931 0429 | 17
PD-AAM-239
ISN- 15469

EVALUATION OF THE

ON-FARM WATER MANAGEMENT RESEARCH PROJECT

COLORADO STATE UNIVERSITY

AGENCY FOR INTERNATIONAL DEVELOPMENT

Contracts

AID-csd-2126
AID/ta-c-1100
AID/ta-c-1411

Dean F. Peterson
James L. Walker
E. Walter Coward

September, 1979

EVALUATION OF

ON-FARM WATER MANAGEMENT RESEARCH PROJECT

COLORADO STATE UNIVERSITY

CONTENTS

I. SUMMARY

II. INTRODUCTION AND BACKGROUND

A. Purpose of the Review

B. Project Description

1. Setting - Irrigation in Pakistan

2. Project history

C. Team Composition and Evaluation Methodology

PROJECT OBJECTIVES

A. Discussion of Objectives

IV. ANALYSES OF ACCOMPLISHMENTS

A. Major Project Achievements

1. Research and Development Outputs

a. Measurement of watercourse losses and establishing their credibility

b. Determining farm application losses

c. Identification of socio-economic constraints to watercourse management

d. Commitment of Agriculturalists to Field Problems

e. Irrigation water user associations and model law

f. Crop, soil, water fertility interrelationships

g. Crop, water salinity interrelationships

h. Watercourse technology

i. Skimming wells

j. Consumptive use

k. Economic benefits and costs

2. Training

3. Information Dissemination and Transfer

a. Publications and reports

b. Workshops and seminars

4. Project Management

a. Identifying the real problems and focusing on them

b. Interdisciplinary approach including socio-economic involvement

c. Multi-linkage and redundancy

d. Colleagual style with counterparts

e. Development of On-Farm Water Management Pilot Proposal

B. Assessment of Achievements

1. Influencing Crop Production Potentials

2. Assisting the Small Farm Sector

3. Assisting in the Development of Organizations and Institutions

4. Training Research Personnel to Support Water Management Development

a. Research

b. Operations

5. Developing Appropriate Technology for Watercourse Improvement

6. Integrating Research Results with the National Setting

7. Reporting and Disseminating Research Results

8. Transferring Processes/Results to Other Development Contexts

V. CONCLUSIONS AND COMMENTS

A. Overall Performance

1. Meeting the Project's Objectives

2. Linkages to Major Pakistani Institutions

3. Important Limitations

4. Mission Relationships

B. Lessons to be Learned

1. Implications for AID Research Activities

2. Management of University Research Contracts

a. Project Planning

b. Involving the Rural Social Sciences

c. In-country Financing

d. Recruitment and Staffing

C. Implications for Title XII and CRSP Activities

D. Recommendations for Project Actions

VI. APPENDICES

A. Evaluation Guideline

B. Persons Contacted

C. Itinerary

D. Brief Project History

E. Reports to be completed by Colorado State University

I. SUMMARY

In 1968, AID initiated a centrally-funded farm irrigation water management research project centered in Pakistan with Colorado State University (CSU) as the contractor. In 1979 this project, executed under three successive contracts, was transferred to ASIA Bureau and, in 1980, to USAID Pakistan. Total dollar expenditures through termination on March 31, 1980 are programmed at $6,471,712. Because of cessation of AID activities in Pakistan, the field work was terminated in September, 1979.

diverted

Pakistan has about 25 million contiguous acres of land under irrigation from canals directed from the Indus River and its tributaries. The irrigation facilities were initiated a century ago by the British and have continuously been extended since then. Canal irrigation is supplemented and the irrigated area expanded another 5,000,000 acres by wells. Since Independence in 1947, multi-billion dollar investments have been made in storage reservoirs (Tarbela, Mangla), the large link canal bringing Indus River water to its other more easterly tributaries and in government-owned groundwater developments, yet increased yields and production generally have been quite disappointing. This research project was designed to take a look at the other end of the canal system, the farm, and how its water is managed, at that level.

The original contract terms for CSU were broad and the project experienced some delay in start up for various reasons which were compounded by the Pakistan war and other political factors. By 1972, the most promising lines of research and institutional linkages had been identified, the general research plan put into focus, and a four-person expatriate team,

later increased to seven, put into place.

The most critical difficulty was found to be in the last element of the water distribution system, the watercourse. The government canals deliver streams of water to areas of about 400 acres each. From here to the farm the watercourse carries it and poor water management is rampant. ~~this water is poorly managed~~. The farmers are on their own. Neither Irrigation nor Agricultural Departments have the responsibility for management of this link in the system, and indigenous institutions are not developed. ~~in this "no-mans land".~~ There are, of course, other critical problems also. Management and control of water on the farm itself, saline groundwater and drainage are among the principal physical ones. All of these are linked to deficiencies in institutions and human resources.

What are the indicators to be used in evaluating ~~this~~ a project of this type? We[1] did not have the resources to collect social and economic data, but we were able to document significant information relating to the impact of the project and to draw some conclusions relevant to centrally-funded research, CRSPs and Title XII programs.

We think significant progress has been made by the project and by projects spawned by it toward mitigating the serious difficulties arising from

---

1/ In this report:

We, Us, Our means the evaluation team

Team means the Colorado State field party in Pakistan

Project means the joint efforts of the Team, its Pakistani associates and the supporting CSU faculty.

poor water management.

The CSU team recognized from the beginning that socio-economic considerations could not be divorced from physical and agronomic ones. Watercourse surveys concurrently collected socio-economic and physical and agronomic data although social studies lagged somewhat. These studies led to concerns about institutional arrangements for watercourse management and development. With Pakistani colleagues the team developed a model water users association law which is now not being seriously considered by the Pakistan government. Even so, understanding of the sociological dimensions of desirable watercourse organizations is at best minimal.

By a series of field measurements, made for the first time in Pakistan by project personnel, deliveries of water turned out of canals to intended fields were shown to be not 85 percent as assumed by Pakistani and donor planners but mainly in the range of 40 to 60 percent. Credibility of these results were established with donors and high Pakistani officials largely through project efforts. Indicators of success include, among others, a matching USAID loan project to improve about 1500 watercourse (out of 89,000), a proposed Government of Pakistan shift in strategy at the national planning level to emphasize water conservation through watercourse improvement and significant commitments toward that strategy by World Bank and other donors.

Following identification of the critical problem, the project developed socio-technical procedures and appropriate agronomic and engineering technology for implementing watercourse improvements which is now being used in the Pilot Project and elsehwere as the result of training and extension

under the project. No single counterpart organization or government agency was available, rather interest and responsibility was diffuse. Thus the project engaged in developmental efforts with a dozen or more. Under the USAID Funded On-Farm Water Management Pilot Project that grew out of the CSU effort, a responsible unit was ~~formed~~ established in the central ministry of agriculture and organizations formed and responsibility fixed in the provinces. Training and education programs in the U.S. and Pakistan for project personnel focused on the project's objectives and proved to be very essential elements of the project's success. Some project concepts have already been transferred in designing AID irrigation water management activities in Sri Lanka and Egypt.

A major strength of the project was its very heavy field orientation. The opportunity to work with a number of different organizations seems to us to have been a very positive advantage. Likewise, the broad terms of the contract permitted identification of the critical issues on the ground prior to drafting fixed work plans. We think this research project may have been unsuccessful had the planning rigidity now often required of many AID projects been in force.

The research project was somewhat unique in that it sequentially diagnosed the difficulties and moved into implementation without interruption. We think this scenario is important for developing country research projects; otherwise the hypothesis that the research is relevant is not tested. This means the problem must be of significant importance to the host country. Demonstrating that the problem really existed was an important project contribution.

The importance of centrally-funded research even in a single country is supported by the success of the project. We do not believe that the very critical problem of farm water management in Pakistan would have been tackled within the foreseeable future by either USAID or the Government of Pakistan. Both the contractor and present Mission personnel indicate that a principal reason that the team enjoyed good relationships with USAID was its independence.

The project demonstrated that to be successful the farmers ~~under~~ on a water course must be fully involved in the planning details from the very beginning and must be willing to contribute resources of labor and preferably some financing also.

Several points which should be of interest to CRSP and Title XII activities are detailed. In addition to some of those mentioned above, these include the value of considerable flexibility in the mode of approach, the need to work under real conditions, e.g. on farms, in LDCs the need to identify problems of primary importance to host countries, the need to make the project a host country one, and the need for in-country funding especially if P.L. 480 funds aren't available. We are impressed that training and institutional development, though not included in the project objectives, were essential activities at every step in the project and must have required a very significant share of the team's time and efforts. For the reader who still has some only limited time left, we suggest he/she read next Sec V on conclusions and recommendations.

With the exception of ~~these~~ reports remaining to be completed by

(see appendix E),

March 31, 1980, we conclude that CUS met all of it's contractual obligations, some of them exceptionally well.

II. INTRODUCTION AND BACKGROUND

A. Purpose of the Report

The primary purposes of the review reported herein are to document and learn from the experience gained from the centrally-funded contract research program on "On Farm Water Management" and to determine the progress made against the objectives (Appendix A) Except for a short time in Vietnam, this project initiated in 1968 under a contract with Colorado State University (CSU), has been exclusively centered in Pakistan, although its objectives are not site specific. Our review is concerned about transferability of research results, in Pakistan and in other LDCs. It is also concerned about the quality and relevance of the results and about conceptional, administration and implementative matters.

The project is scheduled for termination in March, 1980. Since the CSU Field Team[1/] will leave Pakistan during September, 1979 and because of discontinuance of A.I.D. programs in Pakistan under Sec. 669 of the Foreign Assistance Act, dealing with nuclear materials, the staff of the Pakistan USAID will be substantially reduced during the autumn months of 1979, thus

---

1/ To avoid confusion the CSU field team will be referred to as the "Team"; we will use the first person, i.e. "we", "us" or "our" in referring to the evaluation team.

the review was scheduled for July, 1979 in order to take advantage of the presence of both the CSU and USAID staff while they were still assembled in Pakistan.

B. Description of the Project

Inefficient or inadequate management of water supplies from both rain and by irrigation at the farm level has been identified ad a globally occurring constraint to increased agricultural production in developing countries.[2/] In irrigated agriculture, for example, billions of dollars have been invested in irrigation water supply and conveyance works, but realization of the agricultural benefits has been disappointly slow. The centrally-funded A.I.D. research program was conceived in an attempt to find ways to begin to relieve these constraints. Under this program two contracts, focusing primarily on irrigation and drainage, were negotiated; one with Utah State University, whose venue was Latin America, and one with Colorado State University, who was to be concerned with Asia and the Middle East. The field program of the latter project was conducted, except for some work in Vietnam, in Pakistan which has one of the largest and in some ways most intractable irrigation systems in the world. That the impetus for the research came from

---

2/ See "The World Food Problems", White House, 1967, for example, but there are many other authorities also.

the perception of a global problem is an important point to be considered in this assessment. Equally important considerations, however, are the goals and objectives of the Mission in the host country in which such projects are situated. Perceptions stemming from both points of view need to be considered and accommodated or resolved.

Total dollar funding for the project under the contract with CSU for the period March 28, 1968 to March 31, 1980 is $6,421,712. The project was operated under Contract AID-csd-2162 until March 31, 1974, under Contract AID/ta-c-1100 between April 1, 1974 until March 31, 1977 and under Contract AID/ta-c-1411 thereafter. As the project became increasingly concerned with Pakistan applications, it was shifted from DS to ASIA Bureau Management in FY 1979 and to Mission Management in FY 1980. Funds for in-country services and supplies were provided by PL-480 grants to collaborating Pakistani agencies on a project basis. Six such projects were approved totaling Rs. 6,004,000. Four other projects have been proposed totaling Rs. 42,097,000. Presumably, these latter could go forward when approved and are not contingent on continuation of the CSU contract.

Pakistan Setting. Canal irrigation in the Indus Basin was initiated during the latter part of the 19th century with development works continuing up to the present. Some 25 million acres are now under canal command. Groundwater serves another six million acres. The river diversion works, very large primary canals and the distributional network of lesser canals are remarkably well designed hydraulically and represent outstanding engineering achievements in diverting and conveying water. It is ironic that

the technologies of making diversions from large alluvial rivers and of canal design in erodible earth were born and developed to high sophistication in the Indus Basin, but that essentially no attention was given to agricultural use of the water delivered. Water is simply released from the distributing canals through outlets (Moghas) to areas of land of approximately 400 acres. From this point its distribution to the fields and its use on those fields is not the concern of the Irrigation Department. Nor is it the concern of the Agricultural Department. The farmers are expected to fend for themselves. This agricultural water management void is characteristic in degree of most irrigation systems throughout the World; its consequences are more acute on large systems.

By the 1930's, leakage from canals, watercourses and inefficient field applications had raised the water table in many areas of the Indus plain to levels where waterlogging and salinity had become an obvious and accelerating problem. This led to development by 1961 of extensive installations of tube wells (Salinity Control and Reclamation Programs - SCARPS) using public financing to lower water tables and also provide additional water supplies. Unfortunately, the native groundwaters, now overlain by fresher waters seeped from irrigation system, were often very saline leading to difficult water quality management problems. On the positive side, though, the SCARP venture stimulated development of private tubewells, smaller and shallower. By 1972 there were about 8000 public tubewells with an average capacity of about 3 cubic feet per second and about 80000 private ones with capacities ranging from 0.25 to 1.0 cubic feet per second average capacity. These latter have rapidly continued to increase in number and are prized

because water could be obtained as needed by the farmer owners. A number of public tubewells have been permanently shut down because of the high salinity of the water pumped. While opening up another set of opportunities and problems, groundwater development apparently has reversed the spread of waterlogging and salinity.

Resource management and agricultural programs in Pakistan are normally provincial matters. Concerned provincial departments are Irrigation and Agriculture. Comparable Ministries exist at the National level. But donor grants and loans are made to the Central Government through the Finance Ministry. This separation of responsibility complicates the monitoring and administration of aid projects. To deal with the vast construction of civil works, GOP in the mid-fifties formed the Water and Power Development Authority (WAPDA) which plans and constructs, but usually does not operate the projects. WAPDA has broadened its scope to include policy and planning for the entire management of the water resource and is not seriously concerned about agricultural water use. There are a host of other concerned institutions also including universities, research institutes, etc. In agriculture, a national council, Pakistan Agricultural Research Council (PARC), is responsible for planning and coordinating agricultural research.

As social scientists and, by now many engineers and agronomists will assert, canal irrigation is a human, social matter in very substantial degree. Besides a technological vacuum below the mogha, in the same space there are parallel near vacuums or weak institutions at best at all levels from the farm community to the Provincial and National Governments. This

twin difficulty is important in considering the project. Since Independence, Pakistan and its donor constituency, have been successively concerned with settlement of the Indus Basin treaty, with its multi-billi n dollar link canals to offset waters allocated to India; its SCARP program and the Tarbela and Mangla storage reservoirs; hardly an atmosphere conducive to discussing inefficient use of water already diverted. The potential for large construction works is now about exhausted and donors and Pakistan seem more receptive to considering increased water management efficiency as an important potential agricultural resource to increase production, although some elements in the Government may not yet be convinced. These kinds of difficulties are not limited to Pakistan, but are found repeated in degree all over the World.

In spite of many common physical characteristics, the irrigated Indus plain is by no means homogeneous. There is wide diversity in soil and groundwater quality. Even more diverse are the human dimensions. The Canal Colony scheme for setting farmers on the irrigated lands brought under its umbrella a number of different linguistic groups with differing mores and customs. Not all canal irrigation in Pakistan falls under the large canal system, either. Smaller, locally controlled traditional systems exist particularly in the Northwest Frontier and Baluchistan Provinces, which, except for very limited areas, did not come under the Canal Colony scheme.

Agricultural water management problems have a number of characteristics which need to be kept in mind. Efficient use is not simply distribution of irrigation water (which is a social venture itself) and insuring drainage,

but a balancing of water resources, and their management with farm production systems potentials including their agrinomic, economic and social contexts. Thus, it is multi-disciplinary. While technical parts of the problem can be isolated and studied in laboratories or on research stations, if these are important enough; the system itself must be studied in vivro, in the field, using real systems if the real problems are ever to be understood.

Project History. The CSU project was initiated March 28, 1968. Early USAID Islamabad communications to AID/W-to-AID-A state that "AID administrative restrictions prevented the posting of a full time research scientist in Pakistan". CSU TDY inputs in Pakistan were further hampered by the July, 1970 division of West Pakistan into four separate provinces for administrative matters and the resultant unclear definition as to where the responsibilities of the Central Government vis-a-vis those of the Provincial governments commence and end. Thus, against this confusing background, which also included a war the first full time CSU resident leader arrived in Pakistan in August, 1970. During the interim period, 1968-70, many contacts were made with Pakistani officials and institutions by CSU faculty on TDY. Several Pakistani technicians came to CSU for study and to participate in on-campus research studies using some data collected in Pakistan. During the ensuing two years, 1970-72, the focus of the project became more clear and more realistic and, most importantly, the importance of the subject was articulated to Pakistani officials and some linkages with Pakistan organizations were identified. In 1972, three additional CSU researchers arrived in Pakistan. During the next two or three years,

the nature and magnitude of the more critical problems were identified by collecting more pursuasive field evidence and work began on solutions. Watercourse surveys were initiated and included from the beginning socio-economic as well as physical information. Good progress was made toward technological approaches to preventing watercourse losses and improving groundwater management and agronomic practices, and the social and institutional dimensions were identified. Work still remains to be done to identify the best forms of watercourse organizations.

By 1976, the resident staff had been built up to seven. In 1976, the Mission signed a loan agreement to implement the On Farm Water Management Pilot Project having as its purpose to partially line and reconstruct some 1500 watercourses. The cost estimated was about $44 million equally shared by loan and GOP funds; however, under the current AID phaseout, U.S. commitments are limited to those already made or, about $9.8 million. This project is administered in the Central Ministry of Agriculture, Food and Cooperatives with a separate director in each of four provinces under the provincial agricultural departments and has continued concurrently with the On-Farm WAter Management Research Project. By 1978, efforts of the CSU team were shifted toward helping to train personnel for this program and from engineering, toward agronomic and institutional questions. Some work was done by the project in land leveling; this was started under an agreement with CARE. Later, GOP, under an AID loan in 1973, implemented a multi-million nupee program of precision land leveling. This program was managed by the USAID first under an agreement with CARE and then under a PASA with the Soil Conservation Service.

With the shift from more general concerns to increasingly country-specific problems and in the spirit of the 1977-78 AID reorganization, the Project was shifted from DS/AGR to ASIA Bureau Management in FY 1979. Mission management responsibility beginning in FY 1980. At the time of our visit in July, 1979, the resident staff included seven persons; an agricultural engineer, social anthropologist, soils scientist, agricultural economist extension engineer and extension agronomist, and a graduate student working on the land leveling project.

The history of the CSU TDY and long-term involvement in Pakistan and on-campus can be appreciated graphically in Figure 1 and the CSU disciplinary involvement with different Pakistani institution and projects is detailed in Table 1.

In early 1972, the project was evaluated by a Team led by Dr. Marvin Jensen, Director of the USDA Water Conservation Laboratory at Kimberly, Idaho; and including Dr. Earl heady, of Iowa State University; and Mr. Leland Anderson, of USAID, Pakistan. This evaluation, made at CSU in Fort Collins, led to elimination of some of the sub-projects started during the earlier part of the project's history, recommended increased work in the field by full-time resident personnel and appointment of a full-time resident manager on the CSU campus. In 1976, a field evaluation was made by a group led by Howard Haise, retired USDA Agronomist. This group also included John Phelan, Soil Conservation Service; and Douglas Caton, Economist, TA/AG, AID/W. This evaluation supported continuation of the project and made several technical and programmatic recommendations. The recommendations of the Haise group

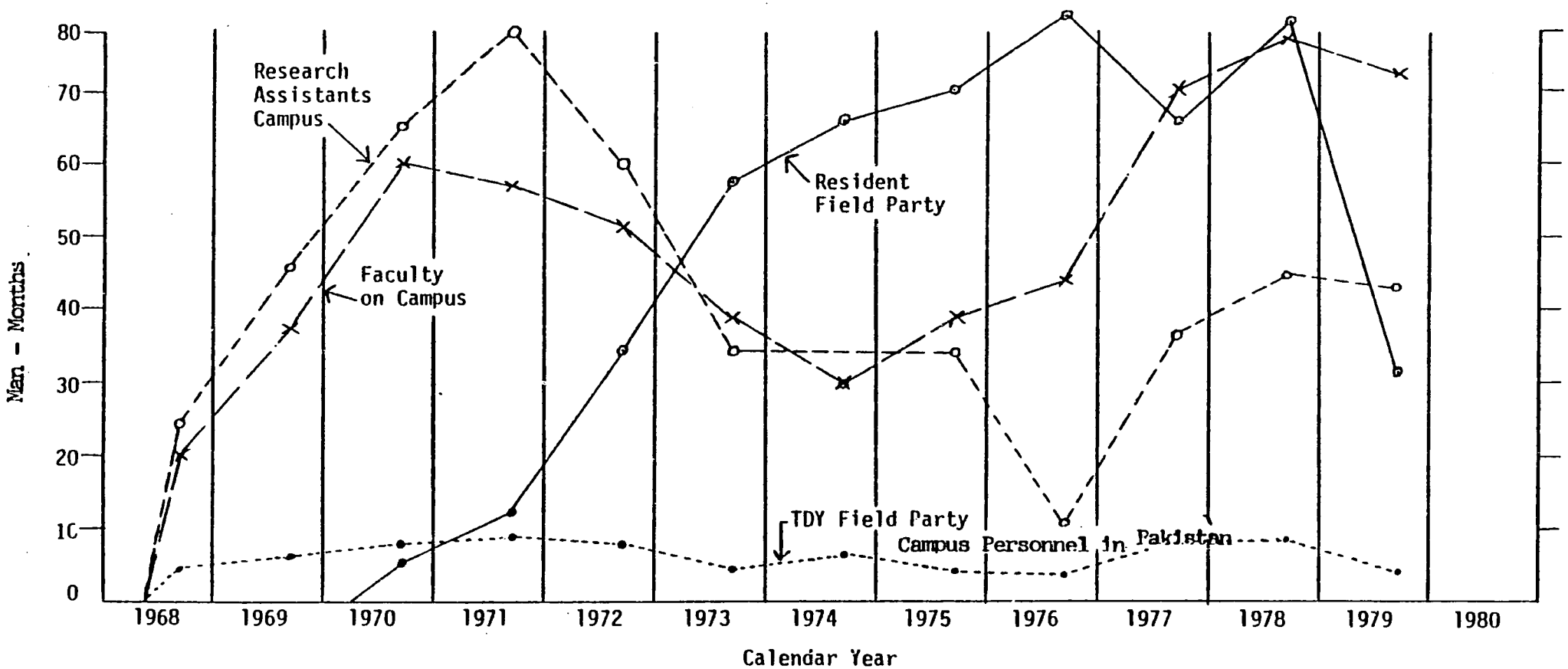

Figure 1 - Location of Manpower Used by CSU on the Water Management Research Contract

Table 1 Man-months of technical advisory services by discipline (Field Party and TDY)

Location		Agric. Eng. To 1/76	2/76 to 3/77*	4/77 to 3/78	4/78 to 3/79	4/79 to 3/80	Agric. Econ. To 1/76	2/76 to 3/77*	4/77 to 3/78	4/78 to 3/79	4/79 to 3/80	Agr. & Soil To 1/76	2/76 to 3/77*	4/77 to 3/78	4/78 to 3/79	4/79 to 3/70	Soc. Law & Exten. To 1/76	2/76 to 3/77*	4/77 to 3/78	4/78 to 3/79	4/79 to 3/80
Mona Reclamation Expt. Proj. (WAPDA)		9.2	5	23	8		61	11	3½	3½		13	11	27	8		3	1	3	1	
Integrated Rural Development Shadab and Lar		1.4	2				9	4				3.5	4				2	1			
Punjab Agricultural Research Institute	Soils Institute (Lyallpur)				2		0.5					6	2	4	3						
	Small Grains Institute (Lyallpur)	6			↓		0.7					1	2	↓	↓						
	Cotton Institute (Multan)	2			↓									↓	↓						
	Rice Institute (Kala Shakaku)	2			↓									↓	↓						
	Maize & Millets (Yousafwalla)	1			↓		0.1							↓	↓						
College of Agriculture, Tandojam		2.1										2									
Land Reclamation Directorate							1.1	0.5													
Islamabad University							1.1	0.5				1									
Engineering University - Lahore							0.6	0.5													
WAPDA - Other than Mona - Incl. Survey		1.1	1				9	4									3	1			
University of Agriculture - Lyallpur		0.5	2	7	6		2	2	1	3		1	1	12	11		2		6	5	
USAID OFWMDP		4.5	1	2	5		7	3	2	5		6		1	3		4	1	12	7	
Other, Regional Analysis, etc.		0.3	1	3	4		6	2	5½	2½		5	1	5	10						

*Planned for February 1976 through March 1977

have been well followed, although these appear to be more as endoresements of plans already formulated by the project than as suggestions for changes in direction.

With the current phaseout of the AID program, prospects for continuing the project or a successor do not exist at the present time.

C. Evaluation Team and Procedures

The present evaluation was conducted by a group led by Dean F. Peterson (irrigation) Director, Office of Agriculture, Development Support Bureau, AID/W; E. Walter Coward, (social science) Chairman, Department of Rural Sociology, Cornell University; and James L. Walker, (Agronomist) Multidisciplinary Program Manager, College of Tropical Agriculture and Human Resources, University of Hawaii, in Pakistan during the period July 9-27, 1979, in Fort Collins September 3-6 and Logan, Utah September 7-8.

To answer the overall evaluation questions set forth in Sec. IIA of this report, we reviewed a large number of reports, contract documents and correspondence related to the project, interviewed a number of concerned GOP officials at various levels from secretarial rank to field assistant, staff members of the Punjab Agricultural University at Faisalabad, and USAID and CSU field and Ft. Collins resident staff members. We also were able to meet with some farmers both during water course inspections and at one village.

During July 10, 11 and 12, we interviewed the following GOP officials in Islamabad: Chief of Water Resources, Ministry of Planning; Chief Engineering Advisor to GOP, Central Ministry of Water and Power; Chairman,

Pakistan Agricultural Research Council; Secretary, Central Ministry of Water and Power; Additional Secretary, Ministry of Science; Secretary, Ministry of Food, Agriculture and Cooperatives; Chief Engineers, Master Planning Division WAPDA, and the Acting Director and other officials of the USAID Mission.

On July 13 to 15 we visited the Mona Experimental Project of WAPDA. This is an experimental area of more than 100,000 acres within a SCARP where field research is conducted. This project was implemented in about 1965 to try to ascertain why the SCARP programs were not as effective in lowering water tables and increasing agricultural production as had been hoped. Most of the watercourse work including socio-economic surveys and much of the skimming well, salinity and crop-water-fertility experiments were conducted here collaboratively with CSU. We discussed the contributions of the CSU team generally with staff members and privately with the Director of the Project. July 16-17 was spent at Faisalabad at the Punjab Agricultural University discussing research and particularly training programs, in visiting a watercourse improvement demonstration project at Thikriwala used in the training program and visiting several watercourse improvement project under the USAID pilot project. A conference was held with the Director of the On-Farm Water Management Pilot project and some of his field staff members.

July 18-21 was spent at Lahore. Conferences were held with the General Manager for Planning, WAPDA, with the Chief Engineer of the Irrigation Research Institute with the CSU staff in residence in Pakistan. Various documents in the CSU staff library were reviewed. The remainder of the

period, July 22-27 was spent in Islamabad drafting the report. Additional conferences were held with representatives of the Canadian International Development Agency; the Director (Water Management) Ministry for Agriculture, Food and Cooperatives and, the Acting Director and Agricultural Officers of the Mission and with the Ford Foundation representative.

During the period from September 2-8, we met in Fort Collins, Colorado with the President of CSU; the Vice-President for Research; the Associate Dean of the College of Arts, Humanities and Social Sciences and Title XII officer, the Dean of the College of Engineering and with officials and members of the Departments of Agricultural and Chemical Engineering, Economics, Sociology and Agronomy who were associated with CSU's efforts in Pakistan.

In Logan, Utah, we met with the former project leader of CSU's Pakistan team during 1974-77.

The Team attempted to make assessments considering the overall objectives stated by the project documents, the questions raised in the Scope of Work based on information obtained during the interviews and a review of the project reports and documentation.

A statement of Evaluation Guidelines, list of persons visited and a detailed itinerary of the Team's visit is given in the Appendix.

III. PROJECT OBJECTIVES

From the outset of its contractual association with the Agency for International Development in March of 1968, Colorado State University had the mission of producing information (research) and expertise (trained personnel) concerning on-farm water management and related farming practices in Asia with

the goal of increased food production.

Additionally, CSU, together with the Council of U.S. Universities on Soil and Water Development in Arid and Sub-Humid Areas (CUSUSWASH) were to cooperatively:

1) Examine all available water management research findings to identify relationships having worldwide application; and, engage in and promote research for filling gaps in knowledge; and, publish a manual "Principles of Water Management" to provide guidance through the whole range of climate, soil and socio-economic situations;
2) Identify, study and characterize the water laws and organizational arrangements of various countries to obtain information concerning the types of laws and the entities affecting water allocation, distribution and utilization in irrigation systems; and, use this information to advise developing countries, particularly those in arid and sub-humid regions, on substantive, procedural and organizational alternatives in water laws and organizations that can be tailored to meet their needs.

The initial focus of the CSU mandate was Pakistan where it was intended that broadly applicable principles and concepts would be derived through obtaining the following objectives under Contract AID/csd-2162:

1) Developing knowledge and data on how best to conserve and utilize water falling on the land as rain and the most efficient means of supplementing needed soil moisture by limited amounts

of irrigation water;

2) Developing knowledge and data to use for the economic design and constructions of water conveyance and delivery systems including structures for control and measurement of irrigation water especially on the farm;

3) Developing surface and sub-surface water removal systems to elimimate the hazards resulting from surface flooding and high water tables;

4) Identifying important factors to be considered in land preparation and leveling of the various irrigated soils[3/] in the major climatic zones and the relationship of these factors to water management erosion, water infiltration, and good land use and cropping practices;

5) Developing and adapting[3/] methods of water application, including time and amounts, suitable and efficient for different soils of varying physical properties with major crops;

6) Integrating the preceding water-use factors into productive cropping systems[3/] consistent with farm size and available farming practices;

7) Studying soil amendments, soil and water management procedures and the use of salt-tolerant where water quality, soil salinity and exhangeable sodium are problems;

[3/] Amendment 7, May, 1973. These items were added under AID Contract AID/ta-C-1411

8) Identifying institutional and policy factors influencing efficient distribution and management and utilization of water at the farm level.[3/]

The basic contract AID/csd-2162 was subsequently amended to add the following objectives to the original ones:

(7-1-69) Produce a research and educational film on land preparation for level-basin irrigation.

(6-3--70) 1. Study, emphasizing on-campus, mathematical models, the types of skimming arrangements for collecting fresh water over saline strata;

2. In cooperation with the West Pakistan Department of Agriculture, advise on land preparation and water control field experiments (leveling, chiseling, slope, length of rain, rate of application and method irrigation;

3. On-campus completion of clay mineralogical studies of Pakistani soils and the relationships of ESP of these soils in the laboratory and greenhouse to applied waters of varying SARs;

4. Cooperatively with the land Reclamation Directorate of the Department of Irrigation and Power study utilization of saline ground water for long-term irrigation;

3/ Amendment 7, May, 1973. These items were added under AID Contract AID/ta-C-1411

5. Cooperatively with the Ayub Research Institute Initiate field studies on management techniques related to water quality and cultural practices (including variables such as water quality, rate amd frequency of irrigation, tillage and amendments);
6. Cooperatively with the West Pakistan Agricultural University, characterize and classify irrigation waters and soils as related to water quality and irrigation practices;
7. Continue studies on-campus on fluorescent dye loss in water flow;
8. Continue on-campus design of economic analysis and data collection and handling in the field; initiate analyses of economic rationale of on-farm input use;
9. Initiate studies on-campus of political science as related to the organization and administration of water management problems;
10. Initiate studies of social science as it relates to the acceptance of water management programs.

By early 1970, these objectives had been defined in a context appropriate for West Pakistan and a Project Agreement was written cooperatively with USAID and the Government of West Pakistan establishing the specific research studies required to meet the following objectives.

CSU activities were expanded to include the Mekong Delta region in Vietnam where operations commenced in early 1974. The objectives of this effort, while specific with regard to in-country efforts, were consistent with the

project objectives previously mentioned. This activity ceased on 21 April 1975 due to the American evacuation from Vietnam.

During 1974, a new contract (AID/ta-C-1100, effective 1 April 1974, was signed with AID/W. In it, project objectives remained unchanged from those mentioned in the preceeding paragraphs of this section.

AID contract AID/ta-C-1411 was approved for the period of 1 April 1977 to 31 March 1980 and contract management was transferred from the Bureau for Developmnent Support to the Bureau for Asia in November of 1978. This contract provided funds for a continuation of the research activities conducted by CSU under contract AID/ta-C-1100. Thus, the objectives of the new contract unchanged. However, this contract was more specific with regard to its conditions than was the previous project, in that it was expected that:

1) most of the research would be conducted on watercourse areas being pilot tested under the USAID/Pakistan On-Farm Water Management Project No. 391-04130;
2) there would be cooperation with Cornell University personnel who were working on the AID funded research project "Determinants of Irrigation" (Proj. No. 931-1005).

The specific tasks under the general scope of work to develop, design and implement guidelines for improving irrigation water use efficiency and effectiveness on farms with emphasis on the pilot project area, were to:

1) give technical guidance on watercourse rehabilitation and land leveling;
2) test the essential improvements program;

3) determine the maintenance and educational requirements of precision land leveling;

4) analyze crop water needs and cropping patterns to efficiently utilize water;

5) make field evaluations of tubewells and pumping devices to develop guidelines for designing and operating skimming wells;

6) provide personnel assistance in designing a training program;

7) prepare a manual describing and recommending minimum training requirements for various aspects of the water management improvement process;

8) develop evaluative tools to measure the effectiveness of farmer organizations and then evaluate a number of such organizations in the pilot project area;

9) document the economic benefit-cost ratios resulting from specific water management alternative technologies for ten pilot experimental watercourse areas;

10) perform farm management studies to ascertain alternative changes in cropping intensities and crop mixes to increase net farm income resulting from the increased water supplies due to reduction of water losses and improved field application practices;

11) analyze the costs of production of water from private tubewells;

12) make an intensive socioeconomic benchmark evaluation on a sample of the 1500 watercourse areas in the pilot project;

13) prepare a manual which can be utilized in LDCs in developing and implementing on-farm water management programs describing the

methodology or systematic process (transfer model) which has evolved from the research experience in Pakistan;

14) prepare, as in item 13 above, a set of technological manuals on:

a) watercourse improvement;

b) land shaping and field arrangement for efficient use;

c) crops and cropping patterns for efficient utilization;

d) institutional and organizational needs;

e) system maintenance;

f) augmentation of supply by wells and farm storage;

15) provide limited (approximately 1 FTE) technical assistance to AID for irrigation water management project planning and evaluation.

Contract AID/ta-C-1411 was amended 8-29-79 to require the following specific manuals/reports at the time of contract termination:

a) Transfer process

b) Water uses Association Brochure

c) Water Course Improvement

d) Evaluation and Improvement of Irrigation System

e) Evaluation and Improvement of Basin Irrigation

f) Evaluation and Improvement of Border Irrigation

g) Design of Jet Junctions

h) Skimming Well Manual

i) Calibration of Cutthroat Flumes

j) Factors Affecting Losses from Indus Basin Irrigation Channels

k) Water Course Cropping Systems

l) Training Manual for Water Management Extension

m) Water Users Associations (Pakistan)

n) Final Contract Report

Thus, over time, the focus of the CSU effort under the three AID contracts became more project specific, but at all times consistent with the objectives of the initial project funded in 1968.

In the chapters which follow, CSU's accomplishments in their pursuit of these objectives will be assessed.

IV ANALYSIS OF ACCOMPLISHEMNTS

A. Major Project Achievements

1. Research and Development Outputs

a. Measuring Watercourse Losses and Establishing their Credibility

For the first time, seepage and operational losses of water in delivery from the canal turnouts to the farmer's fields were measured under operating conditions. 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. Much effort on the part of the CSU team and its Pakistani associates went into establishing the credibility of these findings with high Pakistan government officials and their consultants and donor constituency. The experiments have been repeated over Pakistan first on 40 and then on 61 sample cases. The evidence has been accepted and has led to the $44 million ($22 million AID loan) On-Farm Water Management Pilot Program initiated in 1976 and to suggestions for major revisions in Pakistan's

water management strategy from large water supply works to emphasis on conservation and management as evidenced by the recent report of WAPDA's Planning Division entitled "Revised Action Programme for Irrigated Agriculture" dated April, 1979. This draft plan, which still faces the obstacle of obtaining high-level approval, shifts emphasis from large capital intensive structures toward better water management including the partial lining of 29,000 watercourses in saline groundwater zones and rehabilitation of 60,000 more in freshwater zones. The plan calls for lining 24,000 watercourses and rehabilitating 48,000 more by 1990 and states with regard to partially lined watercourses:

> "Recent studies by Master Planning WAPDA) and Colorado State University, and demonstrated experience in India, have shown that partial lining is economic and the best technology for unusable groundwater areas."

b. Determining Farm Irrigation Losses

Experiments were conducted to determine whether or not fields were over-or underirrigated. No overall general pattern can be deduced. At Mona, in a SCARP area, 71 percent of 64 fields studied showed losses due to overwatering greater than 70 percent; however, in a non-SCARP area near Faizalabad, losses greater than 10 percent occurred on only about one-chird of the 246 fields studied. Poorly leveled land was shown to be a major factor related to over irrigation. Other factors correlating with overwatering are whether or not supplemental well water is available and whether or not the field is located in SCARP. Apparently, serious overwatering occurs more

frequently than has previously been thought, but sufficient work does not appear to have been done to delineate fully what is happening under various conditions throughout Pakistan. Overwatering increases waste of water and waterlogging; underwatering permits damaging accumulation of salts in the root zone. Evidently, one or the other case is the rule rather than the exception.

While first steps were taken which point toward clarifications of this problem, these need to be followed up with many more observations.

CSU probably might have done more; but having initiated the efforts, there is no reason why Pakistan scientists and technicians cannot pursue the matter on their own.

Those studies, or soil water balance studies based on dynamic crop consumptive use requirements, soil water holding capacity and measured applications of water including rain, need to be made at many locations, and usable irrigation guides developed for various crops, sites and climatic conditions if water is to be used efficiently at field level.

c. Identification of Socio-economic Constraints

An important contribution to watercourse development in Pakistan was the project's broad conceptualization of a watercourse as socio-natural unit involving engineering, agronomic, social and economic aspects. With this concept in hand, project researchers were able to take a broad view of the variety of factors influencing water management behavior at the watercourse level and the various constraints that would need resolution if improvements were to be achieved.

During the 1974-75 contract year, research methods were developed and applied first to the survey of a single watercourse in the Mona project agea and then to a larger sample of watercourses in several agronomic zones.

The success of these activities led to the formulation of a large CSU study to be done at 16 different locations throughout the Punjab and Sind provinces. Fieldwork for this study of 40 watercourses was done during 1975-76. This larger study was conceinved as a fundamental activity in the process of problem identification; ie., identifying the range of social and technical problems existing at the watercourse level.

Among its important findings was the indentification of factors related to the low level of watercourse maintenance:

1) the lack of effective local organization to mobilize labor and other resources
2) the lack of knowledge among farmers regarding the magnitude of watercourse losses, and
3) the lack of technical knowledge among farmers for improving their watercourse.

The results of these socio-economic surveys have been used in the design of the present On-Farm Water Management Pilot Project. Furthermore, this work has led to the initiation of a WAPDA/World Bank watercourse study that will investigate 61 additional watercourses for a two-year period, thus providing time-series data. Interim reports are being prepared by WAPDA regarding the results of these long-term studies. The project's work with watercourse surveys, including the findings of various socio-logical variables, has contributed both a wider conceptualization of

problems at the watercourse level and a methodology for investigating such.

d. Commitment of Agriculturalists to Field Problems

Dr. Kemper, Project Director 1974-77, feels that a major achievement of the project was to instill a commitment to field work by a substantial number of Pakistani agricultural engineers and agronomists.

A good academic program was established at UAF a decade ago with Washington State University advice; however, there was no opportunity to participate in real field work either for students or graduates. These graduates move into academic or bureaucratic positions having no real "hands on" exposure. While reluctance to do field work is often viewed as a matter of "status", it may be more one ot lack of confidence. Farmers are knowledgeable about their business and critical of naivete. By providing field opportunities which worked and which farmers appreciated, the project appears to have helped generate a corps of "agricultural engineers" who enjoy and feel confident about doing field work. The advent of the On-Farm Water Management pilot program, land-leveling and other similar interests, provided field oriented opportunities and the surplus of agricultural engineers has turned into a shortage. Agricultural engineers have had no status in Departments of Irrigation. We are encouraged because WAPDA now is hiring them on their regular rolls.

We recognize the importance of Dr. Kemper's point and are confident that the project has made a significant impact, but are unable to assess exactly how much and to predict what the future may hold.

e. Water User Associations and Model Law

It appears that the work initiated by the project represents the first effort to explore issues of appropriate local irrigation organizations for the Indus irrigation system. The initiation of this work is a significant achievement. There have been two directions to this work. One is the work on irrigation law and the identification of needed legislation to provide legal arrangements for organizing water user associations. A proposed water user's association law has been drafted and discussed in all four provinces of Pakistan. Little action by the government is expected in the current socio-political context.

Second, is the program of various field studies that have sought to understand the basic social organization of the Punjabi village, and more specifically, the Punjabi watercourse. These studies had the twin objectives of discovering existing patterns of organization for watercourse management and maintenance as well as identifying structural principles and value systems relevant to attempts to create water user groups. A number of important factors have now been identified.

This work is just beginning a third phase of action research in which various forms of water user organizations will be created (through the OFWM Program, the Water Management Research and Training program for Rural Development at UAF, and the research program of Professor Mirza at UAF) and it is most unfortunate that these activities will not continue into this important next phase.

f. Crop, soil, water, fertility interrelationships

Project research on tillage operations and cultivation practices combined with irrigation has produced very encouraging results, especially with furrowing and bedding. Crop stands were also much improved by practicing ridge and bed planting and by enchancing surface drainage.

The project team found that good fertilizer responses and good yields were consistently obtained with irrigation levels as much as forth percent below those considered to be optimum. Thus, farmer failure to use bagged fertilizers in the Punjab does not appear to be related to the fact that crops are often stressed due to insufficient water.

These findings favor increasing the cropping intensities on watercourses supplemented by tubewells to 1.6 crops/year even if some stressed crops result.

These practices are new to Pakistani farmers and their effectiveness will have to be demonstrated in the context of peasant risk aversion in order that they be adopted.

The projects research on the interrelationships of crop, soil, water and fertility consistently show that yields can be doubled if Pakistani farmers adjust their present operations. Some of the adjustments required are quite simple, all would reduce farmer crop loss risk.

The project is just now shifting from an AID-centrally-funded research mode to a USAID - centered extension and dissemination mode. Discontinuance limits the opportunity to test the effectiveness of this approach. Without continued external technical assistance, Pakistan may find diffi-

culty in mobilizing the field-oriented technical human resources to translate the present findings into an action-oriented program capable of affecting thousands of Pakistani farmers.

g. Crop, water, salinity interrelationships

A major achievement was finding that due to the very high magnesium content in the Mona irrigation waters, the accepted standards for measuring water quality gave erroneous results. CSU is developing an alternative methodology for predicting where water quality problems can be expected. This seemingly esoteric bit of information in reality has very important practical implications. No only is the program for using land plaster (gypsum) for the ameleoration of saline soils affected, but also both crop response to fertilizer and crop yields on unfertilized soils can be severely diminished when irrigated with waters containing high levels of magnesium. This could occur as a result of the plants inability to absorb needed nutrients due to an imbalance in the relationship Mg:Ca:K:. It might also affect the costs of reclaiming saline soil areas.

It is unlikely that these recent research results can be turned into information of use to Pakistan because of discontinuance of the project. For this, a testing phase and then an extension and a dissemination phase would be necessary in Pakistan where the problem exists.

h. Watercourse Technology

Having established the magnitude of watercourse losses, the Project began in 1974 to examine what might be done to reduce them. Various types of linings and treatments, turnout devices, and other appurtenances

and rehabilitation procedures were developed and tested. This work was centered at WAPDA's Mona Project.

Before initiation of watercourse rehabilitation work, extensive discussions were held with farmers regarding acceptability of linings, turnouts, etc., and their own participation. In all cases, farmers participated extensively, providing the labor; and in some cases, purchasing turnouts. Full lining of watercourses was found to be too expensive, but the studies found that most of the losses could be prevented by programs of rehabilitation of earthen water courses, lining of critical reaches and installation of manufactured turnouts (naukkas).

Many good ideas came from these studies and Pakistani colleagues are generous in giving their CSU colleagues credit for their part in evolving them. The naukka design (which is very good), evolved from a number of tiral approaches and tests, involved also the ingenuity of a private concrete artisan and resulted in development of a substantial private enterprise.

While many kinds of irrigation turnouts have been developed, especially in the Western world; these, strangely, often are not adaptable for both economic and cultural reasons. Another i[illegible]e design was a "jet pump" arrangement which uses the velocity of the well outlet to raise canal water in watercourse to levels that are above the canal level thus insuring that introducing well supplies into existing watercourses does not reduce or reverse the flow from the canal outlet. This is a problem to some degree whenever well discharge is added to a watercourse already receiving canal

water. The establishment of the effectiveness in quantitative terms of well designed and maintained earthen channels is an important contribution.

Given the project's impetus, Pakistani technicians should certainly be able to continue needed technological development and testing. On the other hand, continued maintenance of earthen water courses may be very difficult to achieve. This will require social commitments and institutional arrangements not yet tested and is an area where continued expatriate assistance will be needed. Cultural acceptability and interest must continue as a necessary condition.

i. Skimming Wells

Perhaps one-third of Pakistan's irrigated area is underlain by saline groundwater with a shallow layer of fresh water on top. These freshwater supplies are badly needed in the overlying areas; however, extracting the fresh water without drawing in excessive quantities of saltwater is physically very difficult. The project has field tested some well arrangements designed to skim off the shallower fresh waters and to prevent upward coning of saltwater into shallow wells. Considerable work was also done by the project using hydrodynamic theory and mathematical modeling. The physical limitations have been well defined in large part as a result of the project's efforts, but technological and management approaches devised so far are quite limited. An examination was made of the possibility of drawing down the salt water part of these areas and wasting it to the sea in order to provide groundwater storage space for fresh water from monsoon rains and canal seepage. This looks practical physically, but economic and environmental problems could be difficult.

This is one area where we were told significant technical expartiate expertise continues to be needed. Unless some ways are found to enhance quantity and quality of water supplies, in these saline areas, prospects for agricultural improvement are beyond the present level very dim.

j. Consumptive Use

Thousands of irrigation water requirement studies for different crops have been conducted on the subcontinent. These do not differentiate between water lost by deep percolation, water transpired by crops and evaporate from the soil surface between plants, and rainfall added and are site and year specific. Consumptive use includes only crop transpiration and soil evaporation. It is related to climate and is at least partly transferrable between sites. Doubtless consumptive use measurements have been made in the field under cropping conditions (in contrast to fairly common pot or lysimeter studies) at various times and places also. Our impression is that these have been sketchy and erratic.

Consumptive use information is needed for overall irrigation project planning and for irrigation planning at the farm level. Without it, allowances for rainfall and determinations of water needed for irrigation cannot be made accurately.

Under the project, consumptive use studies on wheat, berseem and cotton were initiated in collaboration with the Punjab Agricultural Research Institute at Faisalabad and continued them for several years. Beginning about 1976, a network of consumptive use studies using 8 sites throughout the country was implemented by the Pakistan Agricultural Research Council uti-

lizing PL-480 funding and working directly with USDA. CSU involvement in helping to implement these is not clear from the inquiries we were able to make. In any event it appears that the project played a significant role in getting the work started. CSU's latest annual reports refer to a continuing limited role in helping to refine techniques and operating procedures. We inspected sites at the Mona station. The experiments here appeared to be well managed.

k. Research on Economic Costs and Benefits

The economic activities of the project have been related largely to the cost/benefit analysis of alternative watercourse improvement technologies and watercourse benchmark studies emphasizing cropping patterns and other farm management data.

The research on alternative watercourse technology was important in suggesting various operational policies. The C/B analysis of these improvements is complex because of the difficulties in assuming the life expectancy of the various techniques as well as formulating assumptions about the value of the water saved. One solution to this latter problem has been to equate the value of the losses with the cost of replacing that water using tubewell water. One important finding was that the lowest cost improvements gave the highest return to investment.

Much of the work in economics was devoted to the socio-economic surveys discussed elsewhere in this report.

2. Training

Early on, project personnel recognized that several different types

of training were required so that the research project could have an opportunity to make a lasting impact on Pakistan.

The first problem was that no single Pakistani organization contained all of the components required so that the project's research efforts could be implemented, results tested on farmers' fields and on the watercourses serving them, and; once verified, then disseminated to larger groups of Pakistani farmers.

Thus, Pakistani collaborators had to be prepared not only to perform research planned under the project, but also to identify problems and then initiate problem-solving research in a colleagual style with CSU scientists as well as independently. Many have subsequently moved on to important policy-making positions with the Government of Pakistan.

Then there was the problem of implementing confirmed research results. How should the trainers who would train the future implementers be prepared?

Also, on the practical side was the question of providing U.S. graduate students an opportunity to study the problems of the developing world at first hand in Pakistan where they could contribute to the project's research efforts and gain useful experience for career involvement in seeking solutions to developing country problems. CSU used a variety of approaches to prepare these personnel.

Project funds were utilized so that Pakistani Research Associates could first complete their course work on campus in Colorado and then return to Pakistan to do research that could be used for their thesis under the supervision of CSU/Pakistan staff. Most of these Pakistani colleagues who earned

their Ph.D.'s or M.S.'s at CSU are involved in finding solutions to Pakistan's problems today.

U.S. graduate students from CSU likewise did valuable on-site thesis research in Pakistan.

In order to train the non-graduate implementation personnel, CSU first developed a training program with the University of Agriculture, Faisalabad, and then helped obtain a USAID/Pakistan rupes grant to UAF to support the training program. Nearly one hundred Pakistanis from all of the provinces have been trained to date for the On-Farm Water Management teams.

CSU personnel put a lot of effort into these various types of training activities. It is still too early to tell whether this effort will pay off for Pakistan in terms of widespread adoption by Pakistani farmers of improved techniques for on-farm water management and improved cropping practices which result in increased food production. The training activity will be discussed more quantitatively in part Section IV B.

Training is always essential to the conduct of research, but in the field, especially in LDC, this becomes a large part of the program.

3. Information Dissemination and Transfer

a. Publications and Reports

In February, 1978, the CSU team published abstracts of 154 technical reports and publications exclusive of annual reports produced by the project. Several of these were issued by the Mona Reclaination Experimental Project. About eight of these refer to journal publications, although several other journal publications are known to have resulted from primary citations used here.

These documents report the results of various studies made under the project. They do not include a number of papers also prepared on guidelines and methodology for internal use of the investigators. They are largely addressed to a technical audience at technician and professional levels, although some address policy issues. Films were produced on land leveling and on watercourses.

b. Workshops and Seminars

The first major seminar for on-farm water management under the project was held in Lahore in 1973 and was sponsored by the National Institute for Public Administration. Growing interest in on-farm water management was reflected at a Water Management Seminar sponsored by Esso Fertilizer in November, 1977. CSU and Pakistani project personnel participated in a number of international conferences held in Pakistan as well as in many field days for farmers. In 1977, CSU personnel were given a special invitation to present their views at a national seminar on how a national program of watercourse implementation might be formulated.

On the CSU campus, a 2-hour interdisciplinary seminar was conducted each week during the academic year from 1972-76. In recent years a course has been taught on the interdisciplinary aspects of water management under a related 211(d) project.

There are a number of ways that evaluation of the publications of the project as well as its importance might be assessed. The following is an example. During the period 1975-78, with Ford Foundation assistance, the Planning Commission, GOP made an extensive study of research issues

affecting agricultural development policy in Pakistan. The findings of the study were published in 1978 under the title "The Report of the Indus Basin Research Assessment Group". Membership of the Assessment Group included 10 distinguished Pakistani planners and officials. U.S. members included Dr. John McCool, Ford Foundation; Prof. Walter Pl Falcon; Dr. Ralph Cummings and Prof. Roger Revelle. This report drew extensively on the work of the On-Farm Water Management Research Project for much or most of its information on watercourse performance; soil, water and yield relationships; effects of salinity on crop yields; water use efficiency; irrigation constraints to productivity at the farm level; and effects of the watercourse losses in groundwater. This 106 page report directly cites findings of the project no less than 14 times referring to seven different publications of the project. Since the study was completed in early 1978, only publications dated prior to about 1977 were available to the Assessment Group. Utilization of the project findings by this prestigious group supports their importance.

4. Achievements in Project Management

Many of the achievements in research and development are the direct result of the successful management of both the campus and field project staff. Of particular significance are the following:

a. Focus on Real-World Problems

The project began, of course, with a real-world problem---- the poor management of existing irrigation systems. An important achievement of project management was to maintain this focus over a period of more

than ten years and across a variety of staff members.

Several factors contributed to this significant achievement:

- CSU assigned to Pakistan qualified and highly committed individuals; repeatedly the Evaluation Team heard from Pakistanis praise for the energy, drive and commitment with which the CSU staff performed,
- the early focus at the Mona Reclamation Experiment Station provided and on-farm laboratory in which research and development activities could be vigorously pursued, and
- a degree of dynamic tension between the research team and the USAID Mission contributed to keeping the team focused on a set of policy - relevant research topics.

b. Interdisciplinary Approach Including Socio-economic

A significant feature of the project has been the sustained involvement by staff from several different disciplines. This has included not only the traditionally core activities of engineering and agronomy, but also economics and sociology.

This broad inter-disciplinary approach began in the formative years of the project when most activities were either on-campus or conducted through TDY assignments. The staffing pattern for the current field party continues to reflect this orientation.

The interdisciplinary activities of the research team occurred at two levels. In some instances, separate activities were aimed at a common topic. For example, in searching for suitable technologies for watercourse

improvement, engineering work was done to identify alternative construction materials, construction techniques, etc. Complementary to this was the economic research done to determine the costs and bendfits associated with these techniques. In other cases, a common activity was undertaken by researchers with different disciplinary orientations. An example of this approach is the watercourse survey work in which an interdisciplinary group planned the work, gathered the data and jointly analyzed the results.

Three indicators of the successful management of this interdisciplinary approach are the following:

1) the lack of dominance by any one disciplinary orientation over the period of project implementation,
2) the changing priorities given to disciplines over time; this is especially evident in the watercourse improvement program where initial emphasis was on engineering the technology and determining costs, followed by increased attention to the organizational and institutional requirements for constructing and maintaining these improvements, and,
3) the numerous project publications that are jointly authored by staff with different disciplinary backgrounds.

While it is difficult to identify precisely the specific management actions that created and supported this interdisciplinary approach, and the fundamental importance of particular personalities cannot be ignored, project features that supported this style include:

1) <u>Project Focus on On-Farm Water Management</u> (in actuality, water

management at the watercourse): the identification of this problem as the central focus of the project was both specific enough to avoid a set of interesting but unarticulated research activities and also broad enough to allow different disciplines to identify meaningful aspects for their investigation.

2) Emphasis on Field Work: the continuing emphasis on doing work in the field, in the context of operating irrigation systems and in contact with both farmers and agency staff, must have created a more common definition of the situation than would have occurred had researchers worked in the privacy of their laboratories or experimental stations. The engineer's observations of water flows in the hydrology lab is unlikely to suggest needed contributions from the sociologist. On the other hand, observing the flow of water in a watercourse in Mona can suggest researchable questions to the engineer, agronomist, sociologist and economist.

3) Conceptualization of the Watercourse: growing out of the above points was the team's conceptualization of a watercourse as a dynamic unit in which actions occurred in response to various engineering, agronomic, social and economic factors. This viewpoint was utilized early in the field work program with the initiation of the various watercourse surveys which collected a broad set of physical and socioeconomic data.

4) General Seminars: through most of the contract period one, or more inter-disciplinary seminars dealing with water management issues were conducted on-campus. These seminars may have helped set and maintain the interdisciplinary tone of the project as well as identify specific issues and topics for research.

5) Staff Recruitment: In addition to the above special attention in recruitment was given to evidence of cooperative and collaborative work styles. While recognizing the importance of technical competence, the need for additional attitudinal and interpersonal skills was identified and sought.

c. Multi-linkage and Redundancy

In the implementation of the research activities, the CSU team has worked collaboratively with a number of Pakistani organizations responsible for aspects of on-farm water management. These have included the following:

1) the Water and Power Development Authority (WAPDA)
2) the Mona Reclamation Experimental Project (a unit of WAPDA)
3) the provincial Agricultural Departments
4) important agricultural research stations, including the Punjab Agricultural Agricultural Research Institute, Cotton, Rice and Maize Research Institutes, and others
5) the Agricultural Universities in the three provinces; in particular, the University of Agriculture, Faisalabad, and
6) the Pakistan Agricultural Research Council.

Given the diverse organizational setting for on-farm water management issues, the strategy of multiple contacts rather than a single counter-

part agency has been productive. Through these multiple contacts the team has been able to adjust its linkages in response both to changes in these agencies themselves and changes in the phase of the work being undertaken. For example, the watercourse improvement activities were focused in Mona during the problem-identification and technology generating phases. The current phase of local organizational development and demonstration is more strongly linked with the provincial Departments of Agriculture and the University of Agriculture Faisalabad (UAF).

In order to conduct its research, the team was required not only to identify institutional counterparts but to assist in strengthening and developing them.

d. Developing a Colleagual Style

CSU team members successfully developed a colleagual style of work with a number of their Pakistani associates, particularly fellow researchers at the Mona station, at UAF and in the various agricultural research institutes.

A good indicator of colleagual relations among researchers is the degree of joint authorship that occurs in publication. A review of the list of project publications indicates that a large portion of the documents are jointly authored with Pakistani colleagues and in many cases the senior author is a Pakistani. This is a concrete demonstration of the joint research work that was undertaken. While there were some complaints from Pakistani researchers regarding independent CSU publication of research papers based on data collected in Pakistan, these difficulties seem to

have been connected with the current policies being followed.

As expected, especially strong colleagual relations have been developed with those Pakistani researchers who participated in graduate programs at CSU.

e. Development of On-Farm Water Management Pilot Proposal

The CSU team contributed significantly to the design of the On-Farm Water Management Pilot Project, as is evident from the project paper. After implementation of this project the team prepared guideline materials for field use and assisted in the development of training courses for technicians and extension agents in implementing this program given by UAF. The course for the latter was 4 1/2 months. The first course was started in 1977, but the program was interrupted during a period while the university was closed. The third session was underway at the time of out visit. The CSU team planned to conduct further research, particularly socio-economic and on water users associations on sample watercourses developed under the pilot project, but this will be interrupted because of the present phase out.

B. Assessment of Achievements

1. Influencing Crop Production Potentials

The project's focus since it began in 1968 has been in research concerning on-the-farm water management to increase food production; on the problems faced by farmers in the real world at an early stage of its operations.

Soil and water factors influencing crop production were proposed for study and funds were provided for cooperative research with the Ayub Re-

search Institute, the West Pakistan Agriculture University and the Land Reclamation Directorate under a Pro-Ag signed in early 1970.

The CSU team also forged cooperative links with WAPDA, with the Provincial Departments of Agriculture and with the University of Agriculture at Faisalabad, Quaid-i-Azam University, Sind Agricultural University and the University of Peshawar. In Faisalabad, the Punjab Agricultural Research Institute and the Agricultural Engineering Directorate received CSU technical assistance. It also collaborated in research efforts at the Maize Research Institutes in the NWFP and Yousafwala, at the Rice Research Institute at Kala Shah Kaku, at the Cotton Research Institute at Multan, at the Sind Agricultural College in Tandojam and at the Tarnab Agricultural Institute in the NFWP.

Research was done on crop/soil/water/salinity relationships involving wheat rice, maize, sorghum, berseem, cotton and sugan cane. Research on the use of improved practices of irrigation, planting, fertilization and plant protection demonstrated that yields could be doubled profitably. If a greater area is available for planting, irrigation water should be used at up to 1/3 less than optimum levels on the larger area, for the research results show that yields are only modestly decreased by such a moisture stress. In practice, this means that for wheat, for example, near maximum yields can be obtained with three to four post-emergence irrigations rather that the optimal five to seven irrigations.

CSU was just moving into the extension phase of its actions in Pakistan in anticipation of continuation of CSU involvement when the political de-

cision was made to curtail AID support to Pakistan. Therefore, it will be difficult to assess the project's, influence on peasant crop production. The potential for doubling yields and increasing cropping intensities to 1.6 with modest farmer investments in inputs has been demonstrated. However, the implementation of these findings will not be attended by CSU technical assistance and the task will not be an easy one.

2. Assisting the Small Farm Sector

Research by CSU and Pakistani workers has identified the socio-economic diversity that characterized the typical watercourse in Pakistan; including the mix of large, medium and small farmers. For this reason, it is important that technologies and strategies developed to improve watercourses not disadvantage the small farm users.

Project-devised technologies for watercourse improvement (heavy cleaning; realignment of banks and earthen improvements; various forms of lining; concrete control structures) are provided to the watercourse users as a group and any costs born by the users are assessed proportionate to size of landholding. In this way, small farmers are not denied access to the new technology because of their inability to purchase it.

Similarly, the work with identifying appropriate forms of local organization to operate and maintain required watercourses has sought formal and informal arrangements to protect the rights of the various watercourse users. Particular attention has been given to the desirability of constituting water user associations as legal entities under Pakistani law. Should this be achieved in the future, there may be dual consequences for

small farmers. On the one hand, a legally constituted water users association could protect small holders from the abuses of larger farmers who might dominate the association. On the other hand, providing the association with legal status could mean that some disputes would be take to the courts and become enmeshed in lengthy litigation. The costs of such litigation, both time and finances, could greatly disadvantage the small farmer.

Finally, the USAID-supported On-Farm Water Management Pilot Project now being implemented by the four provincial departments of agriculture has two important provisions in support of small farmers: 1) only watercourses where 75% of landholdings are 25 acres or less are eligible for cost-sharing and 2) priority in selecting watercourses for improvement is given to those where 50% or more of the farmers have holdings of 12.5 acres or less.

Other technologies that have been developed by the project could have potential negative impacts on small farmers unless specific institutional arrangements are designed to insure small farmer access. Examples of these include the skimming-well technology and some of the work with farm machinery.

3. Assisting in the Development of Organizations and Institutions

The project was not an institutions-building project in the usual sense. Nevertheless, concern with a range of organizations and institutions related to improving on-farm water management was an important element in project design. The comments in this section focus on three components of these institutional aspects; 1) the strategy used in working with various existing organizations including government agencies, universities and private enterprises, 2) the activities to increase the pool of individuals and agencies

concerned with water management issues, and 3) the approach used in developing local organizations at the watercourse level. The Multiple-Contacts Strategy: Historically in Pakistan, no single government agency has had clear responsibility for on-farm-water management and irrigation development activities. The Canal and Drainage Act of 1873 assigned responsibility for most watercourse operation and maintenance activities to the cultivators themselves, while allowing the Irrigation Department the right to act, if necessary. In reality, the Irrigation Department has been pre-occupied with operating the main system components and has given little attention to the watercourses.

In recent years, as watercourse losses have been documented, and activities to construct major diversion and coveyance works have been completed, several Pakistani agencies have become interested in this topic. CSU successfully followed a strategy of simultaneously working with several of these groups rather than the more frequent strategy of working with a single counterpart agency. In the Pakistani context, with diverse institutional actors in the water management arena, this has been a productive approach. It has avoided the problems arising from overload of outside assistance to any one agency; permitted the CSU team to shift efforts in response to new opportinities or unrealized developments; and facilitated the shifting of attention between research and action settings.

Three important results derive from this multiple contact strategy:

1) the CSU field team was able to maintain an active overall program in spite of the usual lulls that occur in the activity

of any single host-country institution,

2) no one Pakistani institution became heavily dependent on CSU assistance, since the field team was linked with several different groups, and,

3) the various problems and issues of on-farm-water management have become regularized items on the institutional agendas of organizations such as WAPDA, provincial departments of agriculture and the University of Agriculture, Faisalabad.

Thus, at various times, and sometimes simultaneously, the CSU team was helping to design experimental watercourses at Mona, assisting the Integrated Rural Development Program (IDRP), implementing a watercourse improvement program in Punjabi villages and discussing with faculty at the University of Agriculture, Faisalabad a rural development program based on the strategy of watercourse development.

This multiple-contacts strategy did not dilute the project's emphasis on improved on-farm-water management since that problem was a common concern of the various institutions with which the CSU team worked.

Institutionalizing Water Management Concerns. While not "building" any single water management institution, the Project did impact many organizations and institutions related to water management by training individuals who now staff these organizations, by influencing their program agendas and by facilitating linkages among them.

Pakistanis who received graduate training at CSU are not staff members at the Mona station, faculty members at the University of Faisalabad and administrators in the OFWM program.

As a direct, or indirect, result of the CSU/Mona research on watercourse losses and means to reduce them, watercourse improvements are being implemented by the Ministry of Agriculture and the provincial Agriculture Departments, the UAF is establishing a field laboratory in which watercourse improvements will be a part of the rural development strategy and major donors such as the World Bank and Asian Development Bank are planning loans to Pakistan for watercourse improvement.

Finally, CSU team's many activities have served to strengthen linkages between important organizations such as the Mona station, the faculty at UAF, and the Ministry and Departments of Agriculture. While recognizing their importance, one must also understand their fragile nature.

Developing Watercourse Organizations. Concern with the apparent lack of local irrigation organization and the need to fill that organizational-institutional gap arose early in the project. The pace with which this problem was approached was slow and progress may have been hampered by the absence of a resident specialist on laocal organization until the spring of 1978.

In spite of this void, a number of important activities were undertaken by DSU staff on temporary assignments and by Pakistani colleagues very early in the project, work was done on Moslem water law in general and water law in Pakistan, in particular. A complementary activity was the field study of the social organization of several watercourses in the Mona project area. Additional socio-economic background information was obtained through the various watercourse surveys conducted in Mona and throughout the Punjab

and Sind provinces. More recently, this work has been complemented by the attempts to organize water user committees as part of the On-Farm Management Pilot Project and planned "Experimental" work of Professor Mirza at UAF.

The work on this topic has been strongly influenced by the following factors:

1) A nearly exclusive focus on canal irrigation in the Punjab region which has an almost total absence of traditional local organization for water management.
2) An early, and continuing, concern with water law and the need to create water user associations with legal status, and
3) Until recently, a heavy reliance on the socio-economic surveys of watercourses to generate "organizational" data.

The legal work has documented the need for modifications in Pakistani law if water user associations are to be granted meaningful legal rights and responsibilities. Many local level leaders also perceive this need. However, thus far the government has not taken such actions and apparently prefers, as an alternative, the existence of less formal irrigation groups.

In retrospect, there may have been some value in giving more attention to traditional water user groups in other parts of Pakistan; particularly Baluchistan or NWFP. While recognizing that these two areas each have their own peculiar ecological and cultural settings, detailed studies of traditional water user groups might have produced either, or both, of the following results:

- suggested principles of social organizations for trial in the Punjab case

- provided actual examples for policy-makers and others of the possibilities of local-level organization.

Case studies of irrigation organization in Pakistan would have been useful supplements to the general discussions of irrigation associations in Spain, Taiwan, and the Philippines.

The present situation, particularly in Punjab Province, is very conducive to further work with water user associations and it is most unfortunate that CSU, or some similar contract group, will not be able to continue work on this important topic. The action program of the On-Farm Water Management Pilot Project includes attemtps to organize farmer groups on improved watercourses; these real-world "experiments" could be an important data base for researchers. Likewise, the planned research on alternative organizational models by Professor Mirza and the proposed activities of other UAF staff under the Water Management Research and Training Program for Rural Development will provide important experiences with these associations.

4. Training to Support Water Management

CSU used its long-term professional staff (Table 2) in Pakistan not only to train and guide Pakistani research personnel but also U.S. graduate students from CSU, University of California (Berkeley), Cornell, University of Pennsylvania and the University of Wisconsin (Table 3). All of this thesis work was performed on topics related to Water Management relevant to Pakistan. All of the Pakistani personnel listed in Table 3 returned to work in Pakistan. By itself, this accomplishment highlights the dedication and motivational impact of the CSU staff both on-campus and in Pakistan.

Numerous seminars and training courses were organized and prepared in collaboration with Pakistani colleagues. Among these were:

1) a 4.5 months training course given at the University of Agriculture (UAF) at Faisalabad, Punjab. Intensive theory and on-the-job training was given to prepare Water Management Extension Officers of the USAID/Government of Pakistan On-Farm Water Management Pilot Project. The training focused on improved management practices to help farmers manage improved water supply, leveled land, seed, fertilizers and pest control measures.

The participants in the theree courses given by 8 UAF and 2 CSU advisors to date were from the Punjab, Sind, North West Frontier and Baluchistan Provinces:

First Course, 1977, 16 participants
Second course, 1978, 36 participants
Third course, 1979, 40 participants

2) In cooperation with the SCS-PASA personnel and the Water Management Units in the Provincial Departments of Agriculture of the Sind, Punjab and NWFP, a special training program was developed for the trainers of the engineers slated to participate in the On-Farm Water Management Pilot Project. Eleven trainers received this instruction.

3) A special training program was given to agricultural research station personnel from several Pakistani institutions to prepare them to perform consumptive crop water use studies.

4) Cooperatively with the WAPDA Master Planning Group, thirty technicians in the Punjab and Sind Provinces received on-the-job training in problem identification in watercourse areas.

Thus, CSU staff trained Pakistani personnel at all levels. The results of this training impacted both upward through GOP institutions and horizontally within the Provinces affecting the personnel of State Departments of Agriculture, Universities and semi-autonomous research and technical assistance organizations.

One measure of this impact can be appreciated (Table 4) by the fact that USAID/Pakistan has approved nearly $U.S. 10,000,000 in loans and grants and 6 million rupees in grants to support watercourse and on-farm water management. An additional 42 million rupees in grants is pending final approval.

The total contribution on the Pakistani side at the federal government and provincial institution level at least equals this in terms of manpower, equipment and related institutional services.

Additionally, the World Bank (IBRD) and the Canadian Government (CIDA) are funding loans and grants in excess of $30,000,000 which includes improving watercourses and water management in upper Swat.

If the CSU team had not influenced national thinking at all levels through the impact of its personnel, it would not have been possible to stimulate his magnitude of financial response to help solve Pakistan's on-farm water management problems. The CSU collaborative training efforts undoubtedly played a great role in influencing and generating these decisions.

TABLE 1.

THE MAN MONTHS OF LONG-TERM COLORADO STATE UNIVERSITY PROFESSIONAL SERVICE IN PAKISTAN UNDER THE AID-FUNDED WATER MANAGEMENT RESEARCH PROJECT

Names	Post	Date of Arrival	Man Months	Present Location Sept. 1979
Gilbert L. Corey	Lahore/Islamabad	7-1-70	47	DSB/AID
Jerry B. Eckert	Islamabad	7-13-72	36	CSU/Lesotho
Wayne Clyma	Islamabad	7-25-72	48	CSU and Egypt Associate Director
C. J. deMooy	Islamabad	10-29-72	40	CSU International Projects
W. Doral Kemper	Islamabad	7-2-74	36	Director USDA Snake River Cons. Res. Center
Alan C. Early	Islamabad/Lahore	9-17-74	32	IRRI
John O. Reuss	Lahore	9-29-75	49	CSU/Pakistan
Sam H. Johnson	Lahore	10-7-75	23	Ford Foundation Bangkok
Sidney A. Bowers	Lahore	11-11-75	36	USAID/Pakistan
Larry Nelson	Bahlwal	6-5-76	18	CSU Ph.D Student
Tom Trout	Lahore	9-4-76	24	CSU Res. Asst. Prof.
Helmer J. Holje	Lahore	2-11-78	19	Montana State U.
Norman Illsley	Lahore	3-3-78	18	CSU-Lahore
Dwayne C. Westfall	Lahore	3-2-78	18	CSU
Douglas J. Merrey	Faisalabad	4-26-78	17	CSU-Pakistan
Dwane E. Konrad	Lahore	9-4-78	12	CSU Ag. Exten. Svc.

TABLE 3

Graduate-Level Personnel Trained by CSU in Water-Management Related Projects

Name	Present Title and Institution	Location of Thesis Study	Degree attained and Speciality
Under AID/csd-2162			
J. W. Andrew			
Robt. L. Chandler			Civil Engineering
Mohammad T. Chavohry	Consulting Firm, Pakistan		Civil Engineering
Robt. S. Dildine			Political Science
Svresh Doddiah			Civil Engineering
James H. Duke, Jr.			Civil Engineering
Arlene C. Dwyer			Political Science
Mohammad I. Hague			Civil Engineering
Ahmad Said Khan			
Soon-Kuk Kwun	Korean Ag. Eng. Res. Ctr. with 211(d)		Ag. Engineering
Della L. Langeland	USGS		Civil Engineering
W.A. Lemma			
W.S. Liang	Geo. Wash. Univ. Faculty		Civil Engineering
Ashfaq Mirza	Assoc. Prof. Dept. Rural Sociology and Economics Univ. of Ag. Faisalabad	Pakistan	Sociology M.S.
Mehdi Monadjemi			Agronomy
Khan J. Muhamad			Economics
Ata M. Nazar		Afghanistan	Civil Engineering
Paul S. Osborne	New Mexico		Ag. Engineering
James L. Puckett			Agronomy
Dhan Pat Rai			
Allah Rakhn			Civil Engineering
Emilio Rios			Civil Engineering
Abdur-Rehman Rizwani	Deceased		
Robt. F. Schmidt			Political Science
Alfred J. Tamburj			
Connie S. Trautoran			Sociology
Debebe Worku	Ethiopia		Economics
T.Y. Wu	Taiwan	plus 211d	
Yasumi Yamaguchi			Civil Engineering
F.A. Zuberi	Wapda, Lahore		Ag. Engineering
Under AID/ta-C-1100			
Bashia Ahmad	UAF Faculty	Pakistan	Economics
C. Nur-Vo-Din Ahmad	Assoc. Dir. Land & Water Reclamation Directorate, Lahore	Pakistan	Agronomy, M.S.

TABLE 3 (cont'd)

Jacob Dane			Agronomy
Khalid Gill	Fertilizer Institute Multan	Pakistan	Agronomy, Ph.D. (partial)
Mushtaq Gill	Dep. Dir. On-Farm-Water Management Development Program, Punjab	Pakistan	Agronomy, M.S.
Ghulam Hussain	WAPDA Mona Reclamation Experimental Project	Pakistan	Agronomy, Ph.D.
Sam Johnson	Ford Foundation, Bangkok	Pakistan	Economics, Ph.D.
Muhammad J. Khan	Australia		Economics, Ph.D.
David A. Laver	Watercourse Survey, Pakistan	Pakistan	Sociology
Kenneth Litwiller	Church Agric. Mission	Africa	Ag. Engineering
Larry J. Nelson	18 months in Pakistan		Agronomy, M.S.
Ramchad Oad	Mehrnas Univ. of Engineering & Technology, Nawnbshah, Sind	Indonesia	Cornell, Ph.D. 2 Yrs. Special CSU Training
Mohan J. Reddy	Pak. Watercourse Data Analysis		Ag. Engineering
Muhammad S. Shafique	WAPDA-Mona Reclamation Experimental Project	Pakistan	Ag. Engineering M.S.
T.M. Shariatmadar	Shrine Univ. Iran		Ag. Engineering
Miguel Solanes		Argentina	Economics
Thomas J. Trout	CSU Staff	Pakistan	Ag. Engineering

Under AID/ta-C-1411

Barkat Ali	WAPADA-Mona	Pakistan	Economics, M.S.
Mohammad A.R. Faroogi	Irrigation, Drainage & Flood Controls Research Council, Lahore	Pakistan	Agronomy, Ph.D.
Chaudhry M. Hanif	Punjab On-Farm-Water Management Development Project Training and Research Center, Lahore	Pakistan	Agronomy, Ph.D.
Muhammad A. Kahlown	WAPDA-Mona	Pakistan	Ag. Engineering, M.S.
Zahid S. Khab	UAF Research Staff	Pakistan	Ag. Engineering, M.S.
Ray Renfro	TDY Pakistan	Pakistan	Economics
Muhammad M. Wahla	WAPDA Master Planning, Lahore	Pakistan	Ag. Extn. M.S.
Doug J. Merrey	Special CSU Support	Pakistan	Sociology, Ph.D. Univ. of Penn.

TABLE 4

USAID/PAKISTAN SUPPORT FOR WATERCOURSE AND ON-FARM WATER MANAGEMENT

Title	Project No.	Obligation
I. DOLLAR FINANCING FOR ON-FARM WATER MANAGEMENT PILOT PROGRAM		
OFWM (for watercourse improvement & precision land leveling)	Loan 0413	$7,500,000
OFWM (technical Assistance)	Grant 0413	2,349,604
	Total.....	$9,849,604
I. LOCAL CURRENCY GRANTS FOR WATERCOURSE MANAGEMENT		
A. Projects Authorized and Signed		
Water Management Research	204-75-3	Rs.1,314,000
Water Course Improvement	204-75-4	1,421,000
Water Management Survey	204-76-1	411,000
OFWM-NWFP	204-77-1	1,346,000
Water Users Association ARC-CSU-TD 6/9/79	204-77-3	512,000
Punjab Water Management Research & Water Management Advisory Training (CSU-SCS)-TD 12/31/79	309	1,000,000
	Total.....Rs.	6,004,000
B. Proposed Projects		
Water Users Association		Rs. 2,172,000
Water Management Research WAPDA		12,505,000
Water Management Research Faisalabad University/CSU		9,060,000
Strengthening of Water Management Project Activities-Federal/WAPDA/SCS/CSU		18,360,000
	Total.....Rs.	42,097,000

Total (Rs Grants).....Rs. 48,101,000

5. Developing Appropriate Technology for Watercourse Improvement

This topic has been discussed under the section on "Major Project Accomplishment". While western technology for irrigation water distribution is available, it is often too costly or is otherwise unsuitable because of cultural considerations. For example, brick is a common material in Pakistan and people are experienced using it in construction. Advantage should be taken of construction skills of local artisans. Provision needs to be made for buffalo wallows and for laundering. Gates need to be watertight, but without other utility and too cumbersome to be carried away. A substantial package of lining technology which seems to us to be quite appropriate has been developed under the project. Designers need to know when to use a particular approach in contrast to some other one.

6. Integrating Research Results with the National Setting

The CSU team has consistently given attention to the integration of research results with the policy and operational realities of Pakistan. Some important successes have been achieved.

The outstanding success was the careful investigation of watercourse losses, the documentation of their magnitude and the acceptance of these results by the Pakistan water establishment. Initially, the reporting of water losses of 40-60% by WAPDA/CSU was received skeptically by many government agencies and officials. The CSU team, in collaboration with WAPDA, 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.

Related successes occurred in developing a range of alternative technologies for significantly reducing watercourse losses; prefabricated concrete turnout structures, various forms of partial and complete lining, and techniques for earthen reinforced banks. These alternative technologies, most of low-cost design, provided government policy-makers with feasible choices under Pakistani conditions. In this instance, the CSU team was able to translate research findings into the natural setting through its active participation in formulating the AID-supported On-Farm Water Management Pilot Project. This project builds squarely on the watercourse technologies developed through the project's work at Mona.

The OWFM Pilot Project also incorporated the preliminary Mona experiences with water user organization; specifically, the creation of an Executive Committee of farmers prior to watercourse improvement. It appears that the technique of conducting a socio-economic survey of each watercourse prior to implementing improvements has not been made part of the operations.

Research on water user associations has not proceeded to the point that specific recommendations supported by research results have been identified.

Efforts have been made, through publications and a recent series of seminars, to discuss needed new laws to establish water user associations, as legal entities. Thus far, no such action has been taken.

The project's successes in integrating research results with the national setting appear related to three factors:

1) Project research was highly field-oriented. It was conducted in the context of operating irrigation systems. The results

found in these settings tended to be appropriate for wider application.

2) CSU team members had easy access to administrators and policy makers in WAPDA, agriculture departments and universities and used this access to share research findings and suggest program implications.

3) Generally, good linkages with USAID/Pakistan provided an alternate route to government officials and assisted USAID in translating research results into AID-supported program.s

7) Reporting and Disseminating Research Results

The difficulty of putting the results of research into practice is a common criticism of research projects. In the case of the On-Farm Water Management Research Project, one of the major findings, the inefficient watercourse, led to rapid implementation through the On-Farm Water Management Pilot Project and has supported some substantial changes in strategy at least at reflected by draft plans of WAPDA's Planning Division. The draft law on water users associations has strong support in some quarters and could be passed relatively soon. These actions, as is often the case with research findings, await policy or political decisions. If there is any particular reason for this relatively rapid utilization, it is probably the linkages that were formed with WAPDA and Ministry of Agriculture, UAF, etc. A significant factor may have been timing in regard to heavy capital investment opportunities. Strong mission interest certainly was an important consideration in the

case of the pilot project. These same linkages led to the use of the watercourse reconstruction findings and lining and turnout designs on the pilot project watercourses. Heavy involvement of the CSU team in preparing materials for training technicians and extension personnel, and in designing the courses at UAF was real plus.

Regarding the CIDA/World Bank agricultural development project in Swat, CIDA staff in Islamabad have followed the Mona project rather closely, but the degree to which this work was triggered by the CSU studies and how much of the specific lining technology developed at Mona will be utilized is not clear.

Where there were direct person to person contacts, information seems to have moved rapidly. CSU and its Pakistani counterparts have actively participated in several major workships and these have been useful. In one instance, we were told that the Project findings were strongly challenged in the discussion and also strongly defended. Dissemination of publications appears to have been mixed; however. Opinions were expressed that the WAPDA/ CSUfindings were not penetrating the Pakistan bureaucracy, even WAPDA. There were some complaints that reports, particularly progress reports, were not adequately circulated to interested counterpart agencies. Nearly all of the reports bear joint authorship of Pakistan and CSU counterparts. Seven are joint publications with WAPDA/Mona. There does not seem to be any very good vehicle for distributing this material within the country, but this is not unique to Pakistan or even to LDCs. Considerable effort went into preparing

visual aids including movies on land leveling and watercourse rehabilitation. We viewed the latter and had rather mixed feelings about its potential.

USAID personnel expressed a desire to have been more fully informed, but recognized the problem as basically one of personnel resources and time.

FAO has shown a strong interest in disseminating information arising from the project's efforts in their publications and workshops. This channel is being pursued actively by FAO, AID/DS/AG and CSU.

CSU project personnel also exchanged information with irrigation Researchers at Cornell and elsewhere around the world through seminars and workshops. The first of these was through a visit to Cornell in November, 1977 at which time several public seminars were presented and detailed discussion was held with Cornell faculty members.

A second activity was organized under the auspices of the Agricultural Development Council's Research and Training Network. This workshop gave special attention to the methodological issues associated with the study of irrigation organizations. It was organized collaboratively by Cornell and CSU Faculty members and included more thant two dozen social scientists from around the world.

8. Transferring Processes/Results to other Developing Contexts

Clearly, some concepts developed or reinforced by the Project are very transferrable. These include:

a. Efficient delivery of water below public canal outlets is apt to be a serious problem. This is linked to other agricultural production factors. The problem is organic because in most irri-

gation projects, agriculture and hydraulic engineering are clearly separated. The heavy capital investment is in the latter, but per hectare costs are very high, leading to the omission of adequate investment in the terminal parts of the distribution system in favor of additional major diversion and conveyance works. This situation is aggravated by inadequate revenues for maintenance and operation. Agricultural organizations and institutions often are weak. They are usually in adequately endowed with the resources to support the dramatic shift to irrigation.

b. The problem can be approached successfully only by adequate measurements and information, physical, economic, and social on existing projects or on pilot projects.

c. That experimental steps toward correction and their evaluation under real operating conditions are an important and necessary part of the task, otherwise the research says nothing much. These cannot be separated from educational and institutional considerations. The CSU-advocated approach leads into and encompasses initiation of implementation.

The team has developed systematic approaches to deal with (b) which should be adaptable elsewhere and has gained considerable experience with (c). Actually, AID projects using these approaches have been started in Egypt and Sri Lanka. World Bank and particularly FAO have been interested in the concepts and their application. Possibly, some of the specific

watercourse technology such as lining and turnout designs may transfer; the work on soil, crop, water, fertilizer, salinity applications and on skimming wells can be useful, but will need adaptation.

Consultants were provided at project expense to assist in project conception and design in India, Sri Lanka and Egypt. Two members of the CSU team (Clyma, Schmehl) assisted USAID Sgypt in drafting the project paper for its farm water management project. Their participation had a substantial influence on the nature and design of this project. Previous experience and utilization of the procedures developed in Pakistan permitted the contractor (CID with CSU as lead institution) to move immeidately into the field avoiding at least part of the long start-up time experienced in Pakistan.

CSU up to this point; however, has not really elucidated and described what is transferrable and how to go about doing it. This task is included in the work plans for FY 1979 and 1980. We hope that clear and explicit descriptions will emerge from this effort, but this will be a difficult task requiring sustained and devoted attention by the authors.

New page

V. CONCLUSIONS AND COMMENTS

A. Meeting the Project's Objectives

1. We carefully reviewed the objectives of the CSU/AID contracts detailed in section III of this report. The conclusion derived from this evaluation is that with the exception of the activities presently being concluded by CSU and detailed in section III, CSU has satisfactorily met all of its contracted obligations, often times in an outstanding manner.

2. Linkages to Major Pakistani Institutions

CSU successfully forged linkages at times with USAID/Pakistan assistance

and always with its encouragement, with all of the major Pakistani institutions, at both the federal and provincial level, concerned with on-farm water management research, training and development. The result was, in many respects, a Pakistani rather than a CSU project. For details concerning these linkages, the reader is referred to section IV A 4 and IV B 3 of this evaluation report.

3. Project Limitations

a. Social Science

In view of the current importance of organization issues for operation and maintenance at the watercourse level, it is unfortunate that more field staff was not available at an earlier date. While work on the sociology of the watercourse began very early, it was not until the Spring of 1978 that a resident faculty member was available. CSU did nominate a very qualified resident sociologist to serve in the field several years earlier but that they were unable to accomplish this because of technicalities regarding emmigration in his case. This scientist was, however, able to make several 3-month TDY visits to Pakistan and made very important contributions to the effort in Pakistan and in training on the CSU campus.

We also suggest that as part of the research strategy for water user organizations it would have been helpful to devote more attention to investigating existing local level organizations in areas of Pakistan other than the Punjab. These comparative investigations might have suggested alternative organizational structures and principles for testing in the Punjab. Furthermore, if such indigenous organizations were found to be

successful, this information might have contributed to a more balanced discussion of the advantages and disadvantages of formal (legal) water user associations in the context of Pakistan.

As a general methodology for investigation water user associations in other LDCs, we suggest that social scientists be encouraged to examine the range of existing water user groups as a preliminary phase in their research.

6. Livestock

Livestock (water buffalo, cattle, camels, sheep, goats, ducks, geese and chickens) are present in great numbers in the irrigated areas of the Punjab.

In viewing the great numbers of water buffalo, particularly, it seems almost as though the great irrigation system was imposed 150 years ago as a grid over a pre-existing production system in which man, beast and crop were already inseparably linked.

Today, as the dry season ends, the predominant area planted is in fodder crops and fodder is seen everywhere being cut and carried to the water buffalo in mixtures with chopped wheat straw from the recent harvests. Bullocks and water buffalo appear to be very healthy at the end of the long dry season. And well they should, for they are the principal drayage animals for preparing the small farmer's fields before the monsoon rains hit. Bullocks are used more than buffalos for drayage; buffalo are used more for milk production. A hunger-weakened animal cannot do a good job of pulling a plow or of providing milk.

Dr. Kemper's view is that low fodder yields are primarily the result of a general perception that fodder is not a crop having sufficiently high

value to merit fertilization. A project report to the Punjab Agricultural Department based on a study by C. J. de Mooy and Muhamed Hanif showed dramatic increases in fodder production by fertilization and concluded that fodder was often the farmer's best fertilizer investment alternative. However, according to Kemper, the GOP did not want to emphasize this fact during years when food grain production was less than adequate for human consumption.

In view of the fact that great efforts are expended by Pakistanti farmers to grow fodder crops to increase the strength of their tillage animals, CSU might profitably have given more emphasis to this aspect of the peasant cropping system.

4. Mission Relationships to the Project

On the whole, the CSU team enjoyed good relations with the Mission. In discussing the reasons for this with the Acting Director, the suggestion was made that a major factor could have been the Team's independence. Not being under a Mission contract may have been an advantage even to the Mission. If there were differences, CSU personnel were willing to fight for their views. This led to an atmosphere of mutual respect. The corollary, of course, is that such a team have the professional capability and wisdom in a development situation to command the Mission's respect. These relationships also take time to evolve, which means sustained in-country efforts. An important feature of independence was the fact that the project was basically not a CSU project, but a Pakistani project thanks to the early efforts of CSU personnel.

A measure of the development of the mututal respect between the CSU team and USAID/Pakistan is the strong support of the Mission in pushing for GOP approval of local currency grants for the following projects proposed by various Pakistani entities:

1. Water Management Research
2. Watercourse Improvement
3. Water Management Survey
4. On-Farm Water Management for the North West Frontier Province
5. Water Users Associations-Agricultural Research Council - CSU
6. Punjab Water Management Research and Water Management Advisory Training (USDA/SCS & CSU)
7. Water Users Associations (expansion phase)
8. WAPDA Water Management Research
9. Faisalabad University Water Management Research
10. Strengthening of Water Management Project Activities GOP/WAPDA/SCS/CSU.

The total amount of these grants, 48 million rupees ($U.S. 4.8 million) does not include nearly $U.S. 10,000,000 in dollar financing for a loan for watercourse improvement and precision land leveling and for a grant to provide technical assistance to that effort.

B. Lessons Learned

1. Implications for Centrally-Funded Research

Need for centrally-funded research the Water Management Research Project is an example of evolution of a centrally-funded project originating from a

perceived global problem through an identification of specific variables of the problem in the field, to application in the host country with extension to other LDCs. This experience supports the need for central research initiatives, to resolve general developmental constraints. We found no evidence that a field-level research attack on on-farm water management would have been initaited by either the Pakistan Government of the USAID in spite of the great importance of the problem to agricultural, economic and social development of that country. This does not, of course, prove that all global problems should be given central-funding support. The trick is to identify the most promising ones. We do not have any advice on how to do this, but we caution that all such ventures may not be successful and that some risk, which AID should assume at some level, will be involved in any research program. An important factor in choosing should be the prospect for evolving into an implementation phase without disruption.

Mode of Operation. We suggest that development research projects should not be cast in the classical mode, ending when the research results are published, but should if at all possible to dynamic ventures moving into real extension and application as rapidly as is prudent. Once the main breakthroughs have been made, the responsibilities for their refinements should be passed on to the fullest possible extent to host country counterparts and attention turned to helping the host country to apply the results.

We recognize that host country conditions and timing may not always be as fortuitous as in Pakistan and that many times results will have to be shelved awaiting fortuitous timing, but the principle seems like a good

one. The relatively smooth transition from research to extension as in the CSU case may not always occur. Perhaps there is a role for DS/AG in mediating this focus with the missions to help slow it down or speed it up as needed. Until implementation step is taken the hypothesis implicit in development research remains unproven. To do what is suggested above means that the balance of the team's personnel should shift, as indeed CSU's did, from research toward extension.

Of course, success requires that the research be on a topic which is significantly important to the host country. The water management research effort did survive a devastating war which resulted in dividing the country and in two sudden and drastic changes in the national government.

One function of expatriate research personnel is important. While appreciation for and recognition of the creative technical suggestions made by CSU team members were freely and voluntarily acknowledged, counterpart associates emphasized over and again that much of the value of the CSU team members were their effectiveness in resolving administrative and bureaucratic bottlenecks and delays at levels to which they could not get access. These situations were said to be sufficiently discouraging that host country workers often simply "give up".

"Real" Conditions. The CSU experience emphasizes the need to do research in the field on farms under real conditions and to obtain primary data. Without this, the real nature of watercourse problems would not have been identified nor could the results have been credible. This involves the most important factor and the real change agents the farmers. Under-

standing his limitations and strengths, and gaining his input into solutions are vital to the development of solutions which actually will be used.

Host Country Personnel and Their Development. Availability of host-country technical personnel and resources is a problem in many countries. Centrally funded research projects cannot expect first call on these. Pakistan has been relatively well endowed with basically trained engineers and agriculturalists. CSU arranged to send a number of these to the United States for additional training at an early stage of the project. Part, but not all of the costs were paid from project funds. Some were borne by the students themselves. This seems to have been an important element in the success of their project and implies that some resources for ex-country training should be provided in centrally-funded field research projects.

Making arrangements for both Pakistani and U.S. graduate students to do their thesis research in Pakistan on project problems has the advantage of keeping Pakistani graduates in Pakistan and of introducing young U.S. professionals into developmental work in LDCs.

Cooperative identification of training needs and the specific participants by host country administrators and CSU team members resulted in training government employees to do specific jobs which needed to be done. Trainees knew what they were being trained for. Their studies were better focused than those of most foreign students studying in the U.S.

Use of in-country workshops, seminars and training courses, if properly designed, are effective ways of getting training accomplished. Involving the University of Agriculture at Faisalabad (UAF) in giving these courses to junior government specialists using CSU as

advisers is one model which could work well providing the governmental agencies give it adequate continuing support by sending their people to participate. AID needs to look at in-country training needs arising from the implementation of research and development. How are these related to training activities now carried out for AID by USDA? To what extent should training resources be made available through research or development projects vis a vis through AID's training programs? How can the results of AID-funded research be integrated in AID training programs?

Funding Local Costs. The Mission was able to get many host country activities funded using PL-480 local currency grants to counterpart institutions. Without this support, active field research would have been impossible or very difficult to carry out. Before such funds became available the resident leader and others actually paid for some essential project costs out of their own pockets or stretched the legality of using a small revolving fund to provide essential project inputs that could not be obtained otherwise. A revolving fund to be used at the discretion of the ~~project~~ teams Chief of Party ~~director~~ and to be accounted for was a major factor in helping the team to get started on equipment manufacturing and other small items needed to get the project moving. There are dangers in setting up such funds so they must be managed carefully.

It seems important that adequate in-country resources be available if centrally-funded field research is to be successful. Excess currency resources may not be available so that adequate funding for this component needs to be provided centrally unless USAID is willing to use Mission re-

sources; however, if a project is to really be a host country one, that countries commitment must be more than a token one.

Intermediary Role. The Mona Reclamation Experimental Project leadership has quite effectively kept UAF faculty involved in an advisory and information linkage mode. The fact that CSU was involved with both has helped to keep these ties active. CSU advised the Mona director to continue paying the small consulting fee to UAF staff members on two occasions when the Mona director was considering dropping them. This suggests the role that a research contractor could play as an intermediary between a university and a governmental agency.

Identifying the Problem. The relatively slow start up of the field research gave us some concern early in our studies. There was need to clarify more specifically the nature of the problems in the field, find sites where research could be conducted and identify counterpart organizations or resources. While this might have been done more quickly than was done on the CSU project, gearing a project to host country realities takes time and intelligence from the field frequently greatly underestimated in project planning. It is noteworthy that CSU did not finish this phase until it had a senior scientist in residence in the field for a year or more. This suggests that projects of the size and scope of the one under review may need to be implemented in two steps, the first of which would be identifying and designing the specific approach to be taken in the host country.

The question of design of research projects was discussed with the Acting Director of the Mission and others. While conditions may vary de-

pending on the level of country development; there is great merit in not specifying the work too rigidly. This could even result in missing the salient points, especially for projects dealing with large and complex systems. A better course is to specify the work generally and leave it to the contractor to assess the situation in the field. This should be followed up by early evaluations involving both the Mission and DS. In the case of the CSU experience, full-time residence of a senior leader seems to have been an essential element. Backing him up with TDY personnel in disciplines other than his own was also important. The CSU experience testifies to the need for early social science analysis and advice not only to understand the constraints at farm and village level; but, to relate the work to those at the macro-level also. There will be some comparative advantages among options, thus these should not be foreclosed by overly rigid planning or too early crystallization of work plans.

Need for Long-Term Efforts. We strongly stress the importance of a long-time commitment of sustained effort and this view is supported by Pakistan USAID personnel. The CSU Project has taken twelve years to reach its present stage of maturity. We do not see how this period could have been compressed. Pay off in two or even six years cannot be expected.

Institution Building and Human Development. Perhaps the most important lesson learned is that, while not billed as an institution building project, every single step involved development of human resources and strengthening of institutions. While we don't know, we suspect that these activities may have occupied the greater part of the Team's time. Without

these efforts very little, if any, relevant research would have gotten done. We are impressed that on this project, developmental research seemed not to be separable from human and institutional development. We think this is generally a necessary condition for success.

2. Management of University Research Contracts

a. Project planning

An important lesson that emerges from the CSU experience is the need for flexible planning in the initiation of a research and development program. A necessary complement to this flexible planning, however, is the identification of a research problem that has the dual qualities of focus and scope. Too broad a research topic will lead to an unarticulated set ot activities, at best, or confusion and lack of activity, at worse. In contrast, too narrow a research topic may provide little scope for creative problem-solving and may lead to a pre-mature definition of the problems to be investigated.

USAID Missions need to understand the significant differences between research and development efforts and more standard technical assistance activities with regard to the extent and specificity of pre-project planning that can occur. While it is important to insist that research and development projects have an articulated research theme, less certainity should be expected in the initial phases with regard to exact specification of activities to be undertaken, individuals and agencies with whom to collaborate, etc. We note, in particular, that a log frame of projected activities was not prepared until 1976. While we believe it would have been

possible and useful to prepare the log frame before 1976, especially if there had been an earlier field evaluation of the project, we doubt that this could or should have been done in 1968 at the start of the project. It may be that tolerance for this ambiguity is greater with central offices, or regional bureaus than with specific country missions. This would suggest that management of at least the initial phases of research and development activities would be best managed by offices other than the country mission.

b. Involving the Rural Social Sciences

The CSU project experience is consistent with a growing number of experiences world-wide; the improved management of land and water is a socio-technical issue and can be achieved only when a variety of inter-related engineering; agronomic, economic and organizational constraints have been modified.

In the CSU project social scientists were involved from the start and began collecting background information relevant to watercourse management early in the project. This represents a much more productive approach than one in which the social scientists would have been called-in only after the project experienced difficulties in organizing watercourse farmers.

One strength of university contractors is the breadth of disciplinary skills they can mobilize to undertake specific lines of work. The lessons confirmed in the CSU experience are that social science perspectives are basic to many research and development efforts and that the activities of the social scientists need to be initiated in the early stages of the work.

Dr. Kemper who was resident project director 1974-77 feels that social