Chapter IV

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SUMMARY

This foreign irrigation experience with on-farm water management provides insights for problem analyses and technology adoption relevant to irrigated agriculture in the United States, in particular:

- use of a multidisciplinary team approach to problem analyses, data collection and evaluation, and design of the most appropriate technology package for effective on-farm water management;
- maximum farmer participation in development and adoption of technology solutions, including farmer involvement in water-use planning, design of the technologies and irrigation practices, and training in maintenance requirements for such technologies; and
- information synthesis and dissemination of project results and water management knowledge and techniques so that other projects can analyze the experience for possible relevance to their own agricultural water-use needs.

INTRODUCTION

Meeting future needs for increased food production will depend heavily on improving existing agricultural schemes that manage water. One study, for instance, projects that about one-third of the increased food production from 1975 to 1990 in Asia on irrigated lands would come from improvements to existing systems.[1] To what extent these increases can be achieved depends, in the opinion of many development experts, on successful water management and other practices at the farm level. As one U.S. Agency for International Development (AID) paper stated:

> The present drama in irrigation is not one of simply more large dams and reservoirs, but the improvement of water management for the total system with a special focus at the farm level to help farmers make more efficient use of water for increased crop production. z

Modern agricultural irrigation systems have involved billions of dollars in dams, reservoirs, and water conveyance works. At the same time, there is growing recognition that little emphasis has been placed on water allocation and application on farms.[3] Instead, irrigation planners often have assumed that delivering more water to farmers would improve crop yields without the need to consider actual farmer practices and participation. Yet an obstacle to increased agricultural production in many countries is poor on-farm management of water supplies.[4] A recent World Bank paper[5] proposing the establishment of an International Irrigation Management Institute identified the following problems with current irrigation schemes:

1. uneven distribution of water to farms along the canals, with lower productivity

[1]International Food Policy Research Institute, *Investment and Input Requirements for Accelerating Food Production in Low Income Countries by 1990* [Washington, D. C.: IFPRI, September *1979), p. 26.*

‘Agency for International Development, ‘‘Planning Concepts for a Flexible Irrigation Water Management Strategy in Asia, ” Asia Bureau memorandum, Jan. 25, 1982, p. 4.

[3]Ibid.

[4]Colorado State University, “Evaluation of the On-Farm Water Management Research Project, Colorado State University, ” report to the Agency for International Development, September *1979,* p. *6.*

[5]Proposal by the Technical Advisory Committee to the Consultative Group on International Agricultural Research for the establishment of an International Irrigation Management Institute, April 1982.

at the plots farthest from the diversion point in the canal;
2. low crop yields caused by water loss in transmission;
3. unreliable and untimely water deliveries; and
4. waterlogging (the condition in which the water table rises to near the surface of the soil) and salinity.

Methods exist to improve on-farm water management, but implementing these methods has been difficult for a number of reasons. Close cooperation among farmers and between farmers and irrigation technologists is required. However, institutional mechanisms for involving farmers generally have developed piecemeal and without regard to deriving lessons that may have general application for future projects. Lack of systematic documentation of methods or results has constrained transfer of successful experiences from one country to another. An analysis by AID states that "the flow of scientific knowledge in irrigation is slow, erratic, and piecemeal" and that "seldom does one country know what works under what conditions at what costs in a neighboring country."[6]

A recent AID project in Pakistan was an attempt to address these problems by improving on-farm water management.

[6]Agency for International Development, Asia Bureau memorandum, op. cit., p. 11.

AID PROJECT IN PAKISTAN*

In 1968, AID contracted with Colorado State University (CSU) to help Pakistan address its problems of low water-use efficiency** on farms and low food production. A unique aspect of the contract was the requirement that CSU analyze and report the processes developed during the project, so that AID might draw from these experiences for use in other developing countries. CSU also was asked to develop information and training materials for use in graduate courses on water management.

The focus was the small farm. The pilot research area, the Mona Reclamation Experimental Project, covered 30 villages and more than 10,000 acres. Project work was later extended to other areas of Pakistan. The key participants were the CSU team, local Pakistani universities, farmers, and local and provincial governments.

*The description of this project is based on the evaluation report, other project reports, and telephone interviews in April and May 1982 with Max Lowdermilk, senior water management specialist consultant to AID, and Colorado State University project personnel, including Gaylord Skogerboe, project coordinator, 1974-80, and Thomas Trout, project agricultural engineer, 1976-78.

**Water-use efficiency refers to crop production per unit of water used, irrespective of water source, expressed in units of weight per unit of water depth applied to unit area.

Background

The broad objective of the AID-Pakistan water management project was to improve the effectiveness of water use through better control of irrigation water. This ultimately would help to increase economic returns to the farmer. Pakistan has about 25 million acres (10,125,000 hectares) of land under irrigation through the use of canals which divert water from the Indus River and its tributaries. This irrigation system is the largest contiguous system in the world. The river diversion process, large primary canals, and the distributional network of smaller canals are outstanding engineering achievements in diverting and conveying water. Yet little attention traditionally had been given to agricultural use of the water once it was delivered to the farm. The farmers were left to fend for themselves. Water distribution to the fields after release from the canals was poorly managed. Despite multibillion-dollar investments, crop yields remained low, and problems of waterlogging and salinity frequently were severe.[7] Salinity control and reclamation programs in the 1960's attempted to lower wa-

[7]Colorado State University evaluation op. cit., p. 7.

ter tables and provide additional water supplies, but they were not so effective as had been anticipated.[8] In 1976, as a result of research findings, Pakistan approved a $44 million matching loan agreement with AID for an on-farm water management pilot program to partially line and reconstruct 1,500 watercourses (out of more than 80,000 in the Indus River System). The research project continued under three successive contracts until AID activities ceased in 1980. The World Bank and the Pakistani Government are supporting many of the programs started during the AID/CSU project.

Collecting and Evaluating Data

One of the first tasks of the project was to measure watercourse losses that occur between the time water is diverted from canal turnouts to when it reaches the farmers' fields. Instead of 10- to 15-percent seepage losses as had been assumed by planners in Pakistan, real losses were found to be 40 to 60 percent.

Once the extent of watercourse losses was determined, the CSU team and farmers discussed various technologies and practices that could reduce those losses. They concluded that most of the losses could be prevented by rehabilitating earthen watercourses, lining critical reaches, and installing manufactured turnouts (devices to allow water to flow from the watercourse into the field).

The findings about losses of water in delivery to the fields also led to recommending less emphasis on large water supply works (such as dams) and more emphasis on water conservation and management.

Project Actions

Major project efforts were in technology adaptation, farmer participation, training, and information transfer.

[8] Ibid.

Adapting Technology To Meet Local Needs

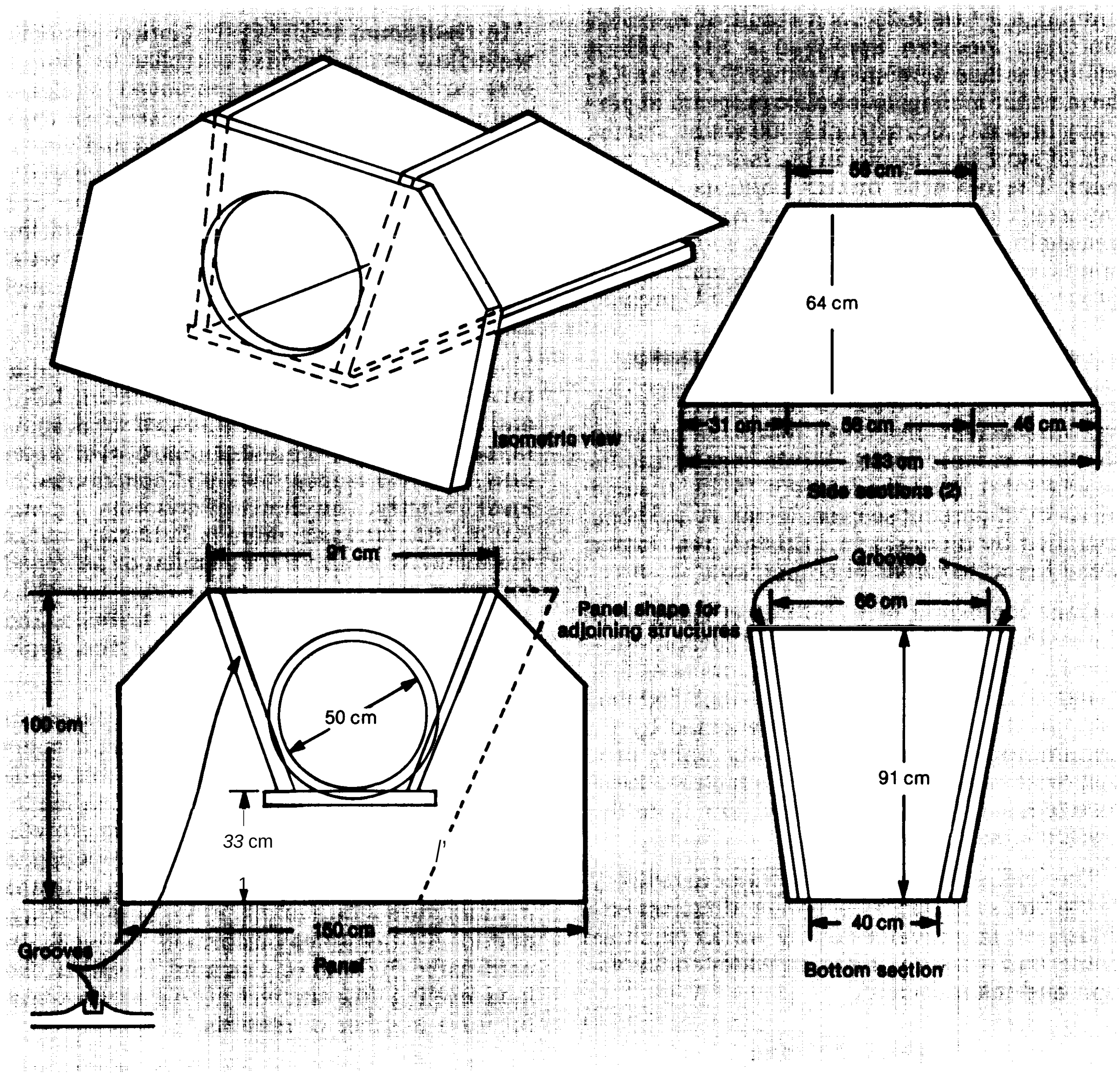
In traditional Pakistani irrigation systems, waterflow to the field is controlled by temporary earthen dams that are removed to release water and then rebuilt. This constant destruction and reconstruction has weakened watercourse walls, decreased efficiency of water delivery, and required considerable time and labor. Working with the farmers to find the most suitable system, the project staff went through several design phases of a new turnout device for controlling water flow to the fields. The final modified version was a simple, durable, locally built, and easy-to-install concrete turnout (see fig. 2). In addition to saving labor and water, the turnouts eliminated weak spots in the canal walls, improved control over water flow, reduced seepage loss, and contributed to local industry. The choice of concrete, a material of little intrinsic value in Pakistan, meant the turnouts would not be stolen or salvaged for other uses. Existing technology was thus adapted by the local artisans, the farmers, and the CSU team to solve a common local problem.

Uneven fields were another major factor in overirrigation. When a field is uneven, farmers overwater to cover the high areas; this leads to waterlogging of the lower areas, possible increased soil salinity, and uneven crop growth. To address this problem, the CSU team began a precision leveling program. Local artisans manufactured the equipment for land leveling, and local companies performed the work. In contrast to the concrete turnout, however, the land leveling program was not entirely successful for a number of reasons. *

1. It was less efficient, and thus more expensive, on small farms than on large.

*In spite of these problems, in 1973 the Pakistani Government embarked on a multimillion-rupee program of land leveling under an AID loan agreement.

Figure 2.—Precast Concrete Slab Installation for Panel Turnouts
(dimensions shown are for a 50-cm diameter turnout)



SOURCE: T. Trout, W. D. Kemper, and H. S. Hasan, *Circular Concrete Irrigation Turnout: Design and Construction, Handbook No. 1* (Denver, Colo.: Colorado State University, 1981), p. 49.

2. Leveling a typical small field in the Mona area required careful scheduling of equipment and nonuse of the field for a season. Most Mona area farmers, and in fact most of Asia, have small farms and cannot afford to take land out of production for a season.
3. Land leveling actually reduced yield for an additional season because topsoil was shifted. Most small-farm operators cannot sacrifice the yield necessary to have their fields leveled.
4. There may be additional environmental problems with erosion, since the soils will have been redistributed and infiltration to stabilize the soils may be reduced for the first season at least.

Farmer Participation

Social and economic constraints to effective water use and watercourse maintenance centered on the lack of: 1) effective local organization to mobilize labor and other resources, 2) knowledge among farmers regarding the magnitude of watercourse loss, and 3) technical knowledge among farmers for improving their watercourses.

Project workers recognized that, without farmer participation and cooperation on a long-term basis, technological solutions would have limited impact and any improvements made would be short-lived. The farmers were therefore involved in water use planning, designing experimental technologies and irrigation practices, and learning the maintenance requirements for such technologies.

The first step was enlisting farmers to assist in improving their watercourses. It was necessary to convince the farmers that if something needed to be done, the farmers would have to take the lead responsibility. Farmers were shown examples from other villages that had undertaken watercourse improvements with visibly beneficial results. They were encouraged by these demonstrations to reline and reconstruct their own local watercourses at sites where water loss had been greatest. The result was that water transport loss was greatly reduced in the area and farmers gained a sense of responsibility for their own watercourse maintenance.

Photo credit: Kay Muldoon for World Bank and IDA, December 1970

Using the traditional Pakistani method, a farmer opens his irrigation ditch to water his wheatfield on his 5-acre farm near the village of Bal

The next step was to setup water user organizations to help distribute the increased flow more equitably. Unfortunately, since water management in Pakistan is handled on a provincial basis, laws to assist the process had to be enacted one at a time. Nevertheless, far--reaching legislation was adopted in 1981 in a number of provinces to give legitimacy to the farmer organizations and provide them with legal status for bargaining purposes.[9]

Training and Information Transfer

The need for training local personnel became apparent early in the project. Pakistani research associates were brought to the university campus in Colorado for this purpose. This exchange proved valuable over the long term. According to one AID report, most of the train-

‘M. Lowdermilk, “State of the Art on Water User Associations for Improved Farm Water Management, ” paper for AID (undated].

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ees who earned doctorates or masters degrees at Colorado "are involved in finding solutions to Pakistan's problems today." In addition, nearly 100 Pakistanis were trained in Pakistan for on-farm water management teams. The research and training functions also provided the opportunity for U.S. graduate students to study the problems firsthand in Pakistan.[10]

Perhaps the most significant result of the Pakistan project was the development and documentation of methodology for possible transfer to other settings. Project coordinators realized that in order to reap full benefits from the project, information would need to be circulated both within Pakistan and to other developing countries.

AID has published numerous manuals and technical reports explaining in detail the Pakistani process of onsite problem identification and the development of site-specific solutions and their implementation. It has produced handbooks describing the concrete-turnout design and manufacture, plans for encouraging farmer participation, and land leveling techniques. These handbooks are published in French, Spanish, and English. Within Pakistan, agricultural extension agents trained by the program continue their outreach work with farmers. A series of lectures has been videotaped for university instruction. (See app. B for a listing of AID-produced materials on irrigation water management.)

[10] Colorado State University evaluation, op. cit., p. 27.

Project Evaluation

Project evaluators identified several important factors that helped the project achieve some level of accomplishment:

- focus on a real world problem—i.e., "the poor management of existing irrigation systems;"
- use of an interdisciplinary approach, with a CSU team including a civil engineer, an agricultural engineer or agronomist, and a rural sociologist;
- CSU's collaboration with a number of Pakistani organizations responsible for varied aspects of on-farm water management;
- CSU's working relations with Pakistani colleagues (a large proportion of the project publications were of joint U.S.-Pakistani authorship); and
- CSU's contribution to the project design, made possible by AID's flexible management strategy .11

Broadly based data on crop yields as the result of this joint U.S.-Pakistan effort at improved water management are not available. On test plots, however, the project team found that good fertilizer responses and good yields were consistently obtained with irrigation levels as much as 40 percent below those previously considered to be optimum. CSU researchers have estimated that yields could be doubled if Pakistani farmers made some simple adjustments in their practices to reduce crop loss risk.[12]

[11] Ibid.
[12] Ibid., p. 23.

OTHER PROJECTS AS OUTGROWTH OF PAKISTAN PROJECT

Project in Egypt

Based on the successful efforts in Pakistan, AID embarked on a similar project in Egypt in 1978. Designed by many of the experts who worked in Pakistan, the Egyptian project also had as its goal improving the productivity of the small farm. The project components ineluded study of the economic effects of water distribution methods, fostering farmer organizations and better communications between farmers and the Ministry of Irrigation, and conducting research on techniques to increase agricultural productivity. This project is scheduled to continue until mid-1984.

Water Management Synthesis Project*

Drawing on the Pakistani and Egyptian projects data, AID launched a Water Management Synthesis Project. Its purpose was to stimulate international exchange of irrigation water management knowledge and techniques. The project is managed by the Consortium for International Development, a group of universities with experience in providing technical assistance to developing countries. The effort involves both information transfer and technical assistance. Information on irrigation developments worldwide is regularly analyzed and systematically distributed to about 700 officials, researchers, and other individuals in some 30 countries. A few countries have requested assistance applying the Pakistani/Egyptian problem-solving process to their own agricultural water-use needs.

*This discussion is based on information received from a telephone interview with Wayne Clyma, Colorado State University, codirector of the Water Management Synthesis Project, in August 1982. Utah State University shared project responsibility.

TECHNOLOGY TRANSFER CONSIDERATIONS

There is some disagreement within the U.S. agricultural community about the degree to which the approach to problem analyses and technology adoption used in Pakistan is now used in U.S. irrigated agriculture. Nevertheless, with billions of dollars of new irrigation investments being planned by the United States and other bilateral and international lenders, many opportunities exist for validating and developing further some of the processes used in the Pakistani and Egyptian AID projects. Elements that have broad value for planning and implementing improved water management schemes include:

Interactive Field Research

In both projects, research teams worked closely with local officials, farmers, and researchers to identify the practical problems and those areas that appeared to have high potential for payoffs. This interaction also was important to obtain feedback as the new technologies and methods were tested. The projects demonstrated that when farmers perceive potential or actual benefits from improved water management, they become more active in contributing their ideas, labor, and capital.

Integration of Research Results With Government Policy

In Pakistan, the project findings of 40 to 60 percent water losses were received skeptically by many Government agencies and officials. The project team, in conjunction with Pakistan's Water and Power Development Authority's planning unit, persisted in its efforts to convince policy makers of the validity of the findings through individual discussions, seminars, publications, and the replication of the research on additional watercourses.[13] The result was a draft "Revised Action Programme for Irrigated Agriculture" calling for lining 24,000 watercourses and rehabilitating 48,000 more by 1990. In Egypt, the government has high expectations for the project, and both the Ministries of Irrigation and Agriculture already are looking to the project personnel for general guidance on the design of further programs that will increase agricultural production.[14]

[13] Colorado State University evaluation, Op. cit., p. 43.

[14] Mid-Project Evaluation Report of the Egypt Water Use and Management Project prepared for the Agency for International Development, November 1980, p. 19.

Multidisciplinary Approach

This was considered a significant factor by project participants and evaluators. The multidisciplinary approach brought together economics, institutional aspects, and sociology, along with the traditional disciplines of engineering and agronomy, in planning, implementation, and training. The multidisciplinary training of water management specialists is one of the major innovations required in the future. Demand for broad-based water specialists may exceed supply, given the scale of planned investments in existing and new irrigation schemes. The International Food Policy Research Institute (IFPRI) estimates, for instance, that in eight Asian developing nations alone, an additional 55,000 professionals, technicians, and extension personnel will be required annually until 1990 to manage and operate new irrigated areas. [15]

An outgrowth of CSU's work in Pakistan and other developing countries was a grant from the Ford Foundation for partial support of an intensive interdisciplinary course. * The course, offered in 1981, is noteworthy in its coverage of social, institutional, and technical aspects of improved irrigation water management. Most participants were from foreign countries.[16]

Information Dissemination

Worldwide

The Water Management Synthesis Project is a step toward creating an information system to meet irrigation management information needs. Such an organization would need to be: international in scope, cross-disciplinary, concerned with improving irrigation systems management, focused on developing countries and small farms, directly linked with action on research, able to identify and report on improved management practices, and backed by sufficient resources. No organization currently publishing and distributing information on irrigation combines all these features.[17]

United States

Irrigation technologies and the institutional arrangements for implementing them are generally site-specific. Nevertheless, U.S. project participants in the Pakistan and Egypt efforts maintain that the experience gained in those projects provides insights for solving irrigation problems in the arid lands of the American West. One of the Pakistan project participants, for instance, applied the problem analysis and techniques he developed abroad to work being conducted with Colorado farmers. The project involved organizing farmers to use water management technologies to reduce the salinity of discharge into the Colorado River from the Grand Valley .18 This demonstration project, funded by the U.S. Environmental Protection Agency (EPA), was later expanded with support from USDA's Soil Conservation Service.

Another example comes from the feedback of Pakistan's project and the development of CSU's interdisciplinary short course on water management. Although practically all of the attendees have been foreign students, administrators, and researchers, the course is open to U.S. citizens. The cofounder of the course, Everett Richardson, recognizes that the institutional setting for irrigation in the Western United States is different from that in Pakistan or many other developing countries. Nevertheless, he feels that "the principles of problem-solving and organization building are directly applicable to U.S. situations. " In addition, a number of potential applications of these foreign projects to the Colorado situation were identified. They include:

- the research development process;

[15] IFPRI, op. cit., p. *63*.

*The Ford Foundation also has considered support for an international center to conduct interdisciplinary research and training in the irrigation management field. This idea, which was viewed as having a high priority by the Consultative Group on International Agricultural Research, a multidonor-sponsored organization with headquarters in Washington, D. C., was rejected, however, for budgetary reasons.

16 David M. Freeman, Associate Professor of Sociology, Colorado State University, August 1982, telephone interview.

[17] Consultative Group on International Agricultural Research, op. cit., p. 28 (see footnote 5).

'e'' Modest Technologies," *Mosaic* (Washington, D. C.: National Science Foundation, January/February 1977), pp. 46-47.

- foliar spray techniques for applying nutrients, which are not used widely in Colorado but could be and which are being used in the Columbia Basin;
- an inexpensive canal outlet for water control and measurement;
- project publications covering such items as the design of buried pipelines and furrow irrigation systems; and
- improved surface methods and water management techniques that do not involve the costly investments for sprinkler, bubble, or drip irrigation systems which many Colorado farmers feel are the only means to increase water efficiency. *

*Mr. Richardson prepared an informal paper, "Egyptian Experiences Applied to Colorado, " for AID in 1982. He said in a telephone conversation in August 1982 that one or two Colorado farmers were interested in working with him to implement some of the methodology from the Egyptian project. Irrigation farms in Colorado face a fivefold increase in their water charges in 1983 because of assessments on irrigation districts for construction of new dam spillways. Before these assessments, Colorado farmers could afford to hold on to extra shares of water. Richardson believes the increase from $20 to $100 per share (each share equals 7 acre-feet) will make it more attractive to sell shares and to become more water efficient.