# IIMI RESEARCH PROGRAM IN PAKISTAN

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TISSA BANDARAGODA
IIMI Pakistan
1-A/B Danepur Road,
GOR I, Lahore,

# IIMI RESEARCH PROGRAM IN PAKISTAN

by

Pierre Strosser, Marcel Kuper,
D. Jayatissa Bandaragoda and Gaylord V. Skogerboe



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## SUMMARY OF EXISTING AND POTENTIAL RESEARCH PROJECTS

In October 1994, the only research funding in Pakistan for IIMI is the collaboration with CEMAGREF and the Performance Core Add-on Project (CAP). Fortunately, funding for the projects "Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan " and " Research Support for the Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project" should be forthcoming before the end of 1994. Other research projects should be funded in 1995 or early 1996, but a few may never be funded.

A listing of the research projects in given below, in their order of presentation in this paper, along with source of funding, duration and amount.

1. Strengthening the Water Management Component of Left Bank Outfall Drain Project. Funding by Swiss Development Cooperation and World Bank IDA. Duration is 3 years. Funding amount unclear.

2. Research Support for Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project. Funding by Water and Power Development Authority (WAPDA) with World Bank loan funds. Duration is 4 years. Funding is approximately US$ 450,000.

3. Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan. Second phase of funding by Government of The Netherlands. Duration is 5 years. Funding is approximately US$ 3.8 million.

4. Collaboration with CEMAGREF

   (a) Water Markets. Funded annually by the Government of France at approximately US# 30,000 per year.

   (b) Decision Support Systems. Funded annually by the Government of France at approximately US$ 20,000 per year.

   (c) Use of Remote Sensing and GIS. Funded annually by the Government of France. Total amount for 1994 and 1995 (two years) is approximately US$ 150,000.

5. Performance Program

(a) Chishtian Sub-division. Funded annually by IIMI Headquarters. Funding in 1994 was US$ 23,500 and the request for 1995 is US$ 62,200

(b) Farmers Response to Irrigation Services. Funded by IIMI Headquarters at US$ 10,000 total for 1994 and 1995.

6. Pehur High Level Canal. Funding by North West Frontier Province Department of Irrigation with Asian Development Bank loan funds. Duration is 7 years. Funding is approximately US$ 800,000.

7. National Drainage Program. Institutional Framework for Improved Sustainability and Productivity of Irrigated Agriculture in Pakistan. Funding by World Bank and Asian Development Bank. Duration is 3 years. Requested amount for IIMI/IFPRI collaboration is US$ 1.7 million.

## STRENGTHENING THE WATER MANAGEMENT COMPONENT OF LEFT BANK OUTFALL DRAIN PROJECT

### PROJECT DESCRIPTION

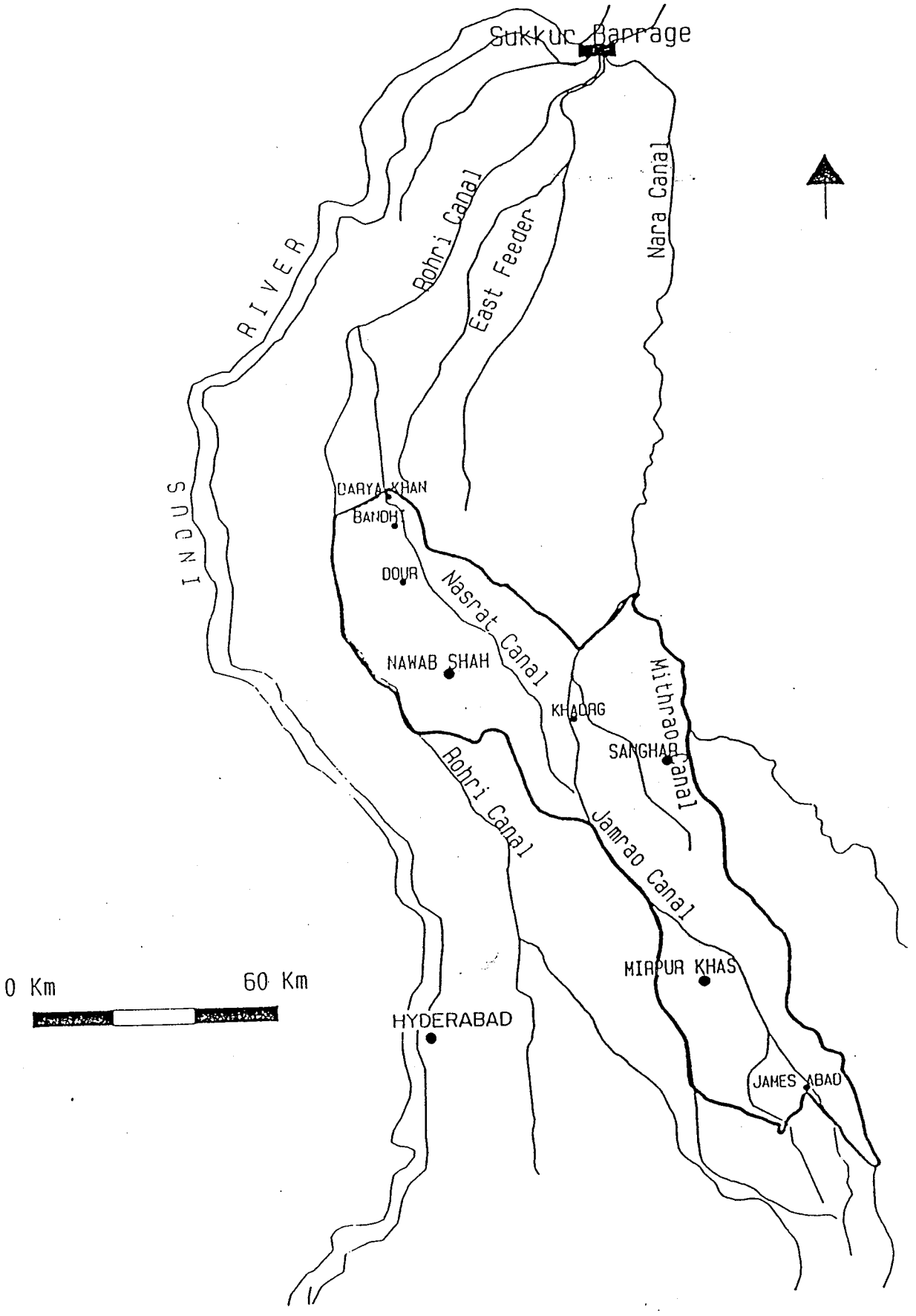
#### Left Bank Outfall Drain

Irrigation has been practiced in the Sindh for thousands of years. Large-scale irrigation began in 1932 with construction of Sukkur Barrage (Figure 1) serving more than three million hectares (ha). Two additional barrages were constructed in 1955 and 1962 on the Indus River downstream from Sukkur. The ground surface has very little gradient, being 1 in 7,000 in the steeper areas, but more commonly 1 in 15,000 to 1 in 20,000 moving southward towards the ocean.

In the early 1960's, serious problems of waterlogging and salinity were occurring over a significant portion of the land. A major drain outlet to the ocean was needed. Thus, the Left Bank Outfall Drain (LBOD) was conceived. The Government of Pakistan (GoP) began construction in 1975 of the main spinal drain having a length of 272 km.

In 1984, seven donors combined to provide loans of US$ 640 million. The present estimated cost is US$ 1 billion, with project completion to be in late 1997, but more likely in the year 2000.

Figure 1: Location Map of Left Bank Outfall Drain Project.



The project consists of: (1) the spinal drain; (2) surface and subsurface drainage that includes vertical drainage tubewells, scavenger wells, interceptor drains and tile drains; and (3) irrigation improvements comprising rehabilitation of the Jamrao and Nara canals, construction of Chotiari Dam, and On-farm Water Management (OFWM) in all project areas. The project area contains 488,300 ha of irrigated land divided among the three districts of Nawabshah, Sanghar and Mirpurkhas.

**Water Management Component**

The Water Management Component (WMC) is being implemented by the Sindh Department of Agriculture and Wildlife. There is a WMC Directorate modeled after the provincial OFWM Development Projects. The major emphasis of the program is watercourse lining, with some land levelling and agricultural plots.

Progress has accelerated in this program since July 1993. At the same time, there was an emphasis by donors that the WMC, with a budget of US $ 12.5 million, should be enhanced by increased emphasis on software measures.**Supplementary Project**

The "Supplementary Project for Strengthening the Water Management Component of the Left Bank Outfall Drain" was devised to provide more flexible approaches in implementing the Water Management Component (WMC) program. The Supplementary Project concept was approved by the Joint Donors Review Mission in June 1993. The World Bank (IDA) and the Swiss Development Cooperation (SDC) would each provide half of the funding.

The first draft of the Planning Commission proforma (PC-I) was completed in August 1993. A later draft included a role for IIMI, with IIMI participating in the third draft during November 1993. IIMI accepted the responsibility for the subsequent drafts (3) at the request of the Director General, Agricultural Engineering and Water Management. The PC-I was finally approved on 5 September 1994. The following details were taken from the approved PC-I; however, the World Bank is now modifying some of these details, so that the role of IIMI is not clear.

## SUPPLEMENTARY PROJECT COMPONENTS

There are three components in the Supplementary Project:

A. Direct Support to WMC;
B. Pilot Activities; and
C. Technical Assistance

## Direct Support to Water Management Component

This component has two subcomponents; (A.1) strengthening farmer participation in watercourse renovation; and (A.2) strengthening of the Irrigation Agronomy Field Teams (IAFTs). The WMC Directorate has an administrative staff plus Engineering Field Teams (EFTs) for watercourse renovation and land levelling, with the IAFTs are responsible for agricultural demonstration centers and organizing the Water Users Association (WUA) for each watercourse to be improved.

Implementation of both subcomponents will proceed in clusters of villages. The rationale behind the cluster approach is: firstly, ease of management; secondly, to facilitate communication with and among neighboring farmers; and thirdly, to demonstrate maximum impact through an integrated approach. Other common elements of the two subcomponents include an emphasis on staff training, farmer training, and farmers participation.

## Pilot Activities

The general objective of Pilot Activities is to promote experimentation, innovation and policy dialogue leading to improvements in selected aspects of irrigation management, watercourse renovation and maintenance, and the systems of agricultural support. The expectation is that the successes will be reflected, through a continuing dialogue between GoSindh, IDA and the co-financiers, as changes in policies, procedures and institutional arrangements for agriculture and water management occur throughout the LBOD project area.

The main function of the Pilot Activities is to motivate, test and support local capacity for innovation. The target group will be all those agencies and individuals who can demonstrate their demand for innovation and experimentation, and that can, with the technical and financial assistance during the project period, themselves sustain their initiatives thereafter.

The project with such assistance may promote agricultural and water management research through existing public sector organizations, but it may also contract with private companies, consulting firms, university personnel, and innovative development projects whenever appropriate. The same approach will be applied to extension, which may be contracted out to Government extension agencies, but also to the private sector and NGOs. For watercourse renovation through farmer participation, the project will support new, experimental approaches by WUAs, community activists, NGOs or local CBOs, working on contract with the local TA team.

The pilot activities will be carried out by the Directorate LBOD WMC with the assistance of the local/expatriate technical assistance team and comprise:

(B.1) Watercourse renovation through local NGOs/CBOs and local activists;

(B.2) Other local contracts for research, extension and farmer support; and,

(B.3) Management of irrigation both at the village level and in federations for water users management of watercourses, minor canals and distributaries; and

(B.4) Policy dialogues to support the above activities.

**Watercourse Renovation through Local NGOs/CBOs and Local Activists**

The objective in this case is to demonstrate, on a total of 20 watercourses and 15 surface drains, various cost-effective approaches through farmer participation that can improve the quality, benefits and maintenance of renovated watercourses beyond what is accomplished currently. Specifically, this Supplementary Project through the local TA team will: (i) Demonstrate the efficacy of farmer participation, defined as the primacy of farmer control over resources and decision making; (ii) Test affordable technical and organizational support mechanisms for farmers to undertake watercourse maintenance and renovation; and (iii) Demonstrate low-cost, labor- (rather than capital) intensive technologies for watercourse renovation that can be maintained by the farmers themselves with their own resources.

To ensure greater farmers participation, the program will be more flexible and farmers will be allowed to exercise various options suitable to their soil texture and socio-economic conditions regarding: (1) Watercourse design; (2) Free labor; (3) Contracting out the works; (4) Advance cost recovery; and (5) Cost recovery for additional lining and other relevant aspects. The Director LBOD WMC will be assisted by the Water Management Engineering Specialist of the local TA team in implementing this activity, who will use the services of suitable local activists, WUAs, CBOs, NGOs or others who can carry out the work in conformity with the above mentioned objectives.

**Other Local Contracts for Research, Extension and Farmer Support**

Adaptive research and extension in agriculture, under which the Irrigation Agronomist as a member of the local TA Agricultural Research and Extension Group will develop, using contract arrangements with local resource persons, a small number of high-payoff recommendations for increasing the productivity of those crops which contribute the highest value added in each major cropping zone (e.g., cotton-wheat and sugarcane-wheat), and those that are of value to small farmers and tenants (e.g., vegetable and fodder), and extend these recommendations for adoption by farmers. The scope of this activity would be restricted to on-farm adaptive research, extension, and the provision of seed of suitable new varieties for priority crops. This person will also assist the OFWM activities of this sub-component, as well as develop priorities and programs for research and extension.

In addition to assisting the Agronomy Wing and IAFTs, as well as their colleagues on the TA team, the Agricultural Research and Extension Group will act as catalysts to organize interested elements of local capacity (including private firms, NGOs and university personnel) around a program for achieving the highest possible payoff in the shortest possible time.

On-Farm Water Management (OFWM) research and extension will be carried out by the Water Management Engineering Specialist of the local TA team. This activity will aim at the outset to generate relevant and adoptable recommendations, in particular, by integrating perspectives from economics and water management. This specialist will work closely with the Agricultural Research and Extension Group of the TA team to develop a joint approach to research in irrigated agriculture. Contract services can be employed for individual researchers or teams from the Directorate of OFWM researchers at Hyderabad, social science researchers from other universities, and such individuals working in development projects and research teams in the country that have something to offer the WMC.

The project may succeed in developing a small number of realistic recommendations for improved OFWM and maintenance, and testing them successfully in major recommendation domains in the LBOD project area. When that happens, the TA Team will arrange for appropriate training and extension, through Component A of the project, as well as by awarding of contracts for training to non-governmental entities.

Training, especially farmer training, is one of the most important features of this project, and funds have been earmarked for it under relevant heads of the budget. Additional training needs, especially recruitment of training and communication experts, are likely to be encountered during project implementation. A lump sum allowance is, therefore, made in the budget to engage such resources as may be needed from time to time, upon request from the TA team or the WMC.

**Federation for Water Users Management of Minor Canals and Distributaries**

On advice of the World Bank and the Consultancy Team to OFWM III, it has been decided to take up a few pilot projects to induce genuine farmer management of irrigation, both at the village level and in federations for user management of minor canals and distributaries.

This will involve placing community organizers in selected communities to listen and learn, and then interact and slowly catalyze the farmers to identify their own problems, solutions, leaders, organization, financing (through collection of the irrigation charges), budgeting, management, and environmental management for their own profit.

Whereas, some 30 countries have succeeded in this and have turned minors and distributaries over to farmer management, in Pakistan the process has not yet begun.

The intention for the Pilot Distributary Turnover Command Areas is to build on and strengthen the existing WUAs and the WUA federations organized during the Command Water Management Project. Success will depend on creating enthusiasm within farming communities. Based on previous OFWM experiences in Pakistan, it may take several years for genuine farmer management to evolve and to result in increased agricultural productivity; however, some countries have experienced rapid progress.

One minor or distributary command area will be selected as a Pilot Distributary Turnover Command Area in each of the three LBOD districts (Nawabshah, Sanghar and Mirpurkhas). A Water Users Organization Team consisting of one Supervisory Community Organizer, two Community Organizers and two Field Assistants (for technical support) will be located in each district with one house rented in each district to serve both as an office and for accommodation. Each Team Member will be provided with a motorbike, thereby requiring a total of 15 motorbikes. It may not be possible at present to hire specialists in rural development, rural sociology, and local institutions. However, considerable effort will go into the selection of Community Organizers using criteria developed in other countries, but adapted to the cultural and socio-economic conditions in the Sindh. The two Field Assistants will provide technical support to their Water Users Organization Team in such matters as field discharge ratings of flow control structures, irrigation channel losses, surface irrigation practices, etc. This activity will be primarily undertaken by IIMI in collaboration with the Directorate of LBOD WMC through the expatriate Irrigation Institutional and local Irrigation Sociologist specialists. The staff of the Water Users Organization Teams would be contract employees of IIMI.

The Irrigation Sociologist specialists will identify, in collaboration with the IAFTs, local resource persons (graduates in agriculture or social science from an agricultural university) interested and prepared to function as a community organizer for some time. The main activities of the Community Organizers will be to focus on inducing the objectives of irrigation management and promoting ideas regarding:

a. Commercializing irrigation water;

b. Re-orientation of the current role for operation and maintenance of minors and distributaries; and,

c. Preparation of communities for ownership of distributaries, so as to assume management of minor canals, management and timing of water, agreement with the Revenue Department on WUA collection of water charges, agreement with the Agriculture Department to provide resources and expertise to WUAs, for the pilot areas.

The Supervisory Community Organizer will be responsible for providing necessary institutional support to the federation of WUAs through such activities as documentation, legal advisor's fees, registration charges, costs on WUAs training, and promotional

events for WUAs, etc. The Irrigation Sociologist specialists will work closely with the Supervisory Community Organizers in preparing the necessary process documentation for each pilot turnover area.

Funds have been provided under this Supplementary Project for an office for each of the three Water Users Federations (WUFs), which can be either rented or constructed, with appropriate equipment (such as communications) to be purchased. Some funds have also been provided for correcting priority deferred maintenance needs. The expatriate and local consultants would work alongside the Water Users Organization Teams in training and facilitating improved maintenance and operation practices by the WUFs. In fact, such activities are important for strengthening the social organization of WUFs.

**Policy Dialogues**

Water is one of the primary scarce agricultural inputs. The question, therefore, should not be restricted to that of improving demand and supply, but it requires major policy changes to create the sense of ownership among the farmers, collection of judicious cost recovery for improvements made in LBOD, and transition of O&M services for the improvements made under the LBOD project to WUAs and FWUAs.

IIMI will provide guidance for this sub-component. The purpose of the sub-component is to discuss with GoSindh and the co-financiers the implications for changes in policy, procedures and institutional arrangements that arise out of the project's work, and provide support to GoSindh for policy dialogues at the provincial and national levels. Toward this goal, the following activities will be undertaken:

- Identify a number of senior GoSindh officials who could serve as an LBOD Institutional Initiatives Planning Group for addressing short-term and long-term O&M issues and options.

- Seek the advice and concurrence of the LBOD Institutional Initiatives Planning Group in the site selection for the three pilot project areas.

- Report the status of this Supplementary Project after each irrigation season to the LBOD Institutional initiatives Planning Group, which will be the responsibility of the Director General, Agricultural Engineering and Water Management.

- Present rigorous documentation (technical, economic and social in the form of case studies, special reports, scientific publications, etc.) on the success and failures of various experiments and demonstrations, particularly as they are perceived by farmers. Data for this and other activities will also be provided by the WMC staff from their work.

- Expose selected GoSindh officials from the departments of Agriculture, Irrigation, Finance and Revenue, Planning and Development, etc. to appropriate locations in Asia, plus other locations such as Mexico, where institutional measures have been implemented that might be adapted to LBOD.

- Organize seminars, annual workshops and other presentations for discussing recommendations regarding alternative institutional initiatives that could be applied in the LBOD project area to agency representatives and the concerned donors including international specialists experienced in this subject area who could participate in the seminars.

- Identify and recommend the procedural and policy innovations that are required for wider adoption of appropriate institutional initiatives.

## Technical Assistance

The Supplementary Project provides technical assistance support to LBOD,WMC through local, as well as expatriate, consultants as indicated below:

1. **Local Consultants**

| | | |
|---|---|---|
| a. | Irrigation Sociologist | 36 person-months |
| b. | OFWM Engineering Specialist | 36 person-months |
| c. | Agricultural Research and Extension Group | |
| | Irrigation Agronomist | 36 person-months |
| | Agricultural Extension Advisor | 9 person-months |
| | Agricultural Research Advisor | 9 person-months |
| | TOTAL | 126 person-months |

2. **Expatriate Consultants**

| | | |
|---|---|---|
| a. | Irrigation Water Management Specialist | 9 person-months |
| b. | Irrigation Institutional Specialist | 12 person-months |
| c. | Irrigation Institutional Expert | 2 person-months |
| | TOTAL:- | 23 person-months |

The consultants will be appointed by IIMI after approval by the Director General, Agricultural Engineering & Water Management, Sindh. For this purpose, the DG will seek clearance from IDA/SDC. The proposed organizational chart is shown in Figure 2.

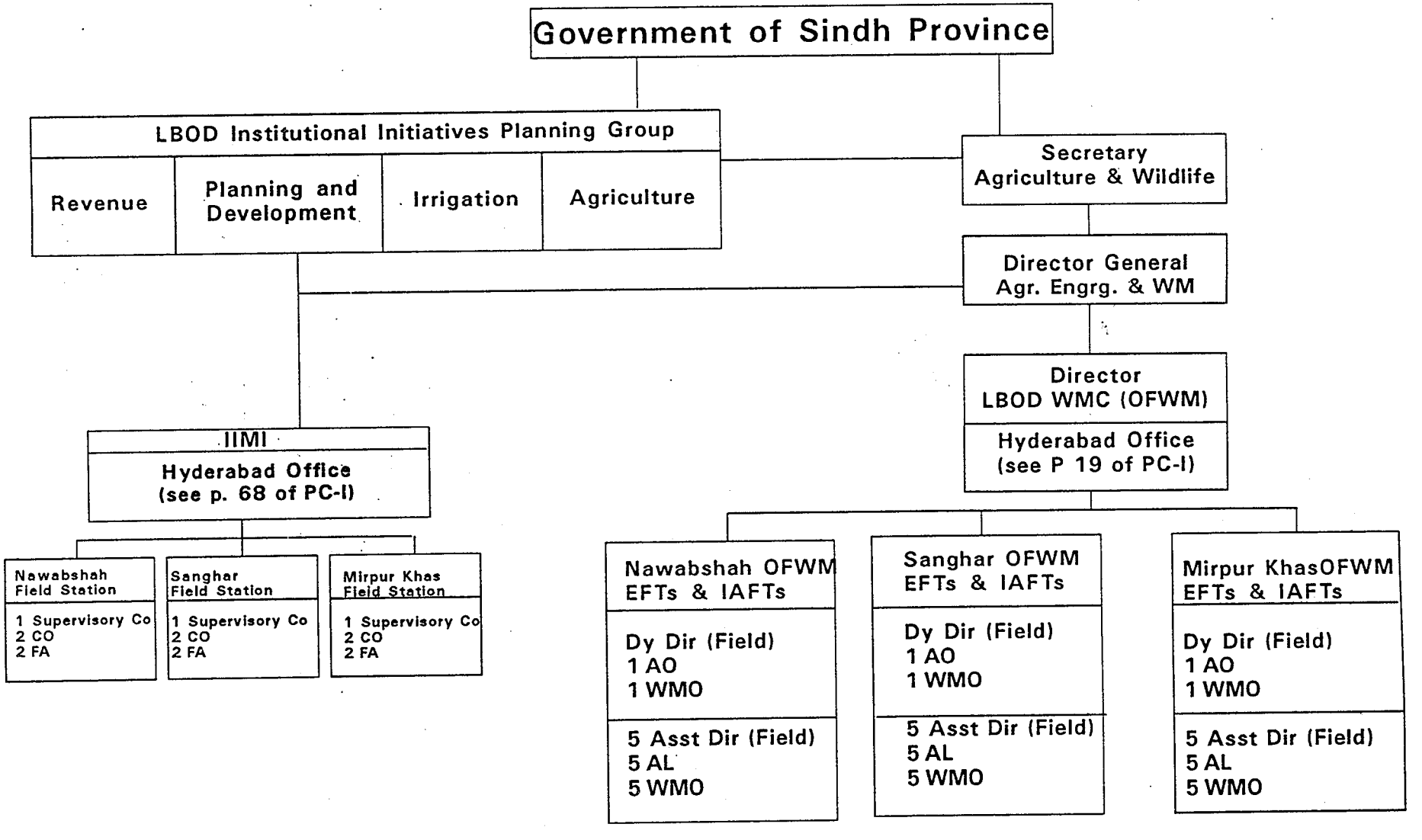



Figure 2: Organization Chart for Supplementary Project for Strengthening the Water Management Component, Left Bank Outfall Drain.

## RESEARCH SUPPORT FOR FORDWAH EASTERN SADIQIA (SOUTH) IRRIGATION AND DRAINAGE PROJECT

The Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project, FES(S), consists of approximately 105,000 hectares (260,000 acres) in the south-eastern part of the Province of Punjab (Figure 3). This area is underlain by saline groundwater. There are some private tubewells where the groundwater is not too saline.

The project has been designed to reduce the groundwater recharge by completing the construction of surface drains, installing interceptor drains along unlined branch canals and distributaries, and lining distributaries and minors, as well as improving numerous watercourses. The construction activities are scattered throughout the project area. In contrast, much of the research activities (but not all) have been concentrated at three Research Demonstration Field Sites. This became a significant part of the research design -- to provide an in-depth integrated research program that would: (1) produce research results that would have applicability throughout the Indus Basin Irrigation System; (2) maximize research results to strongly support Phase-II project preparation; (3) effectively demonstrate these results to farmers; and (4) yield practicable extension messages that can be disseminated throughout the project area.

The research component is highly action oriented. The results will be used to improve the Phase-I Project Design and provide a basis for developing the most optimal cost-effective combination of measures to be implemented in Phase-II for achieving a more productive irrigated agriculture that is environmentally sustainable.

The irrigation and drainage research component consists of the following five subcomponents: (i) evaluation of the impact of waterlogging and salinity on crop production; (ii) introduction of improved technology for planning and monitoring of irrigation and drainage projects; (iii) assessing performance of different types of canal lining; (iv) improvement of irrigation management with a view to match irrigation supply with crop water demand i.e. integrated irrigated agriculture management; and (v) agriculture extension support.

There are two monitoring components: (1) Field Trials and Monitoring for Phase-II Preparation; and (2) Monitoring and Evaluation of Project Impact. The second monitoring component would be supported by the research subcomponent, "Introduction of Improved Technology for Planning and Monitoring of Irrigation and Drainage Projects".

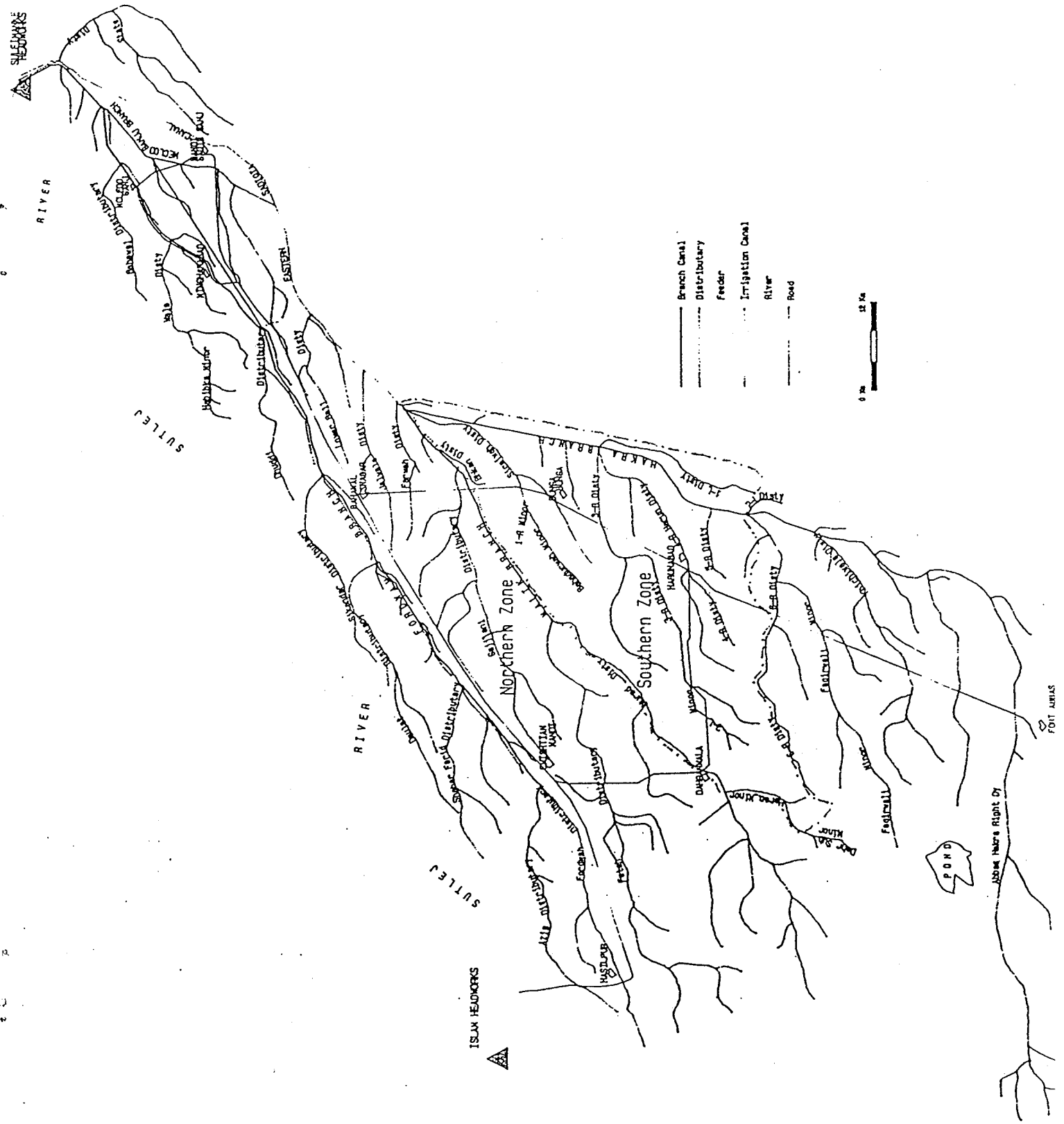



Figure 3: Location Map for the Fordwah/Eastern Sadiqia Irrigation and Drainage Project.

The monitoring components and the research component (Table 1) must be highly coordinated in order to produce significant research outputs that can guide the next phase of this project, as well as provide valuable data and results that will be relevant to other areas of the Indus Basin Irrigation System.

**Table 1: Subcomponents of the Research Component and the Monitoring Components**

| MONITORING COMPONENT | RESEARCH COMPONENT | MONITORING COMPONENT |
|---|---|---|
| **Monitoring of Land and Water Conditions** | **Irrigation and Drainage Research** | **Monitoring and Evaluation of Project Impact** |
| General Monitoring | Impact of Waterlogging and Salinity on Crop Production | Agricultural Production, Income and Employment |
| Groundwater Monitoring<br>Soil Salinity<br>Hydrological Monitoring | Improved Technology for Monitoring and Planning | Cropping Pattern, Cropping Intensities, and Net Farm Income |
| Specific Monitoring | Performance of Different Types of Canal Lining | Water Use and Equity in Distribution. |
| Surface Drains<br>Interceptor Drains<br>Evaporation Ponds | Integrated Irrigated Agriculture Management | |
| Monitoring of the Field Trials for Subsurface Drainage Research | Agricultural Extension Support Services | |

The evaluation of different types of canal lining will be done as a research subcomponent at four selected reaches scheduled for lining. The evaluation of the effectiveness of surface drains and interceptor drains will be done under the monitoring component, "*Field Trials and Monitoring for Phase Two Preparation*". Subsurface pipe drainage is to be evaluated under the same monitoring component using three field trial sites, which represent different soil conditions, as well as different degrees of waterlogging. The research on subsurface pipe drainage and canal lining are particularly important because they have been designed to yield outputs that will have significance for future irrigation and drainage development projects in the Indus Basin Irrigation System.

Under the research subcomponent, "Evaluation of the Impact of Waterlogging and Salinity on Crop Production", there are three themes: (A) Impact of Waterlogging and Salinity on Crop Yields; (B) Development of Improved Irrigation and Agronomic Practices; and (C) Alternatives for Managing Saline Agriculture.

The research subcomponent, "Integrated Irrigated Agriculture Management", would utilize two distributary command areas. Pilot studies would begin on the Bhukan Distributary Command Area (Research Demonstration Field Site No. 1) followed by a more elaborate program for the Sirajwah Distributary Command Area (Research Demonstration Field Site No. 2). The watercourses served by these distributaries will be improved as part of the On-Farm Water Management Development Project. A major effort would be made in "learning" how to organize water users under each watercourse, minor and distributary in a manner that would result in strengthened and sustainable farmers organizations.

The research subcomponent, "Impact of Waterlogging and Salinity on Crop Production," will provide agricultural extension messages that can be distributed throughout the Bhukan and Sirajwah Distributary Command Areas under the research subcomponent, "Integrated Irrigated Agriculture Management". Information from both of these research subcomponents can then be relayed to the subcomponent, "Agricultural Extension Support Services," which can be extended throughout the project area including possibly the Fordwah Eastern Sadiqia (North) under the regular agricultural extension program.

The research subcomponent, "Introduction of Improved Technology for Planning and Monitoring of Irrigation and Drainage Projects," will utilize a new capability in Geographic Information Systems (GIS). This technology will focus on the 21 watercourses reported in the 1989, "Agro-Economic Evaluation Baseline Survey" that are located in the project area. Four of these watercourses are located in the three Research Demonstration Field Sites. Five more watercourses have been added so that nine watercourses selected for intensive study are located in the three Research Demonstration Field Sites, which will benefit from this GIS technology. In addition, GIS will be utilized to the extent feasible for the full command areas under the Bhukan and Sirajwah distributaries.

The Water and Power Development Authority (WAPDA) has selected the joint venture of Euroconsult-Lahmeyer-NDC to provide technical assistance for all drainage facilities. The Punjab Department of Irrigation and Power will utilize the consulting firm of Mott MacDonald for the design of all canal lining. The Netherlands Research Assistance Project works very closely with the International Waterlogging and Salinity Research Institute on drainage research. The International Irrigation Management Institute will be providing technical assistance for specific research activities plus research coordination. These relationships are indicated in Table 2.

**Table 2: Organizations Involved in the Monitoring and Research Components and Subcomponents for the Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project.**

| S.No | Subcomponents | Organizations |
|---|---|---|
| 1. | Improved Technology for Monitoring and Planning | - Watercourse Monitoring and Evaluation Directorate (WMED), P&IO, PD, WAPDA<br>- Netherlands Research Assistance Project (NRAP)<br>International Irrigation Management Institute (IIMI) |
| 2. | Performance Evaluation of Different Types of Canal Lining | - International Waterlogging and Salinity Research Institute (IWASRI), WAPDA.<br>- International Sedimentation Research Institute (ISRI), WAPDA<br>IIMI<br>- Punjab Dept. of Irrigation and Power |
| 3. | Performance Evaluation of Surface Drains | - IWASRI<br>- NRAP<br>- Surface Water Hydrology (SWH), Hydrology and Water Management, PD, WAPDA<br>- Project Director (Drainage) WAPDA |
| 4. | Performance Evaluation of Interceptor Drains | - IWASRI<br>- NRAP<br>- Monitoring and Evaluation Directorate (MED), SMO, WAPDA<br>- Euroconsult-Lahmeyer-NDC<br>Project Director (Drainage) WAPDA |
| 5. | Subsurface Pipe Drainage Field Trials | - IWASRI<br>- NRAP<br>- MED<br>- WMED<br>- Euroconsult-Lahmeyer-NDC<br>- Project Director (Drainage) WAPDA |
| 6. | Impact of Waterlogging and Salinity on Crop Production | - Mona Reclamation Experimental Project (MREP), P&IO, PD, WAPDA<br>- IIMI |
| 7. | Integrated Irrigated Agriculture Management | - Command Water Management Project (CWMP), Punjab Department of Agriculture<br>- Punjab Department of Irrigation & Power<br>- IIMI |
| 8. | Agricultural Extension Support Services | - Punjab Department of Agriculture, Agricultural Extension<br>- MREP<br>- CWMP |
| 9. | Environmental Monitoring and Assessment | - Environment Cell, WAPDA |
| 10. | Monitoring of Land and Water Conditions | - MED<br>- SWH<br>- Euroconsult (EC) (Netherlands) with Lahmeyer (Germany) and National Development Consultants (Pakistan) |
| 11. | Monitoring and Evaluation of Project Impact | - WMED |

The Umbrella Technical Group (UTG) was constituted for the purpose of developing this Integrated Research Plan. The UTG will continue as a Standing Committee for the review and coordination of the research and monitoring components. An Annual Research and Monitoring Workshop will be held in Bahawalnagar. The leaders for each of the research and monitoring subcomponents would present: (1) the results of their past activities; and (2) the implications for future activities.

## MANAGING IRRIGATION FOR ENVIRONMENTALLY SUSTAINABLE AGRICULTURE

### FRAMEWORK

The activities proposed to be undertaken in this project have been developed with the primary aim of bringing about management and institutional improvements in the Indus Basin Irrigation System of Pakistan to sustain irrigated agriculture. The thrust of the activities is, therefore, to make a more productive use of the irrigation waters, to remove the physical constraints on agricultural production, and to maintain a productive environment. The activities, which represent an action-research orientation, have been grouped into three broad categories: 1) Operational Management; 2) Institutional Development; and 3) Salinity Management.

The first category, Operational Management covers the improvement of Main System Management through the introduction of Decision Support Packages, on which exploratory work was undertaken under Phase I. This would be supplemented with Watercourse Management aspects relating to warabandi practices and improved surface irrigation methods that will alleviate trends in soil salinity and irrigation water quality.

The second category, Institutional Development, would largely focus on the development of institutional options and management practices involving the water users and cover related aspects of Farmer-Agency Interactions, Coordination of Irrigated Agricultural Services and Public Institutional Arrangements.

The third category, Salinity Management, would aim at the development of a predictive capability (through the calibration of a soil moisture chemistry model and a groundwater model, and the use of GIS) of the salinity conditions over large areas. Using this capability, a variety of salinity management alternatives would be evaluated in the Rechna Doab (Punjab) and in selected areas in the Sindh Province.

The accompanying figure shows the schedule of project activities (Figure 4). There are three activities under each of three categories, which results in a total of nine activities. In addition, the last three activities come under the general heading of information dissemination.

Figure 4: Summary schedule of project activities.

| SCHEDULE OF PROPOSED ACTIVITIES | | | | | | |
|---|---|---|---|---|---|---|
| Obj | Activity | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
| Ia | Decision Support System - Punjab | | | | | |
| Ia | Decision Support System - Sindh | | | | | |
| Ib | Watercourse Management | | | | | |
| IIa | Water Users Associations | | | | | |
| IIb | Institutional Support for WUAs | | | | | |
| IIc | Coordinated Irrigation Agriculture Services | | | | | |
| IIIa | Soil Chemistry and Groundwater Management | | | | | |
| IIIb | Rechna Doab Salinity Management | | | | | |
| IIIc | Sindh Waterlogging and Salinity Management | | | | | |
| | Workshops | | | | | |
| | National Conference | | | | | |
| | Final Report | | | | | |

## OPERATIONAL MANAGEMENT

### Background

On a modest scale, during Phase-I research, IIMI has developed, adapted and demonstrated practical applications of decision support technology. The target has been managers responsible for canals, drains, public tubewells or agricultural inputs and officials who guide water sector and natural resource policies. The decision support technology provides them with a more comprehensive understanding of overall conditions, and can also support their management decisions in a more systematic, coordinated way.

The applications, mostly computer-based, include the use of hydrologic and solute transport models, MIS, GIS, spreadsheets and graphics programs. When properly calibrated and used with appropriate, reliable and timely data, these tools permit an accurate assessment of existing operational conditions and outputs for, say, canals or tubewells. They also allow managers to make a more accurate prediction of the likely

consequences of alternative resource allocation decisions on soil or water conditions and trends in irrigated agriculture.

**Objectives**

The objectives of this sub-project (component) are:

→ Ia. Create a "visible success story" on Decision Support Systems for Main System Management that can be disseminated among all of the provincial irrigation departments; and

→ Ib. to develop improved irrigation management practices at the watercourse level that will alleviate trends in soil salinity and groundwater quality that threaten the sustainability of irrigated agriculture in Pakistan.

**Activities**

Under Phase-I funding, some significant exploratory work was undertaken on "Decision Support Systems for Main System Management" in collaboration with the Punjab Department of Irrigation and Power (PID). With Phase II funding, this activity will be expanded. Irrigation Department Staff in the Bahawalpur Zone are encouraging such an activity. During the next two years, it is expected that the entire Fordwah Canal will be operated using this technology , and hopefully the entire Fordwah Eastern Sadiqia Irrigation and Drainage Project within five years. Much emphasis will be placed on institutionalizing this technology within the irrigation agency. This effort will begin by establishing formal PID-IIMI collaborative arrangements. By creating a "visible success story" in this irrigated area, it will be much easier for other PID managers to visually perceive the transfer of this technology to their irrigated areas. This will occur as a result of site visits and seminars, beginning early during Phase-II.

Pertaining to Decision Support System (DSS) for Main System Management, the effort will begin by establishing a PID-IIMI Working Group for the Bahawalpur Zone, with three members from PID and two members from IIMI. In addition, there will be a Decision Support Systems Planning Group that will take the lessons learned from the FES in order to plan the transfer of this technology throughout the Punjab. The Planning Group has five PID members and two IIMI members. There is one representative from each organization that will serve on both groups.

An annual training course will be conducted as the program expands into new segments of FES, which will be done jointly by the Government Engineering Academy and IIMI. Trainers will be trained in the "Hydraulic Operation of Irrigation Systems." Participants will be PID staff located at FES and other irrigated areas in the Punjab. Each year, the training site will encompass a new portion of FES until the entire project

area has been completed, This training is an important activity for transferring this technology throughout the Punjab.

In the Province of Sindh, the Swiss Development Cooperation (SDC) and the World Bank through IDA are funding a Supplementary Project to augment the Water Management Component (WMC) of the Left Bank Outfall Drain (LBOD) in three districts; namely; Nawabshah, Sanghar and Mirpurkhas. The implementing agency is the Provincial Agriculture Department (PAD) with IIMI providing expatriate and local staff. A primary component of this supplementary project is establishing a pilot area in each district consisting of a minor or distributary. Besides organizing farmers at the watercourse and distributary levels, there is a significant emphasis on agricultural demonstration centers that focuses on increasing agricultural production, including improved irrigation and agronomic practices. Under the project's Phase-II, a Decision Support System would be established upstream from each of the pilot areas. This would be done in collaboration with the Provincial Irrigation Department (PID). The same procedures described above for the Province of Punjab would be followed. One significant difference is that the Working Group would be reporting to an Institutional Initiatives Policy Group for LBOD that has members from PID, PAD, Planning and Development Department, and the Departments of Finance and Revenue. The concerns of this Policy Group are cost recovery for financing operation and maintenance of both irrigation and drainage facilities.

For the second objective, management improvements at the watercourse level will be introduced for alleviating soil salinity in order to increase agricultural production. This activity will be undertaken in the Province of Punjab at the Fordwah Eastern Sadiqia (FES) Irrigation and Drainage Project, which has a total cultivated area of 205,000 hectares (ha). Under the Phase-I research, IIMI maintained a field station at Hasilpur, which is located in the northern part of FES. Nine watercourses served by three distributaries were selected more than a year ago for intensive studies on warabandi (farmers rotation schedule for receiving water from the watercourse) and water markets. The field studies on warabandi practices will be completed by end 1994. The results will be used for improving watercourse management by also incorporating the findings from studies on water markets and improved irrigation methods and practices described below.

Regarding the development of improved irrigation methods, some research in improving the application efficiency of various surface irrigation methods will be done by Pakistan and Dutch students in collaboration with the Centre of Excellence in Water Resources Engineering (CEWRE) and the Wageningen Agricultural University, The Netherlands. The project will play an initiating and supportive role to the concerned Pakistani institutions only. The basic field studies will be done within the command areas of the nine watercourses mentioned above in FES(N). After some initial studies in late 1994 and during 1995, the findings will be incorporated into the field research program underway in FES(S) by the Mona Reclamation Experimental Project (MREP).

## INSTITUTIONAL DEVELOPMENT

### Background

Provincial legislation was passed in the early 1980s that allowed the formation of a Water Users Association (WUA) on individual watercourses. Since that time, thousands of WUAs have been organized on paper with Government subsidy and support given under the On-Farm Water Management Development Projects. These attempts at involvement of the farmers in the management of the irrigation system so far have not led to sustained farmers participation or to lasting benefits. Also, results from the Phase-I research clearly demonstrate the inequity of irrigation deliveries to watercourses located along minors and distributaries. Among others, they show scope for other improvements to be made in the secondary and tertiary irrigation system. Presently, there is a growing awareness of the necessity for organizing farmers at the level of minors and distributaries, as well as watercourses, so that farmers will have some control over the distribution of water to each watercourse. The World Bank in their report on "Pakistan, irrigation and drainage issues and options" (March'94) proposes a reorganization of the whole sector, including the establishment of autonomous public utilities for the management (including operation and maintenance) of the irrigation water. These proposals of the World Bank have in general been accepted by the Government of Pakistan, although there is considerable pessimism by many government officials about organizing WUAs, and their impact on the productivity and sustainability of irrigated agriculture.

The fundamental problem can be identified as one of governance: an institutional framework in which water rights are clearly specified and enforceable. The task is therefore to identify appropriate institutional frameworks and packages of management practices that would enable farmers to maintain watercourses and manage the water in a sustainable manner. Success in this task would have a very great long-term impact.

Experience from these modest attempts in the past indicates that much can be achieved by promoting a learning process while conducting collaborative research. Environmental and performance oriented studies require a participatory approach to initiate some institutional adaptation for enhancing the potential of learning from the studies.

### Objectives

The principal objectives of the activities under this component are:

→ IIa. to develop feasible irrigation management strategies regarding water users organizations that will alleviate trends in soil salinity and groundwater quality that threaten the sustainability of irrigated agriculture in Pakistan; and

→ IIb. Create institutional support for water users organizations at both the watercourse and distributary, along with strengthening the interactions between farmers and government agencies; and

→ IIc. Explore institutional arrangements for coordinated irrigation services by the provincial agriculture and irrigation departments.

**Activities**

Establishing Viable Water Users Organizations.

Relating to watercourse institutions and management practices, the initial research will be done in the Punjab at the Fordwah Eastern Sadiqia (North) Project Area (FES(N)), where IIMI has a field station at Hasilpur.

The institutional options which will require consideration include: development of workable organizational models and incentives for farmers to form WUAs; effective and enforceable warabandi (water rotation schedules) to replace the increasingly ineffective rotations found at present; efficient water trading and water marketing practices; and improved irrigation methods and practices. These options are not mutually exclusive, but different combinations may be required under different water resource and socio-economic conditions. IIMI has a considerable amount of experience in the area of local irrigation management institutions on which it will draw; the major collaborator will be the On-Farm Water Management Directorate of the Punjab Department of Agriculture.

Initial effort under this activity would be to develop the process for establishing effective water users organizations, taking into account lessons learned from past experiences, both by the OFWM Directorates and by other special projects in the country, such as the Aga Khan Rural Support Program. IIMI has initiated preliminary field work on the 6-R distributary of the Hakra Branch of the Eastern Sadiqia Canal where Water Users Associations had been formed earlier. The objectives of this work are: 1) to try out some elements of the rapid rural appraisal; 2) to explore the extent of prevailing organized behavior and its character; 3) identify the main factors that tend to influence (facilitate or inhibit) the formation of effective WUAs; and 4) identify a monitorable set of indicators relating to the effect of WUAs. Based on the results of this work, planning meetings would be organized with key representatives of the collaborating agencies (OFWM and PID). The discussions are to produce a Research Plan detailing the contributions from various collaborating partners, identifying locations for field work and linkages with other ongoing projects in the area. The Research Plan would be based on the agreed research objectives, methodology, indicators, and planned output. Consultancy input would then lead to the development of the conceptual framework and to identify the processes to be pursued. For this purpose, an inception period of 4 months at the start of the project would be required, to develop the further scope and program of work.

Following the outline of the conceptual framework, field work would be carried out with the help of selected agency staff working in field teams in the selected areas of the FES project, which will include collection of baseline information related to selected indicators, basic information describing the field and social situations, farmer perception of WUAs and their need to get organized, and building a rapport with water users in the area before proceeding with the next stage which would represent action research for the implementation of the feasible options.

As part of the activity, the existing legal framework for the formation of WUAs would be evaluated to establish the need for required changes.

**Farmer-Agency Interactions**

For this activity, the objective will be to establish on a pilot-scale a coordinating mechanism to promote interactions between farmers and operating agencies in a number of selected distributaries. The proposed mechanism will be a Distributary Channel Committee consisting of representatives from WUAs and operating agencies. Between the main Government agencies (PID and PAD) and IIMI, an agreement would be reached to test the effect of such a committee at a few pilot locations in FES and Rechna Doab. Their main functions will be to meet regularly to discuss seasonal cropping plans, and input management including water allocation and use. Other objectives will have to be identified as the committee becomes established. The experience of this pilot effort will be documented and if found feasible, extended to other potential areas. An effective interaction process at the farmer-bureaucracy interface would greatly assist in the diffusion of new concepts and strategies relating to environmentally sustainable agriculture. The difficulties currently identified in introducing improved water management practices, promoting effective Water Users Organizations, and strengthening agricultural extension efforts, are often related to poor communication between farmers and agency staff.

**Coordinated Irrigation Services**

During Phase-I research, an attempt was made to experiment with a Working Group at the level of Superintending Engineer in the Irrigation Department with the objective to create mutual understanding and coordinated approaches to improve the efficiency of water use. Extending this idea to form Working Groups consisting of both Irrigation and Agriculture agency staff, as well as farmers representatives, at several levels (Division, Circle and Zone) will be undertaken as an activity during Phase-II. This will promote coordinated efforts for delivering their services in an integrated package to the farmers, who thereby will be encouraged to respond more effectively to environmentally sustainable irrigated agricultural practices. Also here, an inception period of 4 months will be required to drawn up the full program of work for the total project duration.

### Role of Provincial Institutions

Another activity will undertake a systematic analysis of provincial institutional arrangements, formal and informal decision-making, and management processes whereby irrigation and related irrigated agricultural policies are translated into actions at the field operations level. The purpose is to better understand present organizational structure and processes that affect the implementation of programs or activities derived from new policies and objectives (e.g. to improve irrigated agriculture). This program of activities to be undertaken by the Project would be in line with the new role of the Provincial agencies as recently agreed between the World Bank and the Pakistan Government. Since many of the proposed changes will require several years of study and pilot implementation, IIMI would act as a collaborating research body and as catalyst agency, complementing their local research with experiences drawn from other countries in the world. The research results will be shared in a workshop with representatives from all of the provincial irrigation and agriculture departments, so that they can provide input as to their future roles in the development of environmentally sustainable irrigated agricultural development.

## SALINITY MANAGEMENT

### Background

Results from IIMI research in several canal commands in the Punjab strongly suggest that agricultural production and cropping patterns are significantly influenced both by the quality of groundwater and by the ratio of groundwater to surface water used in irrigation. In areas where the groundwater table is well below the surface, soil salinity develops when farmers consistently irrigate to more or less meet their normal crop water requirements, but fail to use an additional component of water for leaching purposes. The rapid expansion of private shallow tubewell development over large areas of Pakistan, especially in the Punjab, appears to be an important additional contributing factor to the development of secondary soil salinity. When the quality of irrigation water is marginal to poor, the amount of water required for irrigation and leaching purposes must be increased if secondary soil salinity is to be controlled.

For most areas of irrigated agriculture in Pakistan, the maintenance of the salt balance in the crop root zone is of great concern. The downward movement of water through the soil profile contributes to the maintenance of the desired salt balance. Thus, drainage is closely linked with irrigation management as both processes are components of the control system necessary to create and sustain an optimal environment for growing plants. The installation of a surface or sub-surface drainage system will not guarantee the control of a favorable salt balance unless sufficient water is applied in excess of the crop water requirements to maintain a downward flow of water in the root zone. Hence, for the prediction of the salt balance in irrigated soils, the physical aspects of the movement of salts in soils must continue to be evaluated.

Thus far, the largest component of IIMI's work in Pakistan, on assessing the scope and severity of salinity and waterlogging, has been undertaken in Punjab Province. This work has directly resulted in the development of system-specific management interventions to mitigate the effects of these problems. However, waterlogging and salinity are serious threats to sustainable agricultural productivity in many parts of the country, and it has been argued that waterlogging problems are severe and threatening to the sustainability of irrigated agriculture in Sindh where irrigated agriculture is not presently environmentally sustainable.

The intent of this sub-project is to extend the important research advances IIMI has already made in linking better control of salinity to improving the management of irrigation system operations and maintenance through selected interventions in the Punjab into suitable salinity management alternatives for Sindh. This will ultimately lead to implementation strategies for environmentally sustainable agriculture for the Indus Basin Irrigation System.

## Objectives

The objectives of this sub-project (component) are:

→ IIIa. to assist in the establishment of the physical and chemical (salinity) processes occurring in: (a) the unsaturated soil profile between the ground surface and the groundwater table; and (b) the spatial and temporal variation of salinity in the groundwater reservoir resulting from pumping;

→ IIIb. to identify salinity management alternatives for the Rechna Doab in the Punjab using Phase-I research results and the Phase-II research on salinity processes in the unsaturated soil profile and the groundwater reservoir, which could then be considered for implementation by the Government of Pakistan in collaboration with farmers; and

→ IIIc. to assess potential opportunities for alleviating extreme conditions of waterlogging and salinity in the province of Sindh that would result in environmentally sustainable agricultural production.

## Activities

A fundamental problem in developing salinity management alternatives is to first establish the basic subsurface chemical processes that are taking place in the soil profile and the groundwater reservoir. Otherwise, only the existing conditions in a site-specific area can be evaluated.

The project will assist in carrying out data analyses required for use in the solute transfer models in soil moisture chemistry for which the International Waterlogging and

Salinity Research Institute (IWASRI) and the Netherlands Research Assistance Project (NRAP) will take the lead.

An existing three-dimensional groundwater model will be employed to describe the spatial and temporal variation of salinity in the groundwater reservoir, as well as the temporal variation in the salinity of pumped water from tubewells. Previous groundwater exploration studies in the Punjab have disclosed that a significant salinity gradient exists in the groundwater reservoir, with the salinity concentration increasing with depth. The groundwater near the bottom of the unconfined reservoir is usually too saline for either domestic or agricultural use. The groundwater underlying the major rivers is much less saline than in the center of doabs. Fortunately, the Geohydrology Unit within the SCARPS Monitoring Organization (SMO) in the Water and Power Development Authority (WAPDA) has collected the necessary field data for selected areas in Pakistan, but this data has not been analyzed using a groundwater model. Thus, this model will be calibrated for selected areas in collaboration with WAPDA. This will provide the necessary predictive capability for assessing various long-term groundwater salinity management alternatives.

Much of the Phase-I research was done in the Rechna Doab, the land between the Chenab River and the Ravi River in the Punjab. During this same time period, IWASRI/NRAP were conducting subsurface drainage field trials in the center of this doab. The combined knowledge from these two research programs, plus the calibration of the soil moisture chemistry model and the three-dimensional groundwater model, provide a good base for establishing salinity management alternatives for the Rechna Doab. The IIMI GIS capability will be used in conjunction with appropriate ground truth sampling procedures to extend the results of this earlier research. This exercise will initially focus on a single canal system, then be expanded to the entire Doab.

The Province of Sindh represents the most extreme case of waterlogging and salinity conditions. Agricultural productivity is declining in many areas year-by-year. At the present time, irrigated agriculture is not being environmentally sustained. Severe measures are required in order to arrest the present situation and then continually increase agricultural production while maintaining the environment. To begin with, existing irrigation development projects will be studied by field reconnaissance and a review of documents. Based on preliminary studies, three districts (Nawabshah, Sanghar and Mirpurkhas) have been selected for further investigation using IIMI's GIS capability supplemented by ground truth field data. Also, a few technologies, already installed, may be selected for field evaluation. However, the level of field studies will be kept fairly modest, with most of the effort being spent on evaluating existing information.

As a result of this sub-project, it will be possible to define ways in which the severe problems of waterlogging and salinity in canal commands can be more effectively managed under environmental conditions typical for much of irrigated agriculture in the other provinces. The outputs are likely to be broadly similar to those already generated

by IIMI's salinity research in Punjab, but will definitely differ in specific content because of the special characteristics of the irrigation environment in each province.

## COLLABORATION WITH CEMAGREF

CEMAGREF is the national agricultural and forests research organization in France. The collaboration with IIMI is through the Irrigation Unit located in Montpelier. This collaboration has become extremely productive. The funds have been deployed as CAPs, which has supported very valuable research in the Chishtian Subdivision that receives irrigation surface water from the Fordwah Canal. There are three important activities: (1) Water Markets; (2) Decision Support Systems; and (3) Geographic Information Systems and Remote Sensing.

### WATER MARKETS

The Water Markets CAP has focused on surface canal water and tubewell water in terms of water trading and selling among farmers. The field studies have included four sample watercourses served by the Azim Distributary and another four watercourses under the Fordwah Distributary. A watercourse volume balance hydraulic model has been developed. Work has been initiated on farming systems analysis, with a strong focus on agricultural production in the near future. This research is also integrated into the watercourse surveys by the Watercourse Monitoring and Evaluation Directorate, WAPDA and the watercourse surveys being done under IIMI's Performance Program. Remote sensing will also be used to aggregate all of this data. This program has been made possible by the assignment of a CEMAGREF staff member to Pakistan, which has resulted in many additional research activities being undertaken.

### DECISION SUPPORT SYSTEMS

This program has benefited enormously from the CEMAGREF collaboration, both in Sri Lanka and Pakistan. The combination of Marcel Kuper, Zaigham Habib and Jacques Rey has developed the Irrigation Management Information System so that it is now the most implementable program by IIMI in Pakistan. In the future, Dutch funds will be available to further extend this program in the provinces of Punjab and Sindh. This will facilitate IIMI's efforts regarding institutional strengthening with the provincial irrigation departments. (See also the discussion on Pehur High Level Canal.)

## USE OF REMOTE SENSING AND GIS

The objectives of the R&D activities that IIMI and CEMAGREF propose are:

to transfer the methods that the CEMAGREF-ENGREF Remote Sensing Laboratory has developed in the past concerning the use of RS and GIS applied to the management of irrigation systems; and

to define and test new methods of spatial analysis integrating the hydraulic, economic and environmental aspects (waterlogging and mainly salinity).

The proposed activities are presented under three main components: (0) Space maps; (1) Development aspects; and (2) Research aspects. Three areas can be defined within development activities; (1.1) Watercourses network mapping; (1.2) Land-use mapping; and (1.3) Water balance monitoring. The research work is separated into two main components: (2.1) Salinity and waterlogging; and (2.2) Integrated modelling on canal water management and economic aspects at different levels of analysis.

The study area belongs to the Fordwah Eastern Sadiqia system, and corresponds with the Chishtian Subdivision (14 distributaries, 470 watercourses), which can be considered as a complete irrigation subsystem. The area (about 67,000 ha) is totally covered by 2 SPOT, 1 Landsat TM, and 4 ERS-1 SAR scenes. The application related with the analysis of farming system and irrigation water demand at the watercourse level will first focus on Fordwah Distributary (command area of around 10,000 ha), and then on the entire subdivision.

A major benefit to IIMI's program will be the new technical assistance on remote sensing. There are funds included in the Dutch Phase II proposal for purchase of the necessary equipment that will allow satellite imagery to be used.

# PERFORMANCE PROGRAM

## CHISHTIAN SUBDIVISION

Funds from the Netherlands and France have been used to implement the Irrigation Management Information System (IMIS) in the Chishtian Subdivision, which is served by the Fordwah Branch Canal. In addition, the research under the Water Markets CAP is being done on 8 sample watercourses served by two distributaries located at the tail of Fordwah Branch Canal.

A Performance Assessment Study was begun in May 1994. The main objectives for the first year of this program were: (1) gain a better understanding of the impact of irrigation system operations on agricultural production; and (2) develop a set of hydraulic,

economic and environmental performance indicators at different levels in the irrigation system.

The major activity in 1994 has been a farm survey of 560 sample farmers located along 68 sample watercourses spread throughout the Chishtian Subdivision. When the data analysis for the Kharif 94 season is completed, the first estimates of agricultural production and economic performance indicators will be available at the watercourse level.

The same farm survey will be repeated at the end of the Rabi 1994/95 season. In addition, IIMI and the Punjab Irrigation Department will formulate a performance assessment system that can be implemented in the Chishtian Subdivision.

## FARMERS RESPONSE TO IRRIGATION SERVICES

Another collaborative effort between IIMI-HQ and IIMI-PAK will be in answering the questions, "How do farmers perceive the quality of their irrigation services?" and "How do water markets modify the quality of irrigation services?" Rather than policy-makers and irrigation managers, this research will focus on developing performance indicators from the perspectives of farmers.

Selected tools of the Participatory Rural Appraisal (PRA) methodology will be used to incorporate the viewpoints of farmers and to appropriately address the issue of whose reality counts, in what context, and for what purpose. In addition, PRA will be compared with more traditional methods of collecting information, such as: (1) farm surveys through formal questionnaires; and (2) monitoring of irrigation water supply as currently being done by IIMI in the Fordwah Branch Canal.

# PEHUR HIGH LEVEL CANAL

## INTRODUCTION

A mission of the Asian Development Bank (ADB) visited Pakistan in June/July 1993 to discuss with the Government of Pakistan implementation of the proposed Pehur High Level Canal (PHLC) Project, based on the Final Feasibility Report. One of the activities of the project, identified by the Mission, will be to **"develop a comprehensive, user-friendly mathematical model of the PHLC - Upper Swat Canal (USC) system to optimize the use of Indus and Swat River water resources and minimize the loss of energy at Tarbela Dam. The model will be a decision-support tool for the system managers. Operational procedures will be developed for a crop-based operation of the PHLC-USC system".**

In a letter from ADB dated July 15, 1993, IIMI-Pakistan was invited to formulate a proposal to address the objective stated above, detailing staff time and budget required.

On the basis of material provided by consultants and ADB, a proposal has been formulated by IIMI-Pakistan, proposing to develop, introduce and implement computer-based decision support tools, enabling the management of the PHLC-USC irrigation system to attain the following objectives:

1. **Water saving**. To optimize the use of the Indus and Swat River water resources while minimizing the loss of energy at Tarbela Dam.

2. **Flexibility**. To develop operational procedures for a crop-based operation of the PHLC-USC system, requiring different discharge regimes.

3. **Maintenance**. To prioritize canal maintenance for the PHLC-USC system.

## CONCEPT

The concept, which IIMI has successfully applied in Sri Lanka and Pakistan, implies the design of a **Management Intervention Package** [1], including the consideration of problems of measurements, communication, hardware, simulation, etc. rather than the recommendation of a single isolated tool or model. In this section, the Management Intervention Package, developed by IIMI, will be briefly presented. The Package addresses three main areas:

1. A reliable **data collection network** has to be established, incorporating calibration of measuring devices, training of staff to take measurements, formats of data field books, etc.

2. Establishment of an appropriate **communication network** to ensure a timely transmission of data to the decision-making center and to enable a feed-back from the managers to the field.

3. Development of an **integrated tool at the decision-making level** (partly computer based) to support the system manager in the management of the canal system.

This integrated tool has two component parts. Firstly, data that have been collected in the field and transmitted to the decision-making center, are stored in a

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1. A more complete formalization of theoretical concept is given in Rey, J. 1993. Information System for Canal Management, Theory and Practice. IIMI, Colombo, Sri Lanka.

database management system (DBMS). This DBMS processes the data, calculating discharges, strickler coefficients, seepage losses, etc. The DBMS consists of different modules, making it very easy to build a package that targets a specific irrigation environment.

The DBMS permits the manager to compare actual operations/water distribution with the operational targets and detect gaps. A number of performance indicators are calculated so that the manager can evaluate the performance of the irrigation system (once again with reference to targets). Areas of interest are operation (e.g. adequacy and timeliness of supplies) and maintenance (e.g. compare strickler coefficient with acceptable value). DBMS also permits the manager to formulate the operational targets for a specified period of time (e.g. one week or 10 days), based on the actual performance of the previous period and on the demand by farmers.

The second part of the tool is formed by a mathematical model, Simulation of Irrigation Canal (SIC) [2], that permits the manager to simulate the feasibility of operational or given water allocation plans (given the hydraulic characteristics of the system) and to assess the efficiency of operational plans. This model forms an integrated part of the total package and data that are stored in the DBMS (e.g. water levels, strickler coefficients) that are used for SIC simulation runs. The model can be used for three main purposes:

1. Assist in the verification of the lay-out and design of the canals and structures of the irrigation system;

2. Training of the system managers by simulating system operations; and

3. Tool for the manager to formulate and check the feasibility of the operation plan.

## NATIONAL DRAINAGE PROGRAM

### STATUS

The National Drainage Program is presently being formulated by the World Bank and the Asian Development Bank. The program will focus on pilot areas scattered throughout the country. The consultants (NESPAK) prepared a preliminary study at the end of May 1994 and will submit a more detailed report in late October 1994. The total

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2. This model was developed by the Centre National du Machinisme Agricole de Genie Rural des Eaux et des Forets and field tested in collaboration with IIMI's Research Division. The model has been adapted to the Pakistani irrigation environment during research conducted in the CRBC system and in the LCC system in the Punjab by IIMI-Pakistan.

estimated cost of the National Drainage Program is US$ 300 million. The startup is targeted for mid-1995.

This program will have a research component. A summary of a proposed IIMI/IFPRI collaborative study was submitted to NESPAK in late May 1994 and a more detailed proposal in mid-October. The introduction for this detailed submission is included below.

## INSTITUTIONAL FRAMEWORK

Irrigation in Pakistan is at a critical juncture, when increases in irrigated area are becoming more difficult and environmental threats of waterlogging, salinity, and mining of groundwater are degrading the resource base of irrigated agriculture. Growth of total factor productivity in agriculture, which has been strongly influenced by irrigation, is also declining. This implies that new solutions are needed to maintain the resources base and improve agricultural productivity and sustainability in irrigated areas.

One broad and increasingly popular approach to improving the performance of irrigation, in Pakistan and elsewhere, is to change the institutional framework under which the irrigation sector is managed. A recent report by the World Bank, for example, advocates major institutional changes for improvement of the performance of the irrigation sector in Pakistan. Considerable attention is being given to transfer of management responsibility to organized farmers' groups and encouragement of private sector involvement, including markets for surface and groundwater. In addition, there is a growing concern about the management of vertical drainage tubewells and the maintenance of surface drainage networks. Unfortunately, little research has been done to date on these institutional aspects and on the transition process required for such changes. Thus it remains unclear how these strategies will overcome the difficulties faced by previous approaches.

The proposed research will explore the appropriateness and feasibility of alternative institutional arrangements to improve the sustainability and productivity or irrigated agriculture in Pakistan. It will do this by identifying the physical and social parameters which affect the functioning of key institutions involved in irrigation and drainage management, and the impact of those institutions on the performance of irrigated agriculture.

The timing of the proposed research is particularly opportune, because there is a greater interest in institutional experimentation and reform in Pakistan than had previously been the case. Many senior policy-makers recognize the need for change, but wish to have firmly grounded options to avoid making serious errors. Therefore, the proposed research will provide crucial support to fill a clear demand for assistance.

The study will be jointly undertaken by the International Irrigation Management Institute (IIMI), the International Food Research Policy Institute (IFPRI) and national collaborators. The proposed national collaborators will include staff of government agencies (On-farm Water Management (OFWM), Irrigation Departments, and WAPDA Watercourse Monitoring and Evaluation Directorate (WMED)) and research organizations (Punjab Economics Research Institute (PERI), and University of Agriculture, Faisalabad (UAF)).

The study will be an integral part of IIMI's Program on Improving Public Irrigation Organizations and IFPRI's Multi-Country Program on Water Resource Allocation, and will be supported by IIMI's Local Management and Performance Programs. It will build on existing work in Pakistan, especially IIMI's Waterlogging and Salinity Project Phase II (Water Users' Association and Water Allocation within Watercourses), IIMI's on-going research on Water Markets in Pakistan, IFPRI's study of Groundwater Markets in Pakistan, and an international review of factors affecting operation of Water Users' Associations.

The project will establish a study advisory committee of IIMI and IFPRI staff and national collaborators, including government agency staff (such as from OFWM, Irrigation Departments, and WAPDA watercourse Monitoring and Evaluation Directorate (WMED)), and research organizations (such as Punjab Economics Research Institute (PERI) and University of Agriculture (UAF), Faisalabad).