47.3 percent. The study considers this performance as good and suggests the reasons are a large amount of reuse, combined with an effective operational plan to make use of rainfall, and the development of agro-wells. On the other hand, very low financial allocations for maintenance, and continuing weaknesses in government agencies and farmer organizations threaten the sustainability of the system.
- Lack of clarity regarding the water rights of existing farmers and new settlers had a very negative impact on system performance (see Section 4.3.3).
- The total cost of the project was about \$100 million, twice the original estimate in dollar terms (and five times the original Sri Lankan rupee estimate). About 62 percent of this was spent on irrigation infrastructure, and 40 percent on the dam alone. Incremental outputs fell short of the plans: total rice production is 55 percent below expectations, other field crops 14 percent, milk 17 percent, cropping intensity in the new areas 50 percent, and mandays of employment post-construction 20 percent. It is therefore not surprising that the estimated economic rate of return (ERR) is lower than expected: 6.3 percent for the whole project, instead of the 17.6 percent originally expected, and 13.6 percent when the project was reappraised.

Figure 2.8. Map of Sri Lanka showing IIMI's major research sites.



2.5.4 *Impact of Management Interventions on Five Irrigation Systems in Sri Lanka*

Imbulana and Merrey (1995) use secondary data to analyze the performance of five major Sri Lankan irrigation schemes, comparing performance before and after management interventions. These interventions included crop diversification, structural improvements, and joint management with farmer organizations. Rice is the main crop on all these schemes, though several have some diversified crops during the dry season. One system shows significant improvement in both water supply and productivity; two are mixed (water supply improved and agriculture declined, or vice versa), and in two systems performance declined on several of the parameters used. Performance gains in water use were the result of a single factor: decreasing the length of the irrigation season.

The authors also compare the most recent performance to the seasons having the best performance during the study period (1984 to 1993) as a proxy for identifying the gap between current and potential performance. The results are summarized in Table 2.3. All five systems are operating somewhat below their potential (using this conservative definition), though there are exceptions for some systems on some parameters. The authors make suggestions for improving the Irrigation Department's performance assessment and data collection systems, and suggest that institutional strengthening to increase the motivation for achieving better performance could have a significant impact.

2.6 Conclusion

An important unresolved issue permeating IIMI's and others' work on performance assessment is whether having clear objectives is a necessary prerequisite for assessing performance. The term "assessment" implies comparison of a result with a standard. Bos et al. (1994) and Merrey et al. (1995) explicitly state that the framework and methodology they propose presuppose the objectives are known. But clearly there are many systems where management does not set explicit measurable objectives. The new minimum set of performance indicators (Perry 1996a) makes no assumption about the existence of objectives or standards in systems. Ultimately, the objective of the performance assessment exercise will determine the importance of having performance objectives. For system *managers* objectives are a necessary prerequisite for doing management; without objectives there is no management. All irrigation systems have built into their design and operating assumptions some objectives or standards, though how explicit, or realistic, or measurable these are may vary enormously. For the purpose of the proposed minimum set of indicators, intersystem comparison may lead to setting external standards by which system performance can be assessed: achieving a certain level of value produced per unit of water under particular circumstances, for example.⁸

⁸Achieving high performance by this standard in the short run must be balanced with meeting leaching requirements to sustain soil fertility.

Table 2.3. Most recent irrigation performance, as a percentage of the best performance achieved from 1984 to 1993, for five schemes in Sri Lanka.

Performance Indicator	Dewahuwa		Mapakada		Parakrama Samudra		Rajangane		Ridiyagama	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
AIUW (I) ¹	71	71	90	89	86	90	75	65	80	88
AIUW (T) ²	97	73	73	88	72	90	78	66	80	85
Irrigation Intensity	100	50	100	89	100	100	97	100	88	93
RWS ³	94	—	73	99	86	97	85	85	72	81
IWP ⁴	70	—	83	90	75	96	91	81	88	93
Production (tons)	64	—	95	96	81	83	90	87	77	82
Cropping Intensity	78		98		98		97		90	
LP ⁵	95		95		89		83		84	

¹Area irrigated per unit water (irrigation only)

²Area irrigated per unit water (total water supply)

³Relative Water Supply

⁴Irrigation Water Productivity

⁵Land Productivity

Source: Imbulana and Merrey (1995:63, Table 24).

Perry (1994:16) has noted that "IIMI is perhaps much closer to having tested fifty performance indicators in one project than one indicator in fifty projects." While an exaggeration, the point is valid: only a few of the indicators discussed above have been tested in more than one country.

Several changes are now underway in the Performance Assessment Program. First, the work on performance assessment "frameworks" has been completed. Second, the emphasis is shifting from development of indicators, to applying the "minimum set" of indicators (Box 2.1) in a systematic manner for assessing trends in particular systems, assessing the impact of innovations, and comparative studies of performance. Third, the work is being done in a water basin, rather than in an irrigation system context. Fourth, there is a shift from assessing *management processes* to assessing system *outputs*, with the likelihood of more attention in future to impacts (to use the distinctions suggested by Small and Svendsen).

In the past, IIMI had defined its chief clients as irrigation system managers, and its work therefore emphasized performance assessment as a tool for such managers. IIMI is increasingly defining its clients to include policy makers and other researchers, who are believed to be more interested in output and impact performance. In business terms, the previous work presumed that managers were the main clients. Now investors, policy makers, and regulators have become the primary clients for the Performance Assessment Program. But to understand the underlying reasons for a particular level of output, policy makers and investors will also be interested in assessments of management processes. These people as well as irrigation managers will continue to be important clients for the work on Design and Operation of Irrigation Systems, the program discussed in the next chapter.

In its future work, IIMI will place great emphasis on assessing the productivity of water—the “crop per drop.” Its findings will be based on empirical analyses of quantitative data collected and analyzed using sophisticated sampling procedures and statistics. IIMI will also make greater use of new technologies, especially remote sensing and geographical information systems in assessing system performance. Some of the research results discussed in this chapter provide a firm foundation to achieve excellence in its research on irrigation performance.

CHAPTER 3

Research Results: Design and Operation of Irrigation Systems

3.1 Introduction: Evolution and Objectives of the Program

The Program on Design and Operation of Irrigation Systems has evolved out of two earlier programs: Systems Management, and System Rehabilitation and Improvement. In the Medium Term Plan for 1994–1998, it was called “Sustainable Management of Water Delivery and Disposal” and had similar objectives to the present program.

These objectives are

- to improve the physical performance of irrigation systems
- to compare the management impacts of various alternative hardware and software

The program has a strong focus on management of operations and maintenance of irrigation systems. This includes both effective delivery of water to farmers, and minimizing detrimental effects to the environment, especially waterlogging and salinization. Water delivery and disposal constitute the core business of IIMI's traditional collaborators and clients—the irrigation management agencies. Careful documentation of how water is delivered and drained, diagnosis of problems and their causes, and the development and testing of practical operational solutions are essential steps in improving water management, even when the underlying problems have an institutional as well as technical dimension.

This program has been particularly closely linked with the Performance Program, as it makes use of performance assessment methodologies and indicators developed by that program for evaluating performance, and innovations to improve performance. But there are also clear linkages to the other two programs: system management occurs in an institutional context which is often the determining factor in improving operations; and system design and operations have important impacts on the environment and on the health of people. Design and Operation of Irrigation Systems nevertheless constitutes IIMI's central program, in the sense that it is through improved operation of systems that higher productivity will be achieved and sustained. The Performance Assessment and Policy, Institutions, and Management Programs provide the means for identifying gaps and instituting necessary behavioral changes while the Health and Environment Program is largely focused on important outcomes of the way irrigation is managed. An important innovation in the current Design and Operations Program is placing irrigation system management issues in the context of water basin hydrology.

Specific understanding of irrigation systems is critical. Researchers need to spend a long period of time in the field collecting data to develop a real understanding of a system's functioning—physical, institutional, economic, and social. The descriptions of system operations and performance provided by irrigation departments frequently vary significantly from the facts. This is often the result of inadequate field information, and not of deliberate attempts by irrigation engineers to mislead. The consequence for research, however, is that there must be an initial period of learning about how a system actually functions to establish the reality of system performance and the causes. These findings are often resisted initially, as they undermine comfortable assumptions. The perceived problems identified by the country and the donors are often the readily observable symptoms, such as rapid system deterioration and low water use efficiencies; the underlying causes are less often perceived or understood. A major achievement, then, has been the "introduction of realism into the perceptions about the operation of major irrigation systems in the countries in which IIMI is working" (Levine 1992).

The research builds on the state of the art as reflected in the academic literature, and reports from others working on similar problems. Research on water management at the farm level has a long history in industrialized countries, and has been addressed in recent decades by the International Rice Research Institute's water management program, Colorado State University's On-Farm Water Management Project in Pakistan in the 1970s, and others. Research on management of water at the main canal is more recent, often dated from a seminal article by Wade and Chambers (1980) on main system management as a "blind spot" (see also Chambers 1988). In the area of management information and decision support systems, IIMI's role is not to develop new technologies from scratch, but to identify practical systems that irrigation managers can adapt and use; and to apply such systems to answering research questions where appropriate. In recent years, there has been an increase in main system water management research reported in journals from a variety of countries. IIMI's work, in collaboration with a variety of partners, has contributed to improving the understanding of main system management, and its relationship to farm-level water management, crop production, and environmental impacts.

3.2 Water Conservation at System Level

3.2.1 Irrigation Management for Crop Diversification in Rice-Based Systems

World rice prices weakened in the early 1980s. This was in substantial measure due to the successes of rice research and irrigation development, causing production deficits to be replaced by surpluses in several countries. A response to the weakening of prices was a wish to introduce other higher-value crops alongside rice in many irrigation systems of south and southeast Asia. From 1985 to about 1992, IIMI actively participated in this response through a number of collaborative research and development programs in Bangladesh, Indonesia, the Philippines, and Sri Lanka (IIMI 1989b, 1989d, 1990a; IIMI Irrigation Management Group on Crop Diversification 1992; Valera 1992; Miranda 1989; Miranda et al. 1993), and through the establishment of a nine-country network in 1989.

The principal water management requirements of the transition from rice to diversified crops are:

- increased reliability of water supplies
- improved drainage facilities
- improved agency/farmer communication about water, whether through planning mechanisms or through arranged-demand scheduling and the like

In Sri Lanka, the Philippines, Indonesia, and to some degree Bangladesh, much of IIMI's work in its first half decade addressed the problem of managing systems designed for rice to irrigate non-rice crops in the dry season. This research confirmed the potential for growing non-rice crops in systems originally designed for rice, especially systems having substantial areas with well-drained soils and a water supply that is inadequate for meeting the requirements of rice in the dry season.⁹ However, the requirements in terms of management intensity and support services are more demanding than for rice; and though the potential returns to cultivating other crops are higher than rice, the risks are also greater (Miranda 1989).

The research confirmed the paradox that, although economic analyses show many crops to be more profitable than rice, the farmers often do not adopt those crops, and the progress of diversification is very slow. In many cases, water delivery problems seem to explain this. Most alternative crops require much higher levels of investment of time and money, and they also carry much higher levels of risk, than does rice cultivation. If the farmer does not trust the irrigation system to deliver water in the required quantity and time, he will not accept those risks and will stick to the lower but reliable returns that rice can give.

The research and networking have made clear that diversification is not simply a technological matter. It affects production relations, social and economic relations, and institutional behavior at many levels. Effective output and input markets are essential. Diversification does not come about unless these are all successfully addressed (see especially Kikuchi 1992).

In both Sri Lanka and the Philippines, the lack of effective guidelines for system management for non-rice crops has been an important impediment to success. For example, research in Sri Lanka has consistently emphasized the following problems:

- weaknesses in water management below the turnout
- the lack of communication between farmers and managers
- unreliability and inequity of water supply at the turnout

⁹Kikuchi (1992) notes that there are two options for "horizontal" diversification: regional or system specialization, found in Thailand for example, and introduction of non-rice crops in replacement of or in addition to rice on rice-based systems. IIMI's work has concentrated entirely on the latter option. Kikuchi also notes the possibility of "vertical" diversification of rice systems—improving income-earning opportunities through value-adding processing of rice.

- the absence of procedures to measure water deliveries and to respond to changing demands below the main sluice (e.g., IIMI Irrigation Management Group for Crop Diversification 1992)

IIMI worked with the Sri Lankan, Philippines, and Indonesian management agencies in an action research mode to test improved management processes to overcome these problems, with mixed results. For several years, this included a collaborative program with IRRI and with NARS in the Philippines, Indonesia, and Bangladesh (Miranda and Maglinao, eds. 1993a). As the program evolved, it shifted from direct research to support for a Network on Irrigation Management for Crop Diversification. This network brought primarily Asian researchers, policy makers and managers together for annual meetings and field visits (see IIMI 1989d; Miranda and Maglinao, eds. 1992; 1993b). However, it proved difficult to obtain financial support, and the network became inactive after 1992.

Work has continued on this issue in Sri Lanka, especially at Kirindi Oya (see Figure 2.8), in the context of research on a variety of performance, operational, and institution issues. Kirindi Oya is a water-scarce system in southern Sri Lanka where IIMI and several partners have worked since 1986 (see Sections 2.5.3, 3.5, 4.3.3). In the first phase at Kirindi Oya, the research identified two categories of non-rice crops, high-value and low-value. Low-value crops (such as green gram, cowpea, and groundnut) use less water than rice, but the profits are not superior to rice, and the price farmers receive is not very predictable. High-value crops such as chili and big onion have far greater returns but are capital-intensive and also somewhat risky. The report recommended a mixed pattern of low- and high-value non-rice crops supplemented by rice, particularly in the poorly drained soils (IIMI 1990a, vol. 2, chap. 6).

In the second phase, IIMI worked closely with the Department of Agriculture and other government agencies and with farmers to identify crops and on-farm irrigation management practices for non-rice crops appropriate for Kirindi Oya (IIMI 1995a: vol. 2, chap. 5). Recommendations are given related to types of crops, number of irrigations required, timing of cultivation, and locations for diversified crops.

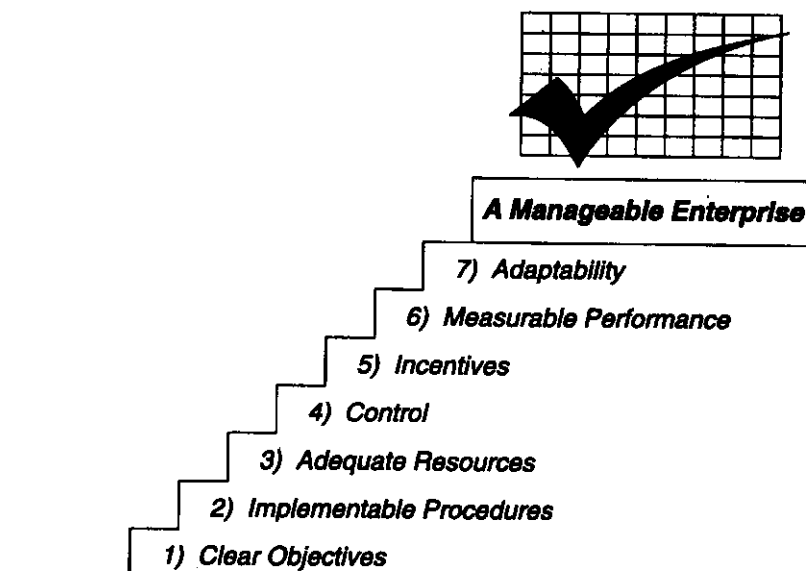
3.2.2 Irrigation Performance in Indonesia

Of the countries where IIMI has worked on crop diversification in rice-based systems, Indonesia shows the most progress. Farmers in Java grow a variety of other crops during the first and second dry seasons, where soils and water supply permit. Yields and crop intensity are high compared to other countries. Nevertheless, research has shown that the actual performance of irrigated agriculture falls far short of the potential. Planning and operational procedures on Indonesia's technical irrigation systems are relatively sophisticated in principle, but in practice these procedures require regular collection of accurate data, and the use of relatively complex calculations to make use of these data. In reality, the field data are not very accurate, and the calculations are often wrong. IIMI worked with provincial irrigation officials to develop practical methods to enhance the quality of the planning and operations processes (IIMI 1987, 1989b; Kelly and Johnson 1991). For example, in 1989 IIMI worked with the West Java Provincial Irrigation Service to pilot-test improved rotational irrigation on a 4,871 ha division of the 7,611 ha Maneungteung Irrigation System (Vermillion and Murray-Rust 1995).

This system has a high level of crop diversification in the dry season, and a high cropping intensity (over 200%); in the dry season, as river water levels drop, rotation of water deliveries is essential. In 1988, research identified serious problems and a high degree of farmer dissatisfaction with the rotations. Therefore, the researchers worked with the system managers and farmers to pilot-test a modified rotational plan, whose objectives were to improve equity in water supply among tertiary blocks and make the rotation more manageable, within the current resources and constraints of the agency. The results are evaluated in terms of seven “essential elements of a manageable enterprise” (Figure 3.1).

1. The pilot rotation *objectives* and criteria for evaluation were clearer than the normal rotation.
2. The new rotation was substantially easier to implement, i.e., it was more *implementable*, because of reduced management inputs and reductions in total gate adjustments required, as shown in Table 3.1.
3. Given the reduction in required gate adjustments and monitoring, *resources were judged adequate*.
4. Realignment of rotation unit boundaries and involvement of farmer representatives in monitoring made the process more *controllable*.

Figure 3.1. Seven essential elements of a manageable enterprise.



Source: Vermillion and Murray-Rust (1995:5, Figure 2).

Table 3.1. Improvements in management requirements between the 1988 and 1989 rotations, East Maneunteung System, West Java.

	1988	1989	% Change
Total management inputs	279	241	-13.6
Total required gate operations	219	166	-24.2
Gate supervisions (hours/week)	32.4	27.4	-15.4
a) Gate to be adjusted	16.4	9.7	-40.9
b) Gate to be kept closed	16.0	17.7	10.7
Downstream flow must be stopped:	10	6	-40.0
a) Using stop logs	10	0	-
b) Using sliding gates	0	6	-

Source: Vermillion and Murray-Rust (1995:25, Table 5).

5. *Accountability* was improved because of a formal agreement about the rotation between the agency and village agricultural officials. However, the lack of sanctions against violating the plan either for farmers, village officials, or agency staff, continued to be a major weakness. Further, because of very low salaries supplemented by unofficial "temptations" and sideline income-earning activities, *incentives for agency staff were not supportive*.
6. Delivery Performance Ratio (DPR), the ratio of actual and planned discharges, was introduced and used to monitor the results. In 1989, there was a much closer relationship between DPR at the system level and at rotation unit levels ($R^2 = 0.44$) than was the case in 1988 ($R^2 = 0.27$), and equity improved. Therefore, *the results were measurable*.¹⁰

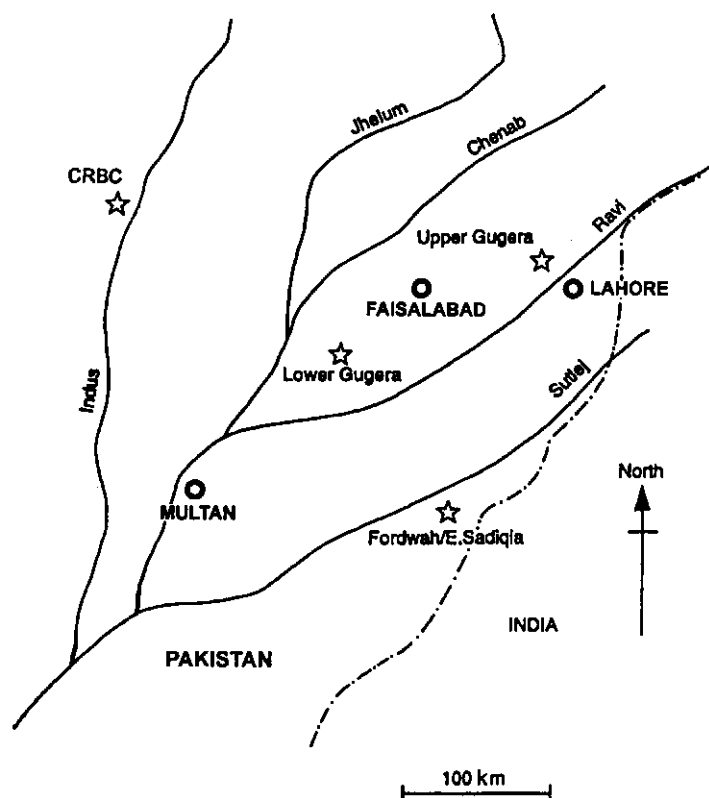
The results demonstrate the potential for increasing manageability and performance of dry-season irrigation rotations at the local level using current resources. However, the authors emphasize that institutional accountability and incentives to manage, and not the identification of management procedures, are the most difficult but essential issues to be addressed.

3.2.3 Canal Performance in Pakistan

IIMI has had a field research program in Pakistan since 1987. There have been three major research locations: the Upper and Lower Gugera Divisions of the Lower Chenab Canal; the Chashma Right Bank Canal (CRBC); and more recently, the Fordwah/Eastern Sadiqia Canal (see Figure 3.2). This section reports research on canal performance under these three headings; Sections 3.3 and 3.4 report on the research on conjunctive use of surface water and canal water and waterlogging and salinity, most of which has been done in Pakistan.

¹⁰The authors do not discuss "adaptability" which is a longer-term element of management that could not be covered in a one-season study.

Figure 3.2. Location of sample areas in Pakistan.



Source: Kijne (1996: Figure 2).

Equity and variability: Research on the Lower Chenab Canal (LCC)

From 1987 to 1993, IIMI carried out intensive field research in collaboration with the Punjab Irrigation Department on four distributaries of the Lower Chenab Canal (LCC) in Punjab, Pakistan. The LCC command area is 1.2 million ha, served by 176 distributary canals whose total length exceeds 2,800 km. Design full supply discharge for the system at the head exceeds 310 cubic meters per second. The results of this research have been reported in several places; the work on canal management is reported by Bhutta and Vander Velde (1992a) and (1992b) and Vander Velde and Murray-Rust (1992).¹¹ The data are from four distributaries with culturable command areas ranging from 6,758 ha to 33,119 ha. On three of the four distributaries, surface flow conditions were measured and observed daily at 20 to 30 locations; crop surveys and monitoring of public and private tubewells were also carried out in these commands.

¹¹See also Bhutta (1990). Results of the research on the impact of lining and desilting carried out on the LCC have been discussed in Section 2.5.1.

The operational objective for canal systems in a large part of India and Pakistan, especially in the Punjab provinces of both countries, is equitable distribution of a scarce irrigation water supply. Rainfall is inadequate for crop production in much of the area; and irrigation is designed to spread water over as large an area as possible. This is to be achieved, operationally, by sustaining constant discharge rates in most major channels, and by constructing outlets to watercourses so that the flow into each is in proportion to its command area. Within each watercourse, water is distributed by fixed time allocations based on area irrigated, called *warabandi* (see Box 3.1). In principle, operating and monitoring of such a system, and feedback about deviations from the operational plan, require relatively simple arrangements. There are therefore fewer opportunities for intervention by managers than are found in a demand-based system. In demand-based systems, managers attempt to match, at least to some degree, water deliveries to crop requirements or farmer demand. The *warabandi* system is a classic case of a supply-based system, and expects farmers to match their cropping patterns to the known (but scarce) water supply pattern (see Box 3.2 on demand- and supply-based systems).

Warabandi systems are found in Pakistan and Northwest India. Some studies of North Indian *warabandi* systems provide evidence that their performance is good, in terms of achieving their equity objectives, and in terms of productivity of water (see Malhotra, Raheja, and Seckler 1984; Seckler, Sampath, and Raheja 1988). However, research findings from Pakistan present a far less positive picture.

Equity objective rarely achieved. Findings from research on LCC distributary canals over several years show that the long-standing system performance objective of equity in water distribution is now rarely achieved and almost never sustained. These results have important implications for similar surface irrigation systems in other semiarid countries, especially India and China.

The distribution of water to outlets along a distributary canal is substantially inequitable when channel design parameters no longer prevail (Bhutta and Vander Velde 1992a). Delivery performance ratios (DPRs), i.e., the ratio of actual to planned (or in the case of Pakistan, design) discharge, are often 1.5 to 2.5 at the head, and can fall to 0 at the tail. For example, Figures 3.3 and 3.4 show the variation in water distribution equity at low and normal discharges (see also Figures 2.3, 2.4, 2.5). Supplies to tail outlets are typically four times worse than those to head- and middle-reach outlets, and often even worse. This is best demonstrated using the concept of "interquartile ratio," a measure for comparing the performance of the worst and best quartiles of outlets (see Abernethy 1986; Rao 1993:18-19).¹² Figure 3.5 shows that the DPR of upper quartile outlets is generally at least four times higher than that in the lowest quartile (for example if the lowest DPR is 0.5 and the highest 2.5, the highest is five times the lowest quartile). Other measures such as days without water and supply variability

¹²Bhutta and Vander Velde (1992a) compare the head-end and tail-end quartiles, and this comparison gives locational inequity. Abernethy's (1986) original interquartile ratio concept compares the best and worst quartiles regardless of location. In some of the cases in Bhutta and Vander Velde, overall inequity exceeds head-tail inequity (Abernethy personal communication, 1996).

Box 3.1. Warabandi: Widening gap between theory and practice.

Bandaragoda and Rehman (1995) report the results of a study of warabandi on 22 watercourses in the LCC and Fordwah-Eastern Sadiqia systems. Warabandi is an institutionalized rotation method with fixed time allocations based on the size of landholdings of water users within a watercourse command. It presupposes an overall scarcity of water supply, and has two related objectives: equity in distribution of the available water, and efficiency of water use. The system also presupposes a set of physical and institutional conditions that ensure uniform and reliable flow of water in the canal system, free flow of the design water supply into outlets, and rotations among users.

As demonstrated by IIMI's research, the water allowances for watercourses and water deliveries are in fact variable and unreliable at all levels, from main and branch canals to distributaries, watercourse heads, and farmers' fields. Thus, as Bandaragoda and Rehman (1995) document, the necessary preconditions for warabandi to operate no longer exist. Their study uses three versions of warabandi: official, agreed, and actual. The official warabandi, usually set by the Irrigation Department, represents the theory and the legal water right of users. The agreed warabandi represents adjustments made in the official warabandi over time by mutual agreement among water users. The actual warabandi represents the observed practice. These three diverge widely on several parameters: list of water users, the number, timing and duration of turns, the distribution of night and day turns, the number of hours per ha, and the average water allocation. The Table illustrates this divergence for one of the 22 watercourses. Exchange of turns is a common feature on the sample watercourses, while buying and selling of turns were observed in just a few watercourses.

Table. Variability of water allocation through warabandi turns, Watercourse No. 89250-L, Pir Mahal.

Description	Warabandi		
	Official (n=36)	Agreed (n=156)	Actual (n=49)
Range (hrs./ha)	0.42–0.93	0.47–3.29	0.65–6.30
Average (hrs./ha)	0.69	0.83	1.81
Standard deviation	0.09	0.25	1.40
Coefficient of variation (%)	13	31	77

Source: Bandaragoda and Rehman (1995:52, Table 12). "n" = no. of turns.

The study links these deviations to the use of tubewells: deviations are greater in watercourses with tubewells. Many of the deviations occur through mutual agreement, in which larger farmers apparently take advantage of others who are less powerful: the authors claim (but do not fully demonstrate) that these deviations increase inequity of access to water—an observation that seems to contradict the results of research on water markets (Section 3.3, below). Trading or selling turns is illegal under the law. The authors suggest retaining the official warabandi to represent farmers' legal "rights," but making exchange and trading legitimate; more regular updating of the official warabandi; and improving O&M to recreate the preconditions for equitable water distribution.

Box 3.2. Demand-based and supply-based irrigation systems.

Two extreme types of irrigation system design can be distinguished. At one extreme are highly "structured" systems, i.e., systems having just a few gates which are operated on an "on-off" and automatic proportional distribution basis. Existing water supply is therefore rationed on an "empty canal" basis at certain levels, and a proportional sharing of supply at others. Such systems are also called "supply-based" because they seek to distribute a particular supply of water proportionally rather than meet particular crop demands; they are most often found in water-scarce environments. An example is the warabandi-based systems of Pakistan and North India.

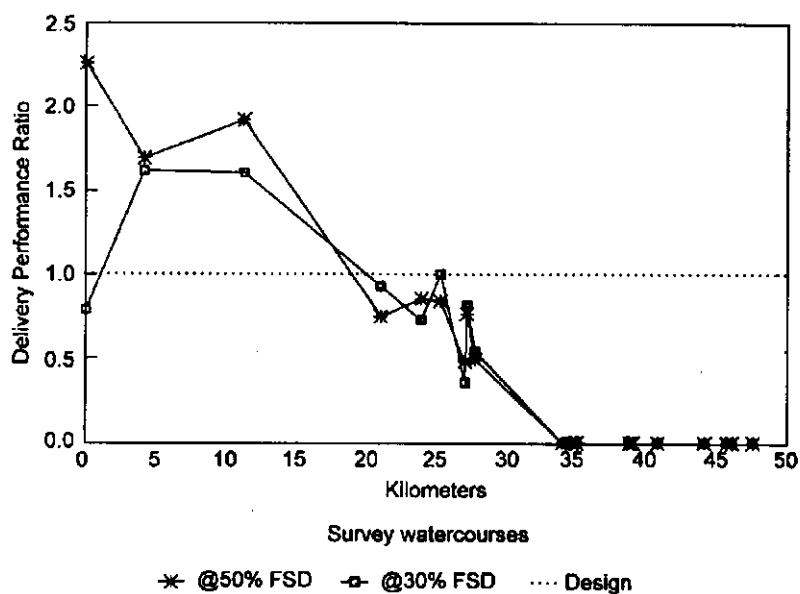
The other extreme is "demand-based" or "just-on-time" systems. This type of system is characterized by a large number of gated control structures so that water deliveries can, in principle, be adjusted to meet changing crop demands. Many systems in South India and monsoon Asia (e.g., Indonesia, the Philippines, Sri Lanka) are based on this design principle. Clearly, actual systems may exhibit varying degrees of being supply- versus demand-based. Thus, CRBC is designed with sufficient flexibility to meet the average crop demands of a particular cropping pattern, but managers cannot cater to individual farmers' needs.

It is often assumed that systems with the flexibility to meet varying demands will be more productive. However, a group of World Bank irrigation specialists has argued that under the institutional conditions found in Asian developing countries, large-scale irrigation systems should be designed as "structured networks" and operated on a supply-based schedule (e.g., Burns 1993; Berkoff 1990). The argument has several strands, but an important basis is the observation that whereas the highly structured warabandi systems of North India operate according to design and achieve high productivity of water, demand-based systems tend to be characterized by high degrees of rent seeking, farmer interference in operations, gaps between objectives and performance, and destruction of gates by desperate farmers. These specialists have argued that even in monsoonal Asia, large systems should be designed for control at higher levels (running canals to particular sections of the system on an "on-off" basis) and structured for automatic operation at middle levels.

IIMI's research results have been used by proponents of structured systems to support their case (e.g., Burns 1993:782). But with one exception, IIMI itself has not contributed directly to this debate about design. For example, the reports on CRBC in Pakistan take for granted the assumption that crop-based irrigation systems will be more productive than warabandi systems. IIMI's work has generally taken existing designs for granted, and has sought to identify performance problems and potential *management* solutions given the existing design. The exception is the comparative study by Murray-Rust and Snellen (1993; see Section 2.4.1) which observes that simplicity in design and operations often leads to better performance than does complexity.

As Abernethy (personal communication, 1996) points out, on-demand and supply-based types of systems may each be appropriate in different conditions. Abundance or scarcity of water relative to demand is a primary determinant: demand-based systems cannot succeed when there is insufficient water to satisfy all demand. Demand-based systems generally require more capital expenditure and more intensive and expensive operations; if these are lacking they become chaotic. But supply-based systems like the warabandi systems are more sensitive to maintenance—poor maintenance leads to ineffective delivery as shown in Pakistan. Finally, *transparency* is a key principle underlying the success of proportional dividers in many traditional farmer-managed irrigation systems (FMIS): farmers can see the system is equitable.

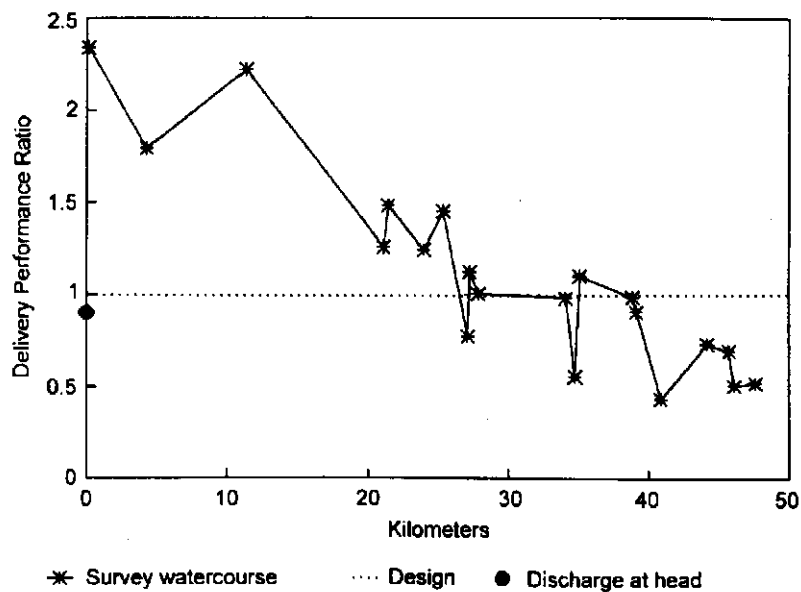
Figure 3.3. Pir Mahal Distributary, Pakistan: Water distribution equity at low discharges.



FSD = Full supply discharge.

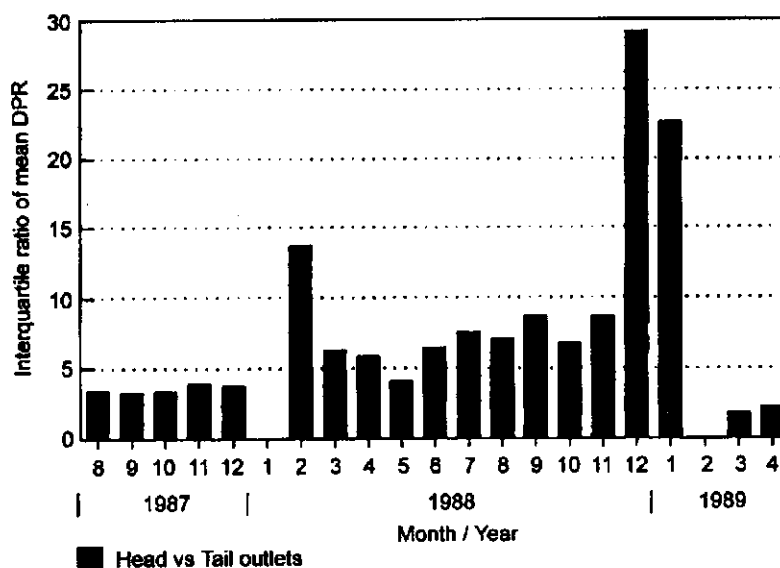
Source: Bhutta and Vander Velde (1992a:242, Figure 11.6).

Figure 3.4. Pir Mahal Distributary, Pakistan: Water distribution equity at normal discharge.



Source: Bhutta and Vander Velde (1992a:241, Figure 11.4).

Figure 3.5. *Lagar Distributary, Pakistan: Water distribution equity.*



Source: Bhutta and Vander Velde (1992a:244, Figure 11.9).

at the watercourse head confirm this condition. The primary cause of this inequity in water distribution is the interaction among several or all of the following conditions:

- markedly changed channel physical conditions resulting from low levels of maintenance and/or deferred maintenance
- changes in outlets from tampering
- frequent distributary operations at low head discharges
- installation of temporary pipes and other physical interventions to capture additional water illegally, especially in head- and middle-reach locations
- permanently installed pipe and flume outlets in head-reach locations through which head-end farmers take more than their due share

The original operational assumptions of water surface level at or near design full supply level and modular outlet flows are no longer valid. Present flow velocities in distributaries vary from 75 percent to 20 percent of original design velocities between head and tail reaches. Existing irrigation laws are often not enforced, and many established operational rules and procedures are now ignored. In Perry's (1995) terms, the system has become "dysfunctional."

Options for improving water delivery equity. IIMI's studies have demonstrated that an effectively implemented and sustained program of systematic heavy maintenance inputs and distributary canal rehabilitation (but not necessarily lining of canals) would create the necessary conditions for achieving the operational objective of water distribution equity (see Section 2.5.1, above). The following options appear to have the most potential for maintaining as great a measure of equity in water distribution along distributary canals as present conditions permit:

- a. The long-standing operational principle in Punjab that distributary canals are not to be operated at less than 70 percent of design or sanctioned full supply must be reactivated and followed. Indeed, available evidence suggests that this lower limit may be too generous for physical conditions now prevailing in most distributaries and it may need upward revision to 80 percent or more.
- b. As a complement to (a) above, suitable rotational programs between distributaries can be implemented to enable maintenance of full supply levels on distributaries. Where existing structures permit and physical conditions warrant, rotational deliveries can be practiced within distributaries as well. Rotational operation has been a long-established option for canal management in Punjab when available supplies are short, but present conditions emphasize the need for it to be more frequently and realistically considered. Designing an effective rotational schedule that will minimally affect the existing system of *warabandi* (fixed rotation of water delivery at watercourse level) is a challenging task, certain to require greater professional attention by the Irrigation Department than is now given. Especially critical to its success will be the timely downstream communication of schedules to field operations staff and to farmers, as well as adherence to the announced schedule to reduce variability in supply while providing assurance to farmers of supply reliability. The gap between myth and reality of water delivery on branch and distributary canals is mirrored in the equally large gap between theory and practice of *warabandi* on watercourses (see Box 3.1).
- c. Within-distributary rotational operation of outlets—maintaining discharge into a watercourse at essentially design flows, but for a reduced time—is an option that deserves serious consideration under conditions of substantial shortfalls in canal supplies. The challenge here is at least twofold; on the one hand, it needs to be planned in conjunction with alternative *warabandi* arrangements,¹³ and on the other, clearly, it will require greater patrolling of outlets and a higher degree of farmer cooperation than is now generally evident in distributary command areas.

For example, a second *warabandi* could be 3.5 days in length, and the distributary operated with about one-half the outlets closed during each half of the week.

¹³Based on a detailed study of *warabandi* on two watercourses in Pakistan, and a review of available literature on *warabandi* systems in India and Pakistan, Merrey (1990) advocates testing ways to delegate flexible water control to farmer groups.

Concomitantly, the need to ensure widespread compliance with such an operational program would provide an excellent opportunity to test the viability of watercourse-level water users associations functioning responsibly and in cooperation with the Irrigation Department at the distributary level.

- d. The impact of physical modifications of outlets and minor offtakes must be evaluated in the larger context of distributary operational objectives. Too often, a significant change in these physical structures is authorized by the Irrigation Department as though such changes were independent of operational consequences elsewhere in the distributary system. With channel physical conditions now very different from design parameters for most distributaries, modification of such physical structures should be approached with considerable caution insofar as there is heightened potential to simply shift the problem elsewhere, usually downstream, and to increase inequity in water distribution.
- e. An effective program of targeted maintenance complemented by occasional heavy maintenance will have a substantial impact (Section 2.5.1). Other suggestions include spatial refocusing of the watercourse improvement project from the current concentration at the head offtakes, to the tails of distributaries; and more careful management of head gate structures, including re-calibration of gauges (Bhutta and Vander Velde 1992b).

Conclusion. These results provide ample evidence that the functioning of irrigation systems can be improved by a combination of measures which include restoring the physical dimensions of canals, reviving—and where necessary improving—existing operational rules, and improving maintenance practices. The findings are relevant beyond the systems whose performances were assessed and where interventions were tested. Two essential steps in the process, however, are to clearly understand how the irrigation systems work, and to identify the causes for deficiencies in system performance. Modern decision support tools incorporating a suitable computer-based hydraulic model can then assist in the third step, which is a rapid, reasonably accurate assessment of the likely consequences of proposed changes in management practices and physical structures for irrigation system performance (see Section 3.5, below).

Introducing crop-based irrigation: Chashma Right Bank Canal (CRBC)

It is often assumed that agricultural production in Pakistan would be increased if irrigation systems are designed to deliver water that more nearly matches demand. This is an application of an assumption that systems designed to meet crop water requirements (“demand-based systems”) will be more productive than “supply-based systems” (see Box 3.2).

In the North-West Frontier Province (NWFP), IIMI worked for over 2 years with the provincial Irrigation Department and the Water and Power Development Authority (WAPDA) on a newly constructed system, the Chashma Right Bank Canal (CRBC), designed to enable crop-based irrigation (see Figure 3.2). When completed, this system is expected to irrigate an area of 230,675 ha in both the Frontier Province and Punjab. Stage I, 57,605 ha, has been com-

pleted and became operational in early 1987; this includes an old system that was remodeled for increased capacity. A preliminary report is contained in Strosser and Garcés (1992) and Strosser, Afaq, and Garcés (1993); the full results are reported in Garcés-Restrepo, Bandaragoda, and Strosser (1994).

CRBC represents an attempt to implement a new irrigation system design in Pakistan. The traditional *warabandi* design attempts to distribute a limited water supply equitably over a very wide area with minimum management interventions. Farmers are expected to adjust their cropping patterns to the limited but predictable water supply. CRBC is designed with a higher water duty (0.6 l/s/ha, compared to the normal 0.21 l/s/ha of *warabandi* systems) and a higher degree of flexibility, to be able to meet the demands of a specified cropping pattern; it is thus called "crop-based irrigation." Crop-based irrigation is a modified demand-based system: while no attempt is made by system managers to meet changing demands of individual farmers, water supplies are adjusted to meet the overall demand of a given cropping pattern in a given season.

To evaluate the performance of this system, the researchers adapted performance indicators from the literature for assessing the objective-setting performance, operational performance, and output performance. But "crop-based operations"—the design assumption of the system—was not the salient objective of either of the two agencies managing the system.

Rather, the system was administered at the higher levels as if it were a supply-based system, with the added objective of sending sufficient water to minimize canal siltation. Further, because construction of the system had not yet been completed, there was an excess of water available relative to the demand. This resulted not only in an oversupply compared to demand for much of the year, but also in a high variance in deliveries to outlets.

The farmers manage their watercourses in a crop-based mode, do not follow the official rotations, and even close outlets when they do not need water (referred to as a "farmers' water refusal system"); but there is no direct relationship between operations at this level and at higher levels. An important response to this oversupply has been a significant deviation from the design cropping pattern. Rice, with a design intensity of 2 percent, had reached 26 percent in 1993, and was still increasing; sugarcane is still increasing as well, though it has not reached the area assumed in the design. Farmers have become accustomed to this water abundance. The authors conclude that unless a "sustained reversal" in the current over-deliveries takes place, there is a real danger of water shortages at the tail of CRBC (Stage III) in the near future.

The performance is more unsatisfactory at higher than at lower levels of the system. The Performance Improvement Capacity Audit reported above in Section 2.4.3 and Table 2.1 gave this system the lowest score of the five systems examined. While the design of the system permits a moderate level of improvement, operations, data collection, the management framework, and the "will to manage" were all given zero scores. There is a serious contradiction between the management conditions necessary to achieve high performance on crop-based systems, and the actual institutional management capabilities of existing irrigation management agencies. Without important changes in these management agencies and the establishment of farmer organizations, the performance of such crop-based systems will remain at a low level. A similar conclusion was reached by a study of the modernization of the Swat Canal (Box 3.3).

Box 3.3. "Since institutional development is everybody's business, it ... [is] nobody's business."

As part of the study of crop-based irrigation on CRBC, the researchers also examined the design and implementation process for remodeling the Lower Swat Canal (LSC) to convert it from a normal warabandi system to a crop-based system (Bandaragoda et al. 1993). The original LSC, also in North-West Frontier Province, became operational in 1885 and irrigates about 64,900 ha today. The design for its remodeling (as well as the new CRBC) called for increasing canal capacities from the traditional 0.28 l/s/ha to 0.77—even more than in CRBC. Its diversion capacity was increased to enable an increase in cropping intensity from 100 percent to 180 percent; and the existing adjustable proportional modules (APM) were to be replaced (or modified) to include gates—a feature having very important operational significance.

The authors document in detail the changes, disagreements, and misunderstandings that occurred as the project fell increasingly behind its time and investment schedules; and the pilot-testing of the new concept proved unsuccessful. Although the design concept called for a "gradual change," the remodeling proceeded to install hardware suited for demand-based irrigation. There was no consultation with either the users or the operating agency staff—the latter played a "passive role" as implementation was done by a federal construction agency. The authors show that the initial planners themselves were not clear about the implications of introducing a demand-based system into "a deep-rooted supply-oriented institutional framework." No specific operational guidelines were developed on how individual farmers' demands were to be identified and processed, and how the main system would be operated to accommodate temporal and spatial variations in flows. In the end, the new gated outlets were not installed in most places (they were apparently stored "until conditions can be made favorable" for their use); and at the conclusion of the project, the donors finally advised the Irrigation Department to revise its organizational chart and "ensure equitable distribution among users."

The mismatch between the physical infrastructure of the remodeled LSC and the institutional capacity for post-project operation characterizes CRBC as well; and leaves the farmers and operating agency with a missed opportunity to try something new, and a dilemma as to what to do next. The LSC and CRBC cases are good examples of "dysfunctional" systems (Perry 1995), as are parallel projects in Sri Lanka analyzed by Nijman (1991; 1992b, see Section 4.3.3). The failure is attributed to the lack of serious attention to the institutional implications of the new mode of operation, reflected in the quotation from Arturo Israel (1987) at the beginning of the paper, the title of this box.

The CRBC case illustrates a frequently observed pattern when irrigation systems are developed in stages: in the first stage, there is abundant water, resulting in farmers' developing agricultural behavior patterns which are not compatible with the planned future expansion of the irrigated area. The viability of the later stages is jeopardized and people who could have received water may be deprived. The transition from water-abundance to water-deficiency in a scheme implemented over a 10-20 year period is a common management challenge that has not received much attention in the literature.

***Adequacy and dependability of water supply:
The Fordwah/Eastern Sadiqia Irrigation System***

In 1991, as the work on the LCC was being wound down and the donor-funded research on CRBC completed, IIMI shifted to a canal system in southeastern Punjab as its major research site, the Fordwah/Eastern Sadiqia (see Figure 3.2). The culturable command area (CCA) is 232,000 ha. The research is being carried out in the Chishtian Subdivision, with a CCA of 67,600 ha. This area forms a distinct hydraulic subunit along the Fordwah Branch; at the point of entering the study area, the design discharge of Fordwah Branch is 33 m³/s. As is the case for the LCC sites, IIMI and a variety of national and international research partners have studied several important issues at this site (see Sections 3.3, 3.4, 3.5); this section provides an overview of the work on canal water delivery performance (Kuper and Kijne 1992; Kuper, Habib and Malaterre 1994).

Using performance indicators and standards for adequacy, dependability, equity, and temporal and spatial variation drawn primarily from Molden and Gates 1990,¹⁴ Kuper and Kijne (1992) show that the performance of the Fordwah Branch Canal is "poor" for every dimension measured (see Table 3.2). The authors note that even though the Gugera Branch of LCC is also "poor" by these standards, the Fordwah Branch Canal is worse: Gugera's performance in terms of discharge and equity of water delivered to secondary canals is significantly better (at 5% level of significance). Performance deteriorates toward the tail of the canal; the explanation for the poor performance lies in the operation of the canal. Nevertheless, farmers have been able to maintain relative water supplies (RWS) at about 0.8 to 0.9 by using private tubewells conjunctively with surface supplies. Kuper and Kijne emphasize the importance of improving the day-to-day decision-making and performance-monitoring processes to improve the overall performance of the system; and note the need for further research on field irrigation practices to evaluate their implications for managing salinity and waterlogging.

Table 3.2. Performance indicators for Fordwah and Gugera canal systems, Pakistan, during kharif.

Indicators	Fordwah Branch	Rating	Gugera Branch	Rating
Adequacy (P_A)	0.67	Poor		
DPR (P'_A)	0.67	Poor	0.81	Fair
Dependability (P_D)	0.47	Poor		
Temporal CV (P'_D)	0.41	Poor	0.24	Poor
Equity (P_E)	0.63	Poor		
Spatial CV (P'_E)	0.56	Poor	0.38	Poor

Source: Kuper and Kijne (1992:13, Table 1.4).

¹⁴Several IIMI studies have used indicators as defined by Molden and Gates (1990), especially for the work in Sudan (Shafique 1993-1994; see Section 3.2.4).

Building on Kuper and Kijne (1992), Kuper, Habib and Malaterre (1994) analyze the present strategy and implementation of water delivery on the Fordwah Branch. They suggest the root of the problem is the gap between crop water requirements and canal supplies, and the high degree of inequity. A third important feature is the high degree of variability, which is generated by the frequent unplanned interventions by local gatekeepers. Operational targets are set by system managers only for major distributaries; but meeting these targets is left to the discretion of the gatekeepers. Gatekeepers therefore manipulate gates to achieve localized objectives (often under farmer influence), without regard for their impacts on other regulators. Fluctuations are passed down the system, and the number of operations increase downstream in response to increasing perturbations caused by upstream operations.

The authors report the results of a simulation exercise which explores two options:

- *improved localized control*, in which operations of cross-regulators are simplified and minimized
- *centralized feed-forward control*, in which the central manager sets targets and controls interventions¹⁵

System managers are reported to favor improved localized control, a scenario closer to present operations. The results of pilot testing have not yet been reported. The potential impact of reduced variability in canal water supply on agricultural performance has also been estimated; the results are presented in Box 3.4.

3.2.4 Canal Performance in Sudan

IIMI has carried out detailed analyses of canal water delivery performance and agricultural performance on two major schemes in Sudan. The Gezira Irrigation Scheme, with 882,000 ha, accounts for 47 percent of the irrigated area of Sudan. On this scheme, IIMI has carried out field research on on-farm water management in collaboration with the Sudan Gezira Board (Haq, Khatib, and Salih 1993; IIMI 1994a), and has reanalyzed detailed performance data collected by the Hydraulic Research Station, Wad Medani, and Hydraulics Research Wallingford (Shafique 1993, 1993–1994). The Rahad Irrigation Scheme irrigates about 126,000 ha at present, with the potential for further expansion; its design and management are modeled on the Gezira. In this system, IIMI has collaborated with the Rahad Agricultural Corporation and the Ministry of Irrigation to collect performance data from a large “Major” canal which is taken as fairly representative of the scheme, as well as making use of existing data. This work is reported in the series of IIMI-Sudan Newsletters (Shafique 1993–1994) and by Shafique (1994).

¹⁵See Section 3.5.2 for further discussion of introducing computer-based management tools on the Fordwah Branch Canal.

Box 3.4. Are farmers sensitive to changes in canal operations?

An important question to be answered is, what is the relationship between canal water supply performance and the performance of irrigated agriculture? To understand this linkage, Strosser and Rieu (1994) analyze two approaches: one using the watercourse as the basic unit, and the second using economic modeling of representative farms. Only preliminary results are reported, but they have important implications. The second approach seems most promising. The quality of canal water supply is characterized by its DPR and the coefficient of variation of DPR. The results of simulations show the large impact of canal water supply variability on total expected gross income, productivity of both land and water, and tubewell pumpage (see Table). As canal supply variability increases, total income and gross income per unit of land and water decline considerably; and tubewell pumpage as a percentage of total water supplied increases as farmers try to minimize the impact of canal variability. The results also show the nonlinearity of some of these relationships.

The paper says that further research is underway to test the two approaches for analyzing the relationship between water supply and agricultural performance.

Other work on agricultural productivity by IIMI has recorded that while agricultural yields in Pakistan are low on a per-hectare basis, they are often very respectable per unit of water consumed: farmers are maximizing the productivity of water, not land (Bhatti, Schulze, and Levine 1991).

Table. Estimated impact of canal water supply variability (CV-DPR) on agricultural production, Pakistan.

Indicator		CV-DPR= 0	CV-DPR= 0.05	CV-DPR= 0.1	CV-DPR= 0.2	CV-DPR= 0.3	CV-DPR= 0.4	CV-DPR= 0.5	CV-DPR= 0.7
Total expected gross income (Rs)		50,790	49,370	47,680	43,880	40,070	36,270	32,450	23,500
Gross income per unit area (Rs/ha)		5,020	4,880	4,720	4,340	3,960	3,590	3,210	2,320
Gross income per unit of water (Rs/1,000m ³)		540	530	450	450	450	450	450	360
Tubewell pumpage	Total (m ³)	46,700	48,500	59,400	58,700	57,900	57,200	56,800	64,900
	% of total supply	50	52	57	61	65	70	77	99

Notes: CV-DPR = Coefficient of Variation of Delivery Performance Ratio.

Rs/ha = Pakistani rupees per hectare.

Source: Strosser and Rieu (1994:3.19, Table 5).

Section 2.3.5, above, reports on the results of measuring performance along canal reaches, as distinguished from control points. The papers on both Gezira and Rahad draw on the framework and some indicators recommended by Bos et al. (1994) and the performance indicators recommended by Molden and Gates (1990) for adequacy, dependability and equity. They also follow the lead of the Wallingford-HRS study of Gezira, and existing practice, to make use of several ratios:

- indent/requirement ratio, a measure of the accuracy of indenting¹⁶
- authorized release/indent ratio, a measure of the adjustment of indents
- actual delivery/authorized release ratio, a measure of the performance of the distribution system
- actual delivery/requirement, referred to as "Management Delivery Ratio" (MDR)

Reliability is also assessed in terms of the portion of the season when performance is "acceptable," i.e., the probability that a given performance parameter lies within an acceptable range. The papers on Rahad use several indices for agricultural performance, including the yield/target ratio (see Bos et al. 1994), and several parameters for distribution and dependability of yields.

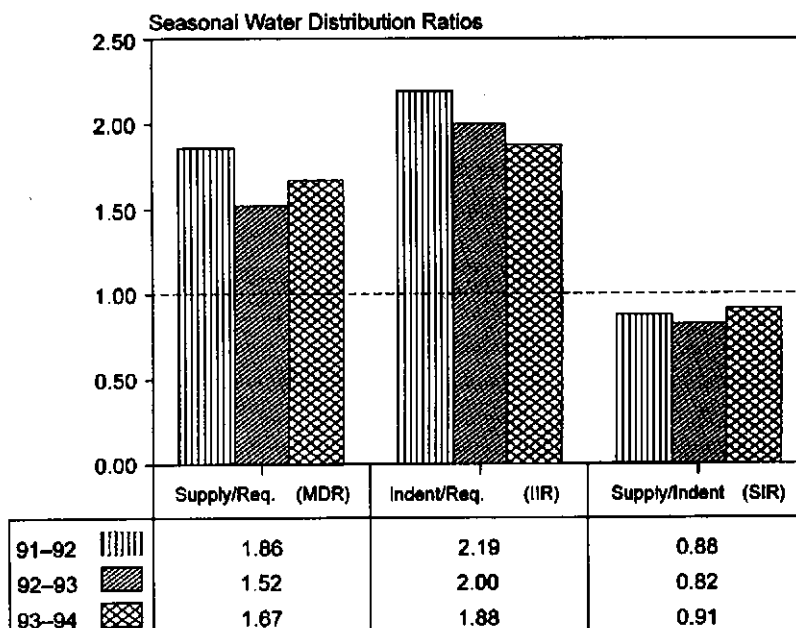
The findings for both the Gezira and Rahad are similar. Some conclusions for Rahad, for example, include the following (Shafique 1994):

- As noted in Section 2.3.5, analysis in terms of control points masks sharp irregularities and variability in water distribution on a reach basis.
- Both irrigation indents and actual supplies range from 0.6 to 2.4 times the estimated irrigation requirements from November to February, with a general and consistent tendency for a high level (70-100%) of over-indenting and oversupply compared to irrigation requirements (Figure 3.6).
- The parameters for both dependability and equity of water distribution exhibit an unsatisfactory performance (following the criteria proposed by Molden and Gates [1990]); there is considerable room for improvement.
- The parameter for adequacy of water distribution is generally either good or fair, with some exceptions; but those reaches with fair to good adequacy also show higher oversupply fractions, implying a potential for surface waterlogging.
- The overall performance of cotton yield distribution is better than that for wheat yield distribution, but is unsatisfactory based on the ratio of potential to target yields.

IIMI and the Gezira Board carried out detailed research on water management practices on selected areas of the Gezira Scheme (IIMI 1994a; Haq, Khatib, and Salih 1993). The findings complemented those on canal performance, and resulted in very detailed recommendations for improvements. A few key findings are:

¹⁶"Indent" refers to the amount of water requested by Agricultural Corporation personnel (inspectors) from the irrigation operations unit of the Ministry of Irrigation.

Figure 3.6. Seasonal water distribution ratios for the entire command area of Major 5, Rahad Irrigation System, Sudan, 1991–1992 to 1993–1994 seasons.



Source: Shafique (1994:12.37, Figure 20).

- The performance of all lower-level canals is poor because of physical deterioration of structures and channels. As a result, farmers resort to “water piracy” and construction of extra field outlets, and breach the night storage system.
- Water indents by the Gezira Board inspectors are a fixed 5,000 m³/day for every crop and every season. This encourages wastage of water when low water-demanding crops are grown, and over-irrigation.
- Not only are yields of wheat and cotton far below what is achievable in this system but water use efficiency (kg/m³ of water) is very low, at 30 percent of recommended values.

3.2.5 Irrigation in West Africa

IIMI has been doing research in five reservoir-based irrigation schemes in Burkina Faso since 1991. These schemes irrigate areas ranging from 42 to 112 ha; four are gravity systems while the fifth is a pump system. The results of this research will be useful not only to improve the performance of existing systems, but to design and implement future small schemes in West Africa (see Sally 1992, 1995, 1996; Sally and Abernethy 1993).

Some of the results of this work are:

- There are no specific targets and criteria for monitoring performance of irrigation systems in Burkina Faso, and no systematic monitoring process. Reliable information, especially over any length of time, is not available. Even basic information on the physical system is unreliable: for example, one of the study systems was found to have a reservoir storage capacity 2.3 times what has been assumed since its construction 25 years ago. These problems make objective performance assessment difficult, but IIMI has been able to contribute much in terms of updating the basic information base.
- Given the limited income from the small irrigation holdings and competition with rainfed farming for allocation of scarce labor and farm power resources at critical times, irrigation farming is not a full-time activity; and the resulting stretching of cropping calendars draws down the reservoirs during the wet season, reducing water availability for the dry season.
- The productivity of land (in terms of gross product value, GPV, per ha) and cropping intensity increase with the relative availability of stored water (storage-land ratio); if the atypical pump scheme is not included, the correlations are very high ($r = 0.78$ and $r = 0.91$ for productivity and intensity, respectively).
- However, the productivity of water (GPV/m³ of stored water) and the productivity of irrigation (GPV/unit of irrigation water released) *decrease* with the increase in the storage-land ratio (excluding the pump scheme again, $r = -0.86$ and -0.43 , respectively). In other words, systems where water is relatively scarce appear to use it better and obtain better returns from it than those with abundant water.
- The average relative water supply (RWS) on four schemes is 2.42; a reduction on three of the schemes to around 2.0 in the 1993/1994 dry season is attributed to better management. Overall, even though rice production is high per unit of land (on average exceeding 4,000 kg/ha of rough rice), water productivity values are disappointing (0.28 to 0.46 kg/m³, compared to a suggested standard of 0.6 to 0.8 kg/m³).
- In the light of the research findings and conditions in the country (long dry season, high evaporation losses), an 'optimum' size of small-scale irrigation schemes in relation to reservoir capacity would appear to require storage-land ratios of 50,000 m³/ha. This will support 100 percent intensity rice cultivation in the wet season, and about 30-50 percent horticulture in the dry season.
- Cost savings in construction of small-scale irrigation schemes of about 30 percent can be achieved by reducing the design duty from 5 l/s/ha to 3 l/s/ha, assuming rice in the wet season and horticulture in the dry season (the usual pattern). Twelve hours of irrigation per day are adequate to meet peak water requirements.

3.2.6 Results from the Muda Irrigation Scheme, Malaysia

With an area of 96,000 ha, the Muda Irrigation Scheme produces over half of Malaysia's total rice crop. IIMI has worked with the Muda Agricultural Development Authority (MADA) to study the trends in productivity and profitability of rice production on this scheme over the past decade. During the 1980s, there was a substantial reduction in rainfall and overall availability of water: total water releases from the dam in 1990–1992 were 15 percent lower than in 1981–1983. Nevertheless, total crop output increased by 16 percent during the same period. Rough rice output per unit of water released from the reservoir increased by almost 45 percent (from 0.827 kg/m³ to 1.20 kg/m³ in a context where total annual rainfall slightly exceeds the total annual water releases from the dam). Higher yields have not resulted in higher incomes for farmers, despite an increase in output price subsidies.

How were the improvements in productivity achieved? Bhatia, Amerasinghe, and Imbulana (1995) suggest there were several reasons:

1. The government strengthened the institutional support and input provision services to the project.
2. Farmers have shifted from transplanting to direct sowing of seeds, and from wet seeding to dry seeding. Although this lowers yield, it reduces water requirements and labor costs substantially.
3. A major tertiary development program has led to a reduction in water consumption estimated at 20 percent per ha, as well as reduced costs by farmers.
4. MADA adopted a new water management control system including daily assessment of water depths in each irrigation block, rainfall monitoring through a telemetry system, and a computer-based management information system that allows MADA to maximize water supply efficiency and effective use of rainfall.
5. Farmers have been organized into increasingly effective groups, that have facilitated lower production costs and improved water availability through the purchase of pumps.

3.3 Conjunctive Use of Groundwater and Surface Water

3.3.1 Conjunctive Use of Groundwater and Surface Water in Pakistan

Most of IIMI's work on conjunctive use of groundwater and surface water has been done in Pakistan, but the results have a wider significance. This section discusses the context and trends in groundwater use relative to the use of surface water, and the emergence of water markets. Section 3.4 discusses the relationship between the use of groundwater and growing levels of salinity in Pakistan. IIMI has carried out research on conjunctive use and salinity issues in

Box 3.5. Lift irrigation and groundwater utilization: Other studies.

The recent attention given to lift irrigation has been the result of its rapid expansion, rising environmental concerns, and the relatively restricted knowledge base on management of lift irrigation. In 1992, IIMI sponsored a workshop on farmer-managed groundwater irrigation in which numerous papers and discussions identified key issues, such as aquifer drawdown, water quality, equity concerns with water markets, and institutional problems. Some key recommendations for research and development include the urgent need to improve the information base and monitoring process about aquifer behavior and environmental degradation, and the need to develop institutions to manage groundwater irrigation at the level of aquifers or groups of tubewells in a larger hydro-management environment (Abhayaratna et al., eds. 1994).

A review of lift irrigation in West Africa concludes that pumping from both groundwater and surface sources using small internal combustion engines will remain important. The important management and research issues for lift irrigation in the region relate mainly to the following: a) support services (credit and marketing); b) supply of spare parts and repairs; c) improving the efficiency of use under local conditions; d) diversification out of rice; e) equity problems of access to the technologies; f) environmental impacts such as aquifer drawdown and maintaining soil fertility; and g) policy and institutional support (Purkey and Vermillion 1995).

both the Lower Chenab Canal and Fordwah-Eastern Sadiqia systems in Punjab (see Section 3.2.3, above). Other studies done are highlighted in Box 3.5.

In recent years, Pakistan's and other countries' agricultural production systems have grown increasingly dependent on groundwater, particularly groundwater pumped from private wells. The results of the research in Punjab, Pakistan show that in the two areas studied, groundwater accounts for over 60 percent of the total water reaching farmers' fields. Groundwater extraction rates already exceed available recharge. With the number of private wells growing rapidly, this deficit will increase, and with it the negative effects of falling water tables.¹⁷

South Asian governments are divesting themselves of control over public wells; government agencies are therefore losing what little control they had over groundwater extraction rates. Past attempts to regulate installed capacity have often failed or produced inequitable results. The research, however, demonstrates how susceptible groundwater use by owners of private wells is to government energy pricing policies, technology promotion programs, and canal water allocation rules.¹⁸

The impact government policies can have is shown by the trends in private tubewell expansion. Because of subsidies for electrical power and taxes on diesel fuel, electric wells cost less than half as much as nonelectric wells. For owners with similar size holdings, flat-rate

¹⁷A national survey in 1991 showed that 46 billion m³ of groundwater are used in the Indus Basin for irrigation, of which 85 percent comes from private tubewells; this exceeds the annual usable groundwater by more than 50 percent (Kijne and Kuper 1995:73). See R. Johnson (1989) for a short overview of past programs, policies, and research on private tubewell development in Pakistan.

¹⁸Chambers, Saxena, and Shah (1989) argue that by creating secure rights and access to groundwater through competitive markets there is great scope for poverty alleviation in South Asia through lift irrigation.

electric wells pump twice as much water as metered electric wells. Extrapolating from these data, private well development limited to nonelectric wells at current diesel prices would maintain sustainable latent groundwater demand levels for one of the sample distributary command areas. Conversely, the proliferation of electric wells billed on a flat-rate basis in this area would quickly result in overexploitation of the underlying aquifer and a steadily increasing burden on an already strapped electrical power network.

Because of extensive groundwater development, much of Pakistan's Punjab is no longer threatened by waterlogging (Kijne and Kuper 1995). However, the threat of waterlogging has been replaced by two equally menacing possibilities: unsustainable groundwater extractions by private wells, and the degradation of soils from the use of marginal quality groundwater (see Section 3.4, below). Past regulatory approaches to managing private groundwater use have failed, as have programs that place pumping facilities in the hands of public agencies. Johnson (1992) illustrates how combinations of government energy pricing policies, technology promotion programs, and canal water allocation rules can dramatically affect the amount of groundwater farmers extract and the overall quality of irrigation water applied to farmers' fields.

Conventional wisdom holds that groundwater is used in Pakistan to supplement surface water supplies. IIMI's research shows this is not so. Data from 41 watercourses on 4 distributaries in the LCC show that *groundwater is more important than surface water*, with dependence on pumped water in head-end areas at 65 percent, rising to over 90 percent in tail areas (Murray-Rust and Vander Velde 1994b). On 5 sample watercourses in the Fordwah-Eastern Sadiqia, groundwater provides 11–93 percent of the total water delivered (Strosser and Kuper 1994). In both areas there is a high density of private tubewells, ranging from 28–95 per 1,000 ha of culturable command area (CCA) on the 5 watercourses studied in the Fordwah-Eastern Sadiqia, to 15–140 per 1,000 ha CCA in the sample area of LCC (Malik and Strosser 1993). Thus the use of groundwater is no longer supplemental, but is an integral part of the irrigated agriculture system.

Use of tubewells must be analyzed in the context of the high degree of inequity and unreliability of surface water deliveries and the gap between surface water supplies and demand (Section 3.2.3, above). There is no apparent relationship between location along canals and density of tubewells installed, despite statistically significant decreases in both surface and total water use and declining water quality toward the tail (Murray-Rust and Vander Velde 1994b). This has important implications for salinity trends, as discussed in Section 3.4.

Policy makers and donors are currently advocating the privatization of the water sector and the development of water markets in Pakistan. However, except for a few studies, not enough is known about how water markets presently operate, and what the social and environmental consequences of privatization will be. Early IIMI research led to expressions of strong reservations about the likely impact on the sustainability of irrigated agriculture with the turnover of public sector tubewells to the private sector (Johnson and Vander Velde 1992; Vander Velde and Johnson 1992). They suggested replacing public tubewells pumping from deep aquifers with private wells pumping from shallow aquifers would result in an overall decline in the quality of available irrigation water; incentives for private electric tubewells would put more stress on an already overloaded electrical system; and terminating public tubewells in favor of private wells might have a significant impact on equity of access. Further research is needed on these issues.

IIMI has carried out two studies on how water markets work in sample areas in the LCC and Fordwah-Eastern Sadiqia systems (Malik and Strosser 1993; Strosser and Kuper 1994). Tubewell owners tend to be larger farmers, non-tubewell owners smaller farmers. Tubewells not only increase the total water supply, but also play a stabilization role in mitigating the effects of unpredictable surface water supplies. Water markets for both surface water warabandi turns and for groundwater improve the flexibility and adequacy of the water supply, and enhance the equity of access between tubewell owners and nonowners.¹⁹ Strosser and Kuper (1994), based on a sample of 60 farmers in 5 watercourses in the Fordwah-Eastern Sadiqia, found sales and purchases of tubewells in a season were 9.4 and 7.2, respectively, per farmer; but there were also 4.4 partial canal turn exchanges per farmer. Exchanges of warabandi turns were aimed at improving the flexibility of the warabandi system and compensating for poor deliveries to tail ends, while tubewell sales increased the quantity of water available to nonowners of tubewells. No relationship was found between yields and tubewell owners versus water purchasers; but owners did tend to have higher irrigation intensities and a higher percentage of area under the dominant crops (cotton and wheat).

3.3.2 *Conjunctive Use of Groundwater and Surface Water in Bihar, India*

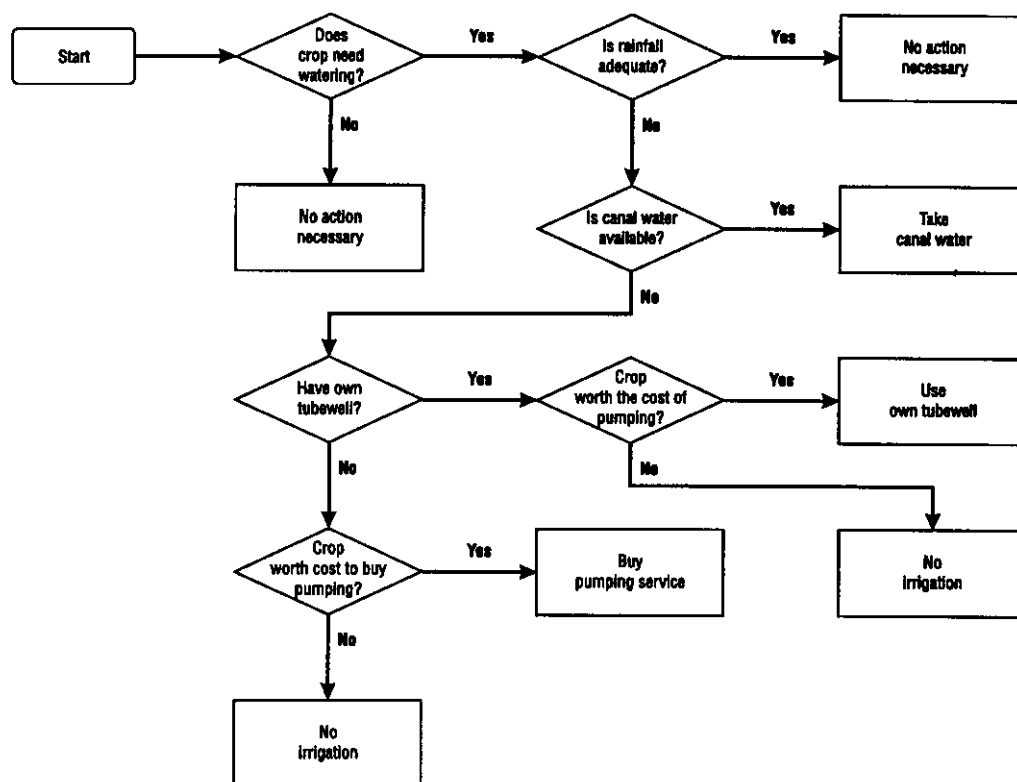
From 1989 to 1992, IIMI collaborated with the Water and Land Management Institute (WALMI) and the Centre for Water Resource Studies, both in Patna, Bihar, on a macro-level study of conjunctive water use management in the Eastern Gandak system, North Bihar. This system was planned to command 600,000 ha, but presently commands only about 70 percent of this area. IIMI subsequently followed up in 1993 with a more detailed study on how farmers actually manage the multiple sources of water available, and how these relate to the low productivity of this seemingly water-rich area. The results are reported in detail by Raju, Brewer, and Sakthivadivel (1994). The research was carried out in the Vaishalli Branch Canal, whose designed command is 64,289 ha, but which irrigates only 17,250 ha because the canal was never completed. The study involved mapping of the area irrigated, crops and water sources, systematic surveys of farmers covering four cropping seasons and of well owners and operators, a detailed study of a smaller sample of wells, and observation and discussions with key informants.

Despite adequate flow in the Gandak River, the Eastern Gandak system has serious performance deficiencies resulting from both physical and management problems; and the area is characterized by very low agricultural production and low incomes. Particularly in the tail areas, water supply is very unreliable; during peak demand periods the canal deliveries fall to about 60 percent of the official demand, while in low demand periods, an oversupply is given. On the other hand, canal water is cheap because water rates are low and rarely collected. Nevertheless, farmers need to use other sources of water as well.

Tubewells are a viable option for farmers. Good quality groundwater is available at relatively shallow depths. There are a large number of both private- and group-owned tubewells. Tubewells represent a large investment, but subsidies are available to enable poorer farmers

¹⁹The study of *warabandi* discussed in Box 3.1, above, suggests greater inequity results from this flexibility, which is consistent with earlier predictions. This is an issue requiring further work.

Figure 3.7. Model of farmers' irrigation decisions, Eastern Gandak System, Bihar, India.



Source: Raju, Brewer, and Sakthivadivel (1994:117, Figure 7.1).

to do so as well. Farmers with larger holdings tend to invest in tubewells to irrigate their own lands; selling pumping services is done by most to cover part of the investment. Operational costs are high for several reasons: although electricity rates are low, electricity is available for no more than 2 hours a day, so all pump sets also have a diesel engine, which is expensive. Poor operating procedures and maintenance combined with high operating costs reduce the total use of tubewells. Tubewells installed by the Vaishalli Area Small Farmers Association (VASFA), a farmers' cooperative established with NGO assistance about 20 years ago, is an exception: their wells are deeper and technically better than others, and more economical to operate.

There is a market for well water but not canal water. Official rates are set based on operating costs, through consultations among water sellers. But most buyers from private pump owners are either relatives or members of the same caste, and they consistently pay far less than the official rate. Sellers do collect the full rate from low-caste buyers, who also tend to be small or marginal landowners or tenants.

Overall, farmers prefer rainfall as their source of water, followed by canal water, then tubewell water. During the summer rainy season (*kharif*) when rice is the main crop, farmers

depend first on rain, then canal water, with a low use of groundwater. For wheat in the *rabi* (winter) season, rain is less important, and canal water is important only on the one minor having a reasonable supply. Groundwater use is more important in *rabi* than in *kharif*, but declines over the season. Costs of tubewell water are high compared to the potential profit from a crop, given the low yields. Figure 3.7 provides a model of farmers' decisions.

The authors conclude that a combination of physical repairs of the canal system and improvements in the institutional environment are needed to raise the current low productivity. These should be aimed at improving the canal water delivery service, and improving the cost-effectiveness of tubewell services. The Water Resources Department officials in charge of the canal system identify inadequate funds, complex and overcentralized decision-making procedures, and farmers' negligence as problems; the authors suggest that officials' lack of data on either water flows or crops combined with lack of accountability for their performance are also important issues. Regarding pumps, the performance of the pumps themselves is the main issue; the relatively lower prices and better service of the VASFA tubewells indicate the potential for raising pump efficiency.

3.4 Waterlogging and Salinity

3.4.1 Nature of the Problem

Section 3.3 has discussed the importance of groundwater in Pakistan's irrigated agriculture system. Over the past 2 decades, waterlogging has become a far less important threat to agriculture in Pakistan than it had been. This can be attributed to the success of the government's public tubewell program in the 1960s to 1970s, and to the rapid growth of private tubewells. Today there are an estimated 300,000 private tubewells in Pakistan (Murray-Rust and Vander Velde 1994b). As noted above, depletion of the groundwater in areas where it is of good quality is now a more serious threat than waterlogging.

The problem of salinization as a result of irrigation is another story. It has long been recognized as a serious threat, and major amelioration projects have been instituted to address it in many countries. The problem is usually identified with water tables that have been brought close to the soil surface as a result of over-irrigation in areas with high evaporation rates. Salinization of the soil as a result of inadequate irrigation with salt-containing water (*secondary salinity*) has received much less attention, particularly in areas where salinity from waterlogging has been considered the major problem. IIMI has been working on salinity issues and over time its findings have evolved; but *the basic conclusion has become firmer: rising salinity and sodicity balances are an increasingly serious threat to Pakistan's agriculture.*

Early research results seemed to show that tail enders compensate for receiving less surface water by using more groundwater than do head enders; but more recent work has demonstrated that head enders use more groundwater than was previously thought, enabling them to attain higher cultivation intensities and to grow higher-value crops (Murray-Rust and Vander Velde 1994b).

More alarming, researchers have documented that many tail-end farmers are using poor quality groundwater (and very little or no surface water) in areas where the authorities as-

sume groundwater is of good quality. In the tail-end areas, increasing secondary salinization consequent to recirculating saline groundwater is resulting in a dangerous build-up of salts in the soils (Johnson and Vander Velde 1992; Bhutta and Vander Velde 1992b; Kijne and Vander Velde 1992; Murray-Rust and Vander Velde 1994b; Kijne 1996).

Where farmers have access to water from a canal, a public tubewell, and a private tubewell, they can apply irrigation water more or less at any time they want; they can more easily trade water, either through buying and selling or on some other basis; and they can move water across previously impermeable watercourse command boundaries. In short, the entire irrigation system has become a complex conjunctive management environment.

A critical aspect of conjunctive use is that groundwater and surface water are not necessarily equally exchangeable. Only when water quality is not a limiting factor is it possible to conclude that surface water and groundwater are of similar agricultural value, where the only differences between them are related to the relative reliability of the two sources and the relative cost of using each.²⁰

In a conjunctive use environment where canal water is of good quality and groundwater is of poorer quality but relatively more abundant, most farmers are likely to seek to mix groundwater with as much surface water as possible to maximize their irrigated area. This, in turn, implies that the availability of greater quantities of surface water also favors a greater use of groundwater, an additive rather than a simple substitution relationship of one for the other. Murray-Rust and Vander Velde (1994b) report that farmers with access to a higher percentage share of canal water also pump more groundwater than farmers who have less canal water. Although the percentage use of groundwater increases from head to tail of each canal examined, there is a net decline in both surface water use and total water use along canals. There is, therefore, no evidence of farmers substituting groundwater for declining canal supplies: groundwater is used as an additive to canal water rather than as a substitute source of water.

In the summer hot season (*kharif*), cropping intensities drop from 80 percent on head-end watercourses, to about 60 percent at the tail, which clearly mirrors the drop in total irrigation water use (from 6.5 mm/day/ha to 3 mm/day/ha). The area under rice drops from nearly 40 percent in head-end watercourses to 20 percent at the tail; and other commercial crops also drop. Access to surface supplies clearly remains the major influence on farmers' *kharif* cropping decisions. In the winter season (*rabi*), evapotranspiration rates are low, and water supplies nearly match demand: there is no decline in cropping intensity during this season (Murray-Rust and Vander Velde 1994b).

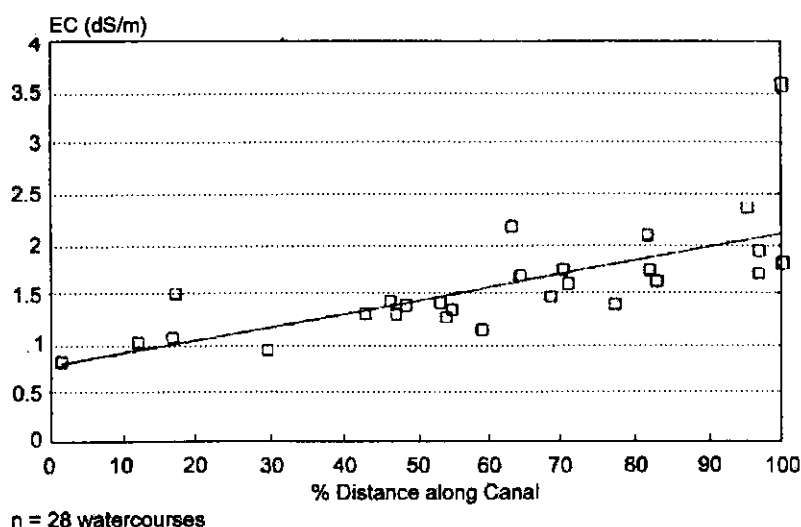
On the 41 watercourse sample area in LCC, quality of groundwater, as measured by its electrical conductivity (EC) and Sodium Absorption Ratio (SAR), declines on each watercourse

²⁰In one typical conjunctive use scenario, such as that examined in Indonesia, groundwater is used to supplement shortfalls in surface water supplies. Tail-end farmers may, albeit at additional cost, attain cropping intensities at or close to those of head-end farmers who have more than sufficient surface water. Pumping occurs during periods of peak demand to ensure that crops do not suffer from drought, but the entire groundwater irrigation system in this situation is supplemental to the surface system (Murray-Rust and Vander Velde 1994b; see also Johnson and Reiss 1993).

from head to tail.²¹ EC, for example, worsens from about 0.9 dS/m at the head to 2.1 dS/m at the tail (Figure 3.8), and SAR values increase from 2 to 4. The rate and direction of change within canal commands of these water quality values are significant at the 1 percent level. Even the head groundwater EC values exceed the FAO standard for “good” water (0.7 dS/m) (Murray-Rust and Vander Velde 1994b).

Removal of salts from the crop root zone to maintain a salinity level compatible with the cropping system requires a downward flux of water and salts. Hence, sufficient water from rainfall and irrigation must be provided to the crop, over and above the evapotranspiration needs, so that there is excess water to pass through and beyond the root zone to carry away salts. This excess water is referred to as the leaching requirement. IIMI’s early studies (Kijne and Vander Velde 1992) indicated that under current irrigation practices, leaching fractions are probably insufficient to maintain the salt balance in the root zone. Kuper and Van Waijjen (1993) indicated that the situation is more complicated than had earlier been considered. It appeared from their analysis that in a number of watercourses farmers keep the salt content of the irrigation water within acceptable limits by mixing canal water and pumped groundwater in an appropriate mixture over the growing season. Above-average monsoon rainfall in

Figure 3.8. Average tubewell water quality of watercourses, Pakistan.



Note: EC = Electrical conductivity, measured in decisiemens per meter (dS/m, equal to mmhos/cm).

Source: Murray-Rust and Vander Velde (1994b:213, Figure 3).

²¹Electrical conductivity (EC) is a measure of total dissolved salts (including sodium, calcium, and manganese) in a sample of soil and water. The more salt there is the higher the EC. Sodium absorption ratio (SAR) is the ratio of sodium to calcium and manganese on the surface of soil particles. A higher ratio both reduces the permeability of the soil (makes it harder) and inhibits plants' taking up nutrients. "Salinity" (high EC) can be reduced through leaching. Sodium (sodicity) cannot be reduced through leaching; other chemicals, for example gypsum, are needed in combination with water to reduce sodicity.

recent years has contributed to maintaining or even reducing salinity levels in soil profiles in some of the sample areas. Long-term monitoring of salt levels and conjunctive irrigation practices are needed over a larger area than can be covered by IIMI's research.

Recently, Kijne and Kuper (1995) and Kijne (1996) have reanalyzed data on soil and tubewell water quality, collected from the three major research sites (LCC, CRBC, and Fordwah-Eastern Sadiqia). Kijne and Kuper (1995) pay particular attention to the hazard of sodification associated with poor quality irrigation water, while Kijne (1996) presents the results of using a new water balance model (Perry 1996b) to analyze salt balances.

Kijne and Kuper (1995) report EC and SAR values (for partially overlapping samples) consistent with those reported by Murray-Rust and Vander Velde (1994b). They call attention to the potential seriousness of sodicity trends, and argue strongly for far more research by agricultural and research institutes in Pakistan. They note that while earlier studies had suggested that farmers are successful in using pumped groundwater to leach salts and control salinity, evidence in the present paper suggests that farmers are not so successful in controlling sodicity. Sodicity's effect is "slower and more treacherous," but likely to increase. Kijne (1996) presents results from a water balance study from the three sites. He concludes that the trends in all three sites make irrigated agriculture unsustainable. In Stage I of CRBC, groundwater recharge is substantial and is bound to lead to waterlogging if drastic measures are not taken soon. In both the Gugera (LCC) and Fordwah sites, overexploitation of groundwater of marginal quality leads to a combination of lowering water tables and increasing salinity in the soil profile.

3.4.2 Solutions: Difficult Choices

When Murray-Rust and Vander Velde (1994b) first presented their results at an IIMI Internal Program Review in 1992, there was considerable skepticism about their conclusions. But Kijne and Kuper (1995) and especially Kijne (1996) now agree that Pakistan is facing a serious threat to the long-term sustainability of its agriculture.

Murray-Rust and Vander Velde (1994b) discuss several short- and long-term solutions. Possible short-term solutions involve increasing surface water either to particular subsystems, or to the tail ends; but all such options are zero sum games in the sense that some areas would benefit at others' expense; and reallocation from head ends to tail ends is probably not implementable. The central issue is the ratio of surface water to groundwater conjunctively used. The present average ratio of 2:5 throughout the distributary command results in an average EC of 1.4 dS/m, twice the FAO standard. To bring it to 1.0 dS/m, still 40 percent above the FAO standard, would require a canal-tubewell ratio of 3:4. For the current total volume of irrigation water, this involves a 50 percent increase in canal water and simultaneous reductions of 20 percent in groundwater. This is not realistic.

The alternative is reduction in irrigated area, a trend already observable in some tail-end areas. Such abandonment may be technically rational, but is difficult politically and socially. However, Kijne (1996), based on his water balance analysis comes to the same conclusion: either a reduction in cropping intensities or in area of high water consumption crops, or in both is required. For the Gugera (LCC) site, if pumping is reduced to equal recharge, the kharif cropping intensity must be reduced by half, to about 45 percent; annual cropping intensity needs to drop from the current 155 percent to about 130 percent. In the Fordwah site, annual

intensity would need to drop from the current 130 percent to 93 percent, again primarily by reducing kharif intensities.

The results have raised concern within an important but limited circle of government officials. But to date it has not led to changes in policy, or significant additional research by national institutes to confirm or refute IIMI's findings. This is partly attributable to the current fragmented organization of Pakistan's institutions (Box 3.6). IIMI is continuing its research on these issues in Pakistan with considerable collaboration from Pakistani research institutes. Its results have obvious implications not only for Pakistan, but for other semiarid areas with limited water supplies, including parts of India and China. At the least, it should stimulate efforts to define the extent of the problem in many countries. IIMI has worked on solving salinity problems in a rice-based system; the results are presented in Box 3.7.

Box 3.6. Institutional dimensions of Pakistan's salinity problems.

Everyone agrees that Pakistan's policy, management, and research institutions need to do more to address the threats to agriculture. Murray-Rust and Vander Velde (1994b) illustrate how difficult this will be.

First, there is no coordinated data collection program on the relevant variables in either national or regional programs, nor are the data assembled in one location: each type of data is collected by a different organization. The Punjab Irrigation Department perceives 'the irrigation system' as a canal system; public sector groundwater operations are organized and implemented separately; private sector tubewell operations are not monitored or regulated; and agricultural data are collected and analyzed by the Agriculture Department and Agricultural Census based on civil, not hydraulic, units. The national institution monitoring public tubewells does not do so with reference to the surface systems or private groundwater development, and uses outdated water quality standards.

Second, there is a similar lack of effective collaboration within the responsible line agencies. For example, the Irrigation Department's surface, tubewell, and drainage divisions have completely uncoordinated boundaries, while the Agriculture Department's boundaries rarely coincide with the hydrological units of the Irrigation Department. The On-Farm Water Management Directorate plans and implements its watercourse improvement programs without knowledge of the Irrigation Department's canal operations or private tubewell development; while the Extension Directorate is ignored by all because it is incapable of advising farmers. Murray-Rust and Vander Velde (1994b) note that the public agencies and research institutions must begin shedding this 'historical baggage,' reorganize internally, and collaborate to solve Pakistan's conjunctive use problems.

A study of the Punjab Irrigation Department's Land Reclamation Department (Bandaragoda and Rehman 1994) found that its operations are not very effective in reclaiming saline soils either. The process for selecting sites is subjective and its reliability is questionable. No evidence could be found that extra water is made available for reclamation as it is supposed to be; and of the 20 reclamation outlets monitored, 12 were at the head and 8 in the middle of distributaries; *none* were at the tail, where IIMI's research demonstrates the highest incidence of salinity.

The institutional roots of the problems facing Pakistan's irrigated agriculture are discussed further in Sections 4.2.4 and 4.3.

Box 3.7. Solving salinity problems in Kirindi Oya, Sri Lanka.

Soon after the construction of the Lunugamvehera Reservoir and the initiation of cultivation in the newly settled upland areas, the farmers in the old Ellagala system began complaining about salinity in their rice fields. Their complaints reached a peak in the 1992/1993 wet season when isolated but visible patches of stunted rice plants could be observed in the flat alluvial plain of the old system. Why did salinity suddenly become so acute, and what can be done to manage the problem?

As part of its larger program in this system (see Sections 2.5.3, 3.5, 4.3.3), IIMI worked with the Irrigation Department, and the Department of Agriculture to analyze the problem (Sakthivadivel, Panabokke, and Roonage 1993; IIMI 1995a, vol. 2). The old Ellagala system is a flat alluvial plain which has been irrigated for 1,500 years or more. It is irrigated from four ancient reservoirs, which since the late 1800s have received supplementary river water through an anicut. After the construction of the new reservoir, they also receive the runoff from the higher residual plain now cultivated by settlers under the new system. Mean annual evapotranspiration is 2,000 mm, while average rainfall (100 years) is 970 mm—and the 75 percent probability rainfall is just 562 mm.

Before construction of the dam, the Ellagala area had been irrigated with Class I water, and had adequate drainage. However, for various reasons this drainage has become restricted in recent years. Water in the Lunugamvehera Reservoir was also found to be Class I for all 12 months of the year. But the quality of the water in the four Ellagala reservoirs was found to fluctuate over a wide range, depending on the amount of salt-enriched drainage water received from the new areas, and the amount of good water received from Lunugamvehera. Therefore, Ellagala is acting as a sink for salts coming from upstream.

As a means of making efficient use of scarce water, IIMI and the Irrigation Department had concluded that deliveries to the Ellagala reservoirs should be restricted, to maintain capacity to store rain water in them. However, this plan has to be adjusted to release a sufficient quantity of good water into the small reservoirs during the critical growth period of the rice crop. Particularly in dry years, it will be important to dilute Ellagala irrigation water to maintain its quality above the critical threshold. An inexpensive monitoring program has now been established, and steps are being taken to reduce the drainage congestion in the old areas.

3.5 Management Information and Decision Support Systems

By the end of 1993, IIMI staff had used a total of 15 different decision support tools in about 20 interventions (Rey, Murray-Rust, and Sally 1993). This section briefly reviews this experience, with special attention to the development and pilot testing of an "Irrigation Management Information System" (IMIS) in Sri Lanka and Pakistan.

The work on IMIS began with the development and installation of a mathematical simulation model in the Right Bank Canal of the Kirindi Oya system in Sri Lanka (Baume et al. 1993). This model was developed as part of a long-term collaborative program between IIMI and CEMAGREF²² of France (Sally and Rey 1992; Rey 1992; Rey et al. 1993). This canal

²²Centre National du Machinisme Agricole, du Génie Rural, des Eaux and des Forêts. The model has since been generalized and applied to a major canal in Pakistan where it is called "Simulation of Irrigation Canals" (SIC).

presents special problems: it is 30 km long with a capacity of just 13 cumecs, but it has 43 offtakes and 19 cross regulating devices whose operations lead to unsteady flow conditions, making it difficult to maintain levels and achieve delivery targets. The model was found to be useful as a research tool and to have potential as a management tool, but it proved difficult to interest the system managers in using it.

The IIMI-CEMAGREF team realized that the model did not really address the priority issues as perceived by the managers—there was something missing. This led the team to re-analyze what the prerequisites to successful use of decision support tools are, and what kind of intervention process is most likely to succeed. This work has in turn led to the development of a generic process for diagnosing the decision-making process on canal irrigation systems, and designing an intervention strategy and a generic Irrigation Management Information System (IMIS) which can be adapted to very different environments (see Rey and Hemakumara 1994; Rey, Murray-Rust, and Sally 1993; Rey, Kuper, and Hemakumara 1993; and Habib, Kuper, and Malaterre 1994).

3.5.1 *Modes of Intervention*

Aside from complete internal development and application of a decision support system, there are three other modes of intervention:

- *Turnkey*: Outsider solves a problem, develops a solution, and transfers the results but not the tools or methods.
- *Semi-participatory or turnkey*: External partner transfers ready-made tools and methods.
- *Participatory approach*: External partner transfers methods for development and application of tools.

The early work in Kirindi Oya was at best semi-participatory and did not result in adoption; the team therefore followed a participatory approach for the next stage of work at Kirindi Oya, and used this approach to initiate work on Fordwah-Eastern Sadiqia in Pakistan. The intervention process has three stages:

1. *Diagnosis*: In this stage, there is a formal process to identify the key issues facing managers, and then break these down into a set of critical management activities that influence performance, leading to identification of the performance drivers, i.e., critical parameters on which the action phase should focus.
2. *Action*, which is collaborative with the system managers and may also involve operational personnel.
3. *Institutionalization*: A phase which the program has entered in Sri Lanka, where the Irrigation Department is now promoting the IMIS on several other systems.

Diagnosis in both Kirindi Oya and Fordwah identified specific “performance drivers.” In both systems *operation of the distribution system* was identified as the key issue for interven-

tion, albeit taking different forms; in both systems decision making was hampered by inadequate information on the parameters required to achieve system objectives.

3.5.2 Irrigation Management Information System (IMIS)

IMIS as an information package integrates three components:

- a reliable field data collection network
- an effective communication network
- a computer-based tool to process data supporting the manager's decision making

Box 3.8. Lessons from introducing a decision support system at Inginimitiya, Sri Lanka.

From 1991 to 1993, IIMI and Hydraulics Research of Wallingford collaborated with the Irrigation Department of Sri Lanka to introduce HR/Wallingford's INCA decision support computer software at Inginimitiya (IIMI and HR/Wallingford 1994). The broad objective was to improve performance by achieving a better match between scarce water supplies and crop demand. INCA is a computer software program which can support managers as a database and operational monitoring system, as a water scheduling tool, and as a pre-season planning aid. It has been successfully introduced in several systems in Asia and an earlier version was pilot tested on another system in Sri Lanka. In Inginimitiya, the project assumed that introducing it could be done quickly, and its availability would be a catalyst for improving the management framework. This assumption proved wrong, and the project failed in transferring and institutionalizing the use of INCA as a management tool.

It was in part this experience that led to the formulation of the "performance improvement capacity audit" (PICA) described in Sections 2.2.4 and 2.4.3. Inginimitiya's PICA score was 3 out of a possible 10 (Table 2.1); while its design, operations, and data collection system offered moderate capacity, it scored zero on the availability of a management framework, and on the will to manage. These two gaps combined with several years of drought made it impossible to implement INCA as a management tool. In retrospect, the study made the following recommendations:

- An initial investment is needed to assess the existing management structure and determine its objectives and likely decision support needs.
- A system that functions as a management information system as a first step is likely to be more readily accepted (a conclusion also reached in Kirindi Oya).
- The adoption of a decision support package must be user-driven, and the institutional framework must provide support and incentives to managers.
- Decision support technologies should replicate in a familiar form the management activities prior to the intervention, so that it addresses immediate concerns.

These lessons underlay the success IIMI had in working with the managers of a major system in India to introduce an improved management information system (Section 3.5.3).

The IMIS computer-based tool uses commercial database and spreadsheet programs and a hydraulic flow simulation model, SIC, which can run on a basic personal computer.

In both systems the managers were involved in configuring the IMIS package to meet their needs and objectives, and then in the implementation (Rey, Kuper, and Hemakumara 1993). Implementation began in 1991 in Kirindi Oya and in 1993 in Fordwah. An important feature of IMIS is the use of display boards in the manager's office: in both places, this has led to discussions of operational targets in a way never done before. The availability of easily accessible and usable data has confronted managers with the effects of their decisions, leading (in Kirindi Oya) to more careful planning of water distribution. In Fordwah, the model has been useful in identifying the impacts of gatekeepers' interventions on water deliveries and identifying potential solutions (Section 3.2.3). In both systems managers have become committed to using IMIS, though it is too early to claim institutionalization. However, in Sri Lanka the Irrigation Department has initiated adaptive research to implement the use of computer models and IMIS on four more schemes on a pilot basis, integrating this experience with lessons from other experiments (Samarasekera et al. 1994; Jayatillake 1995). Box 3.8 describes a case—also in Sri Lanka—in which outsiders tried to take shortcuts in introducing a decision support system, with disappointing results.

3.5.3 Introduction of a Management Information System in Mahi Kadana, Gujarat, India

IIMI has been collaborating for some years with the Water and Land Management Institute (WALMI) at Anand, Gujarat, and the Irrigation Department of Gujarat in research on the performance of the Mahi Kadana Irrigation System. With 212,000 ha of irrigable land, Mahi Kadana is the largest system in the state outside the Narmada Project. It has a mixed cropping pattern; extensive use of groundwater has enabled a cropping intensity of 180 percent. It is operated on the *shejpali* system, intended to match supplies and demand as closely as possible. Following an initial period of collaborative research on the performance and management processes of the system, IIMI, WALMI, and the Irrigation Department collaborated to develop, test, and implement an improved management information system, the Mahi MIS (Murray-Rust et al. 1994).

The first phase involved modification of the existing cumbersome data collection procedures. The primary innovation was the design and implementation of a "Red Book," a revised format for recording data on farmers' cropping patterns and water use by source. This replaced a cumbersome multiple entry ledger system, and enabled information to be recorded systematically and quickly. This innovation reduced the complexity and time required for recording information, improved the quality of the data, and enabled the development of a faster billing system (farmers are billed for water). It also provided the basis for the next step: the computerized Mahi MIS.

This Mahi MIS is designed so that Red Book data can be quickly recorded as computer records at section level. Data on canal water deliveries can also be entered. This enables results from each biweekly rotation to be made available to system managers within a few days of the end of the rotation (it had taken several weeks before). Managers can use the data on field conditions to adjust system operations. An added benefit is the system enables the gen-

Box 3.9. Testing practical options for improving irrigation management information: An example from Indonesia.

Like Mahi Kadana in India, most Indonesian irrigation systems have as their objective matching water supplies to crop demands. Most systems use a process called "Factor-K" to calculate demand on a weekly basis. Factor-K is a logical system but contains stringent assumptions about the quality of information, the infrastructure, communications, and the motivation and skill of the staff. Such assumptions are often not fulfilled. Researchers and others have documented several kinds of gaps in the information used. Therefore, as part of its larger study in Indonesia, IIMI, the West Java Provincial Irrigation Service, and the Directorate of Irrigation I collaborated on a "Management Information Project" (Murray-Rust and Vermillion 1995).

This project involved five tasks:

- developing cost-effective ways to map tertiary blocks
- inventorying of all gates and control structures to determine their condition
- using simple methods to calibrate all gates and measuring structures
- using simple methods to measure conveyance losses
- creating a management inventory of water users associations to assist irrigation inspectors to understand constraints faced by farmers

Carrying out these tasks on four systems confirmed the wide gap between assumptions and reality, and also confirmed that these tasks could be carried out by existing irrigation staff cost-effectively. Records were kept that confirmed the costs of these tasks were very low on a per ha basis. Unfortunately, performance impacts could not be measured in the short time frame of the study. But the authors suggest that improved implementation, improved performance monitoring and evaluation, better maintenance planning, and a high level of job satisfaction will be the major benefits.

eration of farmers' irrigation bills within a few days of the end of the season, rather than the weeks or months it had taken previously. Murray-Rust et al. (1994) describe how the system was used for one section of the system, illustrating its value for processing both tertiary-level and main-system data.

The Red Book has been adopted throughout the Mahi Kadana system and several other large systems in the state. The Mahi MIS was tested and implemented in one subdivision at the time of the report, and has reportedly been implemented more widely since then. Why was it implemented so successfully? Mahi's capacity for performance improvement scored moderately well using PICA: its total score was 6 out of 10, with no "zeros" (Table 2.1). With no serious design constraints, an existing operational and data collection system, a management framework, and the will to manage among some of its staff, it was clear that unlike Inginimitiya, Kirindi Oya, or Fordwah, Mahi had the preconditions for a successful intervention targeted to solving problems identified by the managers themselves.

The Mahi MIS can be used not only in routine performance assessment, but also to assess the operation of cross-regulators, the effectiveness of rotational innovations, and the effectiveness of local gatekeepers in distributing water fairly. The authors suggest it can be adapted for use on other systems both in Gujarat and other states.

3.5.4 Management Information Systems: Conclusion

Clearly, making low-cost and effective means to improve information available to managers can improve the quality of decision making. Such information generally leads to new insights on the reality of performance in the field, and the gap between plans and actual results, as is also shown by the Indonesian case discussed briefly in Box 3.9. There is a strong interest in such tools among many irrigation managers. However, institutional constraints continue to hamper widespread adoption and effective use of new decision support tools, and therefore the potential impacts of such tools are rarely achieved.

3.6 Research on Design, Maintenance, and Modernization Issues

3.6.1 Management of Maintenance and Rehabilitation

Maintenance management. In Pakistan, IIMI has documented the performance impacts and cost-effectiveness of targeted maintenance programs, compared to lining of canals (Section 2.5.1). In Egypt and Sri Lanka, the Institute has worked on the management and cost-effectiveness of maintenance.

In Sri Lanka, IIMI commissioned a study by a local consulting firm on the management of maintenance by the Irrigation Department to examine the question: how can maintenance be done more cost-effectively, given very limited budgets? This study documented that there is no relationship between the *allocation* of maintenance funds, and the *implementation* of maintenance. That is, allocations are done on a rule-of-thumb basis among the Department's divisions. Maintenance is then carried out by the local engineers based on their own perceptions. But significant portions of the maintenance funds are used to cover overhead costs not fully funded from other sources. Further, there is no system for prioritizing maintenance based on its impact on system performance, and no system for monitoring the impact of maintenance on system performance (TEAMS 1991a).

This problem has been addressed in more recent action research in the Kirindi Oya Irrigation System, Sri Lanka. In this study, a more systematic process for planning, prioritizing, implementing, and monitoring maintenance was tested. This methodology includes walking the canal length with field staff and farmer representatives, identifying maintenance needs and costing them, and then prioritizing them according to their contribution to system performance (and safety). As part of this work, improved practices for managing labor were recommended and a methodology was proposed for identifying the optimum area to be managed by an administrative division, to economize on overheads (Karunasena 1993; IIMI 1995a, vol. 2, chap. 3).

In Egypt, a research team developed a process for studying the management of maintenance, and pilot tested it in one area (Vissia 1995). The study process included 14 data collection forms to guide interviews, and analysis of various records. The study came to a set of preliminary conclusions and suggestions for change. These included:

- There are presently six major units in the Ministry of Public Works and Water Resources (MPWWR) responsible for maintenance. Each has its own staff, equipment, workshops, and purchasing system. In the pilot study area three of these units have maintenance facilities on the same water delivery and disposal system, but there is very little coordination among them. Therefore, there are significant opportunities to make more efficient use of equipment, personnel, and supplies.
- The planning and scheduling of maintenance, and the types and features of maintenance contracts could be improved and standardized.
- Some units have useful handbooks and software programs that could be adopted by other units to improve their management.
- The present budgeting and accounting system classifies costs into four broad categories and cannot be used as a management tool for resource management.

In both Egypt and Sri Lanka, maintenance is clearly *administered, not managed*, an observation that applies to many countries. There is no process for setting maintenance objectives and targets based on system performance objectives, and budgeting and accounting systems are not performance-oriented. It is often claimed that underfunding of maintenance is the cause of system deterioration. However, these studies suggest the need to improve the management and cost-effectiveness of maintenance using existing funds, as a basis for identifying the real maintenance gap.

Cost-effective rehabilitation and modernization of irrigation systems: Lessons from Sri Lanka. In Sri Lanka, as in many countries, construction of new systems has largely ended. Beginning in the late 1970s, Sri Lanka has invested increasingly in rehabilitation and modernization of its existing irrigation systems, with the assistance of various donors. Overall, rehabilitation has become a more cost-effective investment than constructing new schemes (see Section 4.2.2). IIMI has been directly involved in several of Sri Lanka's rehabilitation and modernization (R&M) projects, and has also commissioned comparative analyses of these experiences (Abeysekera 1993; ECL/ADRC 1992). The findings are synthesized by Brewer, Sakthivadivel, and Wijayaratna (1992).

Table 3.3 gives the estimated benefit/cost ratios and internal rates of returns for five very different major donor-funded projects. The WMP and ISMP, both funded by the same donor, show the best returns, along with one of the two schemes under MIRP. TIMP, chronologically the first in the series, shows negative IRRs and B/C ratios of less than one. WIIP, where IIMI has worked since 1986 (but failed to influence the implementation), has a low IRR; it is incomplete and the authors predict it will not be cost-effective.

Table 3.3. *Economic evaluation of rehabilitation projects, Sri Lanka.*

Project	Scheme	B/C ratio	IRR
TIMP	Mahawilachchiya	0.56	— ¹
	Mahakandarawa	0.21	— ¹
MIRP	Rajangane	1.30	16.4%
	Huruluwewa	0.67	— ¹
WMP	Gal Oya Left Bank	1.57	33.0%
ISMP	Kaudulla	2.24	30.0%
	Minneriya	1.29	16.5%
WIIP	Uda Walawe	— ²	8.0%

¹The IRRs for these schemes were negative. ² No B/C ratio calculated.

Notes: B/C ratio = Benefit/Cost Ratio. IRR = Internal rate of return.

TIMP and MIRP were funded by the World Bank. WMP and ISMP were funded by USAID. WIIP was funded by the Asian Development Bank.

Source: Brewer, Sakthivadivel, and Wijayaratna (1992:28, Table 2.1).

There were significant differences among these projects in their planning and implementation which explain the differences in performance. These include:

- WMP and ISMP put resources into institutional development; MIRP was intermediate, while the others, with the poorest performance, invested little in such software. Institutional development included forming farmer organizations and involving them in the design and construction activities as well as in post-project management.
- None of the projects involved water users in the early planning. But the successful ones included provisions for monitoring and evaluating progress and making changes during implementation based on lessons learned.
- The successful projects involved both farmers and operators in the design and implementation phases; the unsuccessful ones did not.
- The successful projects did not attempt complete redesign and reconstruction of the systems; rather they adopted an approach called "pragmatic rehabilitation," emphasizing solving problems within the existing design cost-effectively.

Based on these findings the authors offer a conceptual framework for achieving cost-effective R&M, whose main features are given in Table 3.4.

Table 3.4. Conceptual framework for achieving cost-effective rehabilitation and modernization.

<i>Project Planning</i>
1. Selection criteria for R&M determined
2. Diagnostic studies conducted, current status measured against goals of farmers and operators
3. Operational and maintenance constraints identified
4. Water availability studies carried out
5. Suitable technology identified in consultation with system operators and farmers
6. Desired institutional and management changes identified
7. Adequate farmer contribution to costs negotiated
8. Adequate funding for the different components allocated
9. Agreement with farmers and operating agency reached and incorporated into final report
<i>Project Implementation</i>
1. Farmer organizations created and strengthened
2. Orientation and training for agency personnel and farmers conducted
3. Operating agency strengthened for implementing rehabilitation
4. Farmer involvement in design, construction, operation and maintenance planned and implemented
5. Development of the O&M system to be used after the project
6. Use of appropriate design principles and methods
7. Flexibility in implementation methods
<i>Project Management</i>
1. Work plan and schedule developed, sequencing of activities and allowing sufficient time
2. Financial management, including tendering and procurement
3. Progress and impact monitoring, evaluation and feedback
4. Flexibility in planning and oversight to respond to lessons learned and local conditions
5. Midterm external evaluation for project changes
6. Final evaluation and completion of report to document lessons for other projects

Source: Brewer, Sakthivadivel, and Wijayaratna (1992:41, Table 2.3).

3.6.2 Design of Small Irrigation Systems

Work on this topic has involved two main concerns:

- What can we learn from traditional farmer irrigation design principles or technologies to improve the management of construction and rehabilitation of farmer-managed irrigation systems?
- How should new systems or rehabilitated ones intended for farmer management be designed so as to be compatible with farmer institutions and management capabilities?

Both concerns have emphasized questions of design processes as well as appropriate technologies. Some of the social process issues are discussed below in Section 4.6.

In the late 1980s, IIMI recommended that an inventory of traditional design technologies and their contexts be made to improve the general knowledge about the range of options that has proven to be:

- 1) manageable by farmers (for example, proportioning or modular weirs),
- 2) more cost-effective than many modern designs (such as flushing or sluice gates), and
- 3) consistent with local water rights, after long periods of trial and error (Yoder and Thurston, eds. 1990).

In Nepal and Indonesia, researchers have recommended that low-cost and simple-to-manage design structures for FMIS should replace the bias towards costly, overly elaborate, and difficult-to-manage control structures and lined canals (Pradhan 1990a; IIMI 1989e).

Recommendations for improving the process of designing irrigation for farmer management that have emerged include the following:

- The process should begin with dialogues between farmers and agency staff and system 'walk-throughs' to identify management functions needed and priority design items and features.
- Good technical supervision and advice by engineers should be balanced by respect for local knowledge and rights.
- Where possible, the process should be a phased, modular development rather than a one-shot fix-all which denies experimentation (Vermillion 1990).

Action research in Nepal has shown that farmer paraprofessionals can often diagnose causes of design problems and recommend better solutions than can outside engineers (Yoder 1991).

A workshop on design issues for farmer-managed irrigation systems identified five elements of an effective design process; it should:

- 1) be driven by local management objectives,
- 2) be primarily field-based,
- 3) have farmer participation from beginning to end,
- 4) include procedures to encourage the accumulation of learning through experience, and
- 5) incorporate local logic, knowledge, and experience (Yoder and Thurston, eds. 1990).

Contributions to the design of small reservoir irrigation systems in West Africa have been discussed above in Section 3.2.5. In addition to sponsoring a workshop on design issues, IIMI

has recently produced a handbook on designing irrigation structures for mountainous environments (Yoder, ed. 1994). This handbook draws on the practical field experiences of a number of practitioners to identify a range of design options and implementation approaches. The handbook is illustrated and provides 44 examples of a variety of structures for water acquisition, conveyance, distribution, and application.

The design process is analyzed as a *social*, or socio-technical process, in which the users' values, expectations, perceptions, and knowledge are key inputs. Farmers must be consulted about the type of structure they want and how they plan to operate and maintain it; designs should be compatible with local practices; proven traditional design concepts should be accepted or modified minimally within limits acceptable to the users; structures should not result in shifting management responsibility to the government or others outside the community; and local materials should be used to the extent possible to enable local repair and maintenance.

Uncertainty and variability characterize mountain environments to a greater degree than in the plains. Flexibility and self-reliance through effective organizations are therefore essential; social considerations such as equity and transparency may sometimes have to override technical considerations to make infrastructure sustainable. Designs therefore should support, not undermine, local organizations. Sections 4.5 and 4.6, below, discuss other issues related to support for farmer-managed irrigation systems.

3.7 Conclusion

The work done under the Program on Design and Operation of Irrigation Systems has emphasized documentation of the hydraulic and in some cases agricultural performance of canal irrigation systems, conjunctive use of groundwater and surface water, the environmental sustainability of irrigated agriculture with special reference to waterlogging and salinity, the use of modern management information and decision support tools to improve performance, and to some degree management of maintenance and modernization of systems. This work has documented in case after case the wide—and often widening—gap between theory and practice, or myth and reality. Many recommendations for improvement have been made in the reports; and through action research programs, in a number of cases, system managers have been assisted to implement improvements.

The reader may note that many of the cases reported are taken from unpublished papers and reports to donors. It is clear that more emphasis on publishing results is required: there is a wealth of data and insights that needs to be communicated to and debated by other researchers. Another observation is that while IIMI has done a large number of case studies, it has not mined these cases to do comparative analysis to the extent one might have expected. Such comparison is hampered by the lack of consistent sampling and data collection procedures among countries in the past.

In its early years IIMI had a specific program on "design and management interactions." It did evaluate some structural designs, for example the use of duckbill weirs in Sri Lankan canals; and as reported in Section 3.6, it has addressed issues related to designing structures for farmer management. Nevertheless, nearly all the research reported in this chapter assumes

a given design, and seeks to identify how it can be made to work better. This applies to the work in Pakistan on warabandi and crop-based systems, and its work on demand-based systems found in Gujarat, India, Sri Lanka, and Indonesia. With the partial exception of its recent evaluation of a project in India which is introducing more "structured" designs in India (see Section 2.5.2, and Box 3.2), IIMI has done little work recently on the question of what irrigation design principles are most appropriate under given conditions.

Much of the research reported here was undertaken with the specific objective of assisting countries to improve the performance of irrigation. There are some notable cases where the results have been used to make changes or improvements, for example in Sri Lanka. There are some isolated cases where individual managers have done things differently because of the work. However, there is a considerable gap between the expected and the actual impact. In Indonesia and Sudan, perhaps more time in the countries was required to have a real impact. But in Pakistan, IIMI has been working closely with policy makers, managers, and researchers since 1987, and has produced a substantial body of research results. These results raise important questions about the current performance and future prospects of irrigated agriculture in that country. Yet so far, the impact, either in terms of national research priorities to validate or refute IIMI's findings, or in terms of policy and managerial changes, is disappointing.

In the future, the Program on Design and Operation of Irrigation Systems will continue to work on management information and decision support systems using computer models, conjunctive use of groundwater and surface water, waterlogging and salinity, and system operations. But IIMI will strengthen the technical quality of the research, particularly with reference to engineering and computer modeling. It will also pay more attention to design issues, particularly to determine what kinds of designs give the best performance under given conditions. This will involve more attention to the interactions of design and management, and social and technical dimensions of irrigation management.

A consistent theme runs through much of the work reported in this chapter: the weaknesses in organizations and institutions responsible for irrigation management. To a very large degree, the poor irrigation performance documented by the research done under this program is a function of institutional and policy weaknesses. This is the topic of the next chapter.

CHAPTER 4

Research Results: Policy, Institutions, and Management

4.1 Introduction: Evolution of the Program

From its inception, IIMI has had a strong focus on studying irrigation institutions. "Irrigation Institutions" was one of the major topics under the "Systems Management Program" established in early 1986. Of the seven programs proposed in the first strategy paper in 1988, five were directly concerned with institutional issues (Box 1.1). "Policy" was not explicitly recognized in this early period as an important program, but as will be seen in Section 4.2, IIMI worked on policy-related issues as well.

Of the five programs described in the Medium Term Plan for 1994 to 1998, three are now included in the current Program on Policy, Institutions, and Management. They are: Sector Level Management of Irrigated Agriculture (policy), Improving Public Organizations, and Toward the Local Management of Irrigation. Only the latter program was fully funded. The evolution of three programs into one has involved concentrating research on a few key issues, strengthening the attention to policy issues, and a recognition that separating policy, reform of public agencies, and transfer of systems to users' organizations is artificial and causes unnecessary fragmentation of IIMI's work. In addition, one former "crosscutting theme" has now been included under this Program as a key topic: Women and Water.

The new Program therefore emphasizes research on policy tools to optimize the productivity of water, institutional and organizational analysis and options, impacts of irrigation on poverty and food security, gender analysis, and intersectoral competition for water.

4.2 Policy Tools for Optimizing the Productivity of Water

4.2.1 *Resource Mobilization, Cost Recovery, and Institutional Performance*

Until 1994, there was no program specifically addressing policy issues. Nevertheless, the first "generic" research activity was on resource mobilization and cost recovery. In addition, IIMI has worked on policy questions in particular countries; this work has important broader implications, and provides a foundation for future strategic research.

Interest in cost recovery has a long history. Donors have been urging countries to collect at least a portion of the costs of irrigation from users for many years, with mixed success. Many irrigation specialists have been advocating "volumetric" charging for water as a means to increase the efficiency of water use, as well as to cover the costs of irrigation. But the lo-

gistics of measuring water deliveries to millions of individual small farmers, and the political costs of charging farmers higher fees for water have prevented much progress in most countries.

By the early 1980s, increasing concern was being expressed about the returns on investments in the irrigation sector. The combination of falling cereal prices and rising construction costs had greatly reduced the returns to construction of new irrigation systems. Donors and governments were, therefore, diverting irrigation investments to rehabilitation of older schemes—whose deterioration was seen as a direct outcome of lack of O&M, in turn a result of inadequate cost recovery. These rehabilitation projects were based on assumptions regarding the potential returns—but there had been little research to evaluate the relative benefits and costs of new construction versus rehabilitation.

The research in these areas went beyond traditional economic analysis, raising new questions, and suggesting answers with significant implications for irrigation-sector policies. Specifically, IIMI shifted the cost-recovery debate to addressing the broader issue of the determinants of institutional performance, demonstrated the cost-effectiveness of institutional strengthening projects, and tested a methodology for developing and creating consensus on forward-looking policies in the irrigated-agriculture sector.

Linking financial autonomy and institutional performance

From 1985 to 1986, IIMI carried out research on irrigation service fees using data collected from several Asian countries. Although the donor's initial interest may have been in the collection of fees from farmers to finance irrigation, this work developed over time to address a much broader issue: under what conditions would users' financing of irrigation lead to improved irrigation performance? The work is reported in several publications (Small, Adriano, and Martin 1986; Asian Development Bank 1986; Small et al. 1989; Small and Carruthers 1991). The book by Small and Carruthers integrates IIMI's work with that of others and provides a sophisticated and detailed analysis and argument for a particular approach to financing irrigation.

The basic conclusion of these studies is that the preferred approach to financing the costs of irrigation is through "implementation of user fees by a financially autonomous irrigation agency" (Small and Carruthers 1991:217). The argument can be summarized as follows. First, severe shortage of funds to operate and maintain irrigation facilities and poor overall performance of irrigation relative to expectations have emerged as two pervasive problems. These deficiencies can be traced to a combination of unsatisfactory O&M procedures and deficiencies in the investment process itself. Inadequate funding for recurrent costs may make it impossible to operate and maintain irrigation facilities effectively; but a key insight from the research is that the *methods* of financing recurrent costs affect the quality of irrigation management.

Therefore, the research focused not only on the adequacy of funding but on how the way in which funds are provided encourages (or discourages) good service. Various policies were evaluated based on the criteria of resource-mobilization efficiency, resource-use efficiency, and equity. Financially autonomous agencies responsible for collecting a significant portion of their income directly from users have greater potential for improving performance. This is because they control their own budgets, and through payment of fees there is an accountabil-

ity linkage between operators and users. The investment-decision process is potentially also improved because agencies need to recover part or all of the costs resulting from these decisions from the users.

Under conditions prevailing in most developing-country irrigation systems, user fees are not likely to be very important in encouraging individual farmers to use water more efficiently. But user fees can reduce government subsidies, which tend to favor larger farmers, and reduce disparities between farmers with and without irrigation. It is not necessary that user fees cover all the costs of irrigation, or even all O&M costs; irrigation financing needs to be considered within the larger policy environment.

In general, irrigation financing policies are not very good tools for achieving income redistribution or social justice. Prospects for successfully implementing a fee collection system are enhanced if the basis for the fees is seen as equitable, if there are positive incentives to encourage users to pay, and if there are penalties for nonpayment. Prospects that these considerations will be effective are enhanced by decentralization through devolution of operational responsibilities.

The findings and recommendations of this work emphasize the critical importance of financial autonomy of the irrigation agency. This is presently absent in many countries.

More recent research, as part of the collaboration with IFPRI on performance assessment (see Section 2.2.1), has examined the impact of a) financial autonomy and b) dependence on collecting fees from the users, on the performance of a particular irrigation agency (Svendsen 1992).²³ Based on secondary data from the National Irrigation Administration (NIA) of the Philippines, this study confirms that since becoming largely financially dependent on user fees, NIA has responded by improving its financial management practices, using a viability index based on resource mobilization as a key indicator of performance, and attempting to improve its service. The study shows that:

- NIA was successful in reducing operating expenses, bringing revenues and costs into line, and eliminating the recurrent cost burden on the national budget.
- Equity of water distribution across the sample systems improved.
- Yields (adjusted for rainfall and nitrogen application) held constant even though water availability from upstream of the systems declined 13 percent; if water availability had remained constant, the projected increase in system output would have been 13 percent, a significant benefit (albeit foregone) considering that there was no additional capital outlay.²⁴

²³This study is also an explicit application of the "nested systems" analytical framework developed by Small and Svendsen, discussed under the Performance Assessment Program (Section 2.2.1); NIA is responsible for the outputs of the irrigation system which is an important input to the agricultural system (Figure 2.1, above). The results are consistent with the findings of the three-system comparative analysis of performance reported in Section 2.4.4; but see Section 4.4.7, below, for results that raise some questions about the impact of the Philippines' policy.

²⁴In other words, the productivity of water improved by 13 percent, though Svendsen does not put it this way.

Box 4.1. Proposals for phasing in cost sharing for water services in Egypt.

As part of a collaborative program with the Ministry of Public Works and Water Resources (MPWWR) of Egypt, IIMI (1995c) proposed a long-term three-phase plan for implementing cost sharing for water services. This plan is derived from both substantive research (see Section 4.2.1), and the results of a workshop on cost sharing. The workshop analyzed the problem using a five-element framework. These elements are: goals, definition of service, rate base, collection of funds, and use of funds.

If the goal is simply to recover some or all of the costs of O&M, a flat area-based fee can be charged; no significant changes are required in either the service definition or in the Ministry's organization to collect, use, and account for the funds (see Table). As additional goals become important—conservation of water, or improving service—it becomes important to reconsider the service provided, the rate base, and the arrangements for collecting, using, and accounting for funds. For example, if an important goal is to improve the service itself, that service needs to be defined and measured, and the funds need to be used directly for providing and maintaining the service. These changes will entail broader institutional reforms in the Ministry, such as decentralization, introduction of a management-based budgeting and accounting system, and linking performance of service units to financial flows. The study proposed three implementation phases:

1. Implement cost sharing for nonagricultural water services, while preparing for implementing cost sharing in the agriculture sector.
2. Implement cost sharing for agricultural users on a flat area-based fee basis in subphases, while simultaneously implementing a functional budgeting and accounting system in the Ministry and pilot testing both crop-based charging systems and more fundamental institutional reforms, to include experiments with volumetric delivery and charging to water users associations or other middle-level organizations.
3. Based on the results of the pilot tests, implement cost sharing linked to service (either crop-based or volumetric charges to middle-level organizations) including necessary institutional reforms.

The pilot testing of alternative approaches would include attention to benefits and costs in view of the findings regarding the limited benefits of investments in improved management (Section 4.2.1). The detailed proposals are the basis for ongoing discussions in the Ministry, and between the Ministry and the donor.

Table. Relationship between goal and other components of service charging mechanisms.

Component	One goal Stage 1	Two goals Stage 2	Three goals Stage 3
Goal	Recover costs (partial or full)	Recover costs Conserve water	Recover costs Conserve water Improve service efficiency
Service	Responsive to demand	Predefined schedules, or responsive to demand	Measured delivery at defined point
Rate base	Flat rate per feddan	Crop-based	Volumetric
Collection	Ministry of Finance? or MPWWR	MPWWR assisted by WUAs?	Delivery agency assisted by WUAs?
Use of funds	Central MPWWR	Regional and Central MPWWR	WUAs, Regional and Central MPWWR
Accounting requirements	Total national cost of O&M	Cost of O&M by function and region	Cost of O&M by function, region, and distributary

Source: IIMI (1995c:7, Table 1).

Recently, IIMI based its recommendations on cost recovery to the Government of Egypt on the principle that financing should be structured in a way that acts as an incentive for an irrigation service provider to be performance- and client-oriented (Box 4.1).

***Cost recovery from small farmers:
Can they pay, and will paying save water?***

Sri Lanka. Research in Sri Lanka in the late 1980s showed a significant decline in government expenditures on O&M, and the failure of an effort by the government to implement a system of user fees in which the fees would be retained at system level, matched by additional government funds, and used in consultation with farmers. Bureaucratic problems delayed implementation of the first two features, and political opposition during a period of civil unrest as well as legal problems led to its abandonment. Research during this period confirmed that at 4 to 6.5 percent of net farm incomes, farmers could afford to pay the full costs of O&M even with their relatively low incomes from rice farming; but they would not be able to pay these costs plus capital costs (IIMI 1989f; Small and Carruthers 1991:152-154). The failure to implement a clear policy on cost sharing with users has reduced the incentive of farmers to respond more positively to the government's participatory management policy (see Section 4.4.4, below).

Egypt. More recently, IIMI collaborated with IFPRI to answer two questions related to proposals for agricultural cost recovery in Egypt:

- Can farmers afford to pay for irrigation O&M services?
- Can cost recovery be used as a policy instrument to improve water use efficiency by farmers?

The researchers first worked with personnel from the Ministry to update and improve a previously used model for allocating water service costs to the agriculture sector. This model is based on the Separable Costs Remaining Benefits (SCRB) method, which was found appropriate and whose results proved conceptually easy to communicate to nonspecialists in the Ministry. Various sensitivity tests were used, and the result proved surprisingly stable under different scenarios. The main conclusion was that full O&M costs (including replacement) for irrigation services to the head of the *mesqa*, private channels through which farmers get their water, works out to an average of US\$52 per ha (1995 prices). However, there are large regional variations based on differences in pumping requirements, from \$42 to \$56 to \$91 for Lower, Middle, and Upper Egypt, respectively. Full cost recovery at \$52 per ha per year represents some 4.5 to 5 percent of average net farm incomes, suggesting that farmers can afford to pay these costs (IIMI 1995d; Lofgren 1995).

Using these figures and other data, IIMI worked with IFPRI to modify its Egypt Agricultural Sector Model to answer the questions posed above (see Lofgren 1995; IIMI 1995d; Perry 1996c). First, the model was used to analyze the impact on production of three alternative charging mechanisms:

- a flat charge of about \$50 per ha
- a crop area-based charge proportional to the calculated average water consumption, in which the wide choice of crops offered to farmers by the model allows considerable “fine tuning”
- a pure volumetric charge

The first option reduces farm income by about 4.5 percent but as expected has no impact on choice of crops or technology. The second option reduces farm income by only 2.4 percent while reducing overall water demand by a modest 3.5 percent and increasing returns to water by 2.7 percent. The third scenario gives virtually the same result as the second. The results therefore indicate that for the level of charges implied by full cost recovery for water services, the efficiency benefits of a volumetric charge are not significantly better than those of a simple area-based charge. Further, the physical infrastructure and complex accounting principles required for either type of volumetric charging are unlikely to be feasible or cost-effective in the near future.

The model was also used to examine the impact of water shortage on crop production, and the role water charges could play to induce an efficient response from farmers to such shortages. Reductions in supply of 15 percent and 30 percent were analyzed under two scenarios:

- sharing of shortages under the present “inefficient” management (in which shortages would be concentrated at tail or other disadvantaged locations)
- “efficient” management, which would share shortages equitably among all farmers

The results show that from a national perspective, a water shortage of 15 percent if inefficiently managed would result in a 7.1 percent fall in real agricultural value-added while an efficiently managed shortfall would result in a 4 percent reduction. A 30 percent water shortage would have more dramatic impacts: reductions in agricultural value-added of 17 percent and 11.3 percent for the inefficiently and efficiently managed scenarios, respectively. If volumetric water pricing were used to achieve the 15 percent reduction in water consumption, the service charge would have to be at the level of 25-40 percent of farm income—\$280 per ha.

One final point is made in the analysis: the difference in results of the “efficient” and “inefficient” management options to deal with shortages is 3.1 percent. This is the “productive benefit” of improved management, and is equivalent to \$37 per ha. But to achieve these benefits would require introducing better infrastructure to enable measurement of water at farm level. The cost of the current Irrigation Improvement Project, whose infrastructure would meet this need, is about \$1,150 per ha. Therefore, introduction of volumetric water charges is unlikely to be economically viable *at farm level* (Perry 1996c). This finding on the limited returns to infrastructure investments leads to the topic of the next section.

4.2.2 *Investment Trends and Economic Returns*

IIMI carried out a study of the economic returns to different types of irrigation investments, using a long-term data set from Sri Lanka. The results of this study are significant for other countries as well; they are reported by Aluwihare and Kikuchi (1991) and Kikuchi et al. (1992). Sri Lanka, like other Asian countries, has approached self-sufficiency in rice production, a goal set at Independence and pursued by investing heavily in the construction of new irrigation systems. The irrigation sector is now at a turning point, and the research tries to answer the "what next?" question.

Detailed time-series data on several categories of irrigation investment over a 40-year period were compiled, and the costs and benefits of three types of investments compared: new irrigation construction, major rehabilitation, and water management improvement projects. Until the early 1980s, new irrigation construction had accounted for over 90 percent of the total irrigation investment and 20-40 percent of the total public investment in Sri Lanka. The study confirms that during this "construction stage" the investments in new systems gave positive returns, and benefits stayed ahead of rising costs as new rice-seed-fertilizer technologies enhanced productivity.

But by the early 1980s, real costs of construction were sharply increasing as the most favorable sites had been completed; this trend combined with the long-term decreasing price of rice had made new irrigation construction no longer an economically viable investment. Even with substantially higher prices of rice, or successful diversification to higher-value crops in the dry season, no major new construction projects can be justified. "The era of 'major' irrigation construction in Sri Lanka is at an end" (Aluwihare and Kikuchi 1991:45).

By the mid-1970s, a new investment trend had emerged, emphasizing rehabilitation and modernization of systems, and improving irrigation management through institutional strengthening interventions. It was found that the rates of return on these new types of investment are quite high: 24 percent for a major rehabilitation project which included a significant program of institutional strengthening, compared to less than 10 percent for new construction; and for water management improvement projects which include modest investments in physical improvements, returns are as high as 70-80 percent. Even in terms of the absolute value of the benefits generated, these types of projects can compete with new construction. The study concludes that Sri Lanka has shifted from a construction to a "management stage" of development. This work, based on different data and methodologies, confirms the conclusions on cost-effective rehabilitation discussed in Section 3.6.1, above.

In countries where rice production approaches self-sufficiency, and investments in new construction have led to the development of the most favored sites, this shift in emphasis from construction to management will be inevitable and economically rewarding. For Sri Lanka, Kikuchi et al. (1992) note that this shift has significant implications for investment in research: they suggest that since the highest gains from irrigation system improvement at this stage derive from increasing cropping intensity and equity of water distribution, research should focus on achieving these types of gains. Crop diversification will also bring relatively high returns in the long run, and is also an important area where further research would bring high returns in the long run.

4.2.3 *A Participatory Methodology for Developing Sector Policies*

During the eighties, IIMI became heavily involved in providing advice and support on irrigation policy in Sri Lanka, especially in relation to the high degree of interest in "participatory management." Discussions among the then Ministry of Lands, Irrigation and Mahaweli Development, USAID, consultants from a USAID centrally funded project (ISPAN), and the Sri Lanka-IIMI Consultative Committee led to the initiation in mid-1990 of the Irrigation Management Policy Support Activity (IMPSA) (Merrey, de Silva, and Sakthivadivel 1992; IMPSA 1992). Over a 2-year period, IMPSA used a highly participatory process to develop and operationalize the government's participatory management policy, and to create a broad consensus on this policy and the steps required to implement it.

Ten major policy papers, 8 special reports, and over 50 working papers were prepared; more importantly, numerous workshops and consultative committees met to discuss and develop these papers, and achieve a consensus on what the policies should be. These policies covered a broad vision of the objectives over the next decade and beyond; joint management and transfer arrangements to enhance farmers' management of systems; rehabilitation, modernization, and financing policies; reform of the major implementing agencies; training and research requirements; broad (inter-sectoral) water resource management principles; the role of the private sector and commercialization of agriculture; and legal reform.

The workshops and consultations involved a wide variety of people, including farmer representatives, agricultural, irrigation, and other government officials from field and middle levels up to the highest level, and private sector representatives. What is most significant here is not the specific policies that emerged and are being implemented, but the *methodology* that was developed and validated. Policies are often made by a few high-level people, or even by outside consultants, with no consultative process involving those who must implement the policies, or who are likely to be most affected. One often finds, as a result, that there is a high degree of resistance to policies; policies are perceived as misguided, and there is a gap between achievements and expectations.

The participatory methodology used by IMPSA was designed to integrate the use of previous research results, the use of the best expertise available both within and outside the country, and the practical experience of a broad spectrum of people involved in irrigated agriculture. In a series of workshops and consultations preceding the drafting of papers, and in discussion of drafts, a wide range of people became involved in the process, made important contributions, and—very importantly—developed a sense of ownership and commitment to the outcomes. As a result of IMPSA, the Government of Sri Lanka amended its Irrigation Ordinance to legalize the role of farmers organizations in irrigation system management. It had recently amended the Agrarian Services Act to enable registration of farmer organizations as legal entities. Although not all the institutional reforms recommended by IMPSA have been implemented, especially those related to reform of the Irrigation Department and the Mahaweli Authority (these are still being discussed), a large number of other changes in policy and procedures were adopted.²⁵

²⁵ The relatively strong linkage of research and policy in Sri Lanka exemplified by IMPSA is in contrast to the weak linkages documented for Pakistan; see Box 4.3.

IIMI has since used this methodology for development of a donor-funded project on watershed management in Sri Lanka with excellent results (see Section 5.2 on the SCOR Project); and designed and implemented an ambitious institutional and policy analysis project in Egypt based on the IMPSA experience (see Box 4.2).

4.2.4 Consistency in Irrigation Performance Goals: Case Study of Pakistan

The principle that goals and objectives need to be clearly articulated as a basis for planning and implementing actions and assessing performance is widely accepted. The review of performance assessment frameworks in Chapter 2 highlights the necessity for identifying objectives as a basis for performance assessment. But there have been few studies of the appropriateness and consistency of goals set by countries for irrigated agriculture. Vander Velde and Svendsen (1993) report on an attempt to develop and demonstrate a practical research methodology for analyzing existing goals of irrigation and irrigated agriculture, using Pakistan as a case study.

Vander Velde and Svendsen classify irrigation goals in terms of the nested means-end framework of Small and Svendsen (1992; see Section 2.2.1, and Figure 2.1). This framework enables relating narrower goals of irrigation to broader objectives at the levels of the irrigated agriculture, rural economic, and socio-political systems. The authors make a distinction between official public goals ("formal goals"), and the interpretation of these goals by officials responsible for implementation ("operational goals"). Two sources of data are used: official published documents are used to identify the official goals; and a small sample of irrigation and agricultural officials in the province of Punjab's irrigation and agricultural departments were interviewed to ascertain their interpretations of national goals. A formal replicable process for carrying out the interviews and for analyzing and classifying goal statements is followed and reported in the paper (Vander Velde and Svendsen 1993: Appendices 2 and 3). Goals are classified in terms of the organizational level of the country, and the goal levels of the nested framework, as shown in Table 4.1. Selected information on the performance of irrigation systems and of agriculture is also used.

Some of the findings related to Pakistan are:

- Much effort was required to classify and clarify the goals in an objective and consistent manner; a set of such rules is a necessary prerequisite for replication of this type of study.
- Explicit goal statements were far fewer than anticipated; but reanalysis, to include recommendation statements, led to the identification of additional goals. Goals and objectives were more commonly *implicit* than explicit in the nine documents reviewed.
- Although equitable distribution of water supplies is embedded in the design of the irrigation system and was stated as an objective by half of the Irrigation Department engineers interviewed, the focus on this objective is blurred in the official documents as new goals have been added in response to various pressures. Most Punjab Agriculture Department staff identified increasing agricultural production as a goal, but

Box 4.2. Lessons from institutional and policy analysis in Egypt using a participatory approach.

In 1994, IIMI was invited by USAID and the Ministry of Public Works and Water Resources (MPWWR) of Egypt to submit a proposal to assist the Ministry with further planning and analysis of cost sharing issues, and to carry out an institutional analysis of the Ministry's experiences in implementing a multi-component 15-year project funded by USAID. IIMI proposed a highly intensive and participatory approach modeled on IMPSA, and implemented this program in 1995 (IIMI 1995e).

The Ministry established a high-level *Steering Committee* to guide the process and through which results could be communicated and discussed at the highest levels; and a series of *Task Forces* made up of middle-level professionals to assist in data collection and analysis and development of recommendations. Five formal workshops were scheduled, of which four were actually held. The IIMI team of staff and consultants worked very intensively over a 6-month period, interviewing hundreds of people, studying documents, holding informal discussions and consultations, planning and implementing workshops, and preparing and presenting reports. In the end, 18 reports were prepared, including a detailed "Action Plan" for a 3-year program of strategic planning, management training, pilot testing of new ideas, and implementation of agreed changes (IIMI 1995f; see Section 4.3.2, below, for the results of the institutional analysis).

The major objective of trying to follow a participatory approach was to enable the Ministry to accept the results as its own, i.e., to feel a sense of ownership and commitment to the results. While the Ministry clearly appreciated many of the results, the project did not fully succeed in achieving the "ownership" objective. What are the reasons? This can be answered by comparing this experience with IMPSA.*

- IMPSA was a 2-year program while the Egypt program was substantially completed in 6 months. This was far too little time to achieve the objectives following a participatory approach; formal objectives were achieved at the expense of the participatory goal of gaining Ministry ownership.
- IIMI had been working in close collaboration with Sri Lankan institutions for about 5 years before IMPSA began and IIMI staff had close working relations with Sri Lankan counterparts on which they could build. In Egypt, this project was IIMI's first in that country.
- IMPSA reflected a stronger policy-research linkage, as it built on considerable action research and pilot testing of participatory methodologies. In Egypt, there is a strong tradition of technical research but the links between policy and research are relatively weaker, with the notable exception of the research that had provided the foundation for the Irrigation Improvement Project.
- IMPSA involved a large number of Sri Lankan consultants and government officials; it also included a large number of working papers (many prepared by Sri Lankan officials) and informal consultations with officials. Leadership of IMPSA was in the hands of a highly respected Sri Lankan retired official who was IIMI's partner (but was not employed by IIMI). The Egypt project also made use of Egyptian experts and officials, but to a lesser degree, leading to a perception of the product as IIMI's.
- Many of the ideas emerging from IMPSA already had some support; IMPSA functioned as much to build consensus on and suggest how to operationalize existing proposals as to generate new ideas. In Egypt, many of the observations and proposals were relatively new; there was not a strong constituency in place.
- The highest-level civil servant in the Sri Lankan Ministry took a personal and public interest in IMPSA and its results, and began implementing emerging results early on. The level of support in the Egyptian Ministry was less intensive and less clear.
- Participatory ideals and methodologies had become a part of the culture of many of the Sri Lankan officials and experts involved in IMPSA. But they were relatively new to Egyptians, some of whom also had difficulty suspending hierarchical relations for the purpose of generating and exchanging ideas.

*The author of this book was the team leader for both IMPSA and the Egypt Project.

*Table 4.1. Category distribution of goals, Pakistan.**A. Category distribution of goals from documents after classification.*

Organizational level		Goal level					Total (n=)
		Socio-political	Economic	Agro-Economic	Agricultural	Irrigation	
		A	B	C	D	E	
National	1	18	32	24	28	43	145
Provincial (Punjab)	2		8	3	14	18	43
Irrigation System	3		4		9	66	79
Distributary	4					10	10
Watercourse	5	1		2	5	59	67
Total (n=)		19	44	29	56	196	344

B. Category distribution of goals from interviews after classification.

Organizational level		Goal level					Total (n=)
		Socio-political	Economic	Agro-Economic	Agricultural	Irrigation	
		A	B	C	D	E	
National	1						0
Provincial (Punjab)	2		7	1	9	2	19
Irrigation System	3	1			7	26	34
Distributary	4					7	7
Watercourse	5				4	11	15
Total (n=)		1	7	1	20	46	75

Note: Table total exceeds number of database entries because of goals in multiple categories.

Source: Vander Velde and Svendsen (1993: VIII-16, Tables 2, and 3).

few Irrigation Department officials mentioned this. Adding goals over time has blurred the objectives, and there are significant institutional differences in perceptions of goals.

- Despite a great emphasis on “sustainable development” in the official goal statements, there was also a strong emphasis on other goals that would directly contradict this: extending irrigation facilities to new lands outside the present commands is not compatible with the need to control salinity for example (see Section 3.4, above). Contradictory goals are likely to lead to confusion in implementation.

- There is a wide gap between stated irrigation and agricultural objectives and the reality of performance, as has also been documented in other sections of this book (e.g., Section 3.2.3).

The authors conclude that articulating clear, specific, goals and objectives that can usefully guide irrigation management and investment, needs more attention, not only in Pakistan, but undoubtedly elsewhere as well.

4.3 Institutional and Organizational Aspects of Irrigation Management: Governance, Public Organizations, and Management Processes

4.3.1 Introduction

IIMI and other researchers and practitioners have developed numerous management innovations whose adoption would significantly improve the performance of irrigated agriculture. These include improved designs and operational procedures, performance assessment methodologies, on-farm water management practices, as well as specific institutional innovations. At present, there is a significant lag between the production of innovations and their adoption. Put another way, the "supply" of management innovations greatly exceeds the "demand" for them among public irrigation organizations. It is important to understand why this is the case.

The principal determinants of present irrigation performance levels, and of the adoption of improvements, are the capacity and the interest of those organizations responsible for irrigation in most countries. These are two separate though linked concepts. Some agencies can be shown to have the *capacity* to adopt management improvements, but they do not do so for lack of interest or incentives. Others can be shown to have the *interest* but for a variety of reasons have a weak capacity. In many cases, both capacity and interest are in short supply.

More than a decade ago, Bottrall (1981) pioneered the study of public irrigation organizations, with a detailed comparative analysis of the management of four large systems in four different countries. There was little follow-up to this work. Wade carried out important studies of public organizations managing irrigation in South India and in Korea (Wade 1982a, 1982b, 1985); his work on rent seeking in a large Indian system is particularly well-known. More recently, Uphoff and his associates developed an analytical framework and attempted a comparative study of irrigation bureaucracies (Uphoff, Ramamurthy, and Steiner 1991). The latter made use of some of IIMI's work.

While IIMI did not have a specific program addressing the issue of how public irrigation organizations can be improved before 1994 (and never had such a Program with *funding*), it has worked on this issue since its establishment, building on the work of others. The results of its country-level studies are consistent with each other in their overall findings, and are relevant beyond the particular countries where the studies were done. This work is discussed here under two headings: governance and management processes.

4.3.2 Governance

The work on the impact of financial autonomy on organizational performance is discussed above under Policy (Section 4.2), but is relevant here as well. The structure of financing mechanisms provides incentives or disincentives for performance and innovation. The relative success of the National Irrigation Administration (NIA) in the Philippines in achieving improved performance in terms of both cost-effectiveness and its core business of water supply for agriculture, and its reputation for innovative programs to devolve responsibility to farmer organizations (Sections 4.2.1, 4.4.7), contrasts with those countries retaining civil engineering line departments created decades ago.

Institutions and the performance of irrigated agriculture in Pakistan

Several sections of Chapter 3 have identified the serious shortfall in the performance of irrigated agriculture in Pakistan. To fully understand the reasons for this shortfall, and the difficulties in implementing changes, it is essential to understand the institutional context. A paper by Bandaragoda and Firdousi (1992) is an important contribution to achieving this understanding. Box 3.6 discusses the institutional impediments to solving Pakistan's salinity problems. An early publication by IIMI brought together into one volume the work of staff members on institutional issues in Pakistan, done before they had joined IIMI (Merrey and Wolf 1986). Bandaragoda and Firdousi build on this work, as well as on IIMI's own field work to present a broad analysis of the institutional impediments to improving irrigation performance in Pakistan.

Bandaragoda and Firdousi adopt a broad definition of "institutions" to include not only "organizations" but also irrigation "rules"—both formal (laws, regulations) and informal (customs, norms). A strong and complex institutional milieu has evolved in Pakistan. Established irrigation rules and organizations exist simultaneously with an intricate set of informal social institutions, which are often in conflict with the formal system. This dualistic, uncoordinated and increasingly ineffective institutional framework is poorly articulated with Pakistan's physical infrastructure. There is an apparent incompatibility between the emerging requirements for improving the performance of irrigation and the capacities of the institutions (see also Merrey 1987).

The main factors affecting irrigation performance are identified as:

- the overriding effect of socially evolved informal institutions over the formal rules and decisions
- the obsolescence of irrigation rules, codes and procedures
- the declining relevance of organizational structures
- The low value attached to valid and reliable information on irrigation performance

The study urges strong policy initiatives to overcome these problems. But a subsequent study by Bandaragoda (1993) documents the weak linkages of policy and research—and the resulting weaknesses (see Box 4.3).

Irrigation institutions in Sri Lanka

IIMI has dealt with the impact of the overall structure of irrigation organizations on performance and innovativeness in Sri Lanka as well. Merrey (1995) addresses the question of why the Mahaweli Authority of Sri Lanka has been relatively unsuccessful to date in establishing farmer organizations and implementing the government's participatory management policy. After reviewing the experience as documented in various studies, he suggests the problem lies in the mandate, ethos, values, and structure of the Authority itself. In its early years, the Authority had been flexible, dynamic, and achievement-oriented. Over time, it has become increasingly bureaucratic, rule-driven, formalized, and rigid. In addition, from the beginning it has had a philosophy dominated by a combination of idealism and paternalism. These characteristics have led the Authority to approach settlers in a way that in effect (though not in rhetoric) discouraged the evolution of strong self-sufficient farmer organizations. Merrey makes specific recommendations for restructuring the Authority and reorienting its mandate and staff.²⁶

A major component of the Irrigation Management Policy Support Activity (IMPSA) in Sri Lanka, described above (Section 4.2.3), was the development of proposals for restructuring of the Irrigation Department, as well as the Mahaweli Authority. Detailed proposals were developed for the Irrigation Department through a process of consultation with senior officials of that Department (IMPSA 1992). The proposed changes include opening the Department to other disciplines besides civil engineering, accepting responsibility for promoting and strengthening farmer organizations (a task currently entrusted largely to a separate division of the Ministry), and reorganizing the Department to enable it to focus more effectively on joint management with farmer organizations, and improving irrigation performance. These proposals are still being actively discussed within the Department and the Ministry, but to date they have at best been partially implemented.²⁷

²⁶The government and donors have discussed developing a "restructuring" project, but there is no evidence on whether this paper has had any influence on that process. It is also important to note that after this paper was written, the management arm of the Authority, under the vigorous and committed leadership of the former Sri Lankan director of IMPSA, initiated an ambitious effort to develop a joint-management system including strong farmer organizations. This may provide a test for the hypothesis articulated in the paper by Merrey. Early results are summarized in Section 4.4.5, below.

²⁷IIMI has been assisting the Irrigation Department to strengthen a new unit for research, which itself is expected to play a key role in the restructuring and strengthening of the Department. See Chapter 6, below.

Box 4.3. Research-supported policy: The case of Pakistan.

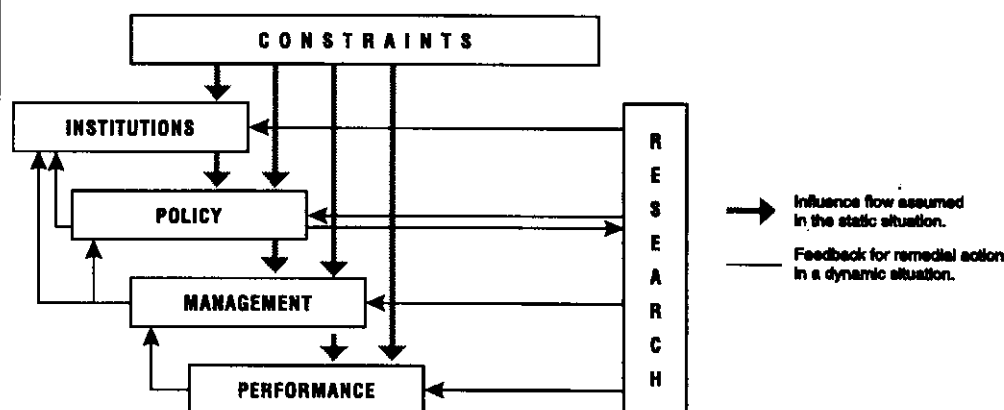
A dominant issue facing both research and policy in Pakistan is the stubbornly stagnant performance of irrigated agriculture. Bandaragoda (1993) argues that policy and institutions are “intrinsically interlinked” and “mutually reinforced;” policy is the product of institutional behavior, and institutions are the expression of policy. In a static situation, the existing institutions give rise to stereotype policies, favoring the status quo. “It is research that can bring about a dynamic situation.” The interlinkages among institutions, policy, management, and performance, with research acting as a catalyst creating dynamism, are illustrated in the figure.

Bandaragoda analyzes seven major programs for improving the performance of Pakistan’s irrigated agriculture in terms of this model. He concludes that while the research-policy linkage has been supportive in some of these programs—and Pakistan’s record is better than some countries’ records—there has not been a continuous and mutually reinforcing relationship between research and policy. Rather, this linkage has been ad hoc and episodic in nature, and the result has been failure to achieve policy objectives.

The various policy thrusts over the past decade can each be traced to separate impulses based on incomplete research or other sources of influence, but with inadequate follow-through on the research side. The public tubewell program was initiated to combat waterlogging; when this led to an unforeseen demand for extra irrigation water the private tubewell promotion scheme was initiated; when the donors became interested in reducing seepage losses, watercourse improvement programs began, and shortly thereafter the command water management program “sprang up.” The latest cliché is “demand-based irrigation.” Those projects related to infrastructure development and increasing water supply have received priority, while the more important institutional development and cost-recovery issues have not received strong research or policy support.

Pakistan has produced a series of plans for agricultural and irrigation development over the years, but the plans have failed to achieve the desired results. Lack of clear policy direction is one major reason (see Section 4.2.4, above); another is the failure to obtain the full participation of all parties, for example the provinces; and another is the continuing fragmentation among sectors (Box 3.6). These problems reflect the failure to achieve a cohesive and comprehensive research-based policy over time. But this failure is itself a product of the sharp divisions among irrigation and agricultural institutions, and their static nature. Even the network of research institutions set up in Pakistan reflects this lack of coherence.

Modified conceptual framework.



Source: Bandaragoda (1993:8 Figure 2).

Institutions, innovation, and performance in Egypt

Egyptian irrigated agriculture is characterized by high average crop yields (per unit of land and water) compared to other developing countries and a high cropping intensity (200%). But this apparent success can be attributed in part to water supplies which are currently adequate to meet demand in most places at most times. This ability to meet agricultural demand for water is remarkable in view of Egypt's total dependence on irrigation water from the Nile, and increasing pressures on its limited water supply. Nevertheless, there are excellent opportunities for accelerating agricultural growth and increasing the value of agricultural output. On the other hand, several trends point to a future of increasing water supply deficits and the likelihood that the productive agriculture of the Nile Valley and Delta will be the first to suffer. Is Egypt prepared to manage this *creeping crisis*—the coming shortfalls in water supply relative to demand?

USAID has been supporting technical, institutional, and human resource development of the Ministry of Public Works and Water Resources (MPWWR) of Egypt for over two decades. In 1995, IIMI carried out an institutional analysis of this experience, to answer the question, what institutional impediments are leading to the perceived slow integration of these and other new innovations into the Ministry's management processes? The study took a broad perspective on the Ministry, and examined a wide variety of issues, based on formal and informal interviews, study of documents, and observations. The detailed results are reported in IIMI (1995g) and summarized and interpreted by Merrey (1996a); the process used for the study is discussed in Box 4.2.

The study documented the considerable fragmentation and duplication of programs and functions among Ministry units. This is amplified by the creation of special units to implement the various donor projects. The use of such special units also creates problems because of perceptions that officials working in these units are favored, i.e., receive extra benefits; and it hinders the integration of project innovations into the normal management processes of the Ministry. While some Ministry units have benefited from donor investments, others, for example the Irrigation Sector, which is responsible for the operation of the entire irrigation system, have been starved. Not surprisingly, interunit cooperation and sharing of information are problematic.

Another key characteristic of the Ministry is the high degree of centralization of authority, and the separation of tasks and the authority needed to fulfill the tasks. Decision making and information flows are therefore slow. A few senior people hold most of the authority; they have a wide span of control, with little delegation of responsibility; and spend much time sitting in committees negotiating decisions. Subordinates are reluctant to assume authority even when it is offered. There is a wide "accountability gap" between the Ministry officials and their customers, the water users. The budgeting and accounting system, while adequate to track total expenditures in four categories, cannot be used to disaggregate costs and evaluate effectiveness. If the Ministry were to shift from an administrative to a more proactive management style, it would need to reform the financial system as a management tool.

Human resource policies are also not conducive to adopting innovations and improving performance. The Ministry is dominated by generalist civil engineers, but other kinds of professionals, though increasingly required to operate the telemetry system for example, have no career prospects. There is almost no link between performance, and either compensation

or promotion; promotions are largely based on seniority, and official compensation levels throughout the Egyptian government are extremely low, even compared to developing countries poorer than Egypt, as shown in table 4.2. The four major South Asian countries, with gross national products per capita of 36 percent to 82 percent, respectively, of Egypt's, pay irrigation engineers at least twice (and in Pakistan nearly five times) the amount paid in Egypt.²⁸

Table 4.2. Compensation of engineers in MPWWR, and GNP per capita in Egypt and selected countries (% of Egyptian compensation).

Country	Entry Level	Upper Level	GNP/Capita
Pakistan	486	383	66
India	470	260	54
Sri Lanka	293	194	82
Bangladesh	230	198	36
Egypt	100	100	100

Sources: IIMI surveys for compensation. For gross national product (GNP) per capita, figures as of 1991 are from the World Bank Development Report for 1993.

Source: Merrey (1996a: Table 3).

In short, the study concludes that while the Ministry is meeting current needs, it will have to make major improvements in its overall framework, management processes, and human resource policies if it is going to make good use of technological innovations in future. This conclusion would undoubtedly apply to many other traditional government water resource management agencies throughout the world.

Conclusion: IIMI's research on governance issues

Most of the work to date on governance issues has been done in three countries: Pakistan, Sri Lanka, and Egypt. The basic conclusions are mutually consistent and consistent with others' findings (e.g., Bottrall 1981; Wade 1995). *The serious policy and management problems underlying the absence of an orientation to achieving high performance or provision of services to customers and the slow pace of innovation are deeply rooted in institutional structures.*

This is an important area for more systematic comparative strategic research in the future and provides a major research opportunity in the next few years—as well as being a prerequisite to improving the productivity of water in irrigated agriculture. Future research should be more systematic, comparative, and analytical. It should examine the functional requirements of successful water resource management, and compare existing arrangements to these requirements. It should include studies of effective governance regimes to understand the roots of their success; and should also include studies of other sectors (e.g., domestic water,

²⁸The number of professional staff per unit of area irrigated in Egypt is over nine times that found in Pakistan, suggesting a high degree of overstaffing; see Merrey (1996a: Table 2).

electricity supply, telephone services) to understand the lessons learned that might be applicable.

4.3.3 *Management Processes in Public Irrigation Organizations*

In Sri Lanka, Indonesia, and Pakistan, IIMI has carried out research on the decision-making processes within irrigation management agencies, the context within which these processes take place, their determinants, and their consequences for system performance. Some of the results have been discussed in other sections of this book. For example Section 3.2.3 discusses the impact on water delivery performance of gatekeepers' interventions on a canal in Pakistan. The work on these issues in Sri Lanka has been particularly detailed.

Accountability and performance: Who cares?

Nijman carried out detailed case studies in two systems in southern Sri Lanka: Kirindi Oya, a new settlement scheme, and Uda Walawe, an older scheme being rehabilitated—both with donor assistance (Nijman 1991, 1992a, 1992b) (see Figure 2.8). This work was combined with other less-detailed cases into a detailed comparative analysis (Nijman 1993). Nijman's work is closely linked with other work in the two Sri Lankan systems (Section 2.5.3, 3.5.2, 3.6.1; see also Box 3.2). Nijman adapts for use in analyzing irrigation agencies an analytical model of management processes developed in the Netherlands for other types of organizations. The model focuses attention on the decision-making process related to the core business of irrigation organizations—water delivery—and the management conditions affecting this process, identifies the key decisions in both “system creation” and “system utilization,” and uses specific indicators to assess the performance of these decisions.

Nijman finds that the lack of responsibility and accountability for water delivery performance in both system creation and system utilization is the crux of the problem; it dominates the decision-making process and leads to the very low levels of performance documented for the two Sri Lankan cases. At the time of system creation, decisions were justified based on theoretical considerations rather than on in-country experience, often with a view to legitimizing what were really political decisions. These decisions were often made by the donor or its consultants, and not by the operating agency, which did not feel responsible for these decisions and their consequences. Similarly, the agencies in both systems did not place a high value on operational performance, and did not have in place effective management procedures. Both lacked a sense of responsibility, and incentives for high performance, leading to flawed decision-making processes and a very disappointing performance. *Nijman concludes that significant changes in both government policy, and the roles of donors and implementing agencies, are required to overcome the serious institutional constraints documented.*

Other work in Kirindi Oya and Walawe have supported Nijman's conclusion that their poor performance can be attributed to organizational and institutional factors. Until recently, in Kirindi Oya, the Irrigation Department was not structured in a way that would enable it to address serious operational issues effectively; its relationships with farmers through the admittedly weak farmer organizations were minimal, leading to serious communication problems and bad decisions; and there was poor interdepartmental coordination (Merrey and

Somaratne 1989; IIMI 1990a). Similarly, in Walawe, which is managed by the Mahaweli Authority of Sri Lanka, the planning and implementation of the rehabilitation project was overcentralized in Colombo, with no involvement of either operational staff or farmers, leading to inappropriate and non-implementable decisions; and the interunit coordination within the Mahaweli Authority in Walawe was no more effective than the interdepartmental coordination at Kirindi Oya (IIMI 1990a; see Section 3.6.1).

Turnaround in Kirindi Oya: Someone cares

In recent years, IIMI's action research programs have documented important institutional changes, and improved performance, particularly in Kirindi Oya. The diagnostic phase of the work in Kirindi Oya had highlighted the very serious problems facing that system: the water supply was far less than anticipated; the ability of the Irrigation Department to manage the distribution system was weak; there was no effective seasonal planning process; there were serious conflicts among old and new area farmers, between farmers and officials, and even among officials; and the institutional framework seemed too weak to support making improvements (see, e.g., Merrey and Somaratne 1989; Sakthivadivel, Fernando, and Merrey 1992; IIMI 1990a; Nijman 1992b; and Section 2.5.3, above). One result of the work in this system since that time has been improved cooperation among departments, and better planning and operation of this water-short system, in cooperation with farmers through joint management committees. The emphasis on a participatory approach to the research (Participatory Action Research—PAR) has played a large role in this development (see Box 4.4). The changes in performance are documented by Brewer, Sakthivadivel, and Somaratne (1993); and IIMI (1995a).

The introduction of an irrigation information management system for the management of the right bank canal has already been discussed in Section 3.5.2; this has enhanced the decision making and resulted in a water savings of about 20 percent during the 1992/1993 wet season compared to the previous season. The solution of a salinity problem affecting the reservoirs in the old system has also been discussed in Box 3.7; the results of work on crop diversification have been mentioned in Section 3.2.1, and the results of a study aimed at making maintenance more cost-effective have been reported in Section 3.6.1. IIMI also worked with the Irrigation Department to develop a water balance as a basis for deciding on allocations between the old and new areas of the system; this study resulted in measures that improved water use efficiency. Overall, cropping intensities are slowly increasing and water duty per ha is decreasing at Kirindi Oya.

The key achievements documented at Kirindi Oya are the development and implementation of a seasonal water allocation and cultivation planning approach which has been accepted by officials, politicians, and the farming community; and the institutionalization of a Project Management Committee (PMC) as the locus for all irrigation-related decisions. This PMC includes representatives of the irrigation, agriculture, and other concerned government departments, and representatives of the farmers elected through their lower-level organizations.

Through the water balance study and a restudy of the probability of reservoir inflows, it was possible to create a firm and credible technical basis for seasonal water allocations. The allocation system is built around two basic scenarios, a "wet" and a "dry" wet season. Its conceptual simplicity enhances its value as a decision-making tool. But achieving agreement and an institutional framework for operationalizing it proved far more difficult. In Sri Lanka,

Box 4.4. Participatory action research as an organizational change methodology: The case of Kirindi Oya and Uda Walawe, Sri Lanka.

The first phase of research at Kirindi Oya and Uda Walawe, Sri Lanka, was a conventional research project aimed at diagnosing problems. In planning the next phase, IIMI took to heart the resistance of some officials to accepting its results. If management solutions were to be tested, as expected by the donor and the government, this had to be done by the agency staff and farmers themselves. IIMI therefore adapted "participatory action research" (PAR) from the literature (Whyte 1991). PAR is a methodology for applied research which involves the agency staff and farmers not as subjects but as active partners in the research, and which is designed to test management innovations for improving system performance. The process and lessons learned at Kirindi Oya and Walawe are reported by Sakthivadivel, Brewer, and Wijayaratna (1992) and IIMI (1995a, vol.1, chap. 2).

The basic premise of PAR is that system operators and farmers should actively participate in planning and implementing the innovations and evaluating the results. They have the most intimate knowledge of the problems and conditions; and they must ultimately accept and implement the results if these are to be institutionalized. Thus PAR is a systematic research-based learning process.

The basic strategy used for ensuring participation was the creation of special committees to oversee each research component. IIMI posted interdisciplinary teams of researchers at both systems to assist in the planning and implementation of the research, and to document both the process and the results. In addition, there were regular meetings with officials, workshops, and special training sessions to create an environment of cooperation and interaction, and to transfer specific skills required. At the end of the project, seminars were organized on each system where the officers and farmer representatives evaluated the results of PAR.

The PAR approach was judged to have been the basis for success in some but not all components of the project. At Kirindi Oya, PAR worked well as a basis for the water balance study, done primarily by the Irrigation Department, so it was viewed as the Department's product (Section 4.3.2); developing the approach to seasonal planning, in which farmers came to play the key decision-making role, with Irrigation Department officials playing the role of technical advisors (Section 4.3.2); improving canal management by introducing an information management system on the right bank canal (lack of sufficient participation was one cause for failure in introducing this on the left bank canal) (Section 3.5); and the introduction of improved maintenance management (Section 3.6.1). The PAR approach was less successful in introducing improvements in tertiary system management because farmer organizations were weak, and the researchers failed to involve the lower-level field officials sufficiently in the pilot studies. At Walawe, the outcome was more mixed, but PAR was considered a key to success in improving main system and tertiary level management. The expected results of a PAR activity include:

- sustainable improvements in system performance that can be implemented elsewhere as they are carried out by regular personnel
- internalization of the results by the implementors
- research reports describing the results, to be used for dissemination to others

IIMI (1995a, 2:34-38) argues that most of the innovations developed in both systems can be sustained there and implemented on other systems; and there is evidence that the results have been internalized by the participants. While many reports were produced, it is not clear that they will be adequate for wider dissemination. PAR can be an effective methodology for using research to introduce management changes, but it has fairly high transaction costs.

water is owned by the government and there is no legal basis for asserting group or individual water rights. The old area farmers claimed a prior right, exaggerating their pre-project cropping intensities, and they found some strong political support for their position. But Sri Lanka does have a set of culturally recognized principles for sharing of water shortages which are intended to protect equity and production. IIMI and its colleagues were able to draw on these principles as a basis for the seasonal allocation plan.

The PMC was strengthened and became the accepted locus for decision making. Brewer, Sakthivadivel, and Somaratne (1993) provide a detailed description of the political process involved in reaching this conclusion: it involved political interventions, crop failures, and politicians' burned fingers. The Irrigation Department—which in the early years had been blamed for technical failures—established its technical credibility and objectivity as the disasters occurred as a result of rejecting its advice.

Since these studies were completed, the PMC has been legalized as the legitimate decision-making body on Sri Lanka's major irrigation schemes (Section 4.4.5). This should further strengthen its position in addressing future water crises.

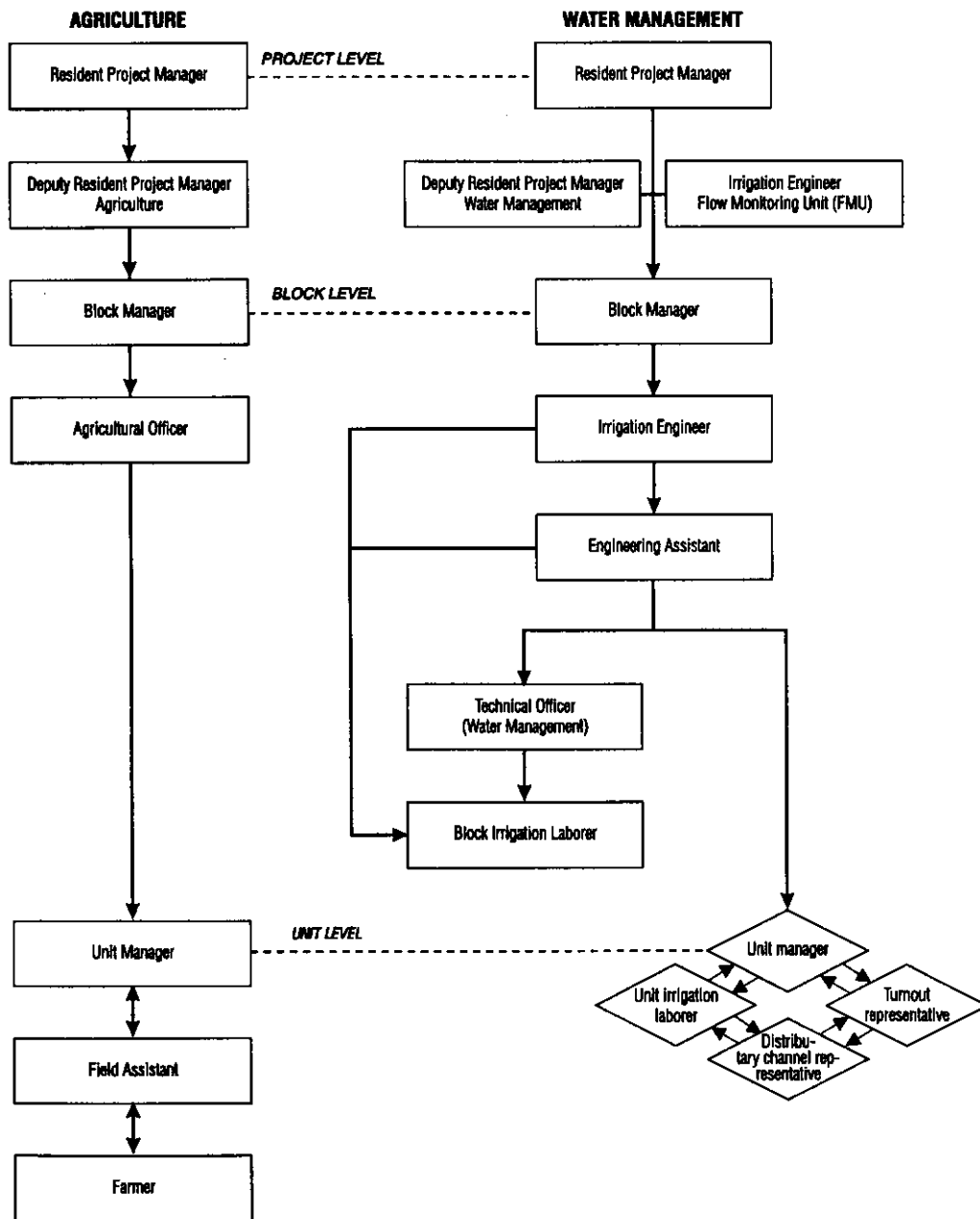
Administrative and entrepreneurial management during a drought

Raby and Merrey (1989) report on a detailed analysis of the management process of the Mahaweli Authority of Sri Lanka in System H (north central Sri Lanka; see Figure 2.8) during a drought season, using concepts derived explicitly from the literature on business management. Focusing on the management control system, they analyze the agency's crisis management. They adopt a distinction between two modes of management, administrative and entrepreneurial. The administrative mode involves implementation of rules having a normative basis; the entrepreneurial mode involves the vigorous manipulation of pragmatic rules to respond to changing opportunities.

The Mahaweli Authority explicitly follows an "integrated management" approach: it combines irrigation, agricultural, and other social services in one organization, as its primary mission is to construct and implement settlement projects based on irrigated agriculture. To achieve this integration, the Authority's organizational structure is based on "matrix management," combining tasks and functions. Figure 4.1 shows that while agricultural management is "simple in form and lean in staff" (Raby and Merrey 1989: 67), the arrangements for irrigation management are more complex and difficult to coordinate and control.

The study finds that the Authority was successful in its implementation of an explicitly administrative mode at the higher levels of the system during the drought season. This involved rigid distribution of the available water among lower units as equitably as possible. But problems arose at the lower levels, at the interface between the main system and the block and unit levels, and between the block and unit managers and the farmers, because the agency did not recognize that different management principles apply at these levels. Unit managers often acted in an entrepreneurial mode, attempting to respond to varying demands of farmers, and opportunities for reallocation of water according to actual demands. But there was no effective system for monitoring the performance of staff at this level, and the entrepreneurial behavior of unit managers was criticized by higher-level staff.

Figure 4.1. Contrasting matrix organizations for managing agriculture and irrigation in Kalankuttiya Block, Mahaweli H, Sri Lanka.



Source: Raby and Merrey (1989:66, Figure 10).

The authors conclude that an entrepreneurial style of management is most appropriate for small systems and at the lower levels of large systems; but on water-short large systems, an administrative style of management is most appropriate at the higher conveyance levels. The study provides a large number of observations and recommendations for improving communications and incentives and institutionalizing "professionalism" in irrigation management.

4.4 Institutional and Organizational Aspects of Irrigation Management: Irrigation Management Transfer

4.4.1 Introduction

A theme characterizing IIMI's research and development work since 1985 has been what is often called "farmer participation," "participatory management," and now "irrigation management transfer."²⁹ While the former terms are vague—"participation" has many dimensions and means different things to different people—"irrigation management transfer" is clearer. IIMI defines it as:

the shift in responsibility and authority for the management of irrigated agriculture from the government to nongovernmental entities
(Vermillion, ed. 1996:7).

The volume of the literature on this topic is immense, reflecting the strong interest of policy makers and researchers over the past two decades. It is the topic on which IIMI has produced the most reports, papers, and books. Work on management transfer has also been closely linked from the beginning to work on farmer-managed irrigation systems (discussed in Section 4.5) and support services for farmer management (Section 4.6).

Transfer of irrigation management responsibilities is part of a broader institutional restructuring process underway throughout the world. It is a policy found in both developed and developing countries. Increasing numbers of developing countries are planning or already implementing reforms that include irrigation management transfer. Why is management transfer happening in so many places? Vermillion (1995) suggests there are four reasons (see also Vermillion 1991):

- the failure of governments to finance, or recover from farmers, the cost of irrigation management
- the desire of governments to reduce costs and reallocate government revenues
- poor performance of government-managed irrigation systems

²⁹Other terms often used are "turnover," "privatization," "communication," "commercialization," "disengagement," "handing over," and "takeover."

- rising confidence in the capacity of farmers and local groups to take over management

IIMI's work to date on irrigation management transfer can be organized under four topics:

- the management transfer *process* and what strategies work best
- the *preconditions for viable management transfer*, which includes the policy and institutional support necessary before, during, and after transfer
- appropriate *organizational models* for local management of irrigation
- the *performance* of local management groups, and impact of transfer on the performance of irrigation and irrigated agriculture

The next eight sections discuss the results of case studies done in recent years in North and South America, Africa, and Asia, organized around the above four topics. Section 4.4.10 discusses some of the general lessons and conclusions derived from the work on management transfer; while Section 4.4.11 presents a few concluding observations on the strengths and weaknesses of the work and the next steps contemplated by IIMI.

4.4.2 Irrigation Management Transfer: Case Studies from the Americas

Columbia Basin Project (CBP), USA

IIMI carried out a detailed study of the process and impact of irrigation transfer in the Columbia River Basin, Washington State, USA. The results are reported in various places (Svendsen and Vermillion 1992, 1994, 1995; Vermillion, ed. 1996: Section 2.1). CBP is a large multipurpose reservoir-based project. The current irrigated area is about 230,000 ha, half the originally planned area. In 1969, the U.S. Bureau of Reclamation (USBR) turned the system over to three farmer-controlled irrigation districts. Each district has 2,000 to 2,500 farmers and is controlled by an elected board. The districts operate on a nonprofit basis, must cover all their operating costs, and purchase water from the USBR to resell to members. The districts also have contracts with USBR under which they are repaying part of the system construction cost. The Bureau retains formal ownership of all system facilities, and jointly operates some, but the districts have the legal right to operate and maintain them and collect revenue from the sale of water.

Supporting conditions. The federal government mandates transfer to farmer management of all irrigation systems it constructs, and farmers knew and accepted this at the time of construction. Federal policy also mandates a continuing Bureau presence, leading to a "partnership culture" and joint management. Policy has remained constant over time, a consistency that encourages farmers to make long-term investments. A fundamental feature is that there is a reliable system for specifying, allocating, and recording water rights; this and the strong

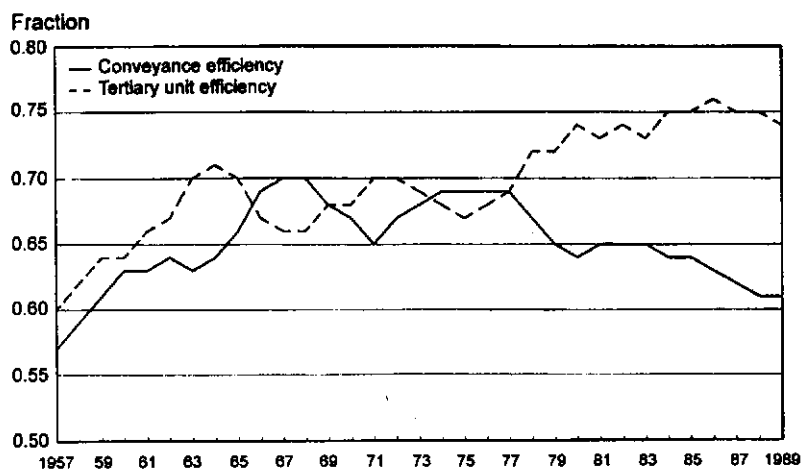
quasi-municipal legal basis for the districts and clear contract law enforced through a relatively accessible and impartial legal system are critical factors.

The transfer process. Farmers had a strong interest in obtaining more local control over water allocation, water fee structures, and O&M expenditures, hoping to minimize charges. The Bureau has a mandate to transfer management to the districts. Therefore, their interests were reciprocal. With assistance from lawyers over a period of about 5 years, contracts between the districts and the USBR were negotiated which specified very clearly the terms and conditions, the key district rights and responsibilities, and the key rights and responsibilities of the Bureau. The strong legal position of the farmer irrigation districts made possible a relative balance of rights and responsibilities, and the possibility for farmers to benefit.

Organizational model. Irrigation districts have clear and strong legal authority to manage water, collect fees, and enforce payments. Sanctions can include cutting off water and seizure and sale of farms for violations of rules. Farmer members elect a board of about seven people from among themselves. This board hires the specialized staff required to manage the system, sets the fees, and supervises the accounts. Svendsen and Vermillion (1994:86) draw attention to the financial autonomy of the districts as being a key factor underlying their success (see Section 4.2.1, above).

Impact assessment. The study collected data on performance beginning two decades before transfer (1969) and extending two decades afterwards. There has been substantial investment in new irrigation technologies at farm level since transfer. The quality of the irrigation service received by the farmers does not appear to have been affected significantly. Equity among the three districts remained about the same; and farmers are satisfied with the timeliness of deliveries (which are based on demand). Tertiary level efficiencies have improved steadily since the mid-1970s, reflecting investment in new technologies. But beginning in 1978, con-

Figure 4.2. Conveyance and tertiary unit efficiency for the three CBP districts, USA, 1955–1989 (3-year moving averages).



Source: Svendsen and Vermillion (1994:63, Figure 13).

veyance efficiency of main canals stopped improving and has been declining, as shown in Figure 4.2. This may be the result of facilities deteriorating, as suggested by evidence from USBR maintenance audits and project managers' statements.

Upon taking over management responsibility, the districts moved aggressively to reduce water assessments to district members. Real per-ha assessments, adjusted for inflation, have dropped to 78 percent of their level just before transfer. This reduction has been offset by increases in income from other sources (power generation, interest, and sales to nonmembers). Average expenditures for O&M by the districts are roughly similar before and after transfer in real terms. It is possible that these should have been increasing to maintain the system and counter accelerating deterioration. Gross returns to irrigated agriculture have risen steadily over the past 30 years; the authors believe this is so for net returns as well. Water assessments have fallen about a third since transfer and are estimated at roughly 15 percent of average net farm income. Finally, the number of USBR staff assigned to CBP has dropped from around 500 to less than 100.

While recognizing differences between developing- and developed-country settings, the authors provide a list of lessons they believe to be useful for developing countries, related both to policy and institutional support, and the transfer process itself (see Box 4.5)

Transfer of irrigation districts in Colombia

In 1993-1994, IIMI carried out research on the transfer of irrigation systems to farmer associations in Colombia. The work initially concentrated on two districts created out of one larger district as part of a turnover program in 1976; they are Coello and Saldaña. This work is reported by Garcés and Vermillion (1994), Vermillion and Garcés-Restrepo (1994, 1996), and Vermillion, ed. (1996: Section 2.2). Another paper reports on the process and results of management transfer on seven Colombian irrigation systems including the two reported earlier (Garcés-Restrepo and Vermillion 1995).

In Coello and Saldaña, farmers themselves initiated turnover in 1975, claiming that having repaid their 90 percent share of construction costs, they had a right to take over and they could manage the systems more cost-effectively. By 1976, the government had transferred management to the users, and had officially recognized the two farmer-managed irrigation districts. Between that time and the end of the 1980s the government did not transfer any other systems; but since 1990 it has transferred five more as part of a new national policy of management transfer. Coello and Saldaña are the largest of the seven systems, with irrigated areas of 25,628 ha and 13,975 ha, respectively; the others range from 1,174 to 11,200 ha.

Supporting conditions. In 1976, the government had created a new institution, the Colombian Institute of Hydrology, Meteorology and Land Development (HIMAT) to improve the performance of irrigation districts; its first task was to transfer management of the Coello-Saldaña District to two separate water users associations. The associations already existed; as in the Columbia River Basin case, they hired lawyers to represent them in detailed negotiations. The transfer was based on a legal provision in the country's constitution enabling delegation of administration of a public good (here, the irrigation district) to a private sector corporate entity. This entity is empowered to hire staff and manage the system, with the proviso that it be financially self-reliant. However, under the law, the government could not relinquish owner-

Box 4.5. Lessons on transfer from the Columbia Basin Project for developing countries.

Svendsen and Vermillion (1994:86–88) summarize the key lessons from the Columbia Basin Project they believe to be applicable to developing countries as follows:

Policy and Institutional Lessons

1. Put in place a clear and consistent policy mandating irrigation management transfer.
2. Do not expect full cost recovery (in the first instance).
3. Mandate financial autonomy for the managing entity.
4. Provide a strong legal basis for irrigators' associations.
5. Provide a system of secure and well-specified long-term water rights.
6. Invest to bring physical facilities up to standard.
7. Create a fair and accessible professional auditing system and mandate its use.

Process Lessons

1. Involve farmers early on in the planning for transfer.
2. Empower farmers by giving them the role and status to successfully negotiate with the public irrigation agency.
3. Use contracts between the irrigator groups and the managing agency.
4. Develop a locally appropriate water allocation system with volumetric measurement and payment.
5. Provide experience with organization and management to farmers.
6. Provide assistance to operating agencies to improve management and human-relations skills.
7. Specify an ongoing role for the operating agency.

ship of the assets and there were continuing legal battles, especially over labor previously hired by the government that the districts could not fire. In 1993, a new land development law was enacted to give districts full control over personnel.

The transfer process. Similar to the USA case, the process was characterized by negotiations over future management policy, financing, staffing, and physical improvements. Unlike the cases in Asia (see below), little attention was given to training and motivating farmers. Even in the later transfers, although initiated by the government, the process was one of negotiation, as farmers generally believed they would benefit. The most common issue prior to transfer was the disposition of existing government staff. The other issue was financing of rehabilitation and improvement: unlike the CBP case, farmers refused to pay for these improvements.

Organizational model. The organizational model also has similarities to the USA case. Farmer members elect a water users association board to supervise the districts. Each board has seven

members, with fixed quotas for small farmers (four members with holdings of less than 20 ha). The board recruits a general manager, sets and collects fees, hires and fires staff, and plans and monitors budgets. The government agency retains considerable influence in providing advice and consent over O&M budgets and work plans, water fee levels, and staff disposition.

Impact assessment. As Table 4.3 shows, in six of the seven schemes, there was an 18 percent to 70 percent reduction in staff, and the area served per staff rose by 21 percent to 235 percent. A consistent pattern of staff reduction and financial viability is emerging. Six of the seven systems have a combined area and volumetric fee; this is the major source of revenue (in Coello "sideline" revenues have slowly increased to about 20 percent of the total). In all the systems there is a declining trend in the level of area fees emerging within a year or two after transfer; and in all but the one pump scheme volumetric rates are also leveling off and declining. Subsidies to the districts are stopped at transfer so the districts must become self-financing. All the districts had deficit budgets before transfer, and all have positive balances since transfer. In Coello and Saldaña, available data show that while the cost of irrigation has risen nearly fivefold in real terms on a per ha basis since turnover, the total gross value of output has risen even faster. In Coello, as a result of crop diversification, gross value of output per unit of water rose 297 percent to \$9.35 per 100 m³ (Figure 4.3).

Based on farmer surveys, there is no evidence of any dramatic change in O&M as a result of transfer. Based on a survey of physical infrastructure in Coello and Saldaña, which found few dysfunctional structures (and these mostly in tertiary canals), the authors conclude that "system maintenance has not yet been ill-effected by turnover management" (Vermillion, ed. 1996:44).

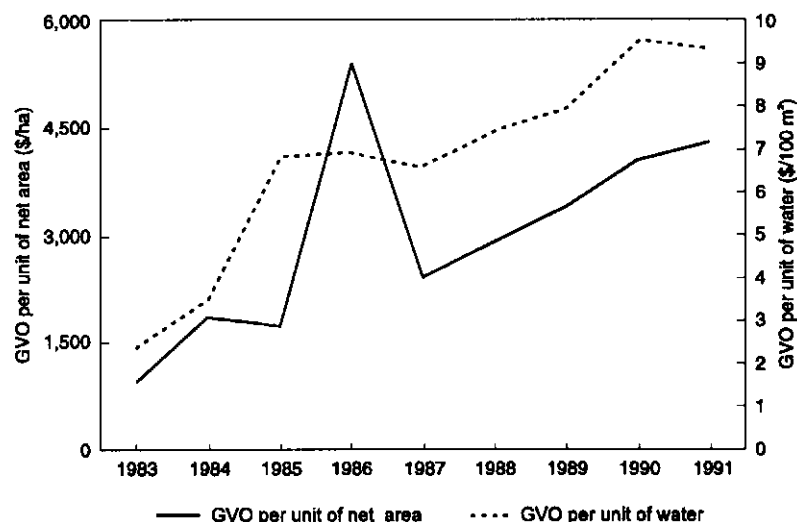
Table 4.3. Staff levels before and after transfer in seven irrigation districts, Colombia.

District	Number of staff			Area served/staff (ha/staff)		
	Before	After	% change	Before	After	% changed
Coello*	300	97	-37	62.3	157.7	+137
Saldaña*	(combined)	92	(combined)	(combined)	135.9	(combined)
Recio	114	34	-70	88.6	297.1	+235
Rut	92	76	-18	105.4	127.6	+21.1
Samaca	13	9	-31	229.3	331.2	+44.4
San Alfonso	12	15	+25	97.6	78.1	- 20.0
Zulia	95	65	-32	117.9	172.3	+46.1

*Before transfer, Coello and Saldaña operated as a single district.

Source: Garcés-Restrepo and Vermillion (1995:376, Table 5).

Figure 4.3. Gross value of output in relation to net area and water uses, Coello District, Colombia, 1983-1991.^a



^a In constant 1988 U.S. dollars (US\$1.00 = Colombian pesos 333).

Source: Vermillion and Garcés-Restrepo (1996:27, Figure 23).

There is some evidence of water distribution problems, especially a tendency to favor larger farmers. The lack of water measuring devices reduces accountability and control over water. Sanctions are rarely enforced. These are all indications of weaknesses in the institutions, reflecting lack of attention to strengthening before transfer.

In sum, the overall impact of management transfer in the Colombia case has been positive, although there are some financial and equity issues that need attention.

4.4.3 Irrigation Management Transfer: Case Studies from Africa

IIMI has worked on irrigation management transfer issues in three countries in Africa: Sudan, Niger, and Nigeria. In Sudan, the government is in the early stages of privatizing support services for irrigated agriculture, and not irrigation facilities; findings from studies of privatization of services in pump schemes are discussed in Section 4.6, while in Niger, IIMI is studying the institutional and financial viability of systems transferred to farmer cooperatives. In Nigeria, IIMI worked with a river basin management authority to pilot test an approach to organizing farmers, based on experiences in Asia.

Financial and institutional sustainability of irrigation cooperatives in Niger

In 1979, the Government of Niger created the Office National des Amenagements Hydro-Agricoles (ONAHA) to manage its state-sponsored irrigation systems. In the early period, ONAHA's activities were to implement, manage and maintain irrigated perimeters, supply inputs to farmers, and provide extension services. However, since 1982 ONAHA has been divesting itself of direct management responsibilities, giving them to the farmer cooperatives that were formed when each system was constructed. ONAHA's own capacity to provide effective support has significantly diminished since 1989, leaving the cooperatives on their own in many ways, in a very unfavorable socioeconomic environment.

Reported research findings to date are based primarily on a case study of one 431-ha system, called Saga Perimeter, which is said to be reasonably representative of such schemes (Lonsway and Abernethy 1994).³⁰ Saga has about 1,080 members and is divided into seven "mutual production units." Located 15 km from Niamey, it is classified as a peri-urban rice scheme. Since it was rehabilitated in 1987 it has maintained a consistent 190 percent cropping intensity. The study covers the period since transfer to the cooperative, so no information is given on the transfer process itself; but it is clear that it was initiated by the government, and not by the farmers.

Supporting conditions. As the government has withdrawn support, there has been a large gap as a result of the weakness of the private sector to provide inputs, maintenance, or credit. Officially all state-sponsored irrigation schemes are organized into cooperatives with self-management as the ultimate goal. But the cooperatives have no access to credit, and are unable to raise sufficient funds to cover their costs, including investment renewal such as pump replacement and a share of ONAHA's costs. Niger goes further than most countries in terms of the costs it is trying to transfer to farmers, which would require both effective markets and strong organizations.

Organizational model. There are three levels of organization on government-sponsored irrigation schemes. The smallest is the Mutual Production Unit (GMP), representing all farmers in a hydraulically defined section of the system; there are 7 in Saga but some systems have up to 15. Each GMP has about 155 farmers and an average irrigated area of 55 ha. The farmers in each GMP elect seven representatives, who act as the GMP committee and are also delegates to the Development Committee of the Cooperative. This committee elects an Executive Committee of seven members which is the effective managing organ of the Cooperative. The Executive Committee conducts the Cooperative's business with ONAHA, banks, and other outsiders.³¹ The third level is ONAHA itself, which delivers management and mainte-

³⁰In the April 1996 Internal Program Review, Lonsway stated that some findings reported in this paper on financial sustainability needed revision: the situation is more favorable than this paper suggests. The research results from Niger should be more fully reported by 1997.

³¹In addition, there is an audit committee consisting of external people with some accounting background, and an administrative council (joint committee of the cooperative, the ONAHA Director, and others), but the authors express doubt about their validity or effectiveness.

nance services to Cooperatives in return for payment. ONAHA's system director is the sole ONAHA staff member assigned to the system.

The Cooperative structure is not indigenous; responses to interviews suggest that members have not internalized the Cooperative as their own. The Cooperative has problems in maintaining accountability to its members, and the system of incentives is weak at best.

Impact assessment. Average rice yields are high—about 6 tons per ha per season. Cropping intensity is 190 percent for rice, and the unofficial cultivation of other crops brings the total to 200 percent. But since 1988, although the overall fee recovery rate is 99 percent, payments are often 3 to 4 months late. This creates cash flow problems.³² Members who are public servants or traditional leaders are the biggest debtors to the Cooperative. Whether the late fee payments reflect low capacity to pay or dissatisfaction of farmers with the Cooperatives is not clear; but the authors suggest the institutional weaknesses of the Cooperatives are the most important problem. The authors estimate that the system's operating and capital costs are currently about 15 percent of the total gross revenue obtained by farmers at Saga.

The institutional weaknesses underlay the financial problems which threaten the viability of the irrigated perimeters of Niger.

Pilot testing joint management in Nigeria

In 1991–1993, IIMI worked with the Hadejia-Jama'are River Basin Authority (HJRBDA) on the Kano River Project to experiment with the introduction of water users associations on tertiary and secondary canals. The results are interesting but not conclusive given the short time period; they are reported by P. Pradhan (1993), IIMI (1994b), and Musa (1995). The program emphasized development over research objectives, and was implemented on just three pilot distributaries ranging in size from 126 to 271 ha.

Supporting conditions. In 1987, Nigeria began to implement a new commercialization and privatization policy, in which the River Basin Development Authorities (RBDA) were partially commercialized: the subsidies covering the cost of providing irrigation services were eliminated. Therefore, the RBDAs became more interested in establishing partnerships with farmers, i.e., shifting from "agency management" to "joint management" of systems.

The transfer process. IIMI worked with the HJRBDA in an action research mode to develop and strengthen local water users associations, induce these associations to carry out maintenance on distributaries and collect irrigation fees to be paid to HJRBDA, and create a partnership between the Authority and farmers' organizations for joint management of the system. The process of organizing the water users associations was facilitated by IIMI and the Authority staff, through a series of meetings and consultations. Farmers were encouraged to hold regular meetings, and to take responsibility for improving their dilapidated field and distributary channels.

³²Abernethy, personal communication, 1996; the 1994 report had erroneously suggested a declining payment rate.

Organizational model. The HJRBD Board authorized the establishment of water users associations, and the provision of incentives for them to collect irrigation service fees to be paid to the Authority. Efforts were underway to establish a procedure for registering the water users associations as legal entities under the authority of the Authority. Water users associations are organized on a hydrological, not village, basis. The project deliberately avoided imposing a specific organizational design ("blueprint") for these associations.

Impact assessment. Early results were very positive. Maintenance of the distributaries led to improved water flows, higher crop intensities, higher profits for farmers, and an increase in irrigation service fee collections. However, the data are not strong on any of these points. The reports imply that the HJRBD management and Nigerian policy makers were impressed by the possibilities; but the Authorities would need to be dramatically reformed and reoriented to implement such a policy successfully.³³

4.4.4 Irrigation Management Transfer: Case Studies from Asia

IIMI has worked on irrigation management transfer issues in at least seven Asian countries since 1985: Sri Lanka, Nepal, India, Bangladesh, the Philippines, Indonesia, and China. It is not possible to cover all this work in detail here. Therefore, the results of selected recent studies are emphasized in the following sections.

4.4.5 Participatory Management in Sri Lanka

Supporting conditions. In 1986, IIMI cosponsored a national workshop to discuss the variety of experiments then underway related to management transfer (IIMI 1986a). The recommendations of this workshop led 2 years later to the government officially adopting its "participatory management policy" through a cabinet paper (reprinted in IIMI 1990b). The Irrigation Management Policy Support Activity (IMPSA) discussed above in Section 4.2.3 was intended to further refine and operationalize this policy. Under this policy, full responsibility for O&M and resource mobilization for field and distributary channels on major systems (over 80 ha) is being turned over to farmer organizations, and on smaller systems farmer organizations are to take over full responsibility, with technical support from the government.

The policy is being implemented through three programs. On 35 major schemes a special unit of the Ministry, the Irrigation Management Division, is responsible for promoting farmer organizations and joint management committees, in cooperation with the Irrigation Department. This is called the Integrated Management of Major Irrigation Schemes (INMAS) Program. On 160 medium sized schemes (80 to 800 ha) the Irrigation Department is promot-

³³At the international conference on irrigation management transfer at Wuhan, China, a Nigerian policy maker (Musa 1995) presented this IIMI-sponsored case as the basis for Nigerian policy. Unfortunately the project ended when donor funds ran out.

ing a similar program referred to as MANIS. The Mahaweli Authority has recently initiated its own version of the same program on the four large schemes it manages.

Organizational model. The basic model calls for formal farmer organizations at the distributary canal level, made up from informal field channel groups. As the formal organizations develop some capacity, the responsibility for operation and maintenance is “handed over” to them, though the government continues to give maintenance contracts for distributary maintenance. Representatives of the farmer organizations participate with government officers on a project management committee to make overall policy decisions on system water allocation, scheduling, cropping patterns, etc. These committees, and the role of the farmer organizations were informal until the Irrigation Ordinance was amended in 1994 to legalize their roles.

Transfer process. Where donor funds have been available through rehabilitation projects, the government has often used “institutional organizers” as catalysts to organize farmers, and in some cases involved farmers in the rehabilitation process itself, with positive results (see Sections 3.6.1, 4.2.2). On the 35 INMAS schemes, a Project Manager is appointed who has the dual responsibility of coordinating the various government departments’ services to farmers, and developing the farmer organizations and joint management committees. In the Mahaweli Authority and MANIS schemes local officials are responsible for organizing farmers. The transfer of O&M responsibility on distributaries is through contracts with farmer organizations. Maintenance contracts are most common, but increasingly farmer organizations are taking operational contracts as well.

Impact assessment. On both village and government schemes, the record of nongovernment organizations as catalysts for change in Sri Lanka is mixed (see Box 4.6; and Section 4.6.3, below). A study of the transfer of O&M to distributary organizations on a project generally regarded as “successful” (the ISMP Project see Section 3.6.1, and Table 3.3, above) documented mixed results in terms of farmer response, despite official reports of success; and recommended giving the organizations a stronger legal status and more concentration on institutional strengthening (TEAMS 1991b).

Results of the Kaudulla case study

More recently, IIMI carried out a detailed case study of the farmer organizations on one of the schemes included in ISMP, Kaudulla Irrigation Scheme (Kloezen 1995) (see Figure 2.8). Kaudulla is a reservoir-based system under the INMAS program officially irrigating 5,088 ha (and unofficially possibly up to 7,000 ha). There are 23 distributary farmer organizations. A unique feature is that the farmers on their own initiative have established a “scheme level farmer organization” parallel to but separate from the official project management committee. The findings on a specific distributary at Kaudulla are compared to the findings from a distributary of Mahaweli System C (Vermillion, ed. 1996: Section 2.4).

A major achievement since the participatory management program was initiated at Kaudulla has been to increase cropping intensity from less than 150 percent annually to 200

Box 4.6. Effectiveness of nongovernment organizations in developing local irrigation organizations in Sri Lanka.

There is a widespread belief that nongovernment organizations (NGOs) are more effective than the government in facilitating local organizational development. But there are few detailed studies of how effective NGOs actually are at this task. Athukorale, Athukorale, and Merrey (1994) report on a detailed sociological study of two 3-year change projects implemented by a national NGO in Sri Lanka. The study analyzes the change agent's strategy, its impact, and farmers' and government officials' perceptions of its strategy and impact; and relates the findings to the overall participatory management policy of Sri Lanka.

Overall, the study concludes that while the change agent had an important impact in both irrigation schemes, it did not achieve its objectives, and the changes introduced were not sustainable. In both systems the farmers clearly had an improved knowledge of irrigation management and its potential importance but the impact on actual water delivery or agricultural performance was minimal. Similarly, while most farmers were supportive of the concept of joint agency-farmer management of systems, the actual success and sustainability of the joint management systems introduced were limited. There is evidence the officials became somewhat more responsive to farmers' needs, but this did not translate clearly into improved system performance.

The study attributes the mixed outcome to the strategic choices made by the change agent, particularly its having had too great a hand in choosing the farmer "leaders," and its deliberate creation of conflict between farmers and officials. Notwithstanding this mixed success, the program did contribute to the overall evolution of the participatory management policies of the government. The authors suggest NGOs need to improve their professional expertise in planning, implementing, and monitoring social change projects, and need to have a practical and achievable vision rather than a romantic ideology.

Finally, NGOs face a strategic choice: do they want to be involved in the routine implementation of programs with the danger that they will become less innovative; or do they wish to focus on cutting edge social experimentation, which may produce important innovations but carries a higher risk of failure? A related question involves the NGOs' relationship to the government: a close relationship involves a greater opportunity for influencing policy, but at the risk of becoming a "captive" of the government.

percent in 4 of the past 5 years, while reducing the irrigation duty slightly. The farmer organizations in both systems have had considerable success in supplying agricultural input services to members as well. On the other hand, the evidence for improved O&M of distributaries which are "turned over" to farmer organizations is mixed. The organizations have used the profits from agricultural inputs services and bulk purchasing and sales of rice, as well as money received from the Irrigation Department for maintenance and rehabilitation contracts, to build up their funds. But they have had serious problems with managing their finances and lack transparency in contract management. Their income is never invested in improving irrigation O&M. In the 1980s the government failed in an attempt to implement an irrigation service fee, and currently is not enforcing existing laws requiring such payments.

As Kloezen (1995:261) notes, the mixed results of the participatory management policy in these systems is the result of partial implementation of the participatory management policy. Financial accountability and responsibility do not accompany formal O&M responsibility. The organizations remain dependent on the Irrigation Department for financing O&M, and

concentrate their efforts on the other services provided by the organizations. The modest degree of management transfer has had little impact on the way O&M are financed and consequently has neither led to increases in farmers' contributions nor to a reduction in government expenditures.

Results of assessment of participatory management policy

IIMI and national collaborators have recently completed a large-scale national study of the results of Sri Lanka's participatory management policy under all three government programs to date (IIMI 1995h). The study involved a survey of a sample of 51 schemes and 172 farmer organizations; recurrent surveys of 30 farmer organizations in 18 schemes; process documentation in 6 schemes; and several special studies. The study was designed to evaluate the progress and impacts to date with an eye to recommending changes in the policy and strategies, and to develop better monitoring and evaluation methodologies the government itself could use. Some selected findings of this detailed study include:

- Participatory management has resulted in better water distribution on distributaries.
- Farmer organizations' maintenance performance is more equivocal: they do a reasonably good job of clearing brush and desilting but do not undertake any other maintenance work. They handle maintenance as well as the irrigation agencies do, on the whole.
- A significant minority of farmer organizations is involved in other business activities (45% in INMAS and 22% in Mahaweli).
- Government agency support to farmer organizations is strongly related to their organizational strength, reflecting the fact these organizations were initiated by the government, and not by the farmers.
- The performance of joint project management committees varies and depends largely on the support of the agency.
- There are many variations on the theme of "turnover," but nowhere is transfer of maintenance complete. Some farmers and officers oppose complete turnover of maintenance. The government needs to clarify its intentions including the question of subsidies. Unless the profitability of rice farming deteriorates significantly, farmers can afford to pay for maintenance of distributaries.
- No evidence was found for increased cropping intensity or yields; in fact, average yields may have declined slightly (see also Section 2.5.4; and 4.7). Profitability has improved slightly. There is no decrease in government O&M expenditures, but the expenditures are being shifted from the distributary to the main system. Overall therefore, participatory management has had little discernible impact on farmer incomes or government finances.

The results of the case study and survey are consistent. Sri Lanka appears to be a case of what Vermillion (1995) calls “‘false’ failures of irrigation management transfer.” Transfer has not happened yet: financial flaws and lack of water rights stifle farmer investment and there is no accountability between agency and farmers.

4.4.6 Irrigation Management Transfer: Survey of Experiences in India

In 1995, IIMI collaborated with the Indian Institute of Management, Ahmedabad (IIMA), to carry out a study of what is happening in various parts of India regarding management transfer. The study is not complete, but it has produced interesting results, as reported in draft reports. The study has two components: a rapid assessment of policies and activities in seven states (Bihar, Gujarat, Haryana, Kerala, Maharashtra, Tamil Nadu, and West Bengal³⁴); and more in-depth “process documentation” of about 20 selected cases in Gujarat, Maharashtra, and Tamil Nadu where interesting activities were believed to be underway. Aside from draft reports on some states’ policies and activities, several draft papers are available which analyze the results to date (especially Brewer and Raju 1995; Sakthivadivel 1995; Kolavalli 1995; and Kalro and Naik 1995).

The National Water Policy issued by the Government of India in 1987 and its subsequent actions have encouraged states to both increase irrigation service fees and promote management transfer. But irrigation is a state subject, and states have varied widely in their interests and approaches. The IIMI-IIMA study has looked at three classes of systems:

- large systems, both gravity and lift systems
- well systems and small lift systems
- small gravity systems

The source of water—surface water or groundwater—is a basic determinant of management principles. Every state claims ultimate responsibility to allocate surface water, but none presently restrict landowners from exploiting groundwater beneath their lands.

Brewer and Raju (1995) define five pre-transfer water allocation and distribution policies, ranked from those that give the state the most power, to those giving the least; they are:

- *shejpali* (Gujarat, Maharashtra; see Section 3.5.3, above)
- assured irrigation area (Bihar; see Section 3.3.2, above)
- land classification (Kerala, Tamil Nadu)
- block system (Maharashtra, for sugarcane)
- *warabandi* (Haryana)

³⁴Although West Bengal is listed, no results are reported as yet.

The greater the state's power over allocation, the lesser the farmers' assurance of irrigation water, and the greater the effort required by the state agency to make the system work properly (Brewer and Raju 1995:6-7). In large systems the states vary little in the assignment of management responsibilities: the government is responsible for O&M from the headworks to the outlet, while groups of farmers served by an outlet are collectively responsible from this point. Haryana is a partial exception as the state has accepted responsibility for maintenance of some lined channels below the outlet, and can define and enforce a rotation below the outlet if requested by the farmers. None of the states collect sufficient funds through irrigation service fees to cover O&M costs: both fee levels and collection rates are low; and nowhere are the payments linked to performance or to incentives for farmers or officials to be more efficient.

The six states have four basic types of transfer policy for large systems:

- mid-level water users associations and volumetric charges (Gujarat, Maharashtra)
- mid-level water users associations only (Bihar)
- three-tier water users associations (or joint committees) (Kerala, Tamil Nadu)
- outlet level water users associations only (Haryana)

These proposals differ radically on the amount of water control to be transferred to farmers. On the assumption that this issue of farmer empowerment is basic, Brewer and Raju (1995) make the following predictions:

- Transfer in Gujarat, Maharashtra, and Bihar is most likely to succeed, though shortage of resources to support the transfer policy makes Bihar more risky.
- The success of transfer in Kerala and Tamil Nadu will depend heavily on officials' attitudes and actions, which are not encouraging to date.
- Transfer in Haryana will not succeed; and given the high degree of assurance the warabandi system gives to farmers, transfer may not be necessary or wise.

Supporting conditions. Brewer and Raju (1995) suggest three basic legal provisions are needed for successful transfer. These are: recognition of the water users associations and joint committees; legal authority for these bodies to take actions to carry out their irrigation management functions; and legalization of changes in water allocation procedures contemplated as part of turnover. They note that no state in India has made legal provision for all three of these items, though partial provision exists in some states.

Water users associations can be registered under a variety of societies registration and cooperative registration acts, so this is not a serious constraint. But only two states have laws defining the functions of water users associations in irrigation management (Madhya Pradesh and Kerala) and these both have limitations. Gujarat attempted to pass an ordinance to support transfer, but it was never ratified by the legislature.

Both Gujarat and Maharashtra have attempted to make fundamental changes in water allocation and distribution principles, as the *shejpali* system is seen as incompatible with transfer to farmer organizations; but further legal changes are necessary. In other states, the policies on transfer are not yet sufficiently clear to provide a basis for legal reform.

Using qualitative judgments of the performance of ten of the systems studied, Sakthivadivel (1995) suggests that the physical state of the turned over system and the quality of main system management are two conditions that will affect the performance outcomes of turnover.

The transfer process. The cases examined by the study vary greatly in the process by which organizations were formed, and in the functions they took over. In some places, for example Haryana, nothing has been or will be transferred in the usual sense of the word. In Gujarat, NGOs have facilitated the process of group formation, negotiations with government agencies, and initial stages of management of turned-over facilities; in others, it has been research institutions or government agencies. In Bihar, a dedicated irrigation department official fostered the transfer of a major distributary (Paliganj) to a farmer organization (Srivasta and Brewer 1994); this case is now the model based on which Bihar is formulating its future policy. Tamil Nadu includes cases of "spontaneous" organizations, in which farmers organize themselves to assert or protect claims to water on large irrigation systems. Some states, especially Gujarat and Maharashtra, offer specific incentives to farmers who organize and take responsibility for their portion of the system. In most cases, there is a negotiated agreement regarding the service to be provided by the agency, and the responsibilities (including payments) of the farmer organization.

Organizational models. There are basically two types of laws under which water users associations are legitimized, which then determine their structure and authority: the societies registration acts (Bihar, Haryana, Kerala, and Tamil Nadu) and cooperatives registration acts (Maharashtra, Gujarat). No observations are offered on the outcomes of these two options. Kerala organizes joint management committees (similar to those in Sri Lanka) and Tamil Nadu is considering this option; but Brewer and Raju (1995) say the former are not performing well, and express doubts about the likely performance of the latter.

Impact assessment. From a policy perspective, it is premature to assess impact. Brewer and Raju (1995) suggest foreseeable benefits from farmers' perspectives and from the states' perspectives while other studies provide some information in impacts of the few cases studied.

Foreseeable benefits for farmers of turnover on large systems are:

- Reversing deterioration of water distribution and maintenance. In Bihar, farmers are aware that the capacity of the agency is declining, and the Paliganj case suggests farmers can do a better job (Srivasta and Brewer 1994; see also Section 3.3.2, above; and Raju, Brewer, and Sakthivadivel 1994).
- More assured water supply and reduced hassle, by replacing the *shejpali* system (Gujarat, Maharashtra), and ending restrictions on cropping patterns and conjunctive use of groundwater (Maharashtra).

- Improved water supply (Tamil Nadu's "spontaneous" associations).
- Few irrigation benefits (Haryana, Kerala), but may obtain subsidized outputs (e.g., Kerala).

The primary reason for the adoption of transfer in all states has been the wish to reduce costs to the state; some policy makers also mentioned expectations of improved productivity.

Kalro and Naik (1995) report on the performance outcomes and financial viability of ten water users associations in Gujarat, Maharashtra, and Tamil Nadu; and Kolavalli (1995) also evaluates the potential returns in 20 cases (overlapping sets of cases). Because the study was more focused on understanding the transfer process and used rapid assessment techniques, the results are qualitative and tentative (see Tables 4.4 and 4.5).

The significant outcomes in general are increased water availability and control, improved reliability, flexibility and equity of water, and a shift to higher-value crops as well as some

Table 4.4. Comparative analysis of WUAs in gravity systems, India.

	Mohini	Datta	Shevare	Banganga	Jay-Yoge	M. Phule
Cropping pattern changes	No	Yes	Yes	Yes	Yes	Yes
Cropping intensity	Slight increase	Increased	Increased	Increased	Increased	Increased
Water rates margins	Medium	High	Medium	High	High	High
Water use efficiency	No change	Some improvement	Some improvement	Some improvement	Some improvement	Some improvement
Charges for usage of wells	No	Yes	Yes	Yes	Yes	Yes
Additional charges for R&M management	No	Yes	Yes	Yes	Yes	Yes
Income from non-irrigation activities	Yes	No	No	Marginal	Marginal	Marginal
Receiving management subsidy and grants	Not at present	Yes	Yes	Yes	Yes	Yes
Availing payment discounts	No	Yes	Yes	Yes	Yes	Yes
Recovery rates	Substantial drop	Medium	High	Medium	Reasonably high	Reasonably high
Financial viability without subsidy	Questionable	Yes	Yes	No	No	No
Financial viability with subsidy	Not applicable	Yes	Yes	Yes	Yes	Yes

Source: Kalro and Naik (1995:29–30, Table 3.3).

Table 4.5. Incremental benefits of turnover in selected Indian cases.

System	Other water sources	Incremental change in		Comments
		water control	income	
Anklav	high	medium	low	Abundance of groundwater
Mohini	low	medium	low	Surplus water in the command
Shevre	low	high	high	Surplus water in one WUA
Ozar	medium	high	high	
Datta	medium	high	high	
LBP	high	low	low	
PAP	high	low	low	
PVP	high	high	high	
Saliperi	medium	medium	high	
V'kulam	medium	high	high	
Pingot	low	high	medium	
Baldeva	low	high	medium	
Bhima	low	high	high	
Parunde	low	high	high	
PK tank	low	high	high	
PP tank	low	high	high	
Kedar	medium	medium	high	
Dusi	low	low	medium	Water is not sufficient
Kadoli	low	high	high	
Phulewadi	low	high	medium	Little emphasis on agriculture

Source: Kolavalli (1995:27, Table 12).

improvement in yields. Farmers have also saved time and reduced hassles, especially in formerly shejpali systems. There is evidence that costs have increased; although benefits have increased more than costs, the cases vary in the willingness of farmers to cover the increased costs. Therefore, questions are raised about the future financial viability of some farmer organizations studied (Kalro and Naik 1995). Some societies have found subsidiary sources of income to support irrigation-related activities (Kolavalli 1995).

The irrigation agencies have also benefited in terms of improved recovery of water charges and reduction of time spent in water distribution and conflict resolution; but they have also had to make additional investments in improving the physical systems and providing financial support to the organizations. These costs and benefits are not quantified.

Overall, the states of India exhibit a mixed picture. Interviews in Tamil Nadu and Haryana revealed there is little interest in transfer in these states (with good reason, perhaps, in Haryana, but Tamil Nadu has a strong tradition on which to build). Gujarat's experiments show some interesting results, but there has been little follow-up to date. The Bihar government is interested in the results of one experiment but has not formulated a policy for the next steps. Only Maharashtra seems to have a good balance between policy development and experiments, and has been willing to invest in the program.

4.4.7 Irrigation Management Transfer in the Philippines

The Philippines is a pioneer in developing, testing, and implementing irrigation management transfer. During the period 1989 to 1992 IIMI worked with the National Irrigation Administration (NIA) and several regional universities to carry out diagnostic and action research on NIA's programs to support communal (farmer-owned and managed) systems as well as to strengthen irrigation associations in national systems. Wijayaratna and Vermillion (1994) provide a short overall perspective on the Philippines' transfer programs, while Lauraya and Sala (1995a, 1995b) discuss the results of a study of performance of irrigation associations and the impact of management transfer on system performance in the Bicol region of Luzon.

Supporting conditions. NIA is a partially autonomous public company which is responsible for planning, constructing, and managing national irrigation systems, and supporting the construction and management of communal systems. It is specifically mandated to recover the costs of O&M on national systems through a standardized irrigation service fee (ISF), and to recover part of the capital costs as well. NIA began experimenting with ways of strengthening and assisting farmer organizations on communal systems in the mid-1970s, and adapted the lessons learned to national systems beginning in the early 1980s. Irrigation associations (IAs) are legally registered once they meet certain minimum criteria; and their relationship with NIA is governed by a formal contract. For national systems, there are three types of contracts which are also seen as stages in the transfer process. These are:

- Type I, in which the association takes maintenance contracts for canals
- Type II, in which the association undertakes operations and collects irrigation service fees from members, keeping a portion for itself if it exceeds a certain level
- Type III, in which the association assumes full responsibility for O&M of a system or subsystem, and begins amortizing a portion of the construction costs

Wijayaratna and Vermillion (1994) report that out of 94 systems for which they have data, 54 percent have Type I, 32 percent have Type II, and only 15 percent have Type III contracts. They suggest that the step to Type III—"full management turnover"—is hampered by two issues: first, what to do with existing NIA staff on these systems, and second, a fear NIA will lose revenue by turning over its "best" systems. The ISF is standardized but systems vary in the amount of O&M costs. NIA has a financial incentive to transfer expensive ones—the ones least attractive to farmers—and retain the less-costly systems.

The transfer process. In the early years, NIA used professional community organizers. From about 1983 it has shifted to using farmers as organizers, to save on costs. Farmer irrigator organizers (FIOs) are cheaper individually than professional community organizers but on a per hectare basis they are actually four times as expensive (Wijayaratna and Vermillion 1994: Appendix 4).³⁵ NIA also provides association leaders with formal training in a variety of tech-

³⁵Gonzales, an engineer from NIA who was involved in turning over pump schemes in the Philippines, describes the recruitment and training of farmer irrigator organizers and the outcomes on a particular pump scheme (Gonzales 1993).

nical, management, and financial skills, using experience-based methodologies; and uses various informal opportunities to provide training. Since 1986 its institutional development programs have been consolidated under one department. As associations become stronger, they are encouraged to proceed to more comprehensive contracts.

Organizational model. Irrigation associations are registered formally, and have bylaws and elected officers. In the Bicol study, they were found to have an average of 307 members covering an average of 332 ha (Lauraya and Sala 1995a). Unlike associations in some other Asian countries (for example Sri Lanka), the Philippines associations do not have several layers, for example at field channel and then at lateral level; Lauraya and Sala suggest this is one reason associations are not as strong as they might be.

Impact assessment. Wijayaratra and Vermillion (1994), citing a study done on four national systems by the Institute of Philippine Culture in 1988, claim that transfer has had a positive impact on system performance. Lauraya and Sala (1995b) report briefly on the status of irrigation associations on both communal and national systems in the Bicol region. The sample 31 communal associations are able to irrigate only half the total service area, and not surprisingly, their official "collection efficiency" (percentage of ISF due actually collected) is only 54 percent. The authors suggest the poor performance of these irrigation systems (irrigating 50 percent of the service area as a result of reduced water supplies) can be attributed to both environmental causes (deforestation reducing river flows) and the weakness of association leadership. Based on a study of a sample of irrigation associations on nine national systems, they also report low collection efficiencies and some disenchantment with NIA.

Lauraya and Sala (1995a) report on a detailed analysis using quantitative data of the links between "organizational climate" (using 12 indicators), irrigation association performance (using 7 indicators), irrigation system performance (5 indicators), and production efficiency (defined as the ratio of actual average yield per ha and the highest yield attained in the system). Some key findings are:

- Irrigation associations have a rather large membership base, members generally lack awareness and commitment to association goals (many see the association as having been organized by NIA to improve ISF collections), and the associations lack a sense of mission as a distinct (farmers') organization.
- On the whole, the systems studied have a viability index (ratio of income to O&M costs) of 1.1, an ISF collection rate of 72 percent, a cropping intensity of 78 percent (per season), and a moderate level of satisfaction with services by farmers. However, in spite of these positive performance indicators, the production ratio is only 50.6 percent, meaning average yields are only about half the highest yields attained. This low level of productivity is attributed to various natural calamities.
- The physical condition of facilities is *inversely* proportional to system performance efficiency as measured by the viability index. This suggests the possibility that higher financial viability is being attained at the expense of facilities maintenance. Therefore, the viability index should be complemented with a measure of maintenance costs per ha.

- NIA personnel perceive the transfer program as a threat to their futures; NIA needs to articulate a long-term plan for its personnel.
- Irrigation conflicts and problems *except* for ISF payments are best managed through smooth interpersonal relations; disputes about ISF are best resolved through applying varying degrees of pressure.
- The regression model used revealed that the organizational climate, in general, significantly affects irrigation association performance, which in turn significantly and directly affects system performance.

4.4.8 Devolution of Management Responsibility in China

China has a population exceeding 1.2 billion people. Massive investment in irrigation since the founding of the People's Republic has resulted in an irrigated area of about 48 million ha. Irrigated land produces about 65 percent of China's food grains, 75 percent of its cash crops, and 90 percent of its vegetables; and irrigation districts supply 70-80 percent of the drinking water for people and livestock in rural areas. But by the mid-1970s, poor management and inadequate maintenance combined with substandard construction and poor economic conditions were leading to deterioration of the irrigation systems, a decline in area irrigated, and a reduction in productivity. The reforms initiated in all sectors of China's economy beginning in the late 1970s have had a very significant impact on how irrigation is managed and financed and on the productivity of irrigated agriculture, and have reversed the decline in area irrigated (Johnson et al. 1995).

IIMI collaborated with the Shijiazhuang Institute of Agricultural Modernization (SIAM) to carry out a study of two medium-sized irrigation districts, Nanyao and Bayi, in Hebei Province in northern China. The results are reported by Vermillion, ed. (1996: Section 2.3), and Johnson et al. (1995).

Supporting conditions. Beginning in the early 1980s, the collectivized agriculture sector was thoroughly reformed in an effort to provide incentives for individual farmers to be more productive, and regarding irrigation management, make the lower-level institutions financially independent and self-reliant. The policy has evolved through several stages, each one an attempt to deal with issues raised by the previous stage, but with a strong emphasis on experimenting with various alternatives.

A national "regulation on water fees" has been adopted which states the principle that the costs of irrigation O&M should be covered by irrigation service fees, and that fees should be set based on O&M costs but with a ceiling on the maximum fees that can be charged. A tripartite water fee system is supported, which includes a fixed area fee, a volumetric fee, and an annual labor contribution for each farmer. Another regulation encourages the establishment of "diversified sideline enterprises" to use underutilized assets in irrigation districts, and cross-subsidize the costs of irrigation management.

Reforms in the agriculture sector introduced a market system and price reform. Price reforms have gone through several stages. By the end of 1985, peasants were increasingly at-

tracted by opportunities to earn more income from growing non-grain crops, and engaging in other businesses. Farming, and particularly grain farming, is not competitive with other alternatives. Despite several subsequent reforms aimed at maintaining grain production and keeping peasants in farming, farmers seemed as of 1994 to be worse off, with 110 million having fled to the cities, and huge areas going out of production. There is increasing concern about China's ability to maintain grain self-sufficiency (IIMI 1995i:94-96).

The transfer process. The policy reforms were implemented beginning in the early 1980s. "Village irrigation management groups" (VIMGs) were organized in both counties to take over direct responsibility for managing irrigation. The irrigation district offices were also reorganized to work effectively with the VIMGs, and the Bayi Irrigation District established a "Diversified Management" division to manage its sideline enterprises. Annual assessment of the performance of irrigation district staff linked to salary bonuses was introduced, and incentives were provided to VIMGs to encourage fee collection: in Nanyao for example, if the VIMG collects 100 percent of the fee by the end of March it may keep 5 percent; if by May it still has not collected 100 percent, it pays a fine of an additional 3 percent of the uncollected amount.

Organizational model. Before the reforms, irrigation development and management were done by county level water resources ("conservancy") bureaus, under the Ministry of Water Resources. At the system level, bureau staff coordinated system management with the aid of labor assignments from the commune; subsidies from central, provincial, and commune levels financed the service.

The early phases of reform caused considerable confusion within villages and agencies about the roles and responsibilities related to irrigation management. In the second stage of reforms, the communes were dismantled. Following this, the water resources bureaus were reorganized to create an additional tier below the county level and to introduce financial incentives to increase productivity; and village irrigation management groups (VIMGs) were created at village level and came to be managed separately from village government. A VIMG generally has three to five members selected by the farmers in a village; it is responsible for O&M of the canals passing through the village and collection of water charges. In general, VIMGs manage the lower two or three tiers of irrigation systems, and the irrigation district manages the reservoirs and higher-level canals. The district office has staff members, but Johnson et al. (1995) say the Bayi Irrigation District is operated as an independent utility; none of the employees are civil servants under the Water Conservancy Bureau (the reports are not clear on the status of irrigation district employees in Nanyao, but their salaries are paid entirely from irrigation service fee revenues).

In Nanyao, water availability is not a constraint, and it has so far been able to finance its operations entirely from irrigation service fees. Bayi is relatively water-short—forcing it to buy water from elsewhere—and has higher agricultural production than Nanyao; but an increasing portion of Bayi's income is from sideline enterprises. In 1994, its Diversified Management Division was operating 11 kinds of businesses, and contributing a third of the net income of the irrigation district (Johnson et al. 1995:153).

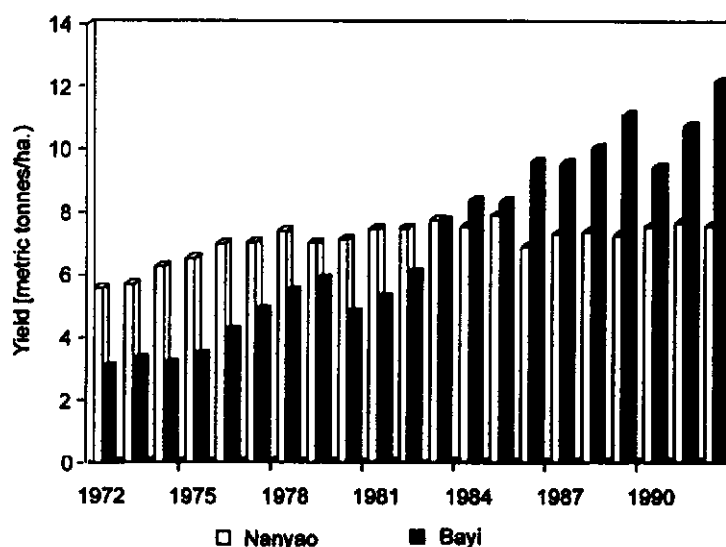
Impact assessment. The researchers examined the impact of these rural reforms on the performance of the two irrigation systems, Bayi and Nanyao. After irrigation was introduced in

these two areas, irrigated winter wheat and summer maize became the dominant crops. More recently, farmers have increasingly shifted to cash crops such as vegetables and fruit to maximize their incomes. Since the reforms, the farmers have also been able to increase the amount of grain sold in the market after selling the government its quota. The combined grain production (wheat and maize, two seasons) has increased from 1,125 kg/ha in 1960 to 11,905 kg/ha in 1992 in Bayi; and from 5,250 kg in 1972 to 8,500 kg/ha in 1992 in Nanyao. Net incomes in both districts have increased dramatically, especially since the reforms, but Nanyao has seen a stagnation in yields and a drop in income in the 1990s.

Prior to the reforms, water fees were paid by the communes, not farmers, and "collection rates" were always 100 percent. When the reforms were first instituted, collection rates dropped drastically; but by the early 1990s collection rates in both systems were 95-100 percent. Steadily increasing water costs have led to reduced water duties in both schemes in recent years, especially in Nanyao.

Nanyao has a relatively abundant water supply, but its system is less efficient (with high water losses in main canals), and it has lower crop yields per ha; it has been slower than Bayi to introduce volumetric water fees and has not yet developed any sideline enterprises. Bayi is water-deficit and must purchase large amounts of water each year, but its crop yields per ha are about 50 percent higher than those of Nanyao. The outputs per unit of water, when surface water and groundwater supplies are combined, are roughly similar: 1.5 kg/m³ in Bayi and 1.3 kg/m³ in Nanyao (see Figures 4.4 and 4.5). Bayi's dependence on purchasing water combined with the farmer's higher ability to pay (due to higher productivity) may be the driv-

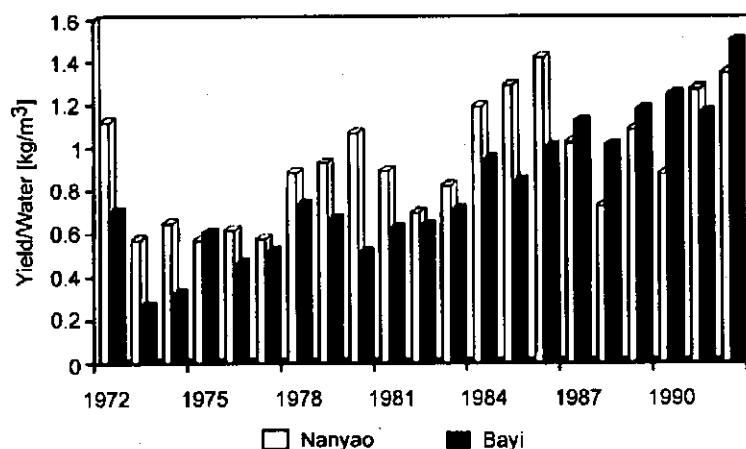
Figure 4.4. Annual wheat and maize yields for two seasons, Nanyao and Bayi districts, Hebei Province, China.



Note: This figure is corrected (from the original) to scale.

Source: Vermillion, ed. (1996: Section 2.3, p. 90, Figure 18).

Figure 4.5. Annual grain yield per unit of water, Nanyao and Bayi districts, Hebei Province, China.



Source: Vermillion, ed. (1996: Section 2.3, p. 91, Figure 19).

ing forces leading to developing sideline enterprises and greater concern about improving water use efficiency. Nanyao needs to reduce internal water losses to improve grain production, which will require funds, which in turn will force Nanyao to strengthen its management institutions and develop sideline enterprises.

The study concludes that the reforms are producing more viable local management, that they provide reasonably clear delineation of rights, responsibilities, and linkage of water rights and payments, and that sideline enterprises are helping to stem the flow of skilled staff out of the irrigation sector by improving salaries and facilities while keeping water costs lower through cross subsidy (Johnson et al. 1995:155; Vermillion, ed. 1996:91).

4.4.9 Initiation of Irrigation Management Transfer in Indonesia

In the late 1980s, the Government of Indonesia adopted a new policy designed to improve the funding and thus the sustainability of O&M of irrigation systems. The policy had two components: introduction of irrigation service fees on larger public irrigation systems (for which pilot testing of implementation procedures began in about 1989³⁶) and transfer to farmer organizations of smaller systems. Implementation of the latter program following a "learn-by-doing" process began in 1987. IIMI participated in this early stage by monitoring and evaluating the transfer process in four areas of two provinces. Detailed results are reported in IIMI 1989e, while the broader implications are discussed by Vermillion and Johnson (1990)

³⁶See Gerards (1995) for a recent description of the implementation of the irrigation service fee program.

and Johnson (1995). The research was done at too early a stage to come to any conclusions on the impact of the program.

The transfer program was initially to be applied to all systems irrigating less than 150 ha, and then less than 500 ha, in a phased manner. From the government's perspective, the primary objective is to make O&M funds available to be reallocated for use on larger publicly managed systems. Using national data, turning over all systems under 150 ha involves less than 4 percent of publicly irrigated land, but 34 percent of all systems; all systems under 500 ha involve less than 19 percent of irrigated land but 70 percent of all systems. The study suggests that at national level, transfer will not have a major impact in terms of making more funds available for large systems. But at local levels the impact on budgets, staff, and future O&M capabilities varies considerably. Figure 4.6 illustrates the budgetary effects of transfer in one section in each of two provinces with relatively large percentages of systems irrigating areas under 150 ha (45 percent and 59 percent). Reallocation projections are based on policy guidelines that funds made available by turnover will be used on systems over 500 ha in size up to the point where O&M expenditures reach Rp 25,000/ha. As can be seen from Figure 4.6A, in the West Java section the target of Rp 25,000/ha is reached after the second period, with a savings (residual) of Rp 33.7 million. However, in the West Sumatra section (Figure 4.6B), the target is never reached: after all the systems under 500 ha in size are transferred, the budget available per ha for larger schemes is Rp 23,832, somewhat short of the Rp 25,000/ha target.

The research also found that small systems vary in terms of their actual dependence on and relationship with the provincial irrigation agency. The first step is therefore to categorize the systems. In the four areas studied, some had substantial areas under systems which were incorporated in government figures merely by administrative classification—they were actually farmer-managed. These can simply be reclassified officially. The other two categories have been classified as government systems based on previous government investments; those which are in good condition need assistance only to organize water users associations, while those needing additional investments will require both physical improvements and institutional strengthening. Although the research was done at an early stage, before any systems were actually transferred, the reports are optimistic about the process and likely sustainability, and make detailed suggestions for making the process more effective (IIMI 1989e).

4.4.10 Irrigation Management Transfer: General Lessons Learned

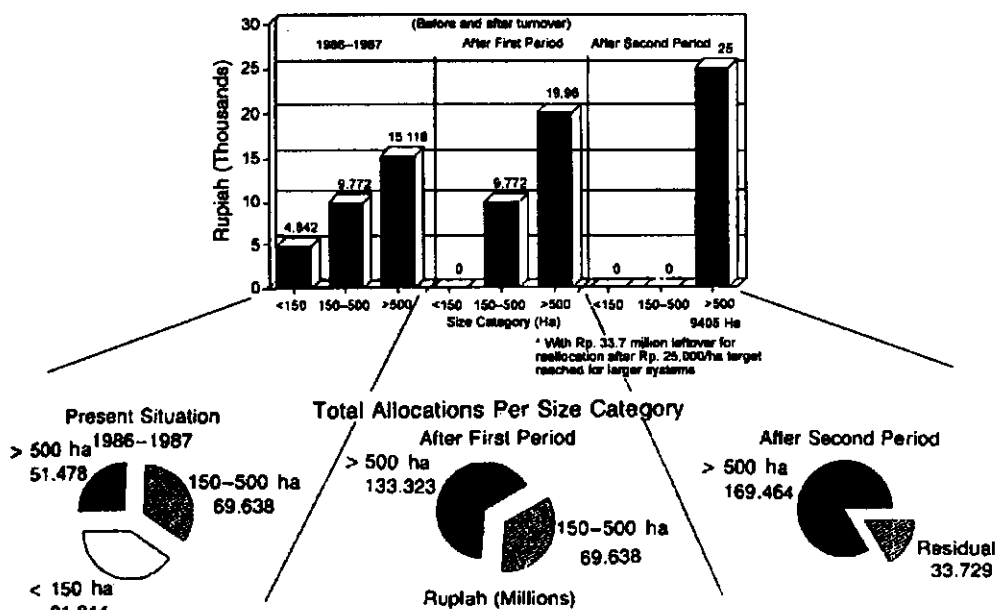
Much of the work on irrigation management transfer until recently has emphasized individual case studies. Several recent papers attempt to derive conclusions and lessons from comparative analyses of cases documented by both IIMI and other researchers. This section briefly discusses some of these conclusions and lessons.

Vermillion and Johnson (1995) list a dozen approaches or variations in management transfer, based on the presentations and discussions at the Wuhan Conference³⁷ (see Box 4.7).

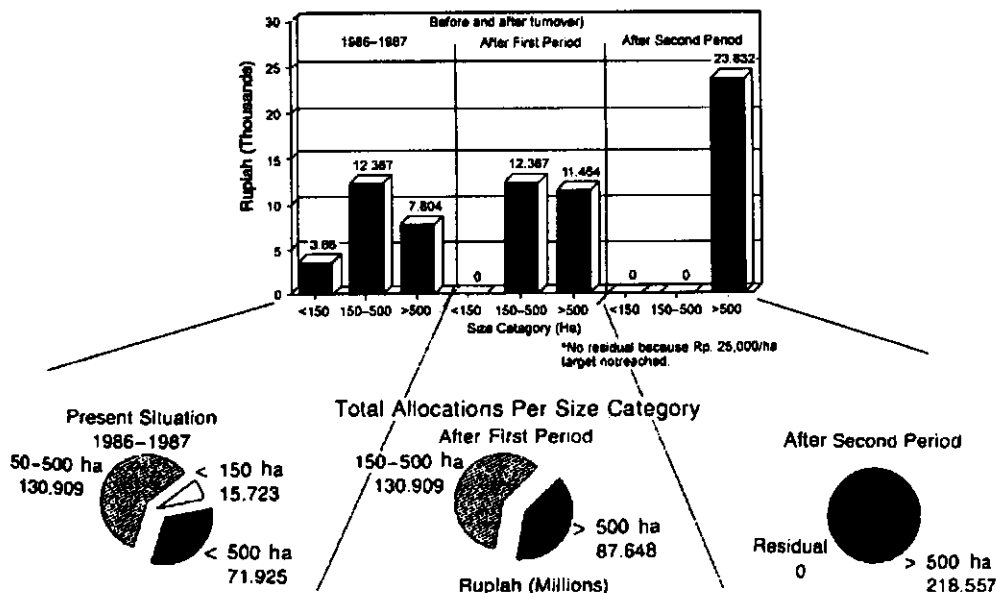
³⁷International Conference on Irrigation Management Transfer, Wuhan, China, 20-24 September 1994, cosponsored by IIMI and the Wuhan University of Hydraulic and Electrical Engineering (WUHEE), assisted by the Hubei Association of Science and Technology and Hubei Hydraulic Engineering Society, and cofinanced by several donors. Selected papers are included in a volume copublished by FAO and IIMI (Johnson, Vermillion, and Sagardoy, eds. 1995).

Figure 4.6. Projected budgetary effects after irrigation management transfer, Indonesia.

B. Budgetary effects of turnover: In Sumedang, West Java.



B. Budgetary effects of turnover: In Solock section, West Sumatra.



Source: Vermillion and Johnson (1990:241, Figures 2-3).

Box 4.7. Approaches to irrigation management transfer.

1. Introducing irrigation service fees (e.g., Indonesia)
2. Fostering competition in service delivery (e.g., Bangladesh, Pakistan, Nigeria)
3. Contracting (e.g., Sri Lanka, Philippines)
4. Vending (e.g., Sudan, India)
5. Franchises (e.g., China)
6. Grants/subsidies (e.g., Indonesia, India)
7. Joint agency/users investment (e.g., China)
8. Agency becomes financially autonomous (e.g., Philippines, Nigeria)
9. Joint agency/users management (e.g., China, Mexico)
10. Devolution of control (e.g., Colombia, Mexico, Sri Lanka, Philippines, Indonesia)
11. Withdrawal of functions (e.g., Senegal)
12. Privatization of assets (e.g., Bangladesh, Pakistan, New Zealand)

Supporting conditions. Johnson (1995) argues that in countries where governments have had the political will to increase water service fees to close to the real O&M costs, the process of irrigation management transfer has been smoother. Increasing water fees to about \$20-50 per ha in public schemes creates a strong economic incentive for members of water users associations to take more management responsibility. Examples cited include Mexico, New Zealand, Indonesia, and Colombia. Countries which have not been willing to create this economic incentive have not had, and are unlikely in future to have, much success with a transfer policy; examples include Sri Lanka, India, and Pakistan. Most studies argue that irrigation management transfer policies are driven by pressures on governments to economize on their budgets and a perception that local nongovernment organizations have the proper incentives to improve performance (Johnson 1995; Vermillion and Johnson 1995; Vermillion, ed. 1996).

Several other preconditions for successful irrigation management transfer are emphasized (see Vermillion and Johnson 1995). These include:

- a firm, consistent long-term political commitment to the policy
- clear water rights with compatible water distribution arrangements
- legal and political recognition of farmer organizations, including their right to raise revenue, enter into contracts, and apply sanctions

- benefits exceeding costs and being proportionally related to farmer investments, even though total costs paid for services may be more than that before turnover

In the post-transfer period several conditions are likely to prove important for sustaining the new management arrangements. These include:

- support services to organizations, especially as they evolve from single purpose O&M organizations to multiple function commercial organizations, to assist them in resolving conflicts and technical problems
- a periodic financial audit of the farmer organization by a qualified neutral external entity to prevent abuses and maintain legitimacy
- higher-level federations of local organizations for planning, allocating, and enforcing resource use at watershed or aquifer levels

The transfer process. Bureaucratic resistance to management transfer is a key issue (Vermillion and Johnson 1995). This can be managed through strong support for the policy from higher levels, dialogues and working groups with key stakeholders in developing the policy and implementation strategy, clear policies on the future responsibilities of both farmers and government agencies, and positive incentives for the agency to support and implement the policy. Agencies pressured to implement management transfer rapidly tend to focus on rehabilitation and organizing farmers, rather than thinking strategically about reorienting the agency and dealing with the issue of staff displaced by transfer. A clear policy regarding the financing of future capital replacement, and effective programs for training farmers and agency staff in new skills are also important.

Organizational models. Vermillion, ed. (1996:180-181) suggests three basic management models are likely to evolve as governments decrease their direct irrigation management role. These are

- direct management of small-scale irrigation systems by farmer organizations
- management of medium-scale or complex systems by irrigation districts governed and supervised by farmer-elected boards and employing specialized staff for management
- management of large-scale or complex irrigation systems by irrigation companies either owned or contracted by a federated farmers' organization and governed by a farmer-elected board

Merrey (1996b) offers a matrix of two organizational dimensions: autonomy—dependence of the organization; and whether an irrigation management organization manages one or many systems. The basic hypothesis is that irrigation systems managed by autonomous system-specific agencies accountable to their customers perform better and are more sustainable than systems managed by agencies dependent on governments (financially and organizationally) and agencies responsible for managing many different systems. The proposed matrix is given

in Figure 4.7. The paper shows the plausibility of the hypothesis with examples, but notes that a more rigorous comparative analysis, using quantitative performance data, is needed to confirm it.

Impact assessment. Vermillion, ed. (1996: chap. 4)³⁸ reviews the evidence on the performance impacts of management transfer emerging from the literature. Very little systematic comparative evidence exists on this important topic; and most evidence to date refers to short-term immediate impacts, mostly positive. Evidence usually comes in four basic types, listed from the weakest and most frequent type to the strongest and least frequent:

- 1) qualitative reports of stakeholders
- 2) post-facto assessment of single cases
- 3) with and without comparisons
- 4) before and after comparisons

Vermillion, ed. (1996) suggests that the limited data available support the following general observations on performance impacts:

- either positive or no effects on O&M performance
- reduction in number of agency staff where this has been an objective

Figure 4.7. Matrix of irrigation system governance arrangements: Performance hypotheses.

		RELATIONSHIP OF AGENCY TO GOVERNMENT	
		Autonomous	Dependent
Agency manages a single irrigation system	1	Achieve highest performance Most adaptive to changing conditions Most sustainable [Hypothesis 1]	2 Mixed but generally low performance Low adaptability Sustainability threatened [Hypothesis 2]
Agency manages multiple irrigation systems	3	Performance will vary among systems but overall will be lower than cell 1, higher than cell 4 Adaptability and sustainability will vary among systems but overall will be lower than cell 1, higher than cell 4 [Hypotheses 3, 4]	4 Wide range of, but generally low, performance Low adaptability and sustainability, with variation among systems based on local factors [Hypothesis 3]

Source: Merrey 1996b: Figure 1.

³⁸A revised version of this chapter was recently published (Vermillion 1997).

- significant increases in costs to farmers where subsidies are removed, but reductions in costs where there is no change in government subsidies (Lift schemes have the most problems achieving financial sustainability.)
- a general increase in service fee collection rates, often accompanied by increased farmer voice in how the funds are used
- a common tendency for farmer organizations to diversify their sources of income
- a general tendency for increases in cropping intensities, area irrigated and yield, though few studies present rigorous controlled comparisons
- very little evidence on the impact of transfer on government expenditures, or on the impact on environment

4.4.11 Observations on Irrigation Management Transfer Studies

It is clear from the length of this section that the volume of work done on irrigation management transfer is substantial. There has been a strong emphasis on country-specific case studies. These studies vary in their conceptual design, depth, and quality of data, but some of them are important contributions to the field. One weakness in this work—as well as work in other areas such as canal performance—is the failure to use a consistent conceptual framework and methodology to facilitate systematic and detailed comparative analysis. Many of the general conclusions reached support others' conclusions but in general are not novel.

These reservations notwithstanding, the work to date provides a good foundation for the next stage of work. Four trends characterize work currently underway or planned for the future. These are:

1. A shift in emphasis from understanding the transfer *process* to documenting systematically the *impacts* of management transfer. A detailed guide for this is currently being field-tested.
2. A shift in focus from examining the relatively narrow topic of transfer, to examining this as one important thread in a broader process of structural reform (see Box 4.8). The implementation of research on management transfer as a separate program from that on public organizations and policy, compounded by donor funding for research on transfer but not on other policy and institutional reforms, has led to this narrow focus. The new program integrating policy and institutional research should enable IIMI to take this broader approach in future.
3. A greater emphasis on the economic implications of transfer. If management transfer results in substantially higher costs for farmers, this may have important implications for the future viability of many irrigation systems, and thus the livelihoods of many farmers.
4. More emphasis on providing strategic research-based advice to governments and donors in deciding on whether and how much to transfer, and planning and implementing such a program as an integrated management reform process.

Box 4.8. Institutional reforms to improve irrigation performance: Are they real?

The received orthodoxy in irrigation reform has been that the role of the irrigator must be changed. Therefore, the focus of most reforms—and research—has been on “farmer participation” and recently, “irrigation management transfer.” In many cases the results so far have been disappointing: there are no dramatic improvements in performance, and impacts are quite modest relative to the effort made (Abernethy, personal communication 1996). The weaknesses of public irrigation management organizations have been documented, but this has not led to serious consideration of more radical alternatives to decentralization, transfer of some but not all responsibilities, and adjustment of existing agencies.

Merrey (1996c) has suggested that different types of organization at policy and implementation levels are likely to have different performance outcomes. For example, a specialized ministry of irrigation may be appropriate for expanding irrigated area, but when a country faces inter-sector competition for water, this mode of organization may prove ineffective. Including irrigation in a ministry of agriculture may enhance its contribution to agricultural production, but may lead to agricultural dominance of water resource use even when scarcity has made such dominance uneconomical. Strong ministries of water (or natural) resources may be most appropriate when competition for water and water quality becomes serious issues.

Another line of research should be studies of other sectors where public organization reforms are believed to have made those sectors more efficient; these include domestic water, electricity, and telephone services in some countries. “Public utility” is frequently advocated as an appropriate organization for irrigation but it has not been seriously explored. Radical decentralization—and even abolition—of existing organizations may have higher returns than incremental reforms of rigid, ineffective, and corrupt institutions.

Finally, more studies of *successful cases* as models (like the Columbia Basin Project case reported here) will be useful, as will detailed studies of hydrologically defined decentralized water basin organizations as found in Malaysia, Morocco, and other countries.

With the establishment of a strong national program in Mexico (which is implementing the most radical irrigation management transfer program in the world), IIMI will carry out research on “second generation” issues facing already turned-over systems.

4.5 Indigenous Farmer-Managed Irrigation Systems (FMIS)

4.5.1 Introduction

Since its establishment, IIMI has been concerned with irrigation managed by farmers. A program on Farmer-Managed Irrigation Systems was one of the original programs (Box 1.1).

Farmer-Managed Irrigation Systems (FMIS) are those that have been constructed, and are owned and managed by groups of farmers themselves, and in which the users control the water source. The area irrigated by FMIS has in the past often been grossly underestimated, but in many countries it is a significant percentage of the total area irrigated. For example, the proportion of irrigated area which is farmer-managed (including lift irrigation) has been

roughly estimated to be 67 percent in Nepal, 64 percent in India, 63 percent in the Philippines, 35 percent in Pakistan, and 21 percent in Indonesia (IIMI 1991). It has been estimated that farmer-managed irrigation systems (FMIS) are supplying basic food for about 30 percent of Nepal's population (P. Pradhan 1990a). The actual area managed by farmers may be even higher because often official area figures for large-scale irrigation are inflated, and informal farmer control above the outlets is underestimated.

Research and information activities have also shown that the area under farmer-managed irrigation has been increasing significantly in recent decades (although this is difficult to measure). The major reasons are the rapid expansion of farmer-managed lift irrigation (especially in South Asia and West Africa), and the transfer of management authority for irrigation from governments to local farmer organizations.

IIMI's work in this area builds on important work carried out by others over the past 2 decades or so. For example, the National Irrigation Administration (NIA) in the Philippines has been a pioneer in developing methodologies for assisting "communal," i.e., farmer-managed, irrigation systems. More recently, the Workshop in Political Theory and Policy Analysis at Indiana University, USA has developed a theoretical framework for analysis of local management (Ostrom 1992); IIMI's work in Nepal has been associated with work by this group.

The work on FMIS has been implemented in conjunction with work on support services to FMIS. This section discusses the results of FMIS research and Section 4.6 discusses the results of work on support services. Work on design of FMIS is discussed above in Section 3.6.2; and work on groundwater and lift irrigation is discussed above in Section 3.3 and Box 3.5. This section provides an overview of some of the findings on indigenous institutions and performance; it then discusses the results of two FMIS case studies: one in Chitral, Pakistan, and the other in the *terai* (plains) of Nepal.

4.5.2 *Indigenous Institutions and Management Performance*

A socio-technical approach is taken to the analysis of farmer-managed irrigation. Management performance is seen as the outcome of a complex interaction of physical, technical, socioeconomic, and institutional conditions and processes. The two key research questions in this area have been:

- What kinds of institutional arrangements and management practices have proven effective and sustainable in traditional or locally managed irrigation?
- What internal or external stresses are interfering with the performance and sustainability of locally managed irrigation?

Several studies and reports have examined what kinds of organizational features accompany successful and long-enduring locally managed irrigation. Most of the field work on FMIS has been done in Nepal, with some work also done in Sri Lanka, Indonesia, Pakistan, and the Philippines. Some of the more salient findings are as follows (from IIMI 1994c³⁹):

³⁹This final report on FMIS and support services work also summarizes the results of studies on performance of FMIS emerging from papers given at workshops sponsored by IIMI.

1. Traditional farmer-managed systems develop rules gradually over periods of negotiation and experimentation (see also Vermillion 1991; de Jong 1989). The construction and improvement process is also an institution building process (Yoder 1994a).
2. Rule compliance and leadership are more effective when rules are established by the irrigators themselves rather than by a supra-level authority.
3. Social differences such as tenure or ethnicity inhibit communication among users and weaken rule compliance.
4. Although severe sanctions such as fines and halting water deliveries are essential as potential threats to rule breakers, FMIS generally use less formal sanctions such as public shame (Yoder 1994a).
5. The intensity of rules and management tends to be proportional either to the local historic level of water scarcity or to the level of investment required for routine maintenance in the system (Martin and Yoder 1988).
6. Durable arrangements for local resource mobilization are usually based on local conceptions of fairness about either property rights (P. Pradhan 1990b) or some sense of proportionality between investment in, and benefit from, the irrigation system (Martin and Yoder 1988). The most common threats to the institutional viability of farmer-managed irrigation are social inequality and non-participatory public intervention in farmer-managed systems (Yoder 1994a).

4.5.3 FMIS in Chitral, Pakistan: Technology and Management Performance

In late 1990, IIMI and Enterprise and Development Consulting carried out a rapid appraisal of three irrigation systems in the mountainous Chitral District, Pakistan (IIMI 1994d). The primary objective was to begin establishing a baseline of knowledge about indigenous irrigation systems in Chitral, as a basis for planning future interventions. The systems studied had not received development assistance in the recent past and were considered reasonably representative of the categories of systems in terms of water availability. It is estimated there are about 1,000 small locally owned and managed systems in Chitral which irrigate a total of about 18,000 ha. All three systems studied are several centuries old and have stable well-established management traditions. The irrigated areas are about 33, 43, and 132 ha.

The three systems are very similar in their design and construction, using low-cost easily repaired local materials. All three systems show "a low level of formal institutional development for irrigation or water management." This lack of formal organization notwithstanding, the authors note that there is no history of conflict, and the systems are maintained and operated effectively. Users have clear water rights, with such rights being defined most clearly in the relatively water scarce system. The authors compare the traditional arrangements for maintenance and conflict resolution favorably to the conditions found on the large systems on the plains. All three systems support two crops per year, and crop yields are higher than the national averages. The authors therefore suggest that opportunities for further improvement lie in improving agricultural support services, and not in water management improvement.

4.5.4 Chhattis Mauja Irrigation System, Nepal

From 1988 to 1989, IIMI carried out a detailed study of a large farmer-managed irrigation system in the *terai* (plains) of Nepal. Resident research staff did formal and informal surveys among farmers, attended meetings, analyzed records, and carried out detailed measurements of water distribution, seepage and percolation losses, and crop yields on 3 of the 44 branch canals of the system. The results are reported in Yoder (1994b); Section 4.8.2 below discusses Chhattis Mauja from a gender perspective.

The Chhattis Mauja Irrigation System was constructed in the mid-1800s by the then-majority community in the area to provide supplemental irrigation for monsoon rice. Rice is still the major monsoon crop, but today winter crops are also irrigated and all available water is used to grow maize in the dry season. Today, the system irrigates a gross command area of 3,500 ha, cultivated by 2,500 households who reside in 54 village units.⁴⁰ An adjacent farmer-managed system, named Sorah, which is partly integrated into Chhattis Mauja as a result of changes imposed by the government, irrigates an additional 1,500 ha; but the study focused on the Chhattis Mauja system.

The system has changed considerably since it was constructed, and continues to change in various ways. First, people from the hill areas have immigrated into the area and now own most of the land and form the dominant group and majority in Chhattis Mauja. Second, these hill people opened up new land, primarily in the head and middle portions of the 11 km long main canal, and thus the area irrigated (as well as cropping intensity) has increased over time. Third, there have been important changes in the organizational arrangements and operational rules over time. A constitution was written in the 1950s, considerably revised in 1979 when the rules being used were also formalized, and has been amended several times since.

Yoder (1994b) provides a detailed description of the system's operation and maintenance, and an analysis of the hydraulic and agricultural performance of the system and the costs and benefits to the farmers. A basic characteristic of the management system is the use of the *kulara* unit. This unit expresses a certain share assigned to a member village, and simultaneously integrates the village's water rights and voting rights, and its obligations for providing labor and cash for system upkeep. The total number of *kulara* is not fixed but is controlled by the executive committee based on certain rules. Villages may apply to open a branch canal, and a branch canal can apply for an increased water allocation, and may also drop out. Between 1980 and 1989, the number of *kulara* was reduced from 183 to 175; all of the reduction took place in the tail areas (where farmers are getting increased access to groundwater).

Final authority for decisions concerning Chhattis Mauja is vested in the general assembly. Each irrigator may attend and participate in this, but only designated *kulara* representatives may vote. An organization with four tiers has evolved to control system O&M. Village-level committees control the branch canals; each of the 9 area-level committees controls 3 to 10 branch canals; a 12-member executive committee controls the entire Chhattis Mauja system; and a joint committee of the Sorah and Chhattis Mauja systems oversees water allocations and maintenance of the diversion structure between the 2 systems.

⁴⁰The name "Chhattis Mauja" means, literally, "36 village units," indicating the expansion that has occurred since it was established.

Yoder (1994b) finds that the organization has a high level of support from the irrigators, and that it is very effective in system management, enforcing rules, and communication. On the other hand, although accounts are audited and open, record keeping is not as systematic as expected; and the actual rules for water allocation differ considerably from the formal rules: the major objective of system operators is to minimize complaints, not to ensure water allocations are proportional to kulara or resources invested. Small adjustments are made to respond to complaints, and formal rotations are avoided unless absolutely necessary.

Although there are large inequities in water delivered to the head and middle branch versus the tail, there is no significant difference in yield. Head-end areas have very high rates of seepage and percolation; tail-end areas get some drainage water and often have access to groundwater. Irrigation delivery for wheat is "excellent" to all parts of the system, but water delivery for dry season maize is less than expected by farmers. Winter wheat area could be expanded somewhat with better water management; and the relatively weaker organizations at the tail ends have resulted in some inequity in water supply and reduction in area. Nevertheless, average yields for irrigated crops on the sample branch canals are equal to or better than the regional average, and the head- and middle-canal yields exceed the government's target yields for the year 2000.

The total estimated value of farmer labor and cash contributions for branch and main canal operations in 1988–1989 was about NRs 997,000 (about \$35,500). The cost of O&M for main and branch canals ranges from NRs 400 per ha in the head sample branch to NRs 160 per ha in the tail branch; the average of NRs 285 falls within the range suggested as necessary for systems managed by the Department of Irrigation.⁴¹ Figure 4.8 shows the allocation of contributions to different O&M activities at higher levels, and the use of cash collected by village organizations. Sixty percent of the contributions are in the form of cash, 30 percent for emergency maintenance alone.

Yoder (1994b:86-87) calculates the "effective rate of taxation," defined as the ratio of resources paid for irrigation to the marginal income from irrigated agriculture, and finds this cost averages 1.73 percent for the whole system, with a range of 1.79 percent to 2.13 percent between the middle and head branches, respectively. Therefore, in spite of the high level of expenditures on O&M, Yoder concludes irrigation is a "highly profitable enterprise."

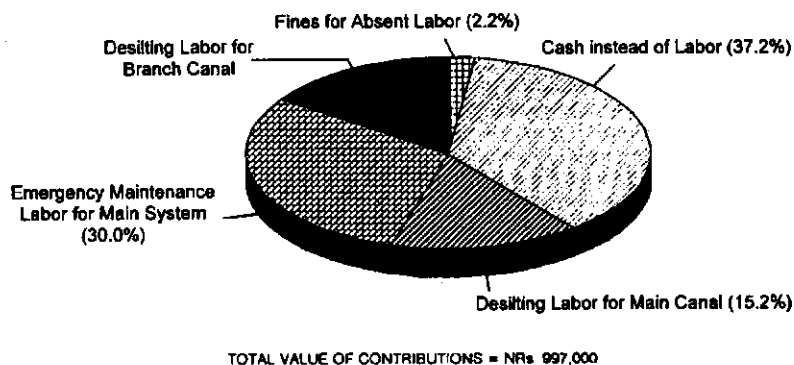
4.6 Support Services to Farmer-Managed Irrigation Systems

4.6.1 Introduction

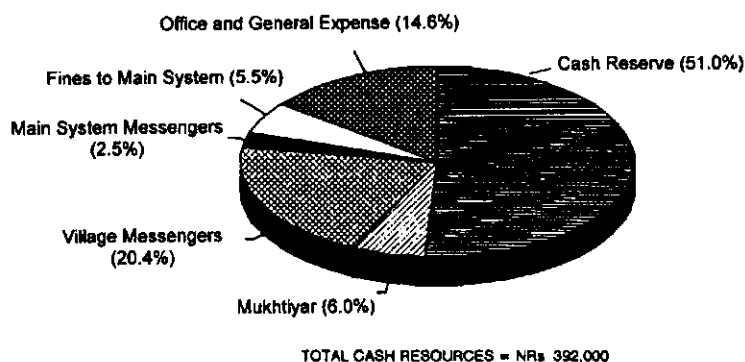
The results of much of the work on support services are summarized in IIMI (1994c). Support services include assistance for construction and repair of irrigation facilities; agricultural input supply; and institutional support such as extension, financing, marketing, training, and regulating and auditing as well as assistance on conflict resolution (Samad and Shivakoti 1994:3). Most of the work has concentrated on support programs for improving physical infrastructure and strengthening farmer institutions. This section first summarizes results from

⁴¹US\$1.00 = NRs 25.10 in 1988 and 28.10 in 1989.

Figure 4.8. Origin and purpose of the NRs 987,000 labor and cash payments made by farmers in the 1988/1989 monsoon, winter and dry seasons, Chhattis Mauja, Nepal.



(b) APPLICATIONS OF CASH RESOURCES BY VILLAGE ORGANIZATIONS



Source: Yoder (1994b:84, Figure 6.1).

earlier work; then reports in more detail on the results of a comparative analysis of support services in Nepal and Sri Lanka, and the development, testing, and application of farmer self-assessment and irrigation resource inventory methodologies. This is followed by a discussion of privatization of services to pump systems in Bangladesh and Sudan.

4.6.2 Overview of Earlier Research Results

After the Workshop on Public Intervention in Farmer-Managed Irrigation Systems in Kathmandu in 1986 (Martin and Yoder, eds. 1989), support services and policies for farmer-managed irrigation became the dominant theme in IIMI's work on FMIS. The emphasis in research activities, in the FMIS Newsletter, and in workshops, has been more on the process of service delivery than on the types of services that are needed. The four main questions addressed in this theme are:

1. What methods work best for creating viable water users' associations?
2. How can external agencies enhance farmer-managed irrigation without creating local dependency on governments?
3. How can external assistance be delivered in a way which encourages local investment and a sense of ownership in the system?
4. What kinds of policies and legal rights are needed to make locally managed irrigation sustainable?

Pilot experiments and studies have shown that relatively small government investments in the FMIS sector, especially involving joint or induced investments by farmers, can produce much higher returns than agency investments in larger-scale irrigation development (IIMI 1989e; Yoder 1994a). This is largely because projects can be completed quickly, benefits are realized sooner, and farmers are more likely to provide corresponding local investment (IIMI 1991). A key finding is that where external assistance occurs without corresponding local investment (such as in labor, materials and knowledge), dependency is reinforced and the benefits of the external investment are not sustained (Yoder 1994a; Dayaratne 1991).

Research has also shown that construction or rehabilitation assistance to farmer-managed irrigation systems should not be done where viable local institutions do not exist to take over management or to coordinate continuing local investment. Support to FMIS is more successful where there is a balance among physical, financial, and institutional development, all of which should occur concurrently, together with local investment. Agency-directed support programs often emphasize physical construction to the neglect of other kinds of support. Local deficiencies in accounting skills and conflict resolution are often more constraining to viable farmer organizations than system disrepair; more emphasis in training and institutional development is therefore needed in these two areas (U. Pradhan, Valera, and Rana 1992).

In addition to stronger legal status, researchers have found that farmer organizations often need the support of irrigation agencies or local governments to empower local conflict resolution capacity (Moragoda and Groenfeldt 1990). Regarding creating viable water users' associations, studies in Sri Lanka and Indonesia confirm that standard organizational formats and training modules are not as successful as approaches which facilitate local group interactions wherein the farmers organize themselves and create their own operational rules and plans based on local conditions (e.g., IIMI 1989e).

Studies have also confirmed that organizing farmers works best starting from the bottom or basic unit first and then working up in scale into nested federations (TEAMS 1990; P. Pradhan 1990b). Basic units generally do not exceed roughly 75 ha, and secondary supra-level organizations, such as distributary canal organizations, have a functional size limit of roughly not more than 500 ha after which further tiers are usually needed. Multitiered farmer-managed irrigation systems exist in Nepal which exceed 14,000 ha (P. Pradhan, Giri, and Tiwari 1988). Studies have also shown that the function of securing water and maintaining canals alone is often an insufficient basis to motivate farmers to organize themselves; farmers are often more motivated to organize as multifunctional entities which provide benefits in addition to water, such as cheaper and timely access to inputs, cooperative marketing, and sideline enterprises (Kloezen 1995; see Section 4.4.5, above).

The nature and level of farmer participation should be driven by local demand rather than by government imperatives (Groenfeldt 1986). Community organizers should be given strong training and supervision to function as catalysts rather than as community leaders (which they are prone to do if their performance is evaluated in terms of short-term physical targets), so as to ensure that dependency is not created and that sustainable institutions remain after organizers depart (see also TEAMS 1990; Athukorale, Athukorale, and Merrey 1994; and Box 4.6).

A workshop on the use of social organizers helped identify various strategies and their results under different conditions. Earlier approaches with intensive placement of highly trained organizers have often been too costly; it was difficult to supply these organizers on a national scale and to sustain organizer motivation because of the lack of a career path (Helmi and Vermillion 1990). New approaches such as multipurpose "Group Organizers" in Nepal, team organizers such as Mobile Campaign Units in Thailand, or farmer-to-farmer trainers in Nepal (Yoder 1991) and the Philippines have proven to be more successful, cost-efficient, and replicable than earlier intensive approaches (Manor, Patamatamkul, and Olin eds. 1990).

In the late 1980s, IIMI carried out a study of a major donor-funded project in Sri Lanka which was heavily focused on construction to the neglect of farmer participation. Based on findings from several communities affected by the project, Abeyratne (1990) found that:

- The intervention disrupted existing rules and patterns of water distribution.
- The farmers' priority for rehabilitation was the headworks whereas the agency emphasized the tertiary network; work on the latter severely disrupted existing property rights.
- Implementation was significantly delayed because of the bureaucratic division between the construction and institutional development departments.
- There was an inadequate institutional basis for future O&M by the users.

Several studies have shown that for agency support programs to FMIS to have favorable local responses, they must be flexible in timing of interventions, responsive to local priorities and capacities; transparent (and even mutually accountable) to farmers for budgets, and should encourage joint investment (WECS and IIMI 1990; Acharya 1990).

Unfortunately, government agencies are generally constrained from such flexibility and participation, often because of standard accounting practices and regulations from finance ministries. NGOs often have an advantage over government agencies in their flexibility and responsiveness to local needs for support (U. Pradhan, Valera, and Rana 1992). NGOs have become increasingly involved in providing both technical and institutional support to FMIS. Through such cost-effective strategies as team-based institutional organizers and farmer-to-farmer training (N. Pradhan and Yoder 1989) they have increasingly shifted from pilot projects to national strategies (Dayaratne and Wickramasinghe 1989). However, NGOs sometimes lack technical expertise and capacity for sustained involvement in the community, and exhibit the same supply-driven tendencies of some government agencies (Jungeling 1989; Dayaratne and Moragoda 1991; Athukorale, Athukorale, and Merrey 1994). A study on NGOs' support to

FMIS indicates that the most viable strategy for governments is often not to rely on one sector or the other but to develop joint agency/NGO activities which can benefit from the strengths of both sectors (Dayaratne 1991).

Finally, studies have shown that water laws and policies related to the FMIS sector are generally poorly defined in developing countries, especially those concerning rights between irrigation systems, within aquifers, and between water use sectors (IAAS et al. 1993; Abhayaratna et al., eds. 1994). Far more research and experimentation are required to develop stronger laws for water users associations, water rights within and between systems, water markets, and institutions to allocate water between sectors (such as urban water, manufacturing and industry, hydroelectric power and irrigation). IIMI has also shown the usefulness of developing information systems about indigenous water rights along river courses (U. Pradhan 1993).

4.6.3 Support Services for FMIS in Nepal and Sri Lanka

The study of support services for FMIS in Nepal and Sri Lanka had two overall objectives: to identify which approaches to delivering support services were more effective; and to formulate broad guidelines for planning and implementing such services (Samad and Shivakoti 1994). In Sri Lanka, unlike Nepal, the FMIS sector has lower yields and lower cropping intensities than government systems. Most FMIS are small reservoir ("tank")-based systems; generally, they have lower water availability and relatively poor farmers. Since 1980 government assistance has shifted from construction to rehabilitation and repair of existing systems, with more attention to small FMIS than previously. There have been a variety of approaches to rehabilitation, most of them rather top-down and dominated by officials or by NGOs with their own agendas (see Dayaratne and Moragoda 1991). Most of these projects have failed to achieve their objectives: the performance impacts have been mixed, at best; and even where the immediate results are positive, the sustainability of the improvements is questionable. Samad and Shivakoti (1994:31-33) attribute this to the lack of beneficiary participation in designing and implementing rehabilitation programs. NGOs are comparatively better but operate on a small scale.

Nepal has a variety of types of FMIS, in both the hill areas and in the plains (terai). Studies of several hundred FMIS and agency-managed systems show FMIS have higher yields and higher cropping intensities than agency-managed systems.⁴² Samad and Shivakoti (1994) report on a wide variety of institutions assisting FMIS following a variety of strategies. They conclude that comprehensive support services, i.e., that assist farmers with agricultural services as well as with improving water supply, which are backed by local initiative, do lead to improvements in agricultural production. Farmer-to-farmer training can enhance performance; and loans to FMIS supplemented with advice and assistance in agriculture had very positive results.

Physical improvements of irrigation facilities constitute a necessary but not sufficient condition for enhancing performance; both agricultural support services and institutional sup-

⁴²See especially Benjamin et al. (1994), who report statistical analyses of data on 127 Nepali irrigation systems, comparing the performance of FMIS and agency-managed systems.

port for local organizations are important as well. Support programs are often fragmented among different units of the government, and often supply-driven; these reduce effectiveness of support programs. The authors suggest the following measures will make support to FMIS more effective:

- coordination of different assistance programs
- decentralization of support provision
- integration of different kinds of support as a package
- farmer participation and investment from the planning stage onward
- private sector provision of commercial services
- legal and institutional support

Services to FMIS in the Philippines are decentralized and delivered as a package. These services are more effective than those found in some other countries; but Box 4.9 shows that their effectiveness can be improved.

4.6.4 Assessment Methodologies and Users' Perceptions

This theme has focused on developing practical and timely information systems based on farmer knowledge which strengthen support services and policy development for the FMIS sector. Rapid or participatory rural appraisal techniques and irrigation resource inventory and socio-technical profile methodologies have been developed and applied in action research programs.

IIMI has developed and applied methodologies for rapid rural appraisal for assessing irrigation management and irrigated agriculture by multidisciplinary teams. It has developed irrigation-related methods for semi-structured interviewing, system walk-throughs, and simple mapping and graphic presentation techniques (Groenfeldt 1989; P. Pradhan, Yoder, and U. Pradhan 1988). Process guidelines and illustrative checklists have been developed and applied in collaboration with government agencies and NGOs for decision support (Ekanayake, Navaratne, and Groenfeldt 1990; IIMI 1989e).

In Nepal and the Philippines, a method was developed to make an inventory of irrigation systems along river courses. The objective is to provide a practical information base to rationally allocate support services among scattered FMIS. The method involves a small team of individuals who map all diversions along a given river course and then briefly visit each system. A walk-through of the system is done, a sketch map of the system is made and similar information for each system is collected about the functionality of structures, the farmer organization, management practices, and needs for support services (WECS and IIMI 1990; Lauraya, Wijayaratna, and Vermillion, eds. 1994).

The irrigation resource inventory has recently been further refined and applied as a decision support tool in Nepal (IIMI 1994e; U. Pradhan 1994). The methodology is divided into three phases: a reconnaissance survey based on a streamlined checklist containing about 100

Box 4.9. Decentralized services to FMIS: Case study from the Philippines.

IIMI's research in several countries has emphasized the importance of effective support services to farmer-managed (including turned-over) irrigation systems. Zapanta et al. (1995) provide a detailed case study using primarily quantitative survey data of the effectiveness of one Provincial Irrigation Office (PIO) of the Philippines' NIA. The PIO is charged with supporting communal irrigation systems. The study documents the structure and management processes characterizing the Iloilo PIO, and a sample of client communal irrigation associations. Of special interest is its evaluation of how effectively NIA is implementing its participatory management program, and how effective the irrigation associations are in managing their systems.

The study says the staff are generally well-qualified, and despite low salaries and "managerial deficiencies," they are positively motivated and reasonably committed to their jobs. However, the authors find important deficiencies that result in lower than expected performance. The most important deficiency is the gap between the participatory ideology of service delivery which requires a decentralized mode of operation, and the continued centralization of authority at the regional and central levels. The PIO is responsible for carrying out most of the work related to developing and improving communal irrigation systems and supporting existing ones; but it must defer to higher levels for decisions and approvals. Central levels control and direct, rather than support, facilitate, and monitor the PIO's work.

Within the PIO, the study also finds problems. For example, there is no systematized management information system, and the office is not making the best use of irrigators' knowledge and experience. The financial management system is also not adequate: it too is overcentralized, and collection strategies for amortization repayments from irrigation associations are not very effective. The recruitment policies, support, and supervision of institutional development officers are also not effective.

In the survey of irrigators, a great deal of dissatisfaction with water services was expressed. Farmers on some systems expressed satisfaction—and in all but one case this was correlated with cropping intensities and rates of payment of service fees and amortization. Nevertheless, overall the cropping intensities on the sample communal systems ranged from 145 to 200 percent—higher than the "norm" of 130 percent and far higher than those reported in Bicol (Lauraya and Sala 1995a; Section 4.4.7, above). Zapanta et al. (1995) suggest there may be a linkage among the reported serious water problems, low ISF and amortization payments, and conflicts over water distribution, but note that more hydrological data are needed. Consistent with the Bicol findings, this study also found there was little involvement of irrigation association members in the institutional and technical work of the association; the pullout of the institutional development officers has led to reduced irrigator participation and rising communication gaps with PIO engineers.

The study concludes that NIA needs to make major changes in its organization to enhance the effectiveness of its participatory service delivery; and that continuing assistance is needed to strengthen irrigation associations. One specific suggestion is to assist the associations to develop agri-business ventures as sources of income both for members, and for the associations to pay ISF and amortization.

data variables used to short-list systems in a watershed or basin that are potential target systems; participatory rural appraisal (PRA) of the short-listed FMIS to prioritize the systems with the most potential for improved agricultural performance through either physical or institutional support; and reporting or reconciliation of the results for the users of the informa-

tion. The inventory then becomes a basis for making decisions about which systems should be assisted and what kind of assistance should be provided. This methodology is a revision and refinement of the earlier inventory approach; IIMI (1994e) reports on its application to two projects in Nepal. Socio-technical profiles are more intensive assessments of the management environments of irrigation systems, which have been developed for use primarily prior to rehabilitation or institutional strengthening assistance (IAAS et al. 1993).

The program in the Philippines developed and tested a methodology for water user association self-assessment of irrigation performance. This action research demonstrated the potential usefulness of the method both in monitoring system performance from the farmers' perspectives and in institutional strengthening; but implementing it on two systems proved difficult and time-consuming. The self-assessment method needs some external inducement for the farmers to continue the assessment process (Lauraya and Wijayaratna 1993; Lauraya, Sala, and Caceres 1994).

4.6.5 Privatization of Services to Pump Systems: Sudan and Bangladesh

Both Bangladesh and Sudan have long histories of heavy involvement of government agencies in pump-based irrigation. In Bangladesh, "minor irrigation" comprising low lift pumps (LLPs), shallow tubewells (STWs), and deep tubewells (DTWs) along with manually operated pumps are responsible for 80 percent of the irrigated area; and the rapid growth in private pumps is one of the major reasons for rapid growth in agricultural production and diversification in that country. From 1951 to 1979 the public sector dominated minor irrigation development; since that period the private sector has played an increasingly important role.

In Sudan, the government began to reduce its dominance of the economy beginning in 1991. This has included downsizing of the parastatal responsible for managing pump schemes along the White Nile, disbanding some parastatals altogether, and trying to encourage private firms to take over management of irrigation schemes. After 3 years the outcome of this policy was below government's expectations (Vermillion, ed. 1996: Section 2.5).

IIMI has carried out research on the privatization policies and their impacts in both countries.

Sudan. For various reasons, the performance and productivity of the agriculture sector in Sudan has been disappointing during the past decade; and productivity as measured by crop yields on the White Nile schemes is particularly low—cotton yields are half the national average for example. In this context, public organizations including the parastatal managing the White Nile schemes were facing serious financial difficulties. This financial burden and the low productivity of agriculture lie behind the government's privatization policy. In the pump schemes, this policy involves divesting of parastatal agencies managing the schemes and withdrawal of the state from provision of agricultural services—land preparation, input supply, harvesting, marketing of produce, and provision of credit. These functions are to be transferred to the private sector and farmer (tenant) organizations. It is important to note that irrigation facilities are *not* being privatized or turned over; they remain with the Ministry of Irrigation.

IIMI's work on privatization of irrigation schemes in Sudan is reported in detail by Vermillion, ed. (1996: Section 2.5), and summarized by Samad and Dingle (1995). There are 174 pump schemes on the White Nile, which irrigate about 151,000 ha. Detailed research was

carried out on 6 of them, including a questionnaire survey of a sample of 155 farmers. Two schemes each were managed by the private sector, farmer organizations, and the parastatal. Research was also carried out at the national level to understand the policy changes and their rationale.

The White Nile Agricultural Schemes Administration (WNASA) is a parastatal whose staff has been reduced by 75 percent and which now administers far fewer schemes than previously (about 90 schemes have apparently been completely abandoned). In principle, this firm is to be liquidated in future. The White Nile Holdings Company (WNHC) is the only private firm to have taken charge of White Nile schemes so far—and it has been highly selective in what schemes it takes. The government gives it 1-year rental contracts and specifies the crops and varieties to be grown, as well as continuing to control the irrigation facilities. In some schemes the tenant unions have been willing to go into partnership with WNHC (as required by government); in some they have refused; but only 6 percent of the sample tenants favored management by farmer organizations.

The study compares the performance of the six schemes under these three forms of management, using several parameters. Based on the responses to the survey of tenant-farmers, the “service delivery performance” provided by the parastatal is rated as superior to that provided by the private firm and farmer organization. The costs of the private firm’s inputs and services are nearly 50 percent higher than those in the other two types of organization. The two schemes managed by a farmer organization exhibited the lowest wheat yields. The schemes managed by the private firm received a better irrigation service, apparently because it invested in repairs to pumps and canals and consulted tenants on the irrigation schedule. There is no relationship between management mode and productivity per unit of water, however. Net returns per ha of wheat was highest on the schemes managed by the parastatal; returns on farmer-managed schemes was less than half, and the privately managed schemes’ net revenue was just 16 percent of the parastatal-managed levels (Table 4.6).

The authors conclude that the privatization policy is flawed, and should be implemented gradually; abrupt withdrawal will not lead to viable locally managed schemes. Further, under present macro-economic conditions, takeover of these pump schemes by tenants or private firms is premature. The results of this study stand in considerable contrast with the results of research in Bangladesh.

Bangladesh. From 1993 to 1995, IIMI carried out a detailed study of privatization of minor irrigation in Bangladesh, in collaboration with the Bureau of Socio-Economic Research and Training of the Bangladesh Agricultural University; the results are reported in detail by IIMI and BAU (1996) and briefly summarized by Mandal and Parker (1995). The study was carried out in five districts representing a range of levels of pump irrigation development. Questionnaires and sampling schemes were devised to collect data from pump owners, irrigating farmers, wage laborers, mechanics, equipment dealers, and other input and service suppliers; and a sample of pumps was selected for technical measurements of their performance.

Bangladesh’s privatization policy has included:

- a shift in distribution of equipment and inputs from the public to the private sector
- liberalization of equipment imports

Table 4.6. Net returns for wheat crop by management modes, Sudan, 1993-1994.

	Units	Parastatal managed	Private company managed	Farmer organization managed
Yield/hectare*	kg	893.00	833.00	714.00
Sale price	\$/kg	0.165	0.165	0.165
Gross returns	\$	147.00	137.00	118.00
Production costs				
Seed	\$	22.00	22.00	22.00
Fertilizer	\$	28.00	37.00	20.00
Chemicals/spraying	\$	12.00	25.00	12.00
Sacks**	\$	3.00	2.60	26.00
Land preparation	\$	10.00	12.30	9.50
Desilting irrigation canals	\$	1.60	2.00	1.40
Harvesting	\$	10.00	16.00	14.00
Hired labor	\$	5.00	2.20	6.00
Other costs	\$	4.00	0.00	2.00
Administration charges				
Harvesting fee	\$	0.00	0.00	1.40
Land and water	\$	8.40	8.40	8.40
Management charges	\$	1.60	3.00	2.00
Total costs	\$	105.00	130.00	100.00
Net returns	\$	42.00	7.00	18.00

*modal yields ** bags for collecting/storing harvest.

Exchange rate: US\$1.00 = Sudanese pounds 425. Based on survey data and scheme management records.

Source: Vermillion, ed. (1996:132, Table 6).

- dropping subsidies on equipment
- the sale of publicly owned pumps

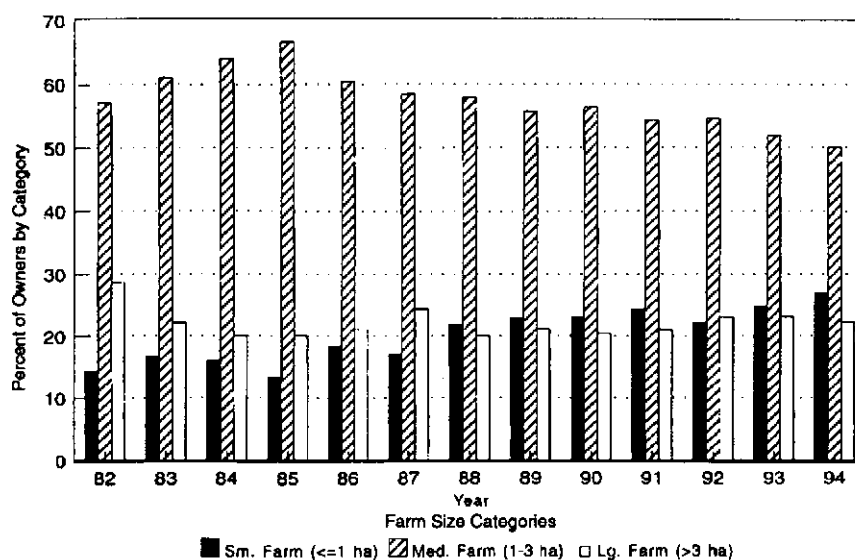
The first two of these policy changes have led to the rapid growth of shallow tubewells (STWs) and to some extent low lift pumps, a growth that has been shared by small farmers. Declining subsidies on deep tubewells (DTWs) and attempts to sell them, however, have revealed that they are not financially viable without subsidies. Liberalization has led to an expansion in availability of irrigation equipment and a significant reduction in prices. The total area irrigated by STWs in particular has expanded rapidly, and a competitive water market has developed, leading in turn to improved efficiency and lower water rates in the intensively developed areas. Financial analysis confirms the solid profitability of STWs, particularly of the inexpensive though less durable Chinese engines which have come into the market. All of

these benefits of STWs are in sharp contrast with the case for the 34,000 DTWs, which are now found to be unprofitable, spare parts are not always available, and in many cases DTWs are being outcompeted by STWs.

What about the impact of liberalization on equity? The study finds that small farmers (<1 ha) form a growing proportion of pump owners, as the availability of inexpensive equipment in a range of sizes has enabled them to increase their purchases (see Figure 4.9); and both male and female rural workers seem to have benefited from increased employment opportunities resulting from the expansion of irrigation. It is not that the serious socioeconomic inequities characterizing rural Bangladesh are being reduced significantly; but the overall trend in a more privatized setting is positive (IIMI and BAU 1996:118).

With the exception of input supplies and some mechanical and information services, in general services for minor irrigation were found to be weak at local levels. Credit is an especially serious problem; but training for mechanics, information and advisory services, and electricity service are also significant constraints. The study proposes a pilot project to experiment with alternative credit delivery systems. Its recommendations also include suggestions for reducing an apparent mismatch between engines and pumps that leads to high operating costs, encouraging manufacture of spare parts, a program for training and certifying mechanics, provision of local-level aquifer information, and phasing out of DTWs in areas where STWs are technically feasible.

Figure 4.9. Shallow tubewell ownership by farm size—Percent of owner categories in each year, Bangladesh.



IIMI/BSERT 1994 sample of 130 STW pump owners in Dogra, Comilla, Faridpur, Hobigani, and Nilphamari Districts.

Source: IIMI and BAU (1996:124, Figure 1).

4.7 Economic Impacts on Poverty, Food Security, and Development

Economic impacts of irrigation, and the contribution of irrigation to food security and as an “engine of development” are new themes in IIMI’s research program. They have not been addressed systematically in the past; most research has sought to find ways to improve irrigation performance in an operational sense, taking for granted the results will have positive economic and social impacts. IIMI has also been aware that others, for example IFPRI, were doing research on these issues, and therefore chose to put its limited resources elsewhere. In future, IIMI will have more to report under this heading; but for the record, the few relevant studies are briefly discussed here.

4.7.1 Country Studies: Sri Lanka

In Sri Lanka, three studies have been done related to the economic impacts of irrigation development, two of which have already been discussed. A detailed study of irrigation investment trends determined that while past investments in constructing new schemes had given very high returns in the past, under current conditions new construction is not economical; but the benefits of investments in rehabilitating existing schemes are potentially quite high (Section 4.2.2). IIMI also carried out a detailed impact evaluation of a \$100 million investment in the Kirindi Oya Irrigation and Settlement Scheme which found that the estimated economic rate of return (ERR) is just 6.3 percent, far short of the originally estimated 17.6 percent ERR or the revised estimate of 13.6 percent. Crop production and employment generation fell far short of expectations; but the study did not adequately evaluate social impacts of the project (Section 2.5.3).

Wijayarathna and Hemakeerthi (1992) studied the trends in production and profitability of rice in Sri Lanka. Just after independence in 1948, Sri Lanka produced only 40 percent of its total rice requirement. A variety of policy instruments including heavy investment in irrigation resulted in rice self-sufficiency levels reaching around 90 percent by 1985, a level that has been roughly maintained to date. In 1983, average productivity reached 3.6 metric tons per ha; but this is far below the technical potential (as demonstrated by researchers); more important, yields have stagnated since the mid-1980s as have area harvested, cropping intensities, and total rice production.

Even with rapid inflation of costs, gross returns to rice farming have increased in Sri Lanka over the years. But net returns have increased only marginally overall and are very low, with considerable variation among districts and water regimes. In areas with a reliable water supply, rice production is becoming more capital-intensive, lowering returns per unit of land. In a country where a large proportion of the population still depends on rice farming on small holdings to survive, with few off-farm employment opportunities, these trends are a cause for alarm.

4.7.2 Global Trends

A group of staff members led by the former Director General published an overview of basic irrigation trends, to place into a context IIMI's Medium Term Plan for 1994–1998 (Samad et al. 1992). That article highlights the importance of increasing yields of irrigated agriculture to meet future food needs and to reduce poverty; but notes this improvement must be made in the context of decreasing quantity and quality of water for irrigation. The “efficiency” (i.e., productivity) of irrigation must therefore be improved. Samad et al. (1992) argue that achieving such improvements will require effective policies, organizations, human resources, and technology, and relate IIMI's research programs to these means to improve irrigated agriculture.

Shortly after this article was published, IIMI commissioned a study of demand and supply of food up to the year 2050 with special reference to the role of irrigation. Yudelman (1993) provides a detailed report on the results, while Yudelman (1994) summarizes the key findings and implications.

Yudelman notes that projections of future demand and supply of food for the next half century “are exercises in ‘futuology’.” The key area of uncertainty, affecting all other projections, is population growth. While observing that population growth rates are declining rapidly, Yudelman nevertheless projects a world population of 8.415 billion by 2025, a level that is slightly higher than the United Nations or recent IFPRI projections (Rosegrant, Agcaoili-Sombilla, and Perez 1995:3, Table 1). Based on these projections, some of his major conclusions are:

- The basic needs of all people could be met if available food supplies were evenly distributed. Failing this, much higher growth rates in supply are needed than found at present to meet the basic nutritional needs of all citizens.
- Demand for food in the developing countries is expected to grow by an average of 3.1 percent up to the year 2000, 2.5 percent up to 2025, then less than 2.0 percent up to 2050. Demand for *cereals* will be slightly higher but will show similar declining trends; demand for wheat and coarse grains will grow at much higher rates than the demand for rice.
- Taking both supply and demand into account, the following regional scenarios up to 2025 are visualized:
 - ◆ severe constraints on food production in the Middle East and North Africa because of water shortages, with rising grain imports
 - ◆ rising imports of grains in sub-Saharan Africa, especially wheat, as it will be unable to raise its agricultural growth rate sufficiently to meet rising demands
 - ◆ uncertainty about China leading to a wide divergence of estimates of future cereal imports into Asia; required doubling of rice yields on existing areas probably not technically feasible.

◆ Latin America becoming favorably endowed for increasing output substantially

What will be the role of irrigated agriculture in meeting future demands? One measure of its importance is the share of the total value of food and agricultural output produced on irrigated land. Beginning with estimates by the Technical Advisory Committee (TAC) of the CGIAR of the annual value of crop production in developing countries between 1987 and 1989, Yudelman makes his own estimates of the irrigation share (Table 4.7). More than 30 percent of all food production (\$96 billion) was grown under irrigation; an estimated 46.5 percent of all grain and 57 percent of the total value of rice and wheat were produced under irrigation. These proportions will grow over time. Yudelman anticipates irrigated area globally will continue expanding at the slower rates of the late 1980s; this slower rate will necessitate improving the efficiency of existing systems to raise yields (Yudelman 1993:74). He expresses concern that while the pressures for increases will be highest in Asia, the potential for further expansion is quite low in this region.

Yudelman is at best cautiously optimistic about meeting future food demands. He concludes his study with a number of recommended irrigation research topics. These include the following:

- improving the database on irrigation and related issues
- completing work on performance assessment frameworks and indicators, and applying them to ongoing systems
- research to examine how to improve institutional capacity and sector management
- assessment of the real potential for expanding area irrigated, and expanding total output of irrigated lands
- the implications of urbanization and growing competition for water and how this can be managed
- research on the optimal size of future irrigation systems

Table 4.7. Estimates of value of food and agricultural crop production and percentages grown in developing countries on irrigated land in 1988-89.

	Value (billions of dollars)		
	Total area ^a	Irrigated ^b	Percentage grown on irrigated land
All crops	364.2	104.1	28.5
Food crops	310.8	96.1	30.9
All grains	148.3	69.1	46.5
Rice and wheat	117.1	67.1	57.1
Wheat	31.1	15.5	50.0
Rice	85.9	51.6	60.0

^a TAC; ^b Yudelman's estimates.

Source: Yudelman (1993:76, Table 4.3).

4.8 Gender Analysis

4.8.1 Introduction

IIMI's work on gender analysis was initiated only in 1993. Therefore, the work is still at an early stage, and results are only beginning to be produced. To date the outputs are of two types:

1. Papers that review previous literature and attempt to establish the place of gender analysis within the broader field of irrigation management (e.g., Zwarteveen 1994, 1995a, 1995b, and 1995c)
2. Case Studies based on detailed field work in specific countries (e.g., Zwarteveen and Neupane 1995; Athukorale and Zwarteveen 1994; Jordans and Zwarteveen 1996)

Gender is one of the key "structuring principles" of human society, and particularly of agricultural production (Zwarteveen 1994:2). When this principle is ignored, as it is often, it leads to wrong assumptions about the nature of the household, and the interests of water users. For example, much of the planning, design, and management of irrigation systems, and research on irrigation management, assumes a unitary household, consisting of two able-bodied adult members plus children, and dominated by a male farmer; and irrigation developers assume raising the male farmers' income leads to improved well-being of the family. Using examples drawn from studies around the world, Zwarteveen (1994, 1995b) shows these assumptions are often not correct, and projects based on these assumptions often lead to unintended outcomes and lower performance than expected. Within a household, men and women have different roles and priorities, and these vary considerably among as well as within societies. Increasingly, women are the real farmers as men take off-farm jobs. This "feminization of agriculture" is an increasingly important process in developing countries.

Gender structures *access* to irrigation water and other resources in different ways in different societies. It structures *perceptions and evaluations* of the objectives and quality of irrigation and other services; and it structures the *impacts* of irrigation. Men generally control the provision of services, control households and other assets, and operate in public contexts more freely than women. Women are often "invisible" and their interests are assumed to be the same as those of male farmers. But women often have different perceptions of the priority objectives of irrigation, of what is meant by "adequacy," and what the timing of irrigation deliveries should be. Wrong assumptions about the roles and relationships of men and women have led to failed irrigation projects in some parts of Africa, and unanticipated changes in women's workloads in Asia, for example.

4.8.2 Gender Analysis: Case Studies

The approach taken in IIMI's field research on gender is based on a framework developed for gender analysis in agriculture by Feldstein and Poats, eds. (1989; see Jordans and Zwarteveen 1996; Zwarteveen 1994). The framework poses three sets of questions:

1. Analysis of activities: who does what, when, and where?
2. Analysis of resources: who has access to or control over resources for production?
3. Analysis of benefits and incentives: who benefits from each enterprise?

The work has emphasized qualitative analysis of gender relationships at household, community and irrigation system levels, as a basis for understanding the processes and linkages which are otherwise "invisible." The Nepal and Burkina Faso case studies have recently been published; other results are based on unpublished papers and in Sri Lanka the research is not completed. An important theme in these studies is intrahousehold gender relations. In Asia, the division of labor based on gender is changing rapidly (Nepal, Sri Lanka, Bangladesh cases). A study in West Africa found an entirely different pattern of intrahousehold gender relations than is found in Asia, with important implications for the future productivity of irrigated agriculture (Box 4.10).

Nepal: Chhattis Mauja Irrigation System. Zwarteveen and Neupane (1995) report a restudy of Chhattis Mauja Irrigation System, a large farmer-managed system in the terai previously studied by Yoder (1994b; see Section 4.5.4, above). Their study focuses on the intra-household organization of production to identify who the water users are; and documents the level and nature of participation of women and men in water users organizations and the implications for system performance.

The nature and degree of women's involvement in irrigated farming are a function of the socioeconomic level of the household and consequent function of irrigated agriculture in the household's livelihood strategy. Households with sufficient off-farm income use hired labor or sharecroppers to substitute for family labor. In "rich" households the organization of agricultural production is either done jointly by husband and wife, or by the wife alone (the most frequent arrangement), as many males are employed elsewhere and more than half of the men had never farmed. In "middle class" households, women are most heavily involved in agriculture: agriculture is often done entirely by women while men earn a cash income; because they cannot afford hired labor, these families use exchange and direct family labor to a large degree. In poor households, there is less farm-related work as the holdings are small; all family members work on labor-intensive activities, often also arranging exchange labor. Overall, 80 percent of the farmers in the sample are women whose husbands are engaged in off-farm employment (Zwarteveen 1995a:89).⁴³ Most of these are in the head end of the system.

Chhattis Mauja is allegedly managed by the "users" through several levels of organization (Yoder 1994b). However, women never participate in any of the top levels—the general meeting, executive committee, or area-level committees. Female household members do sometimes attend village level irrigation meetings if their husbands are not available; but they rarely participate. The authors found one case of a woman *mukhtiyar* or village representative; but she resigned after 5 months because she could not work effectively. Given that there is a high

⁴³Zwarteveen and Neupane (1995:19) say "women (at least in the head-end sections of the Chhattis Mauja) constitute more than half of the user group." No precise figures are given anywhere, but the 80 percent figure probably refers to head-end farmers only, not the entire system.

Box 4.10. Gender relations, allocation of irrigated land, and productivity in Burkina Faso.

West Africa is the source of some of the most dramatic evidence that gender-skewed irrigation policies reduce the performance of irrigated agriculture. This is because the structure, decision-making processes, and labor allocation processes in West African rural households do not conform to the (often western) assumptions of policy makers and planners.

Zwarteveen (1996) describes a recently completed case study on the Dakiri irrigation system in Burkina Faso, one of the few in that country where some women (in addition to men) obtained irrigated plots on an individual basis: 60 women, constituting 9 percent of the total number of plot holders. The study compared households in which only men received irrigated plots to those in which both men and women received plots, to assess the impact on agricultural productivity, labor contribution patterns, and intra-household distribution of agricultural incomes.

The study found that the agricultural productivity of women's irrigated plots (in tons per ha of unhusked rice) is not significantly different from that of men's (in plots without problems women's plots are slightly higher, in plots with problems slightly lower). Since women are obligated to work on their husbands' plots, what is the effect on the productivity of *male* plots of women having their own plot? The study found that the average productivity of male plots in households where both a husband and at least one woman have a plot is somewhat *higher* than those in which only the man has a plot.* In households where the man and woman each has his/her own plots, labor productivity is 60 kg/person day on both plots—which is more than twice the labor productivity in households where only men have a plot. Therefore, efficiency of labor use increases sharply when women also have plots (and labor is a scarce resource in this area).

Finally, in households with female plot holders, women are able to contribute more to the household's welfare; both women and their husbands were unanimous on this point in interviews, and women expressed considerable pride in their achievements. Women with plots usually have three to four sheep and goats and often have a cow, while women without plots have only one to two goats or sheep and no cows.

Having an individual plot clearly enhances women's economic well-being, contribution to their households, and their bargaining position. The study therefore recommends allocating smaller plots separately to men and women instead of allocating larger plots to male household heads in future.

*The significance of the differences is not calculated but is probably not statistically significant.

degree of involvement of women in managing irrigated farms, does this lack of participation in irrigation management organizations lead to discrimination against women irrigators?

The study concludes that noninvolvement of female water users in the organization, rather than being a disadvantage to women, actually enables them to become free riders (Zwarteveen and Neupane 1995:15). Within each village (branch canal), female-headed farms get priority in water distribution, because it is believed they have more difficulty in arranging plowing and transplanting labor. In times of scarcity, women steal water—apparently more often than men do—and get away with it because they are not members of the organization. Women are better able to avoid irrigating at night, though they do so when necessary. Female-headed farms located far from the dam and main canal are also excused from providing emergency labor; they may make cash contributions but the value is often less than the going wage. Women in villages close to the dam do participate in emergency maintenance. Female-headed households therefore pay less in irrigation fees, are among the first to receive water, and are not sanctioned for water theft.

The performance of Chhattis Mauja does not appear to be suffering from the lack of participation of the "real users" in management; the authors confirm Yoder's (1994b) finding that system performance is good. The authors suggest performance could be improved in terms of reducing oversupplies to head-end canals if females did participate in (and thus were made subject to the sanctions of) the management organization. In this case, and contrary to received wisdom, exclusion of women does not have the expected negative impact on women; rather, it is positive from their perspective. Women have no interest in formal participation in the management organization.

The authors predict that as men become increasingly involved in off-farm employment, women will become increasingly involved in farming. But farming is a subsistence strategy, and its contribution to the household's livelihood will decrease over time. If this happens it will be important to involve women formally in the management organization to enforce rules and ensure continued resource mobilization.

Sri Lanka. IIMI is currently carrying out gender research on three irrigation systems of the dry zone of Sri Lanka. All three are systems in which "participatory management" is being implemented and therefore farmer organizations have been initiated (see Section 4.4.5, above). Here we find similarities to Nepal in terms of women's participation in agriculture and farmer organizations, but with different consequences.

First, as in Nepal, women are involved in a wide range of farming tasks; Table 4.8 shows that in both countries, in spite of cultural values limiting women to a relatively few tasks, women are involved in most agricultural tasks, including irrigation. Some activities shown in the Table as "mostly men" are increasingly shared by women (Athukorale and Zwartveen 1994:23).⁴⁴

Second, in Sri Lanka it is estimated that 20 percent to 30 percent of all farm households are headed by females, often widows, as land in Sri Lanka's settlement schemes is normally allocated to men; even in male-headed households, women assume a large share of the farming responsibilities. Women are largely responsible themselves for cultivating non-rice (cash) crops, and are heavily involved in on-farm water management including maintenance of channels, and often financial management. In the two settlement schemes, it is estimated that "at least 30 percent of the men are heavy users of alcohol, placing a great strain on households and their finances" (Athukorale and Zwartveen 1994).⁴⁵

Third, as in Nepal, women rarely participate in farmers' organizations. The authors report the women are supporters of the farmer organizations, and encourage their husbands to participate; but only a few women attend meetings and active participation is exceptional. There are two reasons: legal recognition of irrigator status tends to be limited to men except in those cases where women have inherited land title; and farmer organizations are projected as public organizations associated with male roles. Women actively participate in other community

⁴⁴Table 4.8 does not clearly distinguish cultural expectations and actual observed patterns, but the main point is that even tasks formerly considered as taboo for women, such as threshing in Sri Lanka, are now increasingly shared by women. This breakdown in "traditional" division of labor is reported by Jordans and Zwartveen (1996) for Bangladesh, and other research around the world.

⁴⁵An important difference between Nepal and Sri Lanka is that it is women in Sri Lanka who often work off the farm—emigrating out of the country to take domestic positions in the Middle East. Zwartveen (1995b) mentions this as an important phenomenon, but no data are yet available on its significance or impact.

Table 4.8. Gender division of tasks in irrigation in Sri Lanka and Nepal.

MAJOR CROP	SRI LANKA (Rice cultivation)	NEPAL (Rice cultivation)
First irrigation	women and men	mostly men
Ploughing	men only	men only
Cleaning bunds	women and men	women and men
Building bunds	mostly men	mostly men
Puddling	men only	men only
Leveling	women and men	mostly men
Making nurseries	women and men	women and men
Irrigating seedlings	women and men	women and men
Fertilizing	mostly men	women and men
Transplanting	mostly women	mostly women
Manual weed control	mostly women	mostly women
Chemical weed control	mostly men	mostly men
Thinning and secondary transplanting	mostly women	mostly women
Irrigating	women and men	mostly women
Harvesting/bunding	women and men	women and men
Threshing	men only	men only
Transport	women and men	mostly men
Storage: straw		men only
Storage: grain	mostly women	mostly women
Winnowing	women and men	women and men
Marketing	mostly men	mostly men
OTHER CROPS	SRI LANKA (Chili cultivation)	NEPAL (Wheat and maize cultivation)
First irrigation	women and men	women and men
Land preparation	women and men	mostly men
Bed preparation	women and men	*
Sowing/nurseries	mostly women	men only (wheat) mostly women (maize)
Planting	mostly women	*
Fertilizing	mostly men	mostly men (chemical fertilizer) women and men (manure)
Weeding	mostly women	mostly women
Irrigating	women and men	women and men
Harvesting	mostly women	mostly women
Cleaning/storage	mostly women	mostly women
Marketing	mostly men	mostly men

*No data are given in original.

Source: Zwarteveen (1995a:91, Table 2).

organizations where this is seen as legitimate, such as credit and funeral societies. Women were found to heavily influence decisions through their husbands, but the authors say women often have priorities in irrigation management not shared by men. The authors advocate training and awareness programs aimed at women, and reorientation of farmer organizations as community, rather than male, prerogatives.

Bangladesh. Bangladesh is a highly patriarchal society, in which women are dependent on men throughout their lives, and rules of *pardah* prescribe a marked gender segregation in tasks and activities. Nevertheless these rules are being increasingly challenged because of growing poverty and landlessness; there is also an increasing number of female-headed households, which have low incomes. Jordans and Zwartveen (1996) report on a study of the effectiveness of the strategy of the Grameen Krishi Foundation (GKF) which has targeted much of its effort to enhancing the participation and productivity of women in agriculture. The research was carried out in two of the seven regions where GKF is working, and focused primarily on female GKF group members and women of households involved in irrigated agriculture through a GKF pump program. The research consisted primarily of in-depth interviews and case studies; the sample included 30 women. The research was done in the context of Bangladesh's policy of increasing privatization of agricultural services (see Section 4.6.5, above).

The study finds a high degree of involvement of women in field tasks, as co-farmers with their husbands, as agricultural wage laborers, in group cultivation of jointly rented land, and as female heads of households. In spite of the loss of social status by not adhering to *pardah* norms, most of the women felt this was more than compensated by their increased income. Although women rarely participate in meetings regarding irrigation (such as the management of the deep tubewell), they reported only minor problems in getting access to water. As in Nepal and Sri Lanka, there is a marked shift in the traditional gender division of labor, with women increasingly involved in tasks previously reserved for males, including irrigation; as elsewhere they remain responsible for traditionally female tasks. But women have great difficulty in gaining access to land, credit and other agricultural services, and markets.

Women and men have benefited from increased incomes as a result of irrigation; but increased competition for land has led to a decrease in access for poor people, and a reduction in pastures. The authors report that GKF's programs to assist women to gain better access to land, credit, irrigation, inputs, and agricultural knowledge are having a positive impact.

4.8.3 Gender Analysis: Implications for Management Transfer and Water Rights

Zwartveen (1995a; see also 1995b) analyzes irrigation management transfer from a gender perspective. She notes that in most literature, water users are assumed to be male individuals, while in reality water users are organized into households with members of both genders having parallel, complementary, and sometimes conflicting needs and interests. Therefore, women and men are likely to be affected differently by management transfer and increasing reliance on markets. The introduction of market incentives through area-based fees and water pricing will affect water allocation, with a general shift from low-value uses to higher-value uses. Zwartveen argues the introduction of water pricing may increase female labor contributions (for maintenance or for cash crops to pay the fees) and decrease women's access to water. These costs are often not visible in economic analyses because women's time is often unpaid time.

Water users organizations almost invariably consist of men only. This is partly the result of legal structures and officials' perceptions of irrigation as the men's domain, and partly the result of local social structure and cultural norms. Women and men often have different as-

assessments of the costs and benefits of participation in water users groups. The Sri Lankan and Nepal cases discussed above show that about half of the users of the irrigation system are women, and are excluded from farmer organizations. This can be justified if men adequately represent women's interests, but Zwarteveen (1995a) argues that in Sri Lanka at least this is not the case. Women's exclusion, she argues, is "deeply constraining" and the simultaneous empowerment of men in local communities and dis-empowerment or marginalization of women may have serious impacts on women's well-being.

The restructuring process that irrigation management transfer entails offers an opportunity for critical reexamination of gender relations and redressing the perception that irrigation is an all-male affair.

4.8.4 Gender Analysis: Concluding Observations

It is striking that IIMI did no work on gender issues before 1992 (Basnet [1992], a study carried out in Pakistan, was the first "gender" study); and it is equally striking that in her review of literature on gender issues, Zwarteveen (1994) does not cite any IIMI research relevant to understanding gender issues. Indeed, she hints that some of IIMI's conceptual frameworks for performance assessment (e.g., Small and Svendsen 1992; Bos et al. 1994; see Sections 2.2.1, 2.2.3, above), although appearing gender-neutral, in fact reflect an implicit gender bias regarding the interests of irrigation users. Through documentation of several cases and integrating research results from around the world, the first 2 years of IIMI's work has raised awareness of gender issues, and has raised important questions for further research.

Research on gender issues in irrigated agriculture is at the same stage as work on "farmer participation" was in the early 1980s: a lot of different cases and examples, but no overall conceptual framework or theory has yet emerged. The research to date consists of modest case studies, based on small and sometimes skewed samples,⁴⁶ and with no overall framework that would permit comparative analysis in a more systematic manner. The more topical papers (e.g., Zwarteveen 1994, 1995a, 1995b), while raising important issues, and replacing "myths" about households and water users with observations about "reality," are based on citation of selected examples to illustrate points, making the generalizations open to doubt based on a single contrary case.

In the next stage of work on gender, it will be important to integrate gender analysis into the "mainstream" of research on other topics—something that has not yet occurred. The next stage should also put more emphasis on systematic testing of hypotheses, and on integrating gender issues into "action research" to test possible strategies for reducing biases and improving equity and performance.

⁴⁶The Nepal study does not tell us the number of sample households, but focuses only on head enders; the Bangladesh study is based on a sample of 30 households.

4.9 Conclusion

The Policies, Institutions, and Management Program is the broadest of IIMI's four programs. It is so broad that finding common threads is not easy. Further, except for the work on irrigation management transfer, much of the work is limited to a single country and while suggestive global or cross-national hypotheses emerge, the work is not sufficiently rigorous in terms of methodology and sampling to come to firm conclusions applicable on a global basis.

In a recent special issue of *Water Resources Development* highlighting IIMI's work, Anthony Bottrall (1995) makes several observations applicable to the studies discussed in this chapter. First, he notes that IIMI has maintained its focus on improving canal management even when some donors had turned their attention elsewhere; and commends the "refreshing willingness" to grapple directly with policy and politics. As Bottrall (1995:8) notes:

Because of irrigation's historical dominance over all other water-using sectors, irrigation management reform must lie at the heart of any attempt to develop an effective new framework for water resources development.

He expresses his hope that irrigation management research—and thus IIMI—will persist in its central task of exerting pressure for reform.

Organizational change and reform lie at the heart of much of the research reported in this chapter. The work on policy and bureaucratic impediments to improving performance in Pakistan, Sri Lanka, and Egypt; the work on irrigation management transfer in a large number of countries; and the work on gender issues, modest as it is to date—all this research is aimed at identifying and evaluating necessary reforms and the strategies required to achieve them. As advocated in Box 4.8, above, IIMI should examine more "radical" institutional options drawn from successful experiences and other sectors.

There is a strong theme in all this work valuing participatory approaches: farmer-to-farmer training; support for farmer-managed irrigation systems, strengthening local water users organizations, management transfer, participatory action research, and participatory methods for policy development. This reflects values held by many researchers in common with a large number of development specialists around the world. It is likely IIMI staff will continue to be advocates for particular reforms.

Nevertheless, one clear direction for future work will be to systematically and objectively evaluate the results of management transfer, gender programs, and the introduction of other reforms in the water sector. Policy makers cannot rely on values and hopes alone, and need to have hard evidence on the real results of these reforms.

Another clear direction is that research should be less-fragmented among numerous topics, and more focused on a few key issues. Management transfer is one component, albeit an important one, of a larger political, social, and economic restructuring process underway in many countries, and must be studied in this context. As the quotation from Bottrall above emphasizes, irrigation reform must be integrated with reform of water resource management. This requires a more holistic approach to water management and specific attention to the relationships between irrigation and other uses of water. Studies to understand the reality of water availability and demand through developing improved water databases and analytical

tools will be an important new direction in this Program. Related to this more holistic approach, much of IIMI's future work will be carried out in a *water basin* perspective, rather than treating irrigation systems in isolation.

As indicated in Section 4.7, in the future IIMI will also increase its work on the impact of irrigation on poverty, food security, and economic development. Current efforts to develop a global database on water resources and irrigation potential will constitute one contribution to this area as it will provide a tool for targeting future irrigation investments. Related to this work will be more emphasis on policy options for optimizing the productivity of water, including the allocation of water among competing uses. An important question is how to make the best use of market forces to achieve both higher productivity of water and more equitable access; another is to evaluate the conditions affecting the results of alternative mechanisms such as administrative control and common property regimes.

Finally, it is clear that, in future, policy and institutional research will be more explicitly cross-national (comparative) and more rigorous in its methodology. Its results, and its recommended options based on those results, will therefore have a firmer scientific basis and global applicability.

CHAPTER 5

Research Results: Health and Environment

5.1 Evolution of the Program

This is the newest research program. Before 1994, IIMI's interest in environmental issues was implicit and country-specific. Its research on waterlogging and salinity in Pakistan was the only serious environmental work, but this was (and remains) subsumed under its work on management of irrigation systems and has been limited to that country. Research on watershed management, discussed below, was initiated in 1993.

Interest in health was also informal and unfunded prior to 1994. IIMI co-hosted a workshop on vector-borne diseases in 1985 but this was opportunistic, to support an interest of Sri Lankan researchers working on malaria at a university near its former headquarters.

The Medium Term Plan for 1994-1998 recognized "Environment and Health" formally as research areas, but as a single "crosscutting theme," not a specific program. At least two consultants were engaged to suggest work on environmental issues, but these did not lead to concrete results. Work on environmental issues has remained largely country-specific. But IIMI did initiate a modest program on water-related health issues by recruiting an associate expert with donor support, which is growing into a major effort.

Research on waterlogging, groundwater management, and salinity continues to be carried out primarily in Pakistan, and has been reported in Chapter 3. The other major environmental topic is watershed management, primarily in Sri Lanka. This work is reported below (Section 5.3), as is the work to date on health issues (Section 5.4). Section 5.5 briefly discusses future directions of this Program. The next section describes the intellectual framework for the Program.

5.2 Interactions of Irrigation Systems and Their Environments

Irrigation systems interact with their environments in many ways; the environment has effects on the irrigation system, and the system on the environment. Interactions may be direct and indirect, and may be perceived by different stakeholders as positive or negative. Water is drawn from a source, land is terraced or leveled, new aquatic habitats are created while old ones may be destroyed, natural vegetation is replaced by others, and with all this, the human population support capacity is increased. Most changes are probably not adverse from the point of view of society, but whether they are positive or negative must be evaluated case by case.

Abernethy and Kijne (1993) have proposed a classification of these irrigation-environment interactions, based on two dimensions:

- the degree of control which the irrigating community possesses over the interaction process
- the degree of benefit the irrigating community might expect to gain if the interaction process is amended

Four categories of interactions result, as follows:

1. *Irrigation-environmental interactions which can occur entirely within the domain of the irrigation system and affect its production capacity:* The major examples are salinization and waterlogging. Because these reduce the productivity of the system, in principle, users should have both the self-interest and means to reduce or control the process. This is the reason this topic is addressed under the Design and Operations Program.
2. *Environment change outside the system affects the production capacity of the system:* An example is degradation of the upper catchment areas which are the source of the irrigation system's water. Here, the system's users may want to seek remedial action, but generally the users and managers do not have the authority (control) to do so. An issue addressed in IIMI's watershed management program (Section 5.3) is, how such a community of interests between upper and lower regions of a water basin can be created.
3. *Actions taken within the system by the users cause environmental changes outside the system:* Examples are changes in water quality downstream because of the use of agrochemicals, and changes in river flows due to abstraction by irrigators. Here, users and irrigation managers have the capacity to amend these processes, but may lack the motivation either because such amendments will have costs or because they are unaware of the downstream consequences.
4. *Environmental changes that occur entirely within the system which do not reduce its productive capacity but which are considered undesirable for some non-agricultural reason:* Examples include changes in the overall aquatic environment, loss of wetlands, or changes in particular plant or animal species. Increases in the vector hosts or parasites of certain diseases fall into this category. The actions to mitigate these impacts are within the scope of the system's users and managers but their motivation will depend on the degree to which they are affected directly.

Abernethy and Kijne suggest the chances of improving interactions through management are likely to be strongly influenced by the dimensions of control capacity and economic motivation. However, they note that the observed levels of success are low even in those categories that affect the economic performance of irrigation, such as salinization in Pakistan. This

suggests that current management institutions need to be reformed or complemented by additional institutional arrangements. For the present purpose, those falling into categories two, three, and four fall directly under the Program on Health and Environment. The classification system also helps understand the issues addressed in this Program in a water basin perspective.

Some problems crosscut these categories, for example falling water tables as a result of irrigation; this is not discussed by Abernethy and Kijne. They also do not discuss one additional logical combination, in which irrigators neither control the solution, nor benefit from amelioration (Figure 5.1).

Figure 5.1. Matrix of irrigators' control over irrigation-environment interactions and whether they will benefit from amendments.

Irrigators → ↓		Control the process?	
		Yes	No
Benefit from amelioration?	Yes	Waterlogging, salinity	Catchment erosion
	No	Downstream water pollution	Shortage of water for other uses

An example is shortage of water for other purposes in the water basin; nonirrigation users may solve this problem by unilaterally withdrawing water; irrigators therefore have no control, and receive no benefits. How to manage multiple use of water in systems designed for irrigation will be an important topic under this Program in the future.

5.3 Watershed Management

5.3.1 Introduction: Shared Control of Natural Resources (SCOR)

Researchers in Sri Lanka have long been aware that there are important interactions between the catchment areas above the reservoirs and water supply in irrigated areas. A pioneering study (Kariyawasam, Jayananda, and Kularatne 1984) had documented a reduction in water supply to a major reservoir as a result of the development of small reservoirs (called "tanks" in Sri Lanka) in its catchment. IIMI researchers had also hypothesized that the 40 percent shortfall in inflows to the new Kirindi Oya Reservoir may be the result of the development of small tanks in its catchment. But the opportunity to investigate these issues arose only after 1992 when IIMI was asked by the government and a major donor to develop a new project using a participatory project development approach modeled on IMPSA (see Section 4.2.3, above). The result is a project called "Shared Control of Natural Resources" (SCOR), being implemented in collaboration with the Government of Sri Lanka and a large number of national partners since 1993.

SCOR is designed to use participatory action approaches to integrate conservation of resources and improved production, i.e., simultaneously improve and sustain the natural resource base and increase production and therefore incomes of resource users. The focus is on *water-*

sheds as the basic planning and implementation unit; "watershed" is defined as the area of land surface that drains water into a common point along a stream or river (Wijayaratna 1995). SCOR tries to achieve these objectives by testing and promoting improved *technology* (for example better farming methods), better management of *natural resources* (soil, water, and forests), and *local institutional development*. These three are interdependent factors; therefore much of the work involves integrating better technologies for sustainable and productive use of resources, through new or rejuvenated organizations and institutions.

On the institutional side, a variety of innovations are being tried: formation of small "Resource User Groups" (RUGs, often informal, sometimes formalized); "Resource User Organizations" (RUOs), which are formal and often federations of RUGs; "Service Organizations," which are formal umbrella structures; for-profit farmer companies; and "Watershed Resource Management Teams" (WRMTs), which consist of government officials from various departments, researchers, and representatives of user organizations. WRMTs are chaired by a senior local government official, and provide the means for identifying problems on the ground and mobilizing information and resources to solve them.

SCOR is being implemented in two pilot watersheds: Huruluwewa, a water-deficit watershed in the dry zone of Sri Lanka, and Nilwala, a watershed with no water deficit (see Figure 2.8). Both watersheds are characterized by high population densities and areas of degradation. Much of the action work is carried out with communities in sub-watersheds. Because of the donor's and government's interest, it is fair to say the project has a strong emphasis on achieving agreed *implementation* objectives; hence the regular reports to the donor and government contain detailed data on such items as numbers and strength of the government organization, numbers and types of technologies adopted, numbers of trees planted, and number of policy changes made by the government.

However, the Project is being implemented in an *action research mode*. Therefore, SCOR considers the innovations being tried as hypotheses to be tested, and collects data on the processes, results, and impacts of the innovations. This research is at an early stage. The database is large, and many reports have been produced, but few of these are, as yet, "research" reports. This is a function of the early stage of the project (in operation for just over 2 years), and the initial emphasis on encouraging institutional development processes, gaining the support of government officials, NGOs, private firms and others, and training its own staff.

The SCOR approach is described in several papers (for example Wijayaratna 1994, 1995), and the *SCOR Monitor* Newsletter; implementation progress is reported quarterly (SCOR 1995). The use of Geographical Information Systems is described by Batuwitige (1995). Section 5.3.2, below, describes the results of one season of interventions on the water-stressed watershed. Section 5.3.3 presents the results of other work in the North Central Province of Sri Lanka that draws on the SCOR Project approach, but has developed and tested a methodology for selecting interventions in small tank cascades that enhances the productivity of water in watersheds.

5.3.2 *Water Management in a Water-Stressed Watershed*

Fernando, Hemakumara, and Ariyaratna (1995) provide a detailed account of a set of organizational and management interventions and their impacts in the Huruluwewa watershed for the *maha* (rainy) season in 1994-1995. The Huruluwewa Reservoir is a major tank in north central Sri Lanka with a command area of 3,639 ha. It is well known in Sri Lanka as a water-deficit tank. Cultivation was possible in just 9 of the past 11 rainy seasons (but in one of these only 15 percent of the area was cultivated). No cultivation was possible in 7 of the past 11 dry (*yala*) seasons and the full extent was cultivated with rice during the dry season only in 1994, an unusually wet year. Huruluwewa is supposed to get a supplementary water supply from the Mahaweli River through a 57 km feeder canal (which follows a natural stream, the Yan Oya). In the final 32 km stretch it passes through a cascade of three pre-existing small tanks. Over the years, the land adjacent to the feeder canal has been developed informally to grow both rice and high-value crops; these farmers tap the feeder canal through siphons and pumps. This illicit tapping has taken an increasing amount of water such that by 1993, no water reached Huruluwewa in the dry season, and only 10 percent reached in the wet season. The study found that land productivity along the feeder canal is high, though water productivity is low; while in the command area of Huruluwewa Reservoir the productivity of the land is low, but water productivity is high. The authors note that the administration of this feeder canal and the regulating tank cascades is fragmented between two agencies and is weak.

This is an example of category 2 problems in the classification system proposed by Abernethy and Kijne (1993; Section 5.2): a change outside the system affects the productivity of the system; the downstream irrigators would benefit from amendment but have no control. The SCOR Project staff organized farmers along the feeder canal and on the three small tanks it feeds, and linked them to existing farmer organizations on the irrigated areas under the Huruluwewa Reservoir. The Water Resource Management Team had also been organized, and the interventions were carried out through this Team, with full participation of farmers. There were two major interventions:

- Farmers were organized to make the maximum use of rainfall for land preparation rather than waiting for early rains; in the small tanks, attempts were also made to promote dry land preparation, and to introduce non-rice crops as well as permanent crops in well-drained soils.
- Through their organizations and better coordination of services and input supplies, farmers were encouraged to adhere to the agreed seasonal cropping calendar, which had been developed with their active participation.

Although not all went smoothly, there were significant improvements in performance in both the small tanks and under the Huruluwewa Reservoir. The authors state that in the feeder canal area the most significant achievement was the involvement of farmers in decision making, leading to more systematic cultivation; but there was no improvement in the percentage of water reaching the Huruluwewa Reservoir through the feeder canal. Clearly, the hope for improvements from linkages between upstream and downstream water users was not fulfilled. Achievements in the Huruluwewa Reservoir include:

- Nearly all farmers initiated land preparation with rainfall, and 85 percent completed all operations through sowing using rainfall for the first time in the reservoir's history, saving roughly 5.8 mcm of water (sufficient to irrigate a full rainy season rice crop on 617 ha).⁴⁷
- The net incremental tank storage expressed as a percentage of the total gross inflow to the tank during the season (to account for differences in rainfall) was improved from 51 percent in the previous year to 85.5 percent in the intervention year as a result of improved water management.
- The time period between first and last issues of water from the reservoir was reduced to 94 days (the range for the previous 10 seasons was 120 to 173 days).
- There are no reliable data from previous seasons on crop yields, but the researchers concluded yields in this 1994-1995 season were not very satisfactory: the median yield was 3.2 tons per ha, with 20 percent of farmers getting less than 2.5 tons per ha.
- The indicator "irrigation water duty," defined as the ratio between the total amount of water released for irrigation and the total area irrigated, i.e., the depth of irrigation water used to grow a crop on a given unit of land, was used to measure gross irrigation efficiency. The overall tank duty was 0.67 m, a low value by Sri Lanka standards, and the lowest recorded for a major tank in Sri Lanka for this season. There was considerable variation among sample units, from 0.61 m to 1.2 m, implying differences in the quality of management.
- Another measure of the quality of irrigation management used is Cumulative Relative Water Supply (CRWS), described above in Section 2.3.4. Actual measures of evaporation (using a pan, and converting using standard crop coefficients) and daily discharges were used; seepage and percolation and effective rainfall were estimated using Irrigation Department standards. In Figures 5.2 and 5.3, the straight line represents a perfect match of the water supply to requirements, i.e., the target; the actual can be compared to this standard to judge the management quality. The CRWS plots show a very good match of supplies and demand at the overall tank and left and right bank canal sluice levels, but considerable deviations on the center canal and at lower levels (compare Figures 5.2 and 5.3).
- On two of the three small tanks, although farmers did not adopt dry sowing as hoped, they did land preparation using rains, minimized tank issues leaving a substantial supply at the end of the season to be used in the dry season, achieved 100 percent

⁴⁷The Huruluwewa farmers are reported to have used the water saved to grow soybean on 804 ha, sharing land so all could farm using a traditional land sharing system (*bethma*) (SCOR Monitor, vol. 2, nos.1-2, January-August 1995).

Figure 5.2. CRWS at various measurement points, Huruluwewa, Sri Lanka, 1994–1995 wet season.

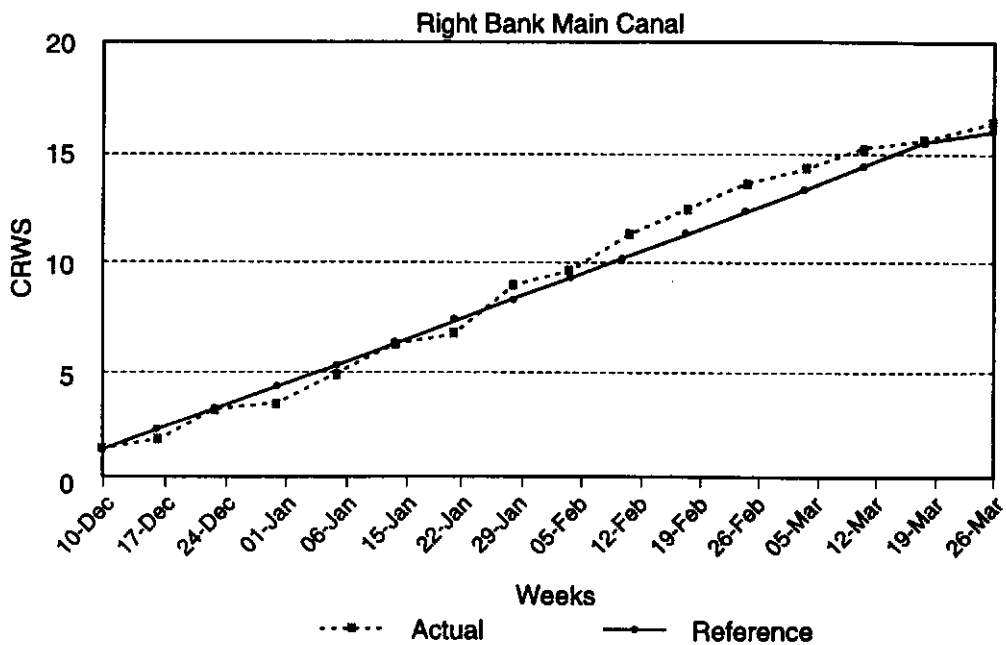
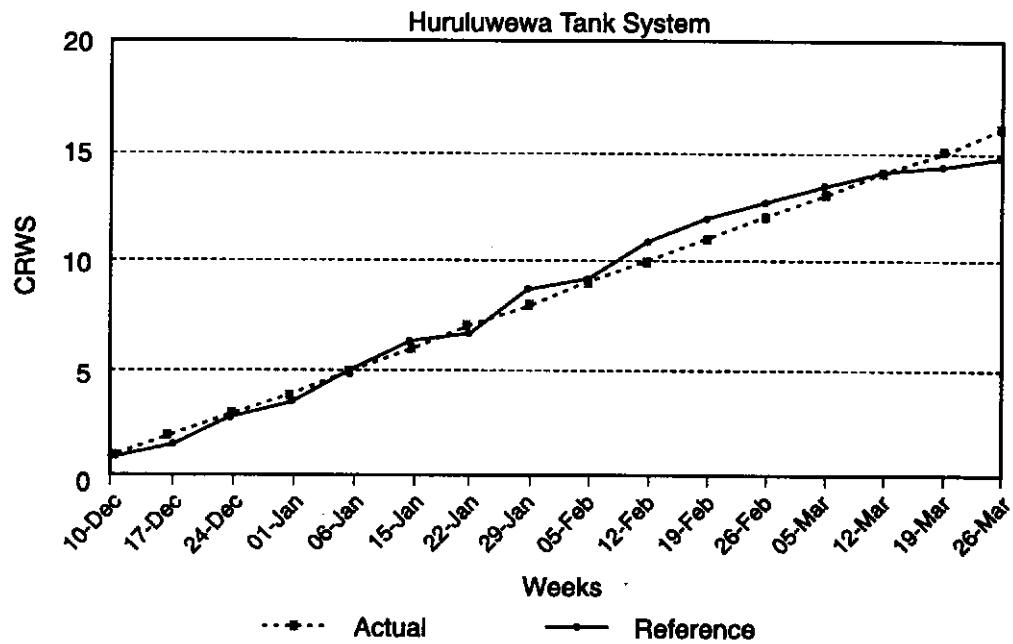
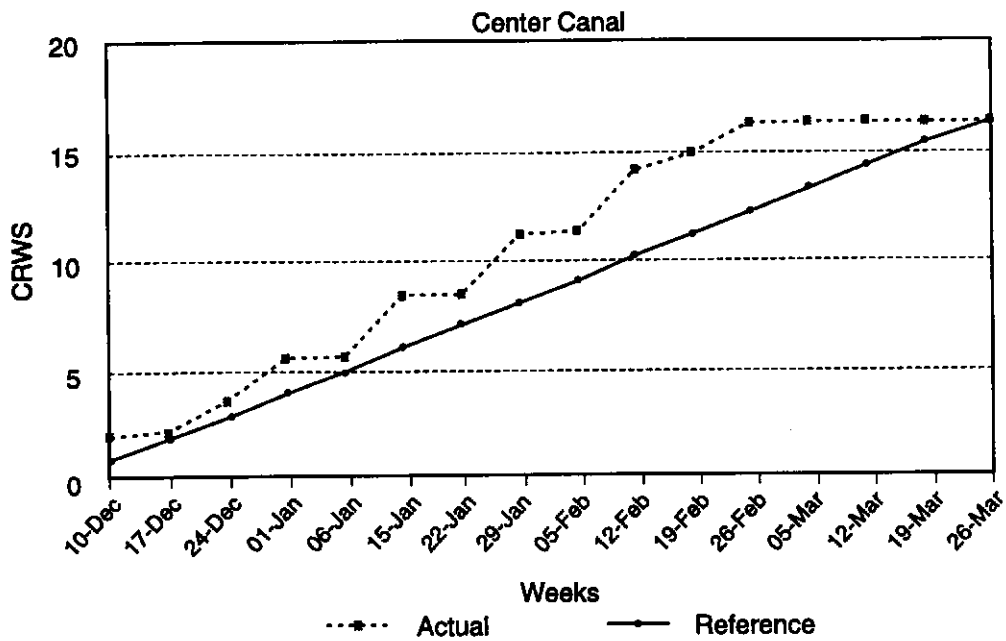
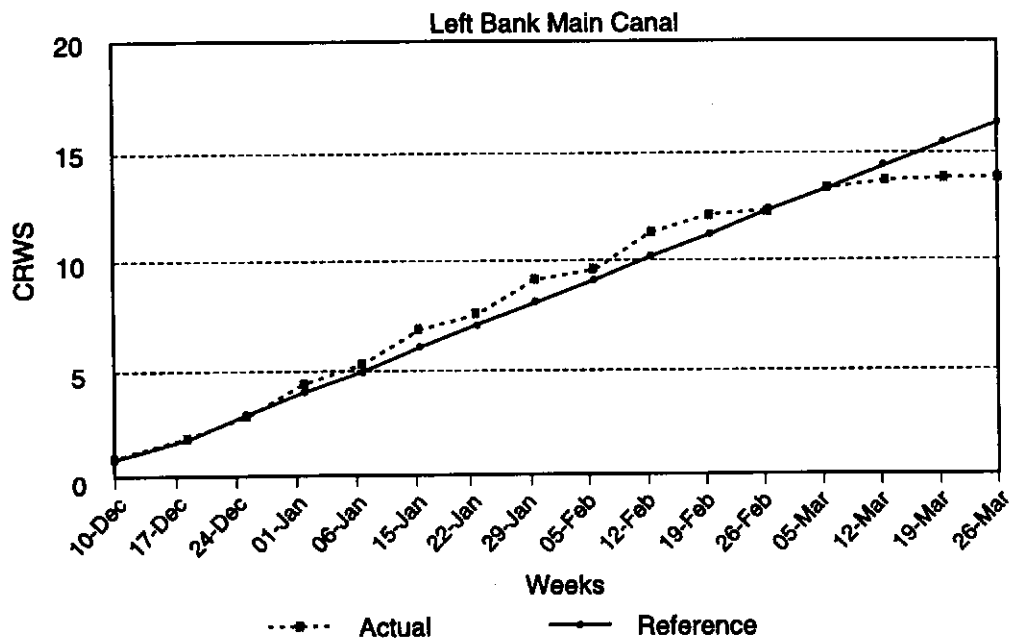


Figure 5.2. Continued.



Source: Fernando, Hemakumara, and Ariyaratna (1995:66, Figure 20).

Figure 5.3. CRWS for right bank sample areas, Huruluwewa Reservoir, Sri Lanka, 1994–1995 wet season.

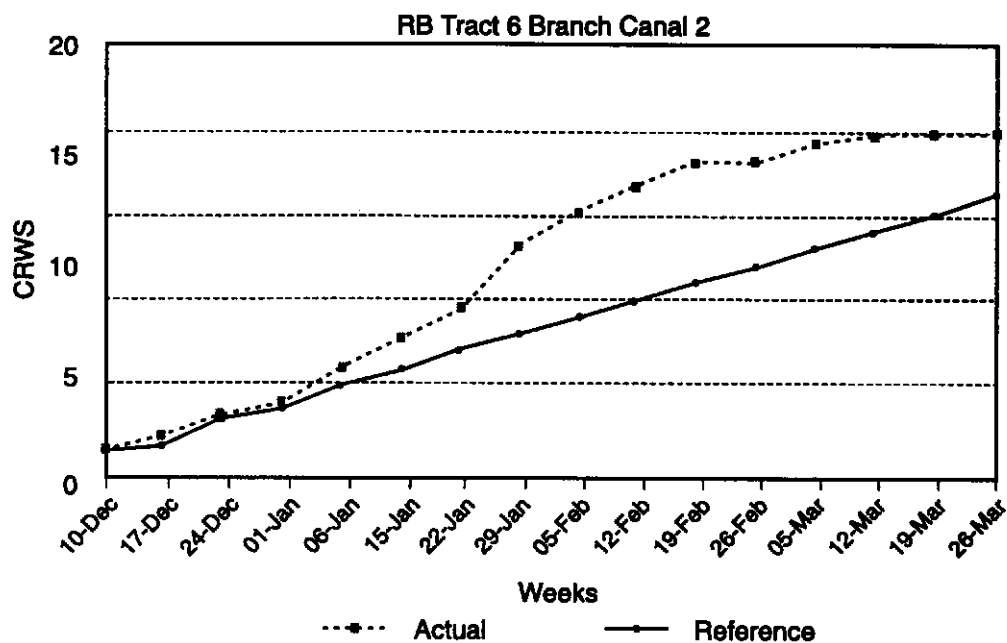
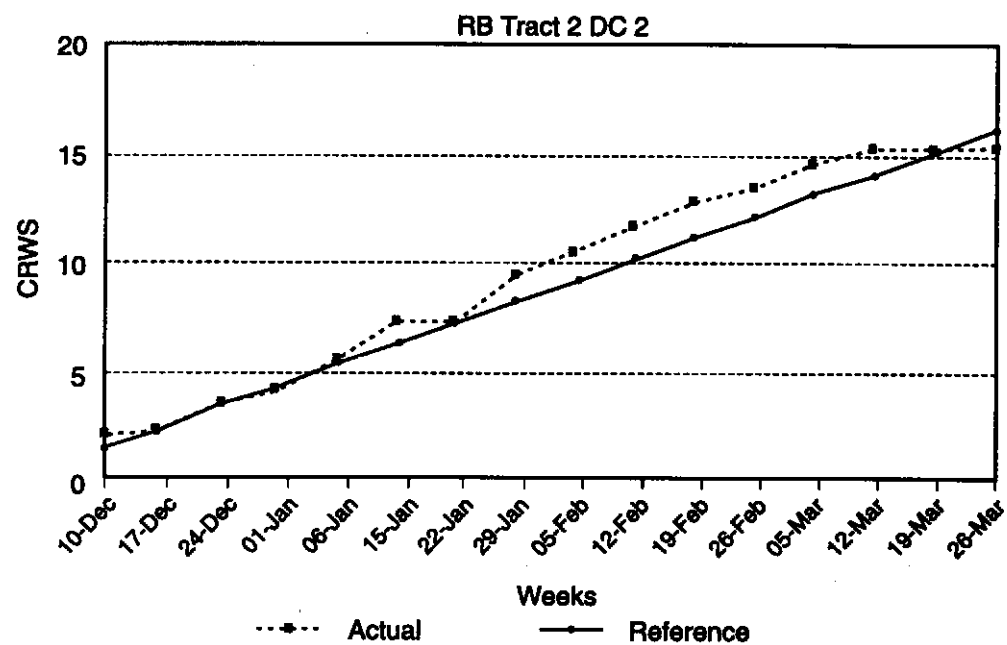
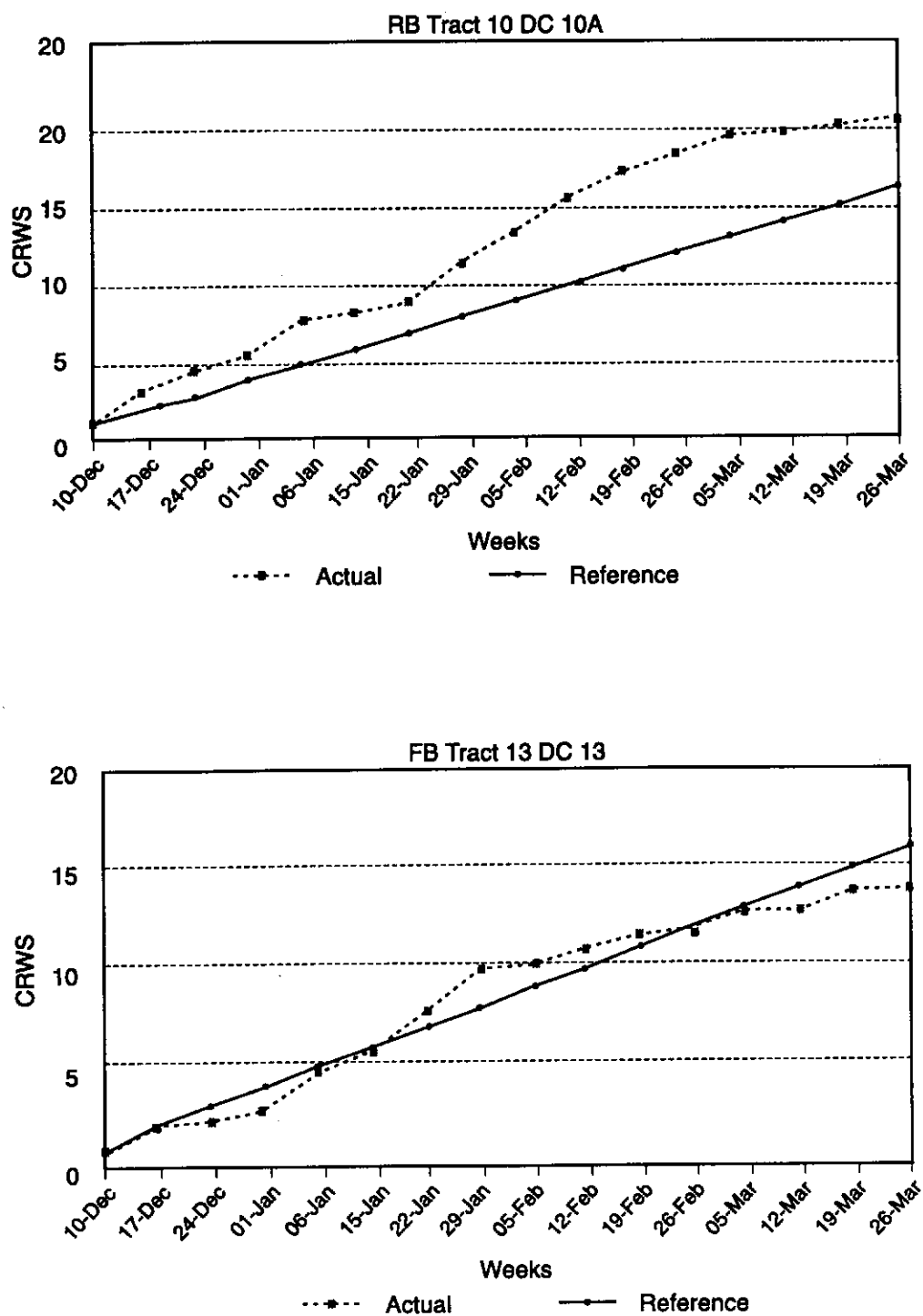


Figure 5.3. Continued.



Source: Fernando, Hemakumara, and Ariyaratna (1995:67, Figure 21).

cropping intensities as opposed to the usual 60-80 percent, and had substantially higher yields than ever before.

Fernando, Hemakumara, and Ariyaratna (1995) do not draw any specific conclusions from these achievements. They demonstrate clearly the potential for improved performance through management interventions made possible by stronger organizations. The sustainability of these improvements, or the degree of dependence on external stimuli, will become clear only in subsequent years.

5.3.3 Water Resource Development on Small Tank Cascade Systems

During the past 20 years, Sri Lanka has invested very large sums of money on rehabilitation of small tanks. As summarized by Sakthivadivel et al. (1995), evaluations and research have shown consistently disappointing results from these investments. The major reasons are that previous projects have taken individual tanks, and not watersheds, as the unit of development; and they have focused primarily on constructing improved irrigation infrastructure and not on what is needed for improving production and incomes. Some areas of Sri Lanka (as well as South India, Northeast Thailand, and other countries) are characterized by large numbers of small watersheds with cascades of small tanks capturing water to irrigate small areas; land and water are the key resources available, but rising population pressures are leading to increasing resource degradation and poverty. In 1994, a donor asked IIMI to investigate why rehabilitation of small tanks had not resulted in the expected benefits, and to suggest how water development projects should be designed and planned; in the following year, another donor asked IIMI to carry the previous analysis further and design the natural resources (i.e., water development) component of a larger area-development project for the North Central Province (NCP) of Sri Lanka (where the Huruluwewa watershed is located). The results are reported in detail by Sakthivadivel et al. (1994) and (1995), and by less detail by Sakthivadivel et al. (1996).

The overall recommended development strategy is based on the SCOR Project experience, combining an integrated approach based on watersheds emphasizing both conservation and production, with an emphasis on institution building using participatory approaches. The innovation introduced is a methodology and criteria for selecting small watersheds with tank cascades, and for identifying the appropriate interventions. Cascade-based integrated development, which may or may not include tank rehabilitation, is the basic approach advocated. The methodology combines an analysis of the hydrological endowment of the cascade, a modified Participatory Rural Appraisal (PRA) approach for identifying farmers' needs, interests and knowledge, and identification of a package of interventions that goes beyond irrigation infrastructure and takes a holistic approach similar to that of SCOR.

Sakthivadivel et al. (1994) provide detailed guidelines for characterizing tank cascade systems including surface water and groundwater potential, characterizing individual tanks and their potential for rehabilitation, characterizing organizational strengths and weaknesses and opportunities for improvement, and technical and economic analyses as bases for prioritizing tanks for rehabilitation. Sakthivadivel et al. (1995) carry this process further by providing a "scoring index" for assessing the land and water resources potential of cascades, and a guided PRA approach that brings together farmers on cascades (rather than limiting this to

individual tanks or village communities) and taps their knowledge and experience to identify problems and possible solutions from their perspective. The major PRA technique used was the drawing of a series of maps as a basis for analyzing problems and solutions. Bringing people together from different tank-based communities on a cascade was an important innovation (PRA is usually done at community level involving people who already have social ties and know each other). Farmers on the sample watersheds were able to identify a variety of solutions to problems faced, identify potential benefits of various interventions, and suggest improved institutional arrangements for cascade development and management.

The water resources development proposal emerging from discussions with farmers is validated using a computer-based simulation model developed by the researchers. This includes analysis of groundwater potential and optimal sites for agro-wells (Sakthivadivel et al. 1995). The authors provide detailed proposals for watershed-based interventions in the two districts of the NCP (which have different topographical and water resource endowments). The criteria for selecting small tanks for rehabilitation are based on the following three criteria (Sakthivadivel et al. 1996):

- maha (rainy) season cropping intensity
- ratio of tank catchment area to water spread area (tank area)
- ratio of command (irrigated) area to water spread area

The watershed or tank cascade approach to resource development in the NCP represents an advance over the previous individual tank-based approaches. Integrating investments in water resource development with the kinds of intervention being tested by SCOR should lead to more effective and sustainable development. If the development programs implemented based on these recommendations are successful, the results will be of interest beyond Sri Lanka. Sakthivadivel et al. (1996) explain the methodology for wider application.

5.4 Water-Related Diseases

One of the first workshops organized by IIMI was on irrigation and vector-borne disease transmission (IIMI 1986b). The focus of that workshop was on resource management measures. For some years IIMI has also participated in the WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM), but was unable to initiate research on irrigation-related health issues until 1993.

Vector-borne diseases such as malaria are an example of the fourth category of irrigation-environment interaction in the classification of Abernethy and Kijne (1993): changes occur within the irrigation system, do not (directly) reduce productive capacity, but are considered undesirable for a nonagricultural reason. Despite the recent start, preliminary research results have been produced and will begin to be published in 1997. Work to date has addressed two issues: the relationship of malaria and irrigation including the household costs of malaria infection; and pesticide poisoning in irrigation schemes. Most of the work has been in Sri Lanka

and to a lesser extent in Pakistan. The Sri Lanka research has been carried out in Huruluwewa, the dry zone watershed site of the SCOR Project (Section 5.3).

5.4.1 Malaria Vectors and Water Management

Malaria is endemic in Sri Lanka, particularly in the dry zone. The relationship of irrigation to the incidence of malaria is complex, as most dry zone settlements are associated with either small tanks or newer major irrigation settlement schemes; in the latter, people often come into the area with no previous experience with or immunity to malaria.

A large-scale entomological survey of a small tank ecosystem associated with the feeder canal in the Huruluwewa watershed was carried out in 1994-1995; results are just beginning to emerge (Amerasinghe et al. 1997; Konradsen 1996). Three major vector-occupied land use zones (stream—the 'feeder canal', tank, and drainage area) showed a major build-up of immature *Anopheles culicifacies*, the major carrier of malaria, within a fairly narrow time frame immediately preceding the main malaria transmission season (which occurs between November and January). Pooled waterways are the key to the breeding of these mosquitoes, and a complex shifting breeding pattern between streambed pools and rain-generated tank bed and drainage pools was observed during the pre-monsoonal rain shower period.

This pattern suggests that water management measures to reduce pool formation from July to September would have a positive effect in limiting the abundance of this vector just prior to the main malaria transmission season (Amerasinghe et al. 1997). For example, the illicit pumping from the feeder canal lowers the flow rate, and creates pools or slow-flowing water which is conducive to the breeding of *An. culicifacies*. A shift to agro-wells is currently being investigated as a possible solution. A planned streambed conservation program to reduce pools, and shading through encouraging more vegetation to reduce sunlight on pools are other possible interventions. The authors also suggest that tank bed rehabilitation—reestablishing indigenous practices of desilting, encouraging vegetation for shade, and reducing the digging of pits in the tank bed—could significantly reduce vector breeding opportunities.

Konradsen (1996) reports that comparison of one year when there was pooling of water and low water levels in the feeder canal with the following year when the water level was kept higher and more constant with no pooling, showed that malaria incidence varied significantly: the first year had a very high incidence, the second year a very low incidence. The current research is seeking to identify the critical minimum water level to avoid breeding of vectors.

5.4.2 Household Costs of Malaria

Researchers have studied the direct household costs of malaria in five villages in the same area, a traditional tank-based irrigation area. Sixty families were monitored on a bi-daily basis over a 1-year period (Konradsen 1996; Konradsen et al. 1997). Some of the findings can be contrasted with those of an exploratory study in the Chishtian subdivision of the Fordwah irrigation system, Punjab, Pakistan (Donnelly, Konradsen, and Birley 1996). The results include:

- The Sri Lankan community has a high knowledge of malaria and seeks prompt diagnosis and treatment at western type facilities: 84 percent make use of government facilities and 16 percent prefer private facilities. Very few seek indigenous cures. Nearly all households use one or more preventive measures such as house spraying or burning coils. These findings contrast with those in Pakistan, where more than half the sample of people interviewed seek care at private facilities; only 2 percent seek care from a government facility exclusively, making this less popular than traditional (indigenous) facilities.
- In the Pakistan area, less than half the patients who did go to a government facility had a blood film taken. Private facilities do not take blood films routinely. The official malaria statistics are likely to represent a significant underestimation of the incidence of malaria.
- The Sri Lankan community ranked malaria as the third most serious community problem after lack of irrigation water and poverty; 95 percent of the respondents consider malaria to be the most serious health problem.
- The direct expenditures of Sri Lankan households on malaria treatment are quite high, with an average of 1.2 percent of annual net household income per episode (some households spend as much as 10 percent of net annual income). These high percentages are largely a function of the low average incomes in the area. Because several episodes often occur nearly simultaneously this can become a large burden; families averaged four episodes per year. The highest expenditures were for special diets.
- Compounding the problem of expenditures, a large number of labor days are lost each year because of malaria (among other illnesses). Stress resulting from the illness was also identified as a significant problem.

5.4.3 Pesticide Poisoning in Irrigated Areas of Sri Lanka

An 8-month survey was also carried out on pesticide poisoning in a major irrigated area of Sri Lanka (Mahaweli System H) (Van der Hoek et al. 1996; Konradsen 1996). Acute pesticide poisoning is a major public health problem in Sri Lanka, and is especially serious in intensively cultivated irrigated areas. The study involved biweekly visits to 30 households, plus interviewing key informants, participant observation, and a review of hospital records. Selected major findings include:

- The incidence of serious acute pesticide poisoning in the sample area ranged from 2.6 to 2.9 per 1,000 population between 1990 and 1994; most patients were young adults, 70 percent were males, and 68 percent were suicides. In 1994, pesticide poisoning accounted for 29 percent and 50 percent of all deaths recorded in the two rural hospitals surveyed.

- People are generally knowledgeable about the use and hazards of pesticides but little such information is obtained from government institutions.
- Despite their knowledge of standard safety precautions to prevent exposure, few are used because of local problems: people find it too hot and humid to use gloves and other protection for example.
- The frequency of spraying, and the range of lethal pesticides used, are excessive by any standard—far beyond what is required or economically justified to control pests. The investments in agro-chemicals are very high, constituting a significant portion of annual family income, and crop failure after these investments can be so devastating as to lead to indebtedness.
- Repeating already known health messages and promoting practices that are not locally feasible will not solve the problem; the authors suggest designing an approach based on communicating the economic and agricultural benefits of reduced pesticide use; and restricting the availability of the most lethal pesticides.

5.5 Conclusion

The work on both watershed management and health issues is at an early stage. Much of the work so far has been confined to Sri Lanka, though some work has recently been initiated on water and health interactions in Pakistan and on watersheds in Colombia. The watershed management project in Sri Lanka, SCOR, is one of IIMI's largest in terms of budget and manpower, and indeed represents a significant proportion of the donor's current investments in Sri Lanka. To date, SCOR has fulfilled its developmental expectations but has only recently been turning more attention to the research output potential of the project. With sites in two watersheds having very different resource endowments, there is an important opportunity to produce research findings applicable beyond Sri Lanka.

Ultimately, the value of irrigation depends on its contribution to human well-being. The contribution of irrigated agriculture to meeting the food requirements of the world is clearly substantial. But this contribution can be maintained and improved only if irrigated agriculture is environmentally sustainable, and does not lead to poor health of people.

"Health and Environment" is potentially a vast topic, with many different kinds of issues and problems. But as a new program, and representing areas in which IIMI is still building its capacity, IIMI will focus its attention on a few key problems during the next half decade or so. Following the classification of irrigation-environment interactions proposed by Abernethy and Kijne (1993; Section 5.2, above), these problems are likely to include the following:

1. *Waterlogging and Salinity*—as part of the Design and Operations Program as these are issues over which system users and managers have control, and whose amendment will benefit irrigators (category one; see Section 5.2).

2. *Management of Water in Watersheds*—problems over which irrigators have little control, but stand to benefit from improvements. In a water basin perspective they are likely to be key questions for improving overall basin water use efficiency (category two).
3. *Water Quality*, in terms of both impact on, and impact of, irrigated agriculture (categories two and three).
4. *Irrigation-Related Vector-Borne Diseases*—that affect the irrigation community (category four).
5. *Management of Irrigation Systems for Multiple (competing) Uses* (not discussed by Abernethy and Kijne [1993] but see Figure 5.1, above).

Items 2-5, above, will be addressed primarily under the Health and Environment Program. The work on health will focus specifically on how water management affects vector-borne diseases such as malaria and schistosomiasis, and IIMI will both build its own expertise and establish partnerships with organizations specialized in health sciences.

The interactions of watersheds and irrigated agriculture constitute a complex multidimensional problem, requiring long-term research by interdisciplinary teams. IIMI does not have sufficient expertise in-house to examine all the issues involved. As is the case for IIMI's work on water and health, it will require partnerships with other CGIAR centers, specialized research institutes in developed and developing countries, and national institutions. The SCOR Project can provide a foundation to develop expertise and partnerships with others, frame increasingly sophisticated hypotheses on watershed (especially hydrological) processes and watershed-irrigation interactions, test these hypotheses, and test solutions through action research programs.

CHAPTER 6

Training and Institutional Strengthening

6.1 Introduction

The topic of this book is research. Nevertheless, “capacity building” or “institutional strengthening” has been so important that some discussion is required. Institutional strengthening has been at the heart of IIMI’s work throughout its first decade. During its first three years IIMI collaborated with the Economic Development Institute (EDI) of the World Bank to hold an annual 6-week multidisciplinary course on irrigation management for middle- and senior-level managers. IIMI subsequently recruited a Training Specialist to its staff. However, this did not evolve into a continuing formal training program, largely because the Institute did not feel it had a comparative advantage in this area.

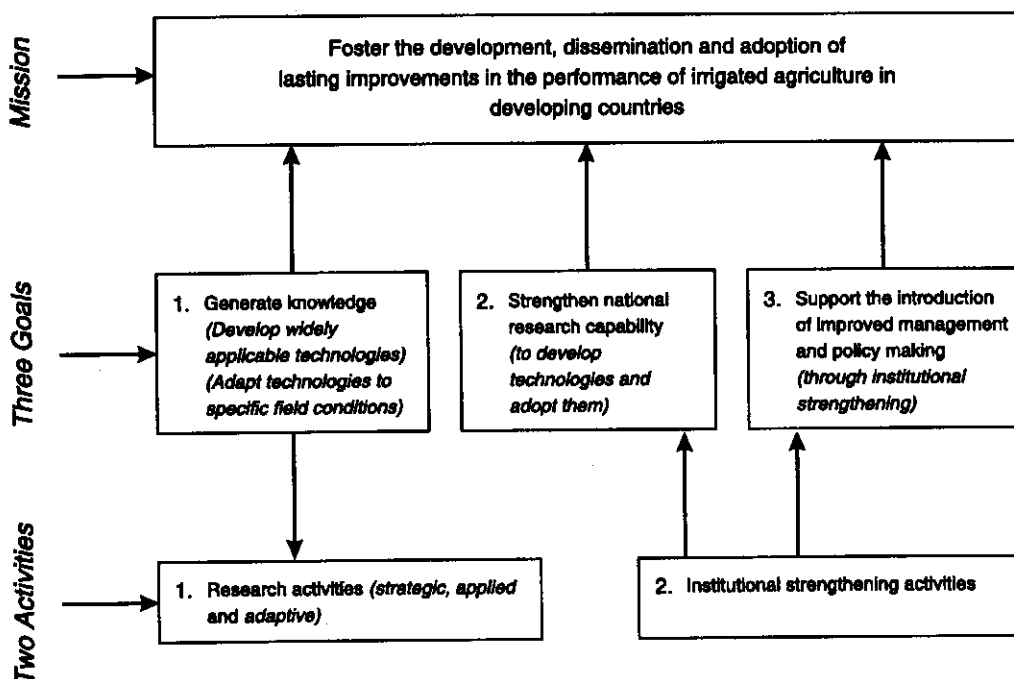
Most of the activities in its country programs have traditionally had institutional strengthening as a key objective—often *the* key objective. The major institutional strengthening efforts have been in collaborating countries, not at a global or even regional level. The research and institutional strengthening programs were and remain inseparable at the country level. The strengths and weaknesses of one cannot be understood without understanding the other.

These strong linkages between research and institutional strengthening have been discussed in previous chapters. Indeed, two of the three goals articulated in the 1994-1998 Medium Term Plan (IIMI 1992) relate to strengthening national *research* capability, and to supporting irrigation policy and management organizations’ *implementation* capacities. The relationships among IIMI’s activities, three goals, and mission are illustrated in Figure 6.1. The following activities already discussed in previous chapters had institutional strengthening as one of their key objectives:

- the Irrigation Management Policy Support Activity in Sri Lanka (IMPSA, Section 4.2.3)
- participatory action research in Sri Lanka (PAR, Box 4.4), Nepal, and Philippines
- the watershed management project in Sri Lanka (SCOR, Section 5.3)
- the work on Irrigation Management Information Systems in Sri Lanka, Pakistan, and India (IMIS, Section 3.5)

In 1992, IIMI commissioned a comprehensive internal assessment of the lessons it had learned from its institutional strengthening efforts, with special reference to its country field operations (Rao and Abeywickrema 1992). This report includes statements by current or former

Figure 6.1. IIMI's mission, goals, and activities, based on the 1994-1998 medium term plan.



Source: Bandaragoda (1994:17.8, Figure 2).

heads of country programs on their perceptions of institutional strengthening achievements; and an overall assessment by the then-Director for Field Operations assisted by a former staff member as a consultant. It discusses both internal and external factors affecting IIMI's impact, in general suggests there has been a modest impact in most countries where it had a residential program up to that time, and makes recommendations on future directions. Two external evaluations had also tried to assess IIMI's institutional strengthening impacts (External Review Panel 1991; TAC Secretariat 1994). More recently, Bandaragoda (1994) and Haq and Hemakeerthi (1994) have reviewed institutional strengthening efforts in Pakistan and Sri Lanka, respectively.

This chapter does not repeat these assessments and does not attempt a complete synthesis of institutional strengthening activities. Rather, in the next four sections it discusses reported experiences with five selected activities that broadly fall under the "institutional strengthening" category, and that have not been discussed in previous chapters. The final section discusses some of the strengths and weaknesses of the institutional strengthening program and likely future directions.

6.2 Enhancing Research Capacity: Pakistan, India, and Sri Lanka

6.2.1 Irrigation Systems Management Research: A Project in Pakistan

In 1991, IIMI accepted an invitation to provide technical support to a set of ongoing donor-funded research activities being carried out by national research institutions after the previous technical support institution withdrew. The research activities were a small component of a very large investment project designed to upgrade major portions of Pakistan's irrigation systems and the capacities of the management organizations. The research was being carried out by a variety of national Pakistani research organizations. IIMI was involved only for the final 2 years of a 6-year project; its role was to provide technical assistance to several of these organizations, with the objective of enhancing their research capacity. The experiences are reported in the Final Report on the Cooperative Agreement supporting the project (IIMI n.d.).

The technical assistance was directed to assisting the research organizations to develop work plans, preparing lists of equipment for purchase, providing technical inputs to the research, and implementing several short training courses. Otherwise, much of IIMI's effort went into organizing a variety of review meetings and workshops, and writing reports. Clearly, this was a fairly standard set of technical assistance activities, over a period that was both too short and too late in the project to have much impact.

The real impacts of these efforts are not clear from the report. Without the project, there is little coordination (let alone collaboration) either among the various research organizations, or between the research and associated implementation organizations within various ministries. IIMI was apparently able to enhance such coordination, and improve the quality of research planning, implementation and reporting for the activities actually supported by the project. But judging from the various officials' appeals for better coordination and more focused research at the wrap-up symposium, one may conclude the project was not able to affect the longer-term institutional relationships among these research organizations. More time would have been necessary, and more attention to the incentives for cooperation among Pakistani research institutions.

6.2.2 Strengthening Irrigation Management Research Capacities in India

From 1988 to 1993, under an agreement with the Indian Ministry of Water Resources through WAPCOS, a government-owned consultancy firm, IIMI worked with research and irrigation management agencies and research institutes in four states to design and implement interdisciplinary research on irrigation management issues (briefly described in Sakthivadivel 1992). The four states are Uttar Pradesh, Bihar, Gujarat and Tamil Nadu, roughly representing four major agro-climatic and institutional regions in India. In each case, a collaborative research program was established in which the irrigation management agency, a research and training institute (WALMI) tied closely to the agency, and a research "center of excellence" designed and implemented a research program with support from IIMI as facilitator and provider of technical assistance and support. Through intensive joint discussions, it assisted in framing the research questions and developing research methodologies. The overall program was guided by a high-level Research Coordinating Committee chaired by an Additional Secretary of the

central Ministry. IIMI's costs were covered by two donors, while the Government of India financed the local institutions' costs. The collaborators and research topics in the four states are shown in Table 6.1.

Table 6.1. Collaborators and research topics: India-IIMI Collaborative Research Program.

State	Collaborators	Research Topic
1. Uttar Pradesh	<ul style="list-style-type: none"> • Department of Irrigation • Water and Land Management Institute (WALMI) • Water Resources Development and Training Centre, Roorkee University 	Conjunctive use and management of surface water and groundwater for irrigation (Madhya Ganga Project)
2. Bihar	<ul style="list-style-type: none"> • Department of Water Resources • WALMI, Patna • Centre for Water Resources Studies, College of Engineering, Patna 	Conjunctive use management (Eastern Gandak Project)
3. Gujarat	<ul style="list-style-type: none"> • Department of Water Resources • WALMI, Anand • Institute for Rural Management, Anand (IRMA) 	Main system management and improved scheduling on minors (Mahi Kadana)
4. Tamil Nadu	<ul style="list-style-type: none"> • Department of Public Works (Irrigation Branch) • Irrigation Management and Training Institute (IMTI) • Centre for Water Resources, Anna University 	Main system management and performance evaluation (Tamilavaruni System)

There has been no formal evaluation of the results of this experiment in collaborative research. It has provided a foundation for subsequent research in India on a nonresidential basis. However, the objectives of the program were not fully achieved. Each of the organizations involved had its own interests and agenda, and these did not necessarily include collaborative field research. The WALMIs are generally stronger in training than in research, and are generally dominated by engineers from the concerned operating agency. They therefore varied considerably in their commitment and interest. Similarly, some of the research centers were more interested in supporting their own students than in implementing research in a collaborative manner, and they were generally not oriented toward carrying out detailed field research. Also, in some cases they were overextended because they were implementing many other activities simultaneously with few senior staff. The operating agencies themselves varied considerably in their interest in the program.

In two cases (Bihar and Gujarat) the research led to further work in collaboration with the operating agency and WALMI (but not the center of excellence). The work on groundwater management in Bihar discussed in Section 3.3.2, and the development of a management information system on a large irrigation system in Gujarat, discussed in Section 3.5.3, emerged from this follow-up work. Working relationships in Tamil Nadu with the Centre for Water Resources have also been maintained, and the contacts established through these studies in

these three states have continued to be valuable to IIMI's more recent work in India. But the project cannot claim that it succeeded in strengthening capacity for irrigation management research in the collaborating organizations.

6.2.3 Building Research Capacity in Irrigation Management Agencies: Sri Lanka

A few irrigation management agencies have developed an in-house capacity for working with researchers and adopting useful research results, most notably the National Irrigation Administration (NIA) in the Philippines. IIMI had collaborated with NIA in a project to strengthen capacities of regional universities to do irrigation management research and linkages with NIA with some success.⁴⁸ In Sri Lanka, IIMI has been collaborating very closely with the Irrigation Department for a decade. While the Department has a long-standing interest in practical applied research results, its ability to identify research priorities, and evaluate and internalize results of interdisciplinary irrigation management research has depended largely on the interests and capacities of individuals in leadership positions. The Department has not had an institutional capacity for this, which has in turn affected its ability to identify and adopt innovations in irrigation management.

Therefore, from 1991 to 1996, IIMI worked with the Irrigation Department to establish such a capacity through a new "Irrigation Management Research Unit" (IRMU). The Department has traditionally been a civil engineering line agency. However, the IRMU has been established as a multidisciplinary unit including engineering, agricultural, social science, economic, and environmental studies (Haq and Hemakeerthi 1994). Three distinct activities were pursued: establishment and strengthening, research and development, and training and technology transfer.

Establishment and strengthening. The concept of developing the IRMU, and commitment of significant donor funding for its support, were established concurrently with the work under IMPSA on possible restructuring of the irrigation management agencies in Sri Lanka (Section 4.2.3). The envisioned restructuring has not been fully implemented, but the establishment of the IRMU was accepted and after some delay, staff were recruited from within and outside the Irrigation Department. IIMI facilitated the development of a medium-term strategic plan and research agenda through workshops and informal discussions; the establishment of a high-level Research Advisory Committee which includes representatives from a variety of interested institutions to provide overall direction to the IRMU; and the creation of a more technical Research Coordination Committee to assist in formulating the IRMU's research agenda, the establishment of a research library, initiation of a regular series of seminars on irrigation management, and a newsletter.

Research and development. The original concept of the IRMU was that it would have the expertise and mandate for managing a research program whose implementation would largely

⁴⁸The research on management transfer reported in Section 4.4.7 and in Box 4.9 on decentralized services to FMIS in the Philippines was done under this project.

be through contracts with specialized research organizations or private firms, but would not itself do much research. However, in its early years, it would carry out some research directly as a means of strengthening its capacity. This is what has occurred. As of 1994, ten studies were being implemented, of which one was being done directly by the IRMU, three by the IRMU in collaboration with other units of the Irrigation Department, and six contracted out to other organizations (Haq and Hemakeerthi 1994). In addition, the IRMU has become the central focus for further testing and implementing the use of computer models and management information systems which have emerged from IIMI's collaboration with the Irrigation Department at Kirindi Oya on IMIS (Section 3.5).

Training and technology transfer. In addition to the monthly seminars and the regular newsletter, IRMU organizes a series of workshops on topics of interest to the Irrigation Department. Topics have included catchment management, computer models as decision support tools, seasonal planning procedures, and farmer participation in planning, design, and rehabilitation of irrigation schemes. A notable feature is the close working relationship established with the Irrigation Department's Irrigation Training Institute. Five fellowships have been awarded to Irrigation Department professionals to support studies for master's degrees.

Results. While the Irrigation Department seems to recognize the importance of IRMU, its performance has not been at the level originally expected. A key problem is holding staff: as of 1994, four of the five trained staff (of the total seven in the staffing plan) had left. Recruitment is on a contract basis, with no assurance of a career (Haq and Hemakeerthi 1994). It is also not clear to what extent the Irrigation Department will commit its own funds to the IRMU after the donor's funds are depleted. If the original expectation that the IRMU would be part of a larger organizational reform package is fulfilled, the IRMU will be more firmly established. In mid-1996, the donor declined to continue funding the strengthening project, precisely because the Irrigation Department's commitment is unclear. But IIMI continues to work informally with the unit.

6.2.4 Strengthening Research Capacity: Lessons Learned

None of the efforts to assist countries to strengthen their capacity to carry out and use irrigation management research capacity has been remarkably successful to date.⁴⁹ In the Pakistan case, the short time period and technical assistance role were important limitations; there was no opportunity to use this opportunity to integrate the national collaborators into IIMI's own relatively strong field research program. In both Pakistan and India, research organizations have serious governance problems that limit their incentives to do field research, and their ability to attract and hold good researchers; the projects were not designed to address these fundamental issues. The outcome of the effort to institutionalize research management capacity in the Irrigation Department of Sri Lanka is not clear. As a long-term program, there should have been a greater likelihood of having a permanent impact. But again, it will be difficult to institutionalize this capacity until the government solves the underlying structural

⁴⁹The External Evaluation Panel (TAC Secretariat 1994: Appendix IV, Table 5) found that of four goals of IIMI, strengthening research capacity scored lowest in clients' evaluations (2.7 out of 5); strengthening management capacity (of implementation agencies) scored highest (3.2).

problems inherent in the Irrigation Department itself. Ultimately, the lack of strong demand for research results by the clients—the operating agencies—is a significant impediment to progress in improving irrigation performance. The case discussed in the next section shows what can be achieved when this demand is present.

6.3 An Integrated Approach to Institutional Development: The Case of Malaysia

6.3.1 Introduction

From 1989 to 1992, IIMI assisted the Department of Irrigation and Drainage (DID) in Malaysia to carry out a series of activities that began with a Training Needs and Organizational Constraints Assessment and continued through a program on strategic planning and human resources development, and identification of research needs. This program was led by IIMI's then-Training Specialist with assistance from other staff and consultants, and demonstrated the potential for such an integrated systematic approach if the client organization has strong leadership committed to the program. The program and its results are described in an easily accessible form by Franca (1993); Franca (1994) provides a very detailed step-by-step description of what was done and what the outcomes and lessons learned were at the end of each stage. Figure 6.2 shows the linkages among the activities—training cycle, strategic planning, and identification of research needs.

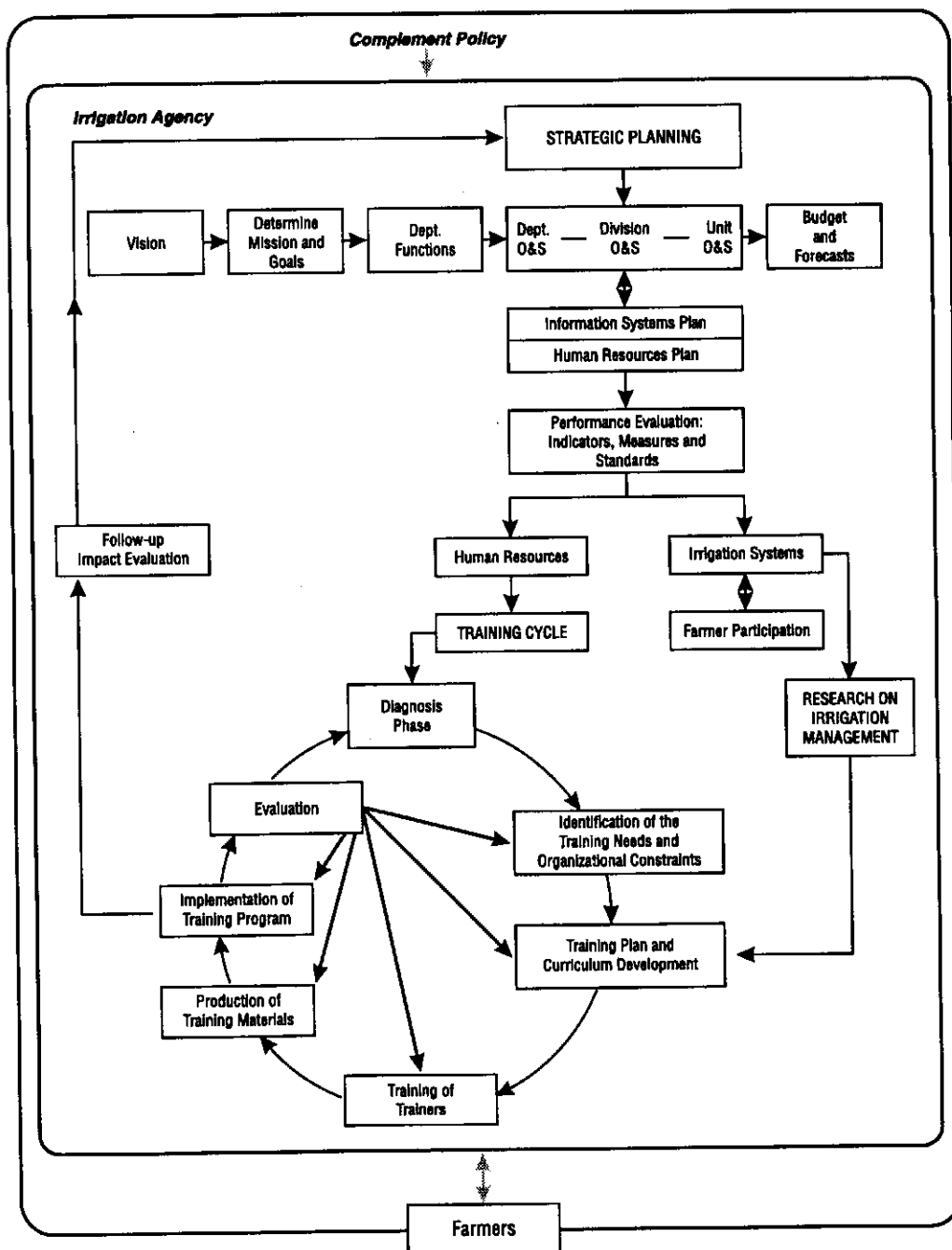
6.3.2 Phase I: Implementing the Training Cycle

The “training cycle” is conceived as having the following steps (Figure 6.2):

- a diagnostic phase leading to the identification of training needs and organizational constraints
- development of a training plan and curriculum
- training of trainers
- production of training materials
- implementation of the training program
- evaluation, and repeat of the cycle over time

The primary objective of the training needs and organizational constraints assessment (TNA) exercise was to identify the factors affecting individual performance and potential solutions. The methodology was to use small group exercises involving a representative sample of staff divided into several categories based on their functions in the organization. The small

Figure 6.2 Organizational linkages: Training cycle and research.



Note: O&S = Objectives and Strategies.

Source: Franca (1993:6, Figure I).

group dialogues focused on concepts of irrigation management, the distinction between managerial and technical activities, and the gaps in knowledge, attitudes and skills of staff; additional attention was given to organizational constraints affecting services provided to DID's clients. The sessions used a variety of standard participatory workshop techniques (especially modified nominal group techniques) to elicit responses.

At the next stage, IIMI worked with senior management in a workshop to analyze the results of the TNA, identify training priorities, and develop a training plan. The workshop was also a forum for senior managers to receive feedback from their own staff regarding the effects of their attitudes and behavior. Based on the results of this key workshop, a workshop on curriculum development involving trainers and managers was organized to pinpoint the gaps identified in the TNA. These gaps related primarily to the development of self-confidence and self-esteem, leadership, management, and interpersonal communications skills. Two training "master plans" were developed, one for engineers, the other for technicians, as well as a curriculum for training trainers to improve their skills.

This was followed by a training of trainers exercise involving the University Pertanian Malaysia and IIMI, and the production of training materials to meet the needs of the training programs. The initial training activities were monitored and evaluated to assist in adjusting and improving the materials and techniques used. At every stage of the training cycle, participants evaluated the results in terms of content, process and program design. The results were generally evaluated very positively.

6.3.3 Phase II: Strategic Planning and Human Resources Development

The performance of the participants in the training programs can only be assessed in terms of the overall objectives of the Department of Irrigation and Drainage (DID). Consequently, the senior management was engaged in a series of workshops and exercises to discuss strategic planning, formulation of a mission statement, drawing up a set of corporate objectives, and devising a human resources development program. The existence of a broad set of national objectives embodied in Malaysia's "Vision 2020" made this process easier than it might be in some countries. After holding three workshops at DID headquarters on these issues, the strategic planning process was extended to the field level in two irrigation schemes. The purpose was to enable DID to measure performance levels of its services at these schemes. An initial workshop with scheme managers enabled them to internalize and understand the mission statement and corporate objectives of DID; this was followed by an information meeting with operational staff and interactive meetings with farmers. These meetings provided a basis for developing a plan for improving the services, and led to the next phase of activities.

6.3.4 Phase III: Developing Research Capacity

Too often, research is carried out by people from outside the irrigation sector, who study irrigation systems for their own purposes without consulting irrigation managers. But if research is going to be relevant to the real needs of the sector, irrigation practitioners must make meaningful contributions to research programs. This is the premise for this set of activities (Franca 1993, 1994). IIMI and DID invited researchers from universities and other agencies in Ma-

laysia to participate in this program. They helped DID staff to identify the skills needed to conduct research, and promoted a useful debate on the state of irrigation research in the country.

The next step was to organize a workshop on *Research on Performance of Irrigation Systems* at the same schemes where the previous strategic planning effort was brought to the field. This workshop helped DID develop an understanding of the nature of research and how it could contribute to solving DID's problems. It also brought out clearly the contribution of research to improving training programs.

6.3.5 Evaluation

Franca (1993, 1994) quotes the Director General of DID and other participants in the process to demonstrate the positive feedback and apparent large impacts on the Department. An indication of the Department's interest was its willingness to invest its own resources including funds in the exercise, to overcome funding constraints on IIMI's side. Franca (1993:13) lists a number of "constituents" she regards as essential to the success of this kind of program. These include:

- complete support and active participation of top management
- recognition that the three components—TNA, strategic planning and human resources development, and development of research capacity—are interrelated and essential
- management training for all levels of managers
- training as an integral part of an overall human resources development plan
- an interdisciplinary training team involving nationals who are experienced professionals and practitioners
- drawing on research results for insights and materials
- use of interactive techniques
- embodiment of the strategic plan and human resources development plan in official documents
- continuous follow-up and evaluation for sustainability of the program

With hindsight it could be said that the program should have begun with strategic planning, and moved on to identifying research needs and training needs. However, the TNA exercise proved to be a means for IIMI and DID to establish close working relationships by addressing a topic that was not directly threatening or sensitive. It was the effective working relationship emerging from the TNA activity that led the DID to invite IIMI to assist in strategic planning.

Building on the Malaysian experience, IIMI organized similar activities in Bangladesh and Sudan. While the workshops in these countries were apparently useful, it was not pos-

sible to follow up by implementing the entire cycle in either country. Neither has IIMI been able to follow up with DID on the continuing impacts of the effort there, or to initiate similar activities in other countries. This experience has been valuable for both DID and IIMI, but IIMI has not yet built on this exercise to expand its own capacity for assisting management agencies to carry out TNA and strategic planning exercises.

6.4 Assessment of Training Investments: The Case of Egypt

In 1995, as part of a larger institutional analysis of the Ministry of Public Works and Water Resources (MPWWR) in Egypt (see Section 4.3.2, Box 4.2), IIMI examined the current capacities and future plans of a new Training Center operated by the Ministry. The results are reported by Rao (1995). The Ministry had established a formal training unit in 1982. This unit was expanded with donor assistance after 1985, and in 1990 construction was initiated on a major Training Center (TC) to house these programs. By 1995 construction of the TC had been completed. The course calendar for 1995 lists 106 short courses for an estimated 2,500 MPWWR participants. Some of the TC training is done in satellite centers (for example a well-regarded course on on-farm water management); other units in the Ministry also carry out their own training activities separately from the TC.

Most of the TC's courses are technical; there are a few courses on administrative procedures required for promotion; a number of computer courses for which there is heavy demand; and two general courses on "management" for which there is also great demand. The TC has a small core training staff complemented by experts drawn from other institutions. Equipment at the TC is excellent, and hands-on work, group discussions, and case study methods are used in addition to lectures. Trainees generally evaluate the courses positively, though some courses are considered too academic and theoretical.

The study points out a number of issues affecting the performance and impact of the TC in the Ministry. First, up to 1995 the TC obtained a considerable portion of its budget from a donor, but the donor had no plans for continuing to fund operating costs. The commitment of the Ministry to funding this gap once the donor funds were gone was not clear, and much concern was expressed on this point. Thus, the sustainability of a very heavy investment in training facilities was in question as of mid-1995.

Second, other units of the Ministry with their own (donor) funding often do their own training, rather than using TC facilities and resources. The TC seemed reluctant to reach out and "sell" its services; similarly, it seemed reluctant to offer new kinds of courses, and organize workshops and seminars, even though there is clearly a demand for new offerings. The leadership of the TC did not view its mandate as including having to identify demand and sell its services to other units of the Ministry. Nor did the Ministry see any need to consolidate training activities, even though it would lead to significant cost savings.

Third, although there are linkages between the TC and the research arm of the Ministry—the National Water Research Center (NWRC)—the study concluded these linkages could be considerably strengthened. Only one course, the on-farm water management course mentioned above, is based on research findings (from a decade ago). Some NWRC units offer their own specialized training courses; some NWRC researchers give lectures at the TC; but

the formal linkages are weak, leaving the TC with an inadequate basis for upgrading the contents of its courses. Rao also notes there is a need for new courses related to changing water resource management demands and new technologies being introduced by the Ministry.

Fourth, there is a need to develop more focused courses through which Ministry officials can acquire needed management skills. The training needs assessment previously carried out by the Ministry with the assistance of foreign consultants had not been designed in a way that would bring out the need for management training. Rao contrasts the approach used to that followed in Malaysia (Section 6.3) and recommends that the TC should consider carrying out a new assessment using this approach.

6.5 Dialogue and Training in Irrigation Management: Southeast Asia

From 1990 to 1994 IIMI collaborated with the German Foundation for International Development (DSE) on a program to address irrigation management and policy issues in four ASEAN countries: Indonesia, Malaysia, the Philippines, and Thailand. Together these countries operate 14 million ha of irrigated land (6% of the world's total) and produce 15 percent of the world's rice (Abernethy 1994). The program was built around two principle elements: 1-week workshops for senior managers and policy makers at which larger issues and emerging new challenges could be debated; and training courses of 3 to 4 weeks in duration for middle managers, which focused on delivering practical ideas for solving current problems. In addition, the program provided modest grants to support research and individuals' participation in international meetings, a study tour to examine management techniques in North Africa, and assistance in revising the engineering curriculum. In all there were 23 major events over 4 years in which over 600 people participated (Abernethy 1994).

Southeast Asia is physically rather homogenous in regard to irrigation, with substantial rainfall and a primarily rice-based irrigation tradition. In all four countries, irrigated agriculture faces numerous stresses, including reduced profitability of rice cultivation (in part an outcome of these countries' success in raising production), efforts by governments to reduce subsidies, and the steady reduction in per capita water resources with growing demand from other sectors compounded by rising levels of water pollution. On the other hand, the institutional and financial frameworks of the four countries exhibit great disparity. The workshops enabled participants to examine these differences, the reasons for them, and the consequences.

A major focus of the workshops was to discuss what kinds of changes might be required in these institutional and financial frameworks to enable them to cope with new conditions and new objectives. These changes and possible responses to them were vigorously debated at the workshops. Although the details varied, the workshop outputs identified needed reforms in policies, laws and institutions, human resource development, investment patterns, and supporting infrastructure (Heim 1994; see also Heim and Abernethy eds. 1994; Abernethy ed. 1996). For example, a workshop on "Irrigated Agriculture in Southeast Asia Beyond 2000" identified a large number of policy, institutional, and water resource concerns in common, and advocated better information exchange and networked research in the region on these concerns (Heim and Abernethy, eds. 1994).

This perception of the value of regional cooperation and exchanges—captured in participants' positive evaluations of the workshops—was crystallized in a proposal to establish an *ASEAN Water Resources Council*. This proposal, subject to ratification by the authorities, was entirely the initiative of program participants and was not sponsored, initiated or guided by either DSE or IIMI (see IIMI 1994f).

6.6 Conclusion

The examples of institutional strengthening activities discussed in this chapter are not comprehensive: in every country where IIMI works, except possibly Pakistan until recently, the importance of institutional strengthening as an objective has been at least equal to, and in some cases has exceeded, research. This emphasis reflects both the dependence of IIMI on bilateral donors for funding its country programs and, to some extent, values held by the staff. These donors and collaborating countries, not surprisingly, emphasize immediate impacts on local performance and local capacity-building, and are less interested in long-term research programs. Much of the research discussed in the preceding chapters has been produced in this context of having to balance institutional strengthening with research; its strengths and weaknesses reflect this schizophrenic view of research as an objective. Whether the recent strong emphasis on strengthening the research program to emphasize production of strategic (rather than site-specific) results succeeds will depend on IIMI's obtaining more balanced funding for field research, and then refocusing its research efforts. But this research will continue to be carried out in collaboration with national institutions. Thus IIMI's obligation to assist in institutional strengthening in its host countries will continue.

As Figure 6.1 shows, IIMI has two types of clients for its institutional strengthening work: national irrigation management researchers and water resource managers and policy makers. Most countries do not have specific irrigation management research institutions, the equivalent of NARS for agriculture; therefore there have been few natural research partners in the countries where it works. In its early years, IIMI therefore emphasized strengthening of irrigation management agencies. It then shifted to trying to strengthen the research management and absorption capacity of several of these agencies. After joining the CGIAR, IIMI has begun placing greater emphasis on strengthening national research capacities, though with minimal results so far.⁵⁰

A serious weakness of these country-level institutional strengthening efforts has been both the lack of a clear vision and strategy for institutional strengthening, and the lack of systematic support and evaluation of its country programs. Each program is carried out as a kind of independent "franchise" (in Randy Barker's words), and its effectiveness depends on the skills of the staff and the country response. IIMI has had no means to learn systematically from successful activities and use them elsewhere or transfer them to others; no mechanism to provide support to these activities; and no system for evaluating results.

⁵⁰Rao and Abeywickrema (1992:28, 35) advocate helping countries establish national versions of IIMI—National Irrigation Management Institutes, or NIMIs.

Another issue facing IIMI is its future role at regional and global levels. If institutional strengthening is confined to the few countries where it has field programs, then one may ask if IIMI is thereby fulfilling its global mandate. The course on irrigation management in collaboration with EDI in IIMI's early years was very successful, but was discontinued for lack of funds and lack of priority given by the management of the time. Similarly, when IIMI had a Training Specialist, funding was a serious constraint and she responded by collaborating with a partner willing to invest its own resources; but again there was no integration of the methodology and lessons into IIMI's larger program. The activity in Southeast Asia in collaboration with DSE was very cost-effective and successful by all accounts, but again there has been no follow-up.

For the future, IIMI is unlikely to attempt to develop a large international training program. IIMI does plan to build regional activities around its major national programs; this will certainly include organizing workshops, networked research, and study tours and exchange programs. The DSE-IIMI regional activity in Southeast Asia provides a clear model for such a regional program. Similarly, the integrated program with DID in Malaysia provides a useful model for country-specific institutional strengthening.

Two matters requiring further attention are: a) how to improve the effectiveness of in-country institutional strengthening activities by internalizing and sharing lessons learned from its experiences and making better use of systematic organizational development methodologies; and b) how to evaluate its impacts objectively and systematically.

CHAPTER 7

Conclusions: Outputs, Impacts, and Future Directions

7.1 Introduction

IIMI has now been in existence for more than a decade. It is therefore appropriate to take stock of what it has achieved, and what it has not achieved during this period. This final chapter does not attempt to summarize the preceding chapters (this is done in the Summary). Rather, it considers some of the limitations in the research outputs to date as a basis for making improvements in the future, and also discusses the implications for future research of the basic conclusions emerging from this work. The final section makes some suggestions for the future, which reflect the author's own views and not necessarily the priorities of IIMI's management.

7.2 Qualities and Limitations of IIMI's Research Results

In its first 10 years, IIMI's program placed greater emphasis on development and institutional strengthening than on producing strategic or generic research results. This emphasis changed in rhetoric but not in reality after joining the CGIAR at the end of 1991. The reasons are clear: nearly all the funding available to support work in the field has come from bilateral donors, with the agreement of partner countries. Both the donors' country program staff and the governments of the partner countries placed the highest priority on practical immediately useable results, and institutional and professional strengthening. Often these were the same donors whose central offices support "strategic research" through the CGIAR. In addition, IIMI's own staff in many cases favored this focus on development and immediate application.

This emphasis on applications was enhanced by signals from the management, which rewarded evidence of "impact" in particular countries; the former Director General maintained an "Impacts File" to which staff were invited to contribute evidence of impacts. IIMI recruited staff whose strengths were in development and institutional strengthening as much as in research. Even at the time of preparation of the Medium Term Plan after it had joined the CGIAR, staff whose work was seen as overly "academic"—i.e., attempts to make scientific contributions to irrigation management—were criticized by management.⁵¹ It is only very recently that

⁵¹One example is the former Director General's criticism of an early draft of a paper which ultimately won its authors shares in the first IIMI "research award." It should also be noted that IIMI's first "Director for Research" had no research background, but was a senior policy manager from a client country.

a “publications” category was added to the form used for evaluating the performance of research staff.

It is therefore not surprising that those who judge IIMI by its scientific outputs find that its work has been insufficiently “cumulative” and scientific, and that staff have not published enough of their results in refereed journals. A good deal of the results reported in this paper have not been published at all, or are contained in project reports which are not widely circulated. The critics are not incorrect in this criticism, but they are applying a criterion that was not a high priority until recently.

It is also true that some of the research exhibits weaknesses in its design, sampling techniques, sophistication of analysis, and use of quantitative data and statistical analysis. In addition, there have been no systematic analytical frameworks and common methodologies guiding IIMI’s research in various countries, limiting the possibility for systematic comparative analysis. This applies for example to the work on performance of canal irrigation systems, and irrigation management turnover. The conceptual frameworks developed under the Performance Assessment Program were rarely used by staff to guide their research. Even the data IIMI has collected in many systems have not been mined effectively for comparative analysis. The few attempts to do such analyses have, until recently, been done by staff on their own time—IIMI did not build such comparative research into staff work plans or provide specific support and resources for staff to do such work.

This is not to say that IIMI has not produced any quality scientific research results. This is not the case; some of its work does meet international standards and has been valuable in its contribution to global understanding of irrigation management issues; this is discussed below in Section 7.3.

If IIMI has emphasized impacts and institutional strengthening through its country programs, what can be said about its success in this area? The evaluations carried out in 1991 and again in 1993 (External Review Panel 1991; TAC Secretariat 1994) seem to show perceptions in partner countries are positive on this point. Unfortunately, it is difficult to measure this impact objectively and certainly. There are no “pre-IIMI” baseline studies to which a “post-IIMI” state of affairs can be compared. Further, IIMI is not the only actor on the scene in any country; and it is often desirable for staff to be modest about their achievements and encourage ownership by partners and collaborators. IIMI has not developed a way of systematically evaluating its impacts, and it may not even be wise to do so; it must rely on perceptions of collaborators to a large degree.

7.3 Contributions of Research Results

The criticisms of the research discussed in Section 7.2 notwithstanding, IIMI can claim to have made important contributions to global understanding of irrigation, and more broadly water resource and irrigated agriculture. First, its documentation in a number of countries of the large gaps between the reality of irrigation performance, and the potential or expected performance, as well as the assumed performance, has been very valuable. Obviously IIMI is not the only contributor to this, but its work has been important, and has credibility, particularly in its partner countries.

Second, the results of its work on the performance of Pakistan's mega-irrigation systems have enormous implications for the future of irrigated agriculture in that country, and possibly other semiarid and arid countries with large water-scarce irrigation systems. It has documented not only the high degree of unreliability and inequity of surface water deliveries on distributaries and minors (previously assumed to perform as designed), but has shown the relationship between this unreliability and inequity and the increasingly serious threat of salinity and sodicity. Similarly, its work on design and performance of irrigation systems in West Africa, its work on management transfer, its documentation of governance and institutional problems, and its use of participatory methodologies in research and policy analysis are all important contributions which can be used to make future improvements.

Irrigated agriculture is facing increasingly serious threats at a time when it is expected to produce more and more food. Negative trends like soil degradation and erosion, declining water quality, and increasing demands for water from other sectors which are leading to largely informal reallocation of water away from irrigation, all have serious implications for the future. *IIMI's (and others') research makes very clear that the underlying causes of these problems are institutional and political in nature.* Government organizations dating from precolonial times, which flourished in the "construction era" that characterized irrigation into the 1980s, are not equipped structurally, culturally, politically, or human resource-wise to solve the challenges facing irrigated agriculture. Far more radical reforms than have been attempted so far will be required in future to enable irrigated agriculture to produce more food and use water more efficiently.

Financial problems are equally serious: the problem is not only or perhaps even primarily the *amount* of funding, but how funds flow into irrigation. In most countries they currently do not flow from users to service providers in a way that would provide an incentive to improve the quality and cost-effectiveness of services. This is again fundamentally an institutional and political issue.

Another key institutional issue is the weakness of water users. Generally, farmers even in relatively favored irrigation systems are poor; there are large numbers of them; and they are poorly organized and politically weak. They are not able to exert pressure on irrigation service providers in current conditions in most countries. They have no clear and enforceable water rights. In most countries the preconditions necessary for the users to take more responsibility for managing irrigation are also not present.

Finally, as competition for water from other users increases, irrigation agencies are in any case becoming irrelevant. They are often mono-disciplinary, inward looking, and in no position legally or politically to deal with water as a multiuse resource requiring an integrated multidisciplinary approach. In many countries the "water resources" sector is not recognized institutionally, and changes in water use and availability are occurring informally and with no documentation. The coming water crisis will affect not just arid and semiarid countries, but even countries with monsoon-based high annual rainfalls, especially the countries of Asia with high population densities and rising demands for both food and good quality water for other uses.

7.4 Conclusion: Opportunities for IIMI

7.4.1 *Changes Underway in the Program*

The new management has recognized that IIMI must strengthen its research program and contribute to improved understanding of, and developing potential solutions for, the threats to the water supplies for irrigated agriculture (IIMI 1996). It has moved quickly to focus attention clearly on production of high quality research outputs. It has introduced a *water basin* perspective on irrigation management issues: the efficiency of irrigation must be improved in a context of increasing competition for scarce water supplies. *Therefore, irrigated agriculture must improve its productivity per unit of water as a high priority.* IIMI is currently strengthening its capacities to use modern information and data processing technologies (remote sensing, geographic information systems, sophisticated statistical analysis packages) and upgrading the technical quality of its research staff. These are all very positive developments.

However, three important questions still need to be addressed in developing the future program. These questions are:

1. Will donors support a research program focused on global water issues?
2. Will IIMI be able to do credible research on, and ultimately influence, the underlying institutional and political causes of water resource problems?
3. How can IIMI reconcile its strong emphasis on research with an effective institutional strengthening program?

7.4.2 *Donor Support for a Global Research Program*

The major reason why IIMI has not had a strong global strategic research program in irrigation management in the past is that it could not attract sufficient donor support. This was the case before joining the CGIAR, when its modest core funding was actually declining. IIMI joined the CGIAR at a time when this system's funding had peaked; a larger number of research centers are now sharing funding whose real size is in decline.

In addition, IIMI was created at a time when overall funding for irrigation development and improvement had peaked and was beginning to decline (Rosegrant and Svendsen 1993). This decline has continued, partly in response to lower food prices that have reduced the economic returns to such investments, and partly because donors have become disenchanted with irrigation investments. In addition to the perceived (and real) poor performance of irrigation, irrigation has come to be seen as "privileged," and as an area in which current concerns with poverty, gender, and environment issues cannot be addressed adequately. The disenchantment undoubtedly extends to IIMI itself, which was created with ambitious expectations that have not been met—nor could they have been met with the limited resources provided.

IIMI's current management hopes this will change. The CGIAR is placing increasing emphasis on natural resource research and IIMI is favorably placed to see some increase in its funding for this reason. However, the CGIAR system itself is, if not declining, at best static in its funding availability. Donor funding for irrigation development is likely to continue de-

clining, unless current concerns about global food supplies turn into a crisis. And it is sometimes difficult for IIMI to “sell” its program because meeting future water needs for irrigation and other uses seems not to be central among the current priorities of donors concerned with alleviating poverty levels and reducing gender-based and other social inequities. These are also central, not peripheral, problems—but research is needed on the *water* issues themselves if solutions are to be developed relevant to alleviating poverty and inequity in the future.

7.4.3 Solving Institutional and Political Causes of Poor Water Management

Everyone involved in irrigation and water resource issues claims to recognize that institutional, policy, and political issues are central causes of poor performance. But it has proven difficult to focus governments’ and donors’ attention on these matters, and develop long-term solutions that can be implemented. In view of the recognition of the importance of these issues, one might have expected that support at least for research if not action would be forthcoming; but this has not proven to be the case, with the partial exception of research on irrigation management transfer. But the latter topic is too limiting, and the broader political and institutional support required for implementing such transfer programs has not been the topic of much research.

Management transfer is not the only institutional issue facing the water resource sector, and in some countries may not be the highest priority issue. For example, clear water rights, mechanisms for dealing with increased water pollution and competition from other users, financial flows that provide adequate resources and incentives for good service, and strengthening research at national level on water resource policy and management issues all require attention.

As Murray-Rust and Merrey (1994:27) note, there is one certainty: “Change is coming and it cannot be resisted.” Policy makers need to understand the forces driving these changes, and implement policies and strategies to guide their implementation. But they need a firmer research basis for identifying what policies and institutional forms are most appropriate.

IIMI itself in the past year has seemed to de-emphasize these political and institutional issues as a focus of research, in favor of more technical questions.⁵² It may be that the research in the next few years will increase our understanding of water basins in a technical sense, and develop better management information tools; but the political will to change, and a clear idea of what options work best under what conditions and how they can best be implemented may still be absent.

IIMI should substantially strengthen its Program on Policies, Institutions, and Management, and put greater emphasis on identifying and documenting what institutional frameworks are needed to generate good policies, how to implement them effectively, and how donors, water users, and other stakeholders can play a more effective role in promoting reforms.

⁵²For example, IIMI recruited three engineers to its staff in 1996, but has not yet moved to strengthen its policy and institutional research capacities as staff in these fields have departed.

7.4.4 *Reconciling Research and Institutional Strengthening*

With the welcome emphasis on strengthening the quality of research has come a sense of drift with regard to IIMI's proper role in the area of capacity building. Indeed, as noted in Chapter 6, IIMI has never had a clear vision and strategy, and a systematic support and evaluation system for its institutional strengthening programs. But the CGIAR itself emphasizes this as part of the mandate of international research centers; and because IIMI's research is done in the field and not the laboratory, involvement in this area is a prerequisite for its field research.

It is not a matter of "tradeoffs"—of having to sacrifice research quality to do institutional strengthening, or vice versa. These are not incompatible activities. In future, IIMI will have to collaborate more closely with national research organizations in carrying out its own research program. It must therefore put more emphasis on professional development of the staff of national research partners. To address the governance issues that weaken the capacities of national research organizations, perhaps it should forge a partnership with the international center charged with strengthening the management of agriculture research, ISNAR. In its research and dialogue with governments on the nature of water resource management agencies, it should put more emphasis on the need for strong research organizations at the national (and regional) level. Strengthening the linkages between research and water resource management organizations, and the capacity of the latter to make use of research results, require a high priority: the project to strengthen this capacity in Sri Lanka, and the positive results of the institutional strengthening activity in Malaysia are two useful models.

IIMI should therefore seek support to develop a strong capacity-building or institutional strengthening program, based on a clear vision of what it wants to achieve, a clear strategy, partnerships with other institutions, and its comparative advantage as an international center of excellence in research on water resource and irrigated agriculture issues.

7.5 Conclusion: IIMI in 2006

The author of this book joined IIMI's staff in 1985 and remained a staff member until the end of 1995.⁵³ It would not have been possible in 1985 to predict the status of IIMI and its research results as they are now. Similarly, in 1996 it is not possible to project a clear picture of what IIMI will be like 10 years from now, or what it will have contributed to the world in terms of its research results and their impacts, or its institutional strengthening impacts. The first 10 years included a period of developing and establishing IIMI as an institution; and its supporters were generally patient and understanding about the time this has taken to accomplish.

But there is no reason for continuing such patience: IIMI must produce results quickly, and be seen to be productive. It must establish and consolidate its reputation for excellence and relevance in the next few years, or lose the opportunity. This author believes the chances

⁵³He wrote this book in 1996 while working as a consultant to IIMI. In January 1997 he rejoined IIMI's staff.

are excellent this will happen. Further, the next 10 years will see an increasing awareness of the need to increase food production in the world, and increase employment opportunities and incomes through agriculture. Simultaneously, there will be far greater awareness of the implications of continued degradation of soils, watersheds, and water quality; better understanding of the roots of inequitable access to water resources; more clarity on the necessary institutional and policy conditions for effective water resource management; and awareness of the need to make big gains in the agricultural productivity of water as competition for this scarce resource intensifies both among sectors and among countries sharing water basins. This is so even if the North becomes an increasingly important source of the South's food supplies, as Carruthers and Morrison (1994) argue, because a vibrant growing agriculture sector will be a necessary foundation for growth in incomes and employment, and for environmental protection.

Will IIMI be the key institutional resource for identifying the real nature of problems, and their solutions? It will be if it succeeds in producing quality research results on both the technical and institutional dimensions of the water and irrigation issues of the future; communicating the results of this research effectively both to other researchers and to policy makers and politicians; and making a serious contribution to strengthening national and regional capacities to address these problems.

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