odi-IIMI

IRRIGATION MANAGEMENT NETWORK

FARMER-MANAGED IRRIGATION: RESEARCH ISSUES

Edward Martin, Robert Yoder, and David Groenfeldt

ODI/IIMI Irrigation Management Network Paper 86/3c November 1986

Papers in this set

Please send comments on this paper either to the author or to

Dr Mary Tiffen,
Editor, Irrigation Management Network
ODI
Regent's College
Inner Circle
Regent's Park
London NW1 4NS.

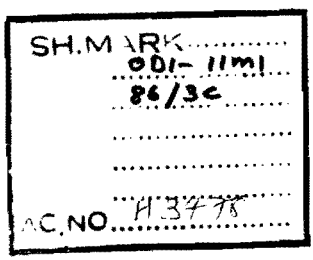
Comments received by the Editor may be used in future Newsletters or Papers.

The opinions represented are those of the author and do not necessarily reflect the policies of the ODI, IIMI or any organisation with which the authors is connected.

ISSN: 0260 8596

FARMER-MANAGED IRRIGATION: RESEARCH ISSUES

Edward Martin, Robert Yoder, and David Groenfeldt



Edward Martin is an Agricultural Economist at the International Irrigation Management Institute (IIMI), Digana Village, Via Kandy, Sri Lanka. Robert Yoder is an Agricultural Engineer at the IIMI headquarters in Nepal; PO Box 3975, Kathmandu, Nepal. David Groenfeldt is an Anthropologist at IIMI, in Sri Lanka.

FARMER-MANAGED IRRIGATION: RESEARCH ISSUES

Edward Martin, Robert Yoder, and David Groenfeldt

This is a revised version of a paper which was sent to the participants of a conference on *Public Intervention in Farmer-Managed Irrigation Systems.* The conference, sponsored by the International Irrigation Management Institute with the Water and Energy Commission Secretariat of the Ministry of Water Resources, His Majesty's Government of Nepal, and held in Kathmandu in August 1986, had as its objective to identify and discuss research issues related to farmer-managed irrigation systems. The purpose of the paper was to provide participants with some background material about research on farmer-managed systems and public intervention in these systems. The authors hope now to establish a research network on these issues. Interested researchers and practitioners will find details at the end of the paper.

1. INTRODUCTION

1.1 The importance of small scale irrigation

There is growing recognition among development planners, irrigation agency officials, and agricultural research scientists of the importance

of small-scale irrigation systems which are managed by farmers, or have the potential for being farmer-managed.[1] Unlike large-scale irrigation projects which typically involve large sums of technical and financial assistance, improvements to farmer-managed irrigation systems can generally be carried out at lower cost, with greater budgetary flexibility, and primarily through local expertise.[2]

Most farmer-managed systems are relatively small in scale, often irrigating less than 100 ha, but farmer-managed systems as large as 10,000 ha can be found in Nepal (Water and Energy Commission, 1981). There are several other examples of systems over 1,000 ha in Asia, and in the USA they may be over 100,000 ha.[3] Study of large farmer-managed irrigation systems may indicate that farmers' management responsibilities need not be limited to small-scale systems or the tertiary level of large-scale systems and may suggest how farmer organizations could take over the management of major portions of large-scale systems or possibly even manage the whole system.

Even though most farmer-managed systems are small, their large number results in a total area irrigated which rivals that of large-scale agency-managed systems in many countries. In the case of Nepal it is estimated that 400,000 ha, or nearly 80 percent of the irrigated area, is under the command of farmer-managed irrigation systems, while in the Philippines farmer-managed systems account for approximately 60 percent (850,000 ha) of the irrigated area (Bagadion, 1986). In Sri Lanka village tank and diversion systems managed by farmers account for an estimated 243,000 ha of irrigated area (Gunadasa et al., 1981), while in Bangladesh farmers manage most of the groundwater irrigation systems.

---

[1]The term "farmer-managed" is used to refer to irrigation systems where groups of farmers collectively manage the system from the water source to the fields. Irrigation systems of this type are often referred to as "communals" or "community-managed" systems. The term "farmer-managed" avoids the ambiguities of the term "community."

[2]While this is often one of the arguments for investing in assistance to farmer-managed systems, the approach taken by some agencies results in higher costs per hectare in these projects than for large-scale projects.

[3] See the chart compiled by Robert Hunt, Appendix to ODI Irrigation Management Newsletter 9a, April 1984.

While irrigation in Africa is not nearly as extensive as in Asia, much of the irrigation is small-scale and, in many cases, farmer-managed. An estimated 2.6 million of a total of 5.3 million hectares of irrigation in sub-Saharan Africa are classified as small-scale or traditional, indicating individual or small group management (FAO, 1986).

1.2 The trend towards intervention in farmer-managed systems

For a variety of reasons government irrigation agencies, international donors, and private voluntary organizations are becoming more interested in farmer-managed and small-scale irrigation systems. In many countries the best locations for large-scale irrigation have already been utilized. In other cases donor agencies, disappointed with the results of investing in large-scale irrigation systems, view small-scale irrigation systems as an opportunity for rapid project implementation with the potential to realize benefits more quickly than large-scale projects. Because of the traditional technologies used in farmer-managed systems, the assumption is often made that with minimal physical improvements to structures, significant gains in production and high economic returns on investment can be achieved. At the same time, farmers and local politicians are making more requests of irrigation agencies to improve their irrigation system and, in some cases, asking the government to take over the management of the system. However, we know little about the results. Except in the Philippines there has been little documentation of significant production gains through outside agency intervention.

The ease with which improvements can be made by developing new small systems or improving old ones can be over-estimated. In some areas, like the hill regions of Nepal, most locations with high irrigation potential have been developed already to some extent by farmers. This has three implications for government irrigation development efforts. First, investment in desirable sites will nearly always involve intervention in farmer-managed irrigation systems or impinge on the water rights of neighboring systems. Second, if improvement were technically easy, farmers might carry it out themselves. They are most likely to request help in technically difficult situations (Gowing, 1986). Third, the remaining areas without any irrigation development are often those in which irrigation construction is technically more difficult and more

expensive. Social and cultural differences may also account for the fact that farmers have not developed irrigation systems and make the intervention by an outside agency more difficult.

The nature of agency involvement in farmer-managed irrigation systems varies considerably. Two opposing trends can be observed, one toward increasing agency involvement in the management of systems and the other toward reduction in agency responsibilities. In Himachal Pradesh, the Public Works Department provides assistance to farmer-managed irrigation systems only after the existing farmer organization turns over management of the system to the agency. A contrasting situation exists in the Philippines where, after construction or rehabilitation by the National Irrigation Administration, the whole system including the dam is turned over to a legally registered water user organization. "Signed documents clearly establish the organization's legal ownership of the facilities--and leave no question regarding its full responsibility and authority for operation and maintenance" (Korten, 1986).[4]

The results of intervention are mixed. In the Philippines farmer organizations have been strengthened and the technical inputs have resulted in more productive irrigation systems (de los Reyes and Jopillo, 1986). There have been other cases, in Nepal for example, where the farmers have ceased to consider the system their own and have balked at mobilizing the resources needed to operate and maintain it themselves following intervention.[5] A dependency relationship has developed between farmers and the intervening agency, and this is undesirable for several reasons.

(1) It is costly for an irrigation agency to post staff to manage a large number of geographically dispersed systems, each of which may irrigate less than 100 ha.

(2) Staff assigned to a small, isolated system may consider it

---

[4]This applies primarily to small-scale systems (under 1,000 ha), but NIA is beginning a phased program of turning over larger systems to the farmers.

[5]Louis Rijk, Project Manager, ILO Labor-Intensive Public Works Program, Kathmandu, Nepal. Personal communication.

technically unchallenging as well as a hardship post and not be motivated to perform well.

(3) The takeover of management responsibility by a government agency will nearly always result in a lower level of internal resource mobilization, even if the agency charges the farmers an irrigation service fee. Since many developing countries find it difficult to mobilize resources internally, especially from the rural areas, replacement of the resources mobilized by farmers to operate and maintain their irrigation systems by an allocation from the central treasury will rarely be desirable.

2. RESEARCH TO UNDERSTAND EXISTING FARMER-MANAGED IRRIGATION SYSTEMS

Before specific interventions can be considered intelligently in a particular country or region, certain basic information must be to hand. The types of understandings which are relevant to intervention can be summarized in two general questions: (1) How do farmers manage their irrigation systems, including both hardware and software technologies, and (2) How well do farmers manage their systems and in what, if any, aspects could they benefit from outside assistance? We then need to analyze different approaches to intervention in farmer-managed irrigation systems and the results of experience.

2.1 A descriptive framework

Two ways of looking at farmer-managed systems have been found helpful. The first focusses on activities. The second focusses on property rights and associated duties.

2.1.1 Activities

Farmer-managed systems are found in diverse environments using a wide range of technologies to exploit different types of water sources. All farmer-managed irrigation systems, however, require that certain essential tasks must be accomplished if the system is to function productively. Some management activities focus directly on the water,

i.e., acquisition, allocation, distribution, and drainage.[6] Another set of activities deals with the physical structures for controlling the water, i.e., design, construction, operation, and maintenance. A third set of activities focuses on the organization of the people who manage the water and the structures, i.e., decision making, resource mobilization, communication, and conflict management (Uphoff et al., 1985). There is interaction among the activities of the three sets; for example, the organization must decide how to operate the structures to distribute water.

Not all activities are of equal importance in every environment, and farmers' irrigation management organizations will reflect the relative importance of activities in a particular location. For instance, in the hills of Nepal where irrigation systems often have long canals which must traverse steep, landslide-prone slopes, the most critical activity of the organization is mobilizing labor to maintain the intake and canals. The farmer organizations for managing systems in such an environment are structured to ensure that this function can be carried out effectively (Martin, 1986). Precise attendance records and cash accounts are maintained, and sanctions for being absent from maintenance work are strictly enforced.

Depending on environmental conditions and on the technology used, however, the management focus varies. In the farmer-managed tank systems of Sri Lanka, group decision-making on the timing of water releases is the most critical management task; mobilizing labor and cash to renovate the physical structures is relatively less important. For farmers in Bangladesh who collectively own irrigation pumps, it is the pump--its operation, repair, and financing--which is the key focus of management activity.

2.1.2 Property rights

Wherever irrigation systems have been developed, property rights regarding the physical structures and water also exist (Coward, 1983).

---

[6] Allocation means the assignment of rights of access to the water among users, while distribution refers to the physical distribution of water among the users.

These property rights, which may be explicit or implicit, define who has access to the water and to how much, as well as the farmers' responsibilities for maintaining the physical works. The nature of property relationships and the way that water is allocated in farmer-managed irrigation systems affect both the efficiency and equity of irrigation resource use.

An understanding of property rights in regard to water is important when an agency is undertaking an intervention aimed at improved productivity of the system. If water is scarce, a system for rationing the water is required so that each farmer can receive his prescribed allocation. In some farmer-managed systems, locally produced proportioning weirs divide the flow proportionally among different secondary and tertiary canals. In other systems, strictly timed rotational distribution is practised with the length of each person's turn computed to supply him the proportion of the supply represented by his allocation. The technology for distributing water involves both physical mechanisms to handle the water distribution and social institutions to manage the mechanisms and to resolve conflicts when they arise. Disturbance of the distribution system without understanding the link between the physical and institutional components and their interactions can lead to disappointing results including the refusal of farmers to maintain the new system, as noted above.

2.2 Studies of the response of systems to change

Farmer-managed irrigation systems exist in many different environments. Those which have survived and prospered have been able to adapt to changes in the environment. Systems are now being exposed to more rapid change. What were once relatively isolated, self-sustained communities are becoming more integrated into regional and national economic systems, bringing different forces to bear on the irrigation organization. Can farmer-managed systems be sustained in the face of increased state intervention in all areas? What happens to farmer-managed systems when labor has a much higher opportunity cost as a result of industrial development? As the state penetrates more into rural areas, what happens when local customary water rights and national water laws are in contradiction? What macro factors induce change in farmer-managed

systems, and are systems able to adapt to the change? These are all questions worthy of research.

Most studies of farmer-managed systems have concerned successful, relatively well-functioning systems. This has, perhaps, resulted in a rather idealized perception of farmer-managed irrigation systems. It is time to study systems which have failed entirely, or which continue to operate only through heavy government subsidies, in order to understand the underlying causes. In addition, studies of why systems have not been developed in areas where there is a potential irrigation resource should also be conducted

2.3 How well farmers manage their systems

Conventional wisdom concerning the performance of farmer-managed irrigation systems tends to place it at either of two extremes. Engineers often assume that the systems are inefficient in the capture, conveyance, and distribution of water because of the rudimentary technologies used. Social scientists, on the other hand, tend to assume that because the systems have evolved as part and parcel of the local social and environmental setting they are more efficient and sustainable than systems constructed and managed according to the designs and procedures of irrigation agencies. Appropriate institutional arrangements may compensate for less sophisticated technology. Little careful measurement and analysis of how well farmer-managed irrigation systems perform, employing the expertise of engineers in addition to social scientists, has been made, however. More rigorous studies are needed which include measurement of water flows, crop yields, and research into the institutional setting of farmer-managed systems. In this way we could see how far they reach goals of efficiency, productivity and equity.

Some principles of water allocation provide incentives for efficient water management and a mechanism for expanding the area irrigated, while others do not. For example, allocation of water in proportion to land area irrigated does not provide incentives for expanding the irrigated area, while allocation by purchased shares does (Martin and Yoder, 1983). In the first case, if a system is improved so that it supplies more

water, the farmers with the water rights have no incentive to allow other farmers access to the water, but can irrigate the same area with less intensive management. If water is allocated by purchased shares, however, when the supply is increased, farmers with more water than needed can sell some water shares, allowing for expansion of the area that is irrigated.

Evaluating the performance of farmer-managed irrigation systems should include agricultural productivity and the extent of area irrigated by a given source. An analysis of the efficiency of performance of farmer-managed irrigation systems and an understanding of the reasons for a given level of efficiency are important when considering how and if to intervene to improve the systems' performance.

For example, it is necessary to determine whether water is a limiting constraint to increased production; if it is not, efficiency of water use should not be considered an important objective in system management. If the topography is such that no additional area could be irrigated with water from the source, for example, water application rates may be high without "wastage" of water.

In other cases, the irrigated area may be constrained by institutional factors, such as water rights. In a system in Nepal, farmers reported that it would be possible to double the area irrigated by changing from continuous-flow to rotational distribution, but the farmers with land adjacent to that which was irrigated had no water rights (Yoder, 1986).

In some cases there are technical inefficiencies in water acquisition, conveyance, or distribution that could be overcome through the assistance of an irrigation agency.

The equity of distribution of the benefits and costs is another measure of performance of farmer-managed irrigation systems. An irrigation system is often said to be equitable if there is proportionality between the costs borne and benefits received by individual farmers. A crucial test of the equity of distribution is presented when the supply is reduced below the amount required to irrigate the entire command. Are all farmers equally affected by the shortage, or do some suffer

disproportionately? Again, before intervening it is necessary to see how and if farmers cope with seasonal shortage. Systems have been studied in the Philippines (Siy, 1982) and Sri Lanka (Leach, 1961) where the landholdings are intentionally distributed such that each household has some land at the head end of the system and some at the tail end. If the water supply is insufficient to cultivate the entire area, the tail section can be cut off, and all farmers still have some land that receives irrigation. Farmer-managed systems in Nepal substitute maize for rice over the entire command when water is scarce (Martin and Yoder, 1983). In North Yemen contributions to the replacement of temporary dams to catch spate floods fall into three classes according to the degree of likelihood that a farmer's land will benefit.[7]

In addition to the equity of distribution of costs and benefits among the members of an irrigation organization, the equity issue regarding access to benefits of the system is also important. If the water rights are attached to the land, then people owning more land also benefit more from the irrigation. Also, when water rights are attached to the land, the only way that persons who did not initially receive water rights can gain access to irrigation is by purchasing high-priced, already irrigated land. In some irrigation systems ownership of land and property rights in water are separated, and water is allocated through the sale of shares in the system. A farmer owning land within the hydraulic command area, but outside the original irrigated area, can gain access to water through the purchase of shares from another farmer or from the organization (Martin and Yoder, 1983). In rare cases (e.g., Sukhomajri in Haryana, India) water rights are distributed equally to all households in the area or in proportion to the family size instead of the size of landholding. Within the context of a project to increase the water supply in a system, it might be possible to bring about a change in the principle of water allocation to allow for greater access to water. This would have to be approached with a great deal of care or the institutions that function on the basis of existing property rights will be undermined. It might be necessary to find ways of assuring current members of the irrigation organization that they would not lose security of their water supply.

---

[7]Mary Tiffen, ODI, personal communication.

3. RESEARCH ON ALTERNATIVE STRATEGIES TO ASSIST FARMER-MANAGED SYSTEMS

It is often the case that several agencies, both governmental and private, are involved in assisting farmer-managed irrigation systems within a single country. The approaches taken by these agencies typically include (1) completely ignoring existing irrigation organizations and systems, (2) taking over the management of existing systems, and (3) implementing projects entirely through the existing farmer organizations. Coward (1984) distinguishes between direct and indirect investment approaches. Under direct investment, the agency takes full control of implementation activities including design and construction. In these cases, the agency often takes over the management of the system, though it may aim to turn it back to the farmers for operation and maintenance after construction is complete. Under the indirect investment approach, the agency provides resources (financial, technical assistance, materials) to existing irrigation organizations in the form of grants, subsidized loans, and technical assistance which support that organization in improving its irrigation system. Management control of the system remains with the farmers.

Historical and bureaucratic factors underlie some of the different approaches taken by different agencies. For instance, departments of irrigation and public works, whose main activities are the design, construction, and operation and maintenance of major irrigation schemes, tend to use the same direct investment approach when dealing with small-scale, farmer-managed systems (Wensley and Walter, 1985). Departments of local and rural development, by contrast, tend to follow an approach of indirect investment by providing assistance to existing irrigation organizations which are responsible for implementing the project and for ongoing operation and maintenance. Systematic study of different intervention programs are needed to identify the key aspects of the particular approaches which seem most effective.

A comprehensive understanding of different agencies' approaches to assisting farmer-managed systems requires analysis of the internal organization of the agencies. The flow of information into the agency and the demand for information within it needs to be understood. Equally important is an analysis of the incentive structure for different groups

within the agency. If, for example, field officers learn that farmers do not want a diversion weir built at a certain location, what are the incentives for going ahead with the project anyway, or for making modifications? The kinds of information which the agency recognizes as important before a project is launched, and the incentives for seeking or not seeking particular kinds of information, can be important aspects of understanding agency behavior in assisting farmer-managed systems. Research in this area would aim to identify the organizational constraints to improved agency operation.

The relevance of this type of research is seen in the example of the National Irrigation Administration (NIA) in the Philippines which wanted to adopt a new approach to assisting farmer-managed systems. It soon became apparent that it would be necessary to make internal changes in the functioning of the agency (Korten, 1982). Socio-technical profiles of the existing irrigation system were compiled and a cadre of community organizers hired to strengthen farmers' organizations' capacity prior to the project. NIA engineers were required to work with farmers in the process of system layout through a series of meetings and a "walk-through" of the proposed canal locations. Farmers' association construction committees were formed to observe the opening of bids from contractors, check the quantity and quality of materials, recruit and place laborers, and record association members' contributions to the project and the project costs. Construction contracts given to farmers' associations were broken down into smaller units that could be completed, inspected and paid for in two-week cycles. NIA reconciled its project accounts with the association every month instead of only at the completion of the project with the result that the association had s clear understanding of project costs. Special training courses in water management and financial management were designed for the associations.

Of particular importance to the viability of farmer-managed irrigation systems is the impact of agency intervention on the mobilization of resources by farmers. When the agency assumes full responsibility for the intervention and does not involve the existing organization in planning and implementation in a meaningful way, farmers may lose their sense of ownership of the system. They will see no reason to contribute their own resources to the maintenance of an irrigation system now owned

by the agency. Without the active participation of existing farmer organizations, the agency intervention may well result in a decline instead of the anticipated improvement in system performance. Comparative research on alternative intervention strategies can help in identifying the essential elements of effective assistance programs.

4. CONCLUSION

Farmer-managed irrigation systems represent a rich field for research into issues of irrigation management. In some countries considerable research has been done on these systems, while in others this sector has yet to receive much attention. Research on farmer-managed irrigation systems is one of the primary program areas of the International Irrigation Management Institute (IIMI). IIMI researchers have begun research on farmer-managed systems in Sri Lanka and Nepal which aims at gaining a better understanding of how farmer-managed systems in different environments function as well as studying government intervention in the systems. The research in Nepal includes both small-scale hill systems and large (5-10 thousand ha) systems on the plains, while in Sri Lanka village tanks as well as diversion (anicut) systems are being studied. In both countries, one focus of the research is the convention of property rights in the irrigation works and water. An issue that is being examined is how the traditional property rights are affected by government intervention, the organization's response to intervention, and the impact on resource mobilization. In Nepal, an action research project in collaboration with the Water and Energy Commission Secretariat aims to develop more effective approaches to assisting farmer-managed systems.

IIMI seeks to facilitate communication and interaction among researchers and irrigation agency officials who are involved in the farmer-managed/small-scale irrigation sector. As a first step, IIMI conducted an international workshop on "Public Intervention in Farmer-Managed Irrigation Systems" in Kathmandu, Nepal, in collaboration with the Water and Energy Commission Secretariat of the Ministry of Water Resources in early August 1986. Participants included approximately 60 researchers and irrigation agency personnel, primarily from universities and

irrigation agencies in Asia and Africa. A research network of interested researchers and irrigation agency officials who are working on similar problems and programs is now being established. It is being called the *FMIS Network* (Farmer-Managed Irrigation Systems). The objective of the network is to facilitate the sharing of knowledge and experience as well as to identify and support new research efforts. Administrative support for the network will be provided by IIMI. Persons interested in the network should write to the FMIS Network Coordinator, IIMI, Digana Village via Kandy, Sri Lanka.

REFERENCES

Bagadion, Benjamin U. 1986. "Government Intervention in Farmer-Managed Irrigation Systems in the Philippines: How Research Improved the Process." Paper presented at the Conference on Public Intervention in Farmer-Managed Irrigation Systems. International Irrigation Management Institute and Water and Energy Commission Secretariat, Kathmandu, Nepal. August 1986.

Coward, E. Walter, Jr. 1983. "Property in Action: Alternatives for Irrigation Investment." Paper presented at Workshop on Water Management and Policy, Khon Kaen University, Khon Kaen, Thailand. September 1983.

Coward, E. Walter, Jr. 1984. "Improving Policies and Programs for the Development of Small-Scale Irrigation Systems." WMS Report 27. Paper prepared at Cornell University for the Water Management Synthesis II Project, USAID Contract DAN-1427-C-00-0086-00, to the Consortium for International Development. Ithaca: Cornell University.

de los Reyes, Romana P. and Sylvia Ma. G. Jopillo. 1986. "An Evaluation of NIA's Participatory Communal Program." Paper presented at the Conference on Public Intervention in Farmer-Managed Irrigation Systems. International Irrigation Management Institute and Water and Energy Commission Secretariat, Kathmandu, Nepal. August 1986.

FAO. 1986. "Small-Scale Water Control Schemes in Sub-Saharan Africa: Past Experience and Development Options." Working paper prepared by the FAO Investment Centre in cooperation with IFAD Africa Division. Rome: FAO.

Gowing, John. 1986. ODI-IIMI Irrigation Management Network Newsletter 86/2a. London: Overseas Development Institute.

Gunadasa, J.M., P. Wickramasekera, H. M. Gamini Herath. 1981. Socio-Economic Survey of Minor Irrigation in the Dry Zone of Sri Lanka. University of Peradeniya, Sri Lanka.

Korten, Frances F. 1982. Building National Capacity to Develop Water Users' Associations: Experience from the Philippines. World Bank Staff Working Paper Number 528. Washington: The World Bank.

Korten, Frances F. 1986. "The Policy Framework for Community Management." In David C. Korten (ed.) Community Management: Asian Experiences and Perspectives. Forthcoming Kumarian Press.

Leach, E.R. 1961. Pul Eliya, a Village in Ceylon: A Study of Land Tenure and Kinship. Cambridge: University Press.

Martin, Edward D. 1986. Resource Mobilization, Water Allocation, and Farmer Organization in Hill Irrigation Systems in Nepal. Unpublished Ph.D. dissertation. Ithaca: Cornell University.

Martin, Edward D. and Robert Yoder. 1983. "Water Allocation and Resource Mobilization: A Comparison of Two Systems in Nepal." Paper presented at

Twelfth Annual Conference on South Asia, University of Wisconsin, Madison, Wisconsin, November 4-6, 1983.

Siy, Robert Y. Jr. 1982. Community Resource Management: Lessons from the Zanjera. Quezon City: University of the Philippines Press.

Uphoff, Norman, Ruth Meinzen-Dick, and Nancy St. Julien. 1985. "Improving Policies and Programs for Farmer Organization and Participation in Irrigation Water Management." A report prepared at Cornell University for the Water Management Synthesis II Project, USAID Contract DAN-1427-C-00-0086-00, to the Consortium for International Development. Ithaca: Cornell University.

Water and Energy Commission. 1981. Irrigation Sector Review. Kathmandu: Ministry of Water Resources.

Wensley, Christopher J. and Michael F. Walter. 1985. "Small-Scale Irrigation: Design Issues in Government-Assisted Systems." WMS Report 39 prepared at Cornell University for the Water Management Synthesis II Project, USAID Contract DAN-1427-C-00-0086-00, to the Consortium for International Development. Ithaca: Cornell University.

Yoder, Robert. 1986. The Performance of Farmer-Managed Irrigation Systems in the Hills of Nepal. Unpublished Ph.D. dissertation. Ithaca: Cornell University.