INCEPTION REPORT

CROP-BASED IRRIGATION OPERATIONS IN NWFP

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on the

TECHNICAL ASSISTANCE STUDY
T. A. NO. 1481-PAK

CROP-BASED IRRIGATION OPERATIONS IN THE NWFP

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I - INTRODUCTION

1.1 Context of the Studv and the Inception Report

This Inception Report relates to the study being undertaken under a Technical Assistance Agreement (TA No. 1481-PAK) dated 25 July 1,991, between the Government of the Islamic Republic of Pakistan (GOP), the Government of' North West Frontier Province (GONWFP) of Pakistan, the International Irrigation Mariagement Institute (IIMI), and the Asian Development Bank (ADB).

Both the Federal Government' and the NWFP government* had requested IIMI's participation in a collaborative effort to determine the most appropriate management system for the new design approaches in the NWFP's Chashma Right Bank Canal (CRBC) and Lower Swat Canal (LSC) projects. The Federal government had expressed its interest in the CRBC and the Provincial government had requested assistance with respect to the conversion of operations to demand system in the LSC. The former is being developed with the assistance of the Asian Development Bank and the latter with the assistance of the World Bank. During the appraisal of the Stage II of the CRBC in 1987, the Federal Ministry of Water and Power had also requested the ADB for technical assistance to carry out an action-oriented study for demand-based irrigation system operations[3]. The TA study program is based on this coalition of interests.

The Inception Report describes the background of the study in general and of the specific study locations, its rationale and objectives, and the accomplishment of its inception activities. The Report also refers to several constraints encountered during the preparatory stages of the study and those that may lie ahead, and more importantly to some proposed changes in the study activities and the workplan. These changes are proposed in view *of* the constraints that were not envisaged at the proposal stage, and also of some recent policy decisions made on the operation of the LSC necessitating a shift in emphasis of the study at the LSC location.

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1. Letter dated 1/3/1988 from the Government of Pakistan Ministry of Water and Power, Mr. Khalid Mahmood, Engineering Advisor.

2. Letter dated 6/10/1988 from Government of NWFP Irrigation and Public Health Engineering Department, Engr. Muhammad Anwar Shah, Section Officer (Construction).

3. ADB Fact-Finding Mission Aide Memoire dated 16/12/1989

1.2 Development of the Study Proposal

IIMI's proposal to the ADB for this study was based on a number of consultations and field visits. In March 1989, IIMI staff along with Dr. Gilbert Levine, Professor Emeritus Engineering of Cornell University and Senior Associate of IIMI, visited the two project areas and held discussions with officials of the NWFP Department of Irrigation and Public Engineering (IPHED), the NWFP Agriculture Department (AD) and the northern division of the Federal Water and Power Development Authority (WAPDA), as well as with some farmers. Later, discussions were also held with the National Consultative Committee for IIMI-Pakistan. IIMI staff also met with the World Bank consultants and the expert who installed an on-demand pilot project in the LSC and visited its 60 acre pilot area.

These visits and discussions clearly identified the need for a more careful consideration of design and supply constraints before embarking upon a full-scale on-demand system of irrigation operations, or even any modified demand irrigation schedule in either of the two projects.

In December 1989, the ADB Fact-Finding Mission which visited the project areas along with IIMI staff, held similar discussions with officials and farmers, and recognized these constraints. They noted ?he confusion resulting from apprehensions *of* those who tend to interpret the term "demand-based irrigation" to mean complete freedom for farmers. The actual intent ***of*** the design changes appears rather to have been aimed at the general purpose of reducing the mismatch between water deliveries and crop water requirements. Discussions with officials of the Federal Ministry of Water and Power, and the Economic Affairs Division, confirmed this position.

Accordingly, IIMI developed a proposal for a collaborative action-oriented study program in the CRBC and the LSC, involving in-depth investigation into present system conditions and operations, and identification of the most appropriate management system for irrigation operations based on crop-water requirements under the given and anticipated project constraints.

After further discussions with Government officials and Bank staff[4], IIMI prepared the proposal document that was submitted for ADB's and GOP's consideration in February 1990. A Bank Fact-Finding Mission visited Pakistan between 2 and 10 April 1990 to finalize the details of the proposed advisory technical assistance. Subsequent to this Mission, a PC-II document was prepared for the project and approved by GOP's Ministry of Water and Power Departmental Development Working Party (DDWP) on 21 August 1990.

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4. To follow up on the Mission in December 1989, the Bank fielded a Contact/Consultation Mission in February 1990.

1.3 Technical Assistance Agreement

Based on these understandings, GOP through its Economic Affairs Division formally requested ADB for technical assistance for this study to be undertaken by IIMI, and an MOU was signed by GOP, IIMI and ADB on 24 September 1990. After ADB's decision on provision of TA for the proposed study, ADB fielded an inception mission on 16 March 1991 to discuss with the parties concerned and finalize the terms of reference for the study. As expected at the inception mission deliberations, IIMI initiated preparatory work for the study in March 1991 with the intention of starting field activities from the beginning of the Kharif season, but administrative delays in signing the TA Agreement tended to retard the process. Eventually, the TA Agreement between GOP, GONWFP, IIMI and ADB was signed on 25 July 1991.

II. STUDY BACKGROUND

2.1 Irriaation in Pakistan[5]

Pakistan has an arid sub-tropical climate with an average annual precipitation less than 300 mm. The country's natural endowment of glacier-based water resources in the northern mountainous region overlooks a vast flat valley with an average slope of about 0.2 m per km, which extends for more than a thousand kilometers to the southern coastline. This situation of perennial sources of water and large tracts of flat land is typically geared to an irrigation-dependent agricultural sector.

Although irrigation has been practiced along the rivers and streams of Pakistan for centuries, the present system which is mostly in the Indus Basin is a result of two sets of more recent development efforts. The initial thrust came from the pioneering work of the British during the period from 1850 to 1947, and later development took place following the Indus Watei Treaty of 1960. The second wave of development work was undertaken with international aid and was meant to stabilize the water supply that was interrupted by the Partition. This resulted in an addition to the existing irrigation infrastructure another extensive network of barrages and canals, and two dams at Mangla on River Jhelum and Tarbela on River Indus.

The present diversion capacity of the canals of Pakistan is 7,318 cumecs. The network of canals of about 64,000 km in total length, and watercourses totalling'to about another 1.6 million km in length delivers water to the fields through 89,100 farm outlets. This is supplemented by groundwater from about 12,500 large public tubewells and another 280,000 small private tubewells. Average annual utilization is about 123.4 billion cubic meters out of an average annual flow of 175.2 billion cubic meters of the three western Rivers i.e., Indus, Jhelum and Chenab. These statistics describe one of the world's largest irrigation systems. Pakistan's 4:1 ratio of irrigated to unirrigated crop land is, in fact, the highest in the world.

2.2 Oriainal *Design for* "Protective" Irriaation

The irrigation system of Pakistan was designed as a run-of-the river system with an objective to command maximum area with the available supplies in the river, ensuring "equitable distribution" between various canals, branches and distributaries and also between individual outlets. The duty of water (or the water allowance) was fixed relatively low in order to irrigate maximum command; the typical duty being 50 to 70 liters/sec per 1000 hectares [3 - 4 cusecs per 1000 acres]. The irrigation intensity was

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5. For a more detailed description of the irrigation systems in Pakistan, please see Annex 1.

also designed to be kept low at an average of about 75%, with 50% during Kharif and 25% during Rabi.

Another design objective was to keep the administrative and operational requirements as low as possible. The "equitable distribution" of water was to be effected without much interference by the operators. The number of control structures in a canal was kept to a minimum. Cross regulators were installed only where necessary to control operating levels for the head regulators. The distributary outlets were not gated, but had fixed structures to provide discharges proportional to the area to be irrigated in the watercourse commands.

Following the "Regime Theory" of Mr. Lacey, an Irrigation Engineer of Punjab Irrigation Department in late 1930s, the canals were designed with slopes, velocities and sections in regime to minimize silting and scouring. The canals were to run most of the time at authorized full supply level and be closed when the supplies fell short of 75% of the full supply discharge to avoid silting.

The Indus River system carries a large volume of suspended sediment during the flood season. This heavy silt load was the main source of the deterioration of the old inundation canals and posed a big challenge to the engineers in designing the new canals. Efforts were made to prevent the heavy load of silt by construction of silt "excluders" as part of the headwork; water was drawn into the canals from the upper layers carrying comparatively less silt load. Any silt,that entered the canals was to be disposed of with the flow of water through the Moghas for deposition on the irrigated lands.

Some of the above mentioned design features, however, appear to have outlived their usefulness. Increased cropping intensities, changed cropping patterns, and an increasing indiscipline in the system surpassed the original design objectives. The idea of "protective" irrigation embodied in the early design criteria was no longer compatible with the emerging new conditions.

2.3 From "Protective" to "Productive" Irrigation

With the introduction of Green Revolution technology, irrigated agriculture in Pakistan underwent some rapid changes. Irrigation intensity increased far beyond the design stage expectations, partly aided by the development of groundwater. New and improved crop varieties were introduced to produce high yields, and most of these varieties acting in combination with a package of inputs on which they were dependent, were highly sensitive to irrigation water. Cropping patterns changed requiring increased quantity and reliability of farmgate water supply. All these changes converged on the need to have a greater control over availability of water: in adequate quantity and quality, at appropriate stages of crop growth, and at the correct time and place. The yield potential of new crops using the new technology was generally known, and the full realization of this potential was seen as dependent on the application of the complete technology package which included a more intensive water management effort as one of its critical elements.

Thus, a departure seemed necessary from the traditional approach of "protective" irrigation to that of "productive" irrigation.

A mismatch between irrigation supplies and crop water requirements has been seen as a prominent characteristic of canal irrigation systems in Pakistan. According to the National Commission on Agriculture', the most adverse effects of the seasonal variability of supplies are (i) the chronic inequity which affects the tail-enders, and (ii) the shortages that occur during critical periods of the crop growth cycle. Both these factors contribute to lower yields in large areas of Pakistan's irrigation systems.

These adverse effects are exacerbated by the low water allowances and the limitations of the physical system capacities in the traditional "protective" irrigation systems. The concept of "productive" irrigation aims to increase irrigation water availability and to manage irrigation deliveries to meet the consumptive water requirements of the crop (crop demand), and thus create the opportunity for improved ,agricultural production.

A declining potential for further enhancement of the resource base is also another reason for looking towards "productive" irrig'ation. Pakistan during its Seventh Five Year Plan period (1988-93) is anticipating a 40% increase in the rate of agricultural production over the rate achieved in the Sixth Five Year Plan period (83-88). This is to be achieved in the context of limited scope for expansion in the irrigated area. Water supply increases indicated by annual growth rates in farm gate water availability -- of 3.9% for 1960-67, 2.7% for 1968-78 and 1.6% for 1978-86 -- do not totally correspond to an expansion in the irrigated area which has increased only at the much lower rates of 2.7%, 1.3% and 1.5% respectively for the same periods[7]. This trend implies a' policy of shifting to "productive" irrigation.

2.4 The Interest in Crop-Based Irrigation

An instance of official recognition of the perceived inadequacy of Pakistan's traditional "protective" irrigation system can be seen in the Report of the National Commission on Agriculture. Here, two specific problems relating to the canal irrigation system have been noted: 1) the persistent tendency of the supply-based system to spread existing supplies widely and thinly, and 2) the consequent difficulty of varying water supplies to meet changing crop water requirements.

The Commission's specific recommendations included the development of macro-level plans for the distribution of irrigation supplies more in line with crop water requirements

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6. Report of the National Commission on Agriculture, Ministry of Food and Agriculture, Government of Pakistan, March 1988, p.289.

7. Report of the National Commission on Agriculture, p.288.

in different canal commands. The Commission also recommended the operation of tubewells and canals to adequately meet both drainage and crop-water requirements.

However, the Commission's explicit caution in this regard reflected a wide-spread concern on the difficulties of adopting full scale demand-based irrigation in Pakistan. The Commission recommended that crop zoning and water scheduling aimed at linking more closely irrigation supplies with crop-water requirements should be first undertaken on a pilot scale before its wider application'.

Another instance of national level ,concern in this regard was seen at the series of deliberations that took place in finalizing the Water Sector Investment Plan (WSIP) of October 1990. In a working paper on policy and management issues by Kirmani[9], the major factors depressing crop yields were seen as, inequitable distribution of water, and lack of adequate matching of water supplies with crop requirements. The latter problem was linked to the practice of using historic withdrawals as the, index for water allocation which therefore was not directly related to crop requirements".

Specific mention of demand-based irrigation operations was made by the consultants to the SCARP Mardan project in the NWFP. At least'two of the consultant reports" have suggested the applicatiori of an on-demand management approach for the LSC system, in which farmers have the opportunity to request water deliveries through a water-user organization, permitting them to take most of the decisions pertaining to the management of their irrigation and agricultural activities.

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8. Government of Pakistan Ministry of Food and Agriculture, 1988. Report of the National Commission on Agriculture. pp. 287, 299 and 300.

9. "Comprehensive Water Resources Management: A Prerequisite for Progress in Pakistan's Irrigated Agriculture", By Mr. S. S. Kirmani was one of three main working papers at the Consultative Meeting on the WSIP.

10. The Working Paper concludes: "More water can be made available for productive use by changing the historic withdrawal pattern to a crop needs pattern, by ensuring equitable distribution and by conjunctive use of surface and groundwater storage. These management methods will not affect the water rights of the canal commands in terms of their total volume of withdrawals in each crop season, but they will help in providing the same volume of supplies to match the crop needs pattern more closely for optimizing crop yields".

11. HARZA-NESPAK Consultants. 1985. Mardan SCARP Operation and Maintenance Manual. WAPDA; and Thompson, G. T. 1988. Consultant Monitoring Report . HARZA Engineering.

2.5 Irriaation in the NWFP

The North West Frontier Province (NWFP), the smallest .of the provinces of Pakistan, has only 5% of the country's irrigated area, but is primarily an agricultural region. The Province's land and water resources are both limiting factors, and therefore is highly dependent on increases in the productivity of its irrigated agriculture. Its present yield in the major crop, wheat, is well below the national average, and yields of other crops are comparable. Thus, it is reasonable to expect a strong interest in the province for improving the performance of its irrigated agriculture.

In an effort to improve irrigation management, the Province has introduced some changes in the planning of its new irrigation systems, leading to substantial increase in the water duty (rate of water delivery per unit area). This change represents a shift in the philosophy of designing systems from "protective" to "productive" irrigation. The revised water duties for channel and outlet designs attempt to provide channel capacities that permit more appropriate matching of water deliveries to crop water needs, as reflected by an anticipated or desired cropping pattern with optimum productivity levels.

2.6 CRBC and LSC Systems in the NWFP

This shift in design philosophy can be seen in two major projects of the NWFP: the Chashma Right Bank Canal (CRBC) offtaking from the Indus and the Lower Swat Canal (LSC) which derives its supplies from the Swat river. The design of CRBC and remodelling of LSC are based on main canal capacities of about 0.60 lps per hectare and 0.77 lps per hectare respectively, compared to the more traditional system capacity of 0.28 lps per hectare. The main features of these two systems are given in Table 1 below, and the characteristics of design changes are further elaborated in Annex 1.

In Figure 1, the General Plan of the Chashma Right Bank Canal Irrigation Project is presented. It highlights the three stages into which the system has been divided for construction purposes.

Similarly, in Figure *2* the Lower Swat Canal Irrigation System's layout is given. The figure also shows the designed Cultural Command Areas of the watercourses.

Table 1 : Main Features of CRBC and LSC Systems

FEATURE (Units)	CRBC	LSC
Year Built	1986, still under Construction	1885; remodelled in 1935 and 1987
Supply source	Indus, Kabul river	Swat river
Source regulation	Chashma barrage	run of river
Type of System	gravity flow	gravity flow
Design discharge (cumecs)	138.07	54.90
Average water allowance (lps/ha)	0.60	0.77
Length Main Canal (km)	271.92	35.40
Type of Main Canal	partially lined	unlined
Length of network canals (km)	603.37	112.63
Number of distributaries	40	10
Type of outlets	Pipe	Gates/APMs
Drainage System	No	Under Mardan SCARP
Cultivable command (ha)	230,675	50.040
Design cropping Pattern (total %) (Kharif, Rabi)	150 (60,90)	180 (90.90)
Other features	Integrates Paharpur Canal system	None

2.7 Manaoernent Implications of the New Design

2.7.1 CRBC

Although the capacity of the CRBC system has been worked out on the basis of the maximum requirements of the CCA, no infra-structure has been provided to run the system with variable discharges according to the crop requirements.

In the 32.3 km length of canal in Stage - I, there are only two cross regulators; one at 11.8 km and the other at 19.9 km downstream of the head regulator. The control structures as provided are insufficient. More control points will be required to introduce demand-based operations.

The CRBC has been designed as a gravity canal to run at nearly full supply discharge to maintain its regime and avoid siltation. For demand-based operations CRBC will run only 40% of the time with discharge more than 75% while 60% of the time it will run with variable low supplies, with 20% of the time less than 50%. This running of variable low flows will have serious repercussion on the regime conditions of the canal.

The design of CRBC envisages the conventional system of distribution of supplies from the distributaries to the outlets i.e., to deliver fixed discharges at full supply level without any intervention. The conventional outlets i.e., open flume or APM have been redesigned to only deliver the increased discharge. No provision of gates has been made to deliver variable discharges according to crop water requirements.

The CRBC draws its supplies from the Indus River at Chashma Barrage having a small component of storage. As such there is no problem in feeding the CRBC at the head. However, the monthly pattern of allocation of water to be utilized has been fixed due to the inter-provincial character of the canal and the barrage. Escapes at distributary level have not been provided.

The communication system is inadequate. Only a few regulating structures have been provided with telephone connections. Regulation messages are sent through messengers to other regulation points. An efficient communication system is essential between all regulation points along the main canal as well as along the distributaries for introduction of any type of demand-based operations. Automation or remote control of some key control points may be required for efficient operation. A communication system between the water users and managers of the delivery system for timely intimation of demand and subsequent delivery schedule is a basic need. No such ,system exists at site.

The old irrigation system of Paharpur Canal has been remodelled for the increased discharges on the basis of the crop requirements, but,neither the operating staff nor the farmers appear to be running the system or using the water in the field according to the requirements of the crops. They seem to be delivering and using the additional water *to* increase the extent of cash crops. This trend is likely to continue, to the limit of available water. The ability to deliver additional water during peak need periods appears to be inadequate under conditions of full development with high delta crops. Thus, if this trend were to continue, the objective *of* matching deliveries to crop-based need is unlikely to be met.

The success of the crop-demand based operations ultimately depends upon the efficient use of water at the farm level. Water User Associations (WUAs) are an essential part of the operation. There are no WUAs in the area except on few watercourses where improvements have been done under the On-farm Water Management (OFWM) program. Even these are only on paper to fulfill the OFWM program requirements.

2.7.2 **LSC Svstem**

The **LSC** System is being remodelled to meet the crop water requirements of the command area. The capacity of the channels is being increased. The watercourses are being converted into minors due to increase in discharge. The outlets are being redesigned and provided with gates to deliver varied discharges at different times as per water requirement of the area. However, the system is not ready to switch over to demand-based operations due to several design management disparities.

The system has been redesigned on the assumption that run-of-the-river supplies will be available for most of the year except two months (October and November) to meet the crop water requirements of the area. A gap between available supplies and demand will occur if demand exceeds due to an increase in intensity or shift in cropping pattern from the design assumptions. With the increase in water supply on demand at the outlet head, the farmers have a tendency to .grow high delta cash crops and increase the intensity beyond the design and demand more water which the system will not be able to deliver. The supplies will fall short for a longer period of time and thus affect the crop production.

The canal system from the headworks up to the outlet is unlined. This has been designed for maximum discharge on the "Regime Theory" concept, and is supposed to run with near design discharge to maintain their regime. The operation of the system with variable discharges less than 75% during 72% of the time (even less than 25% of discharge 28% of the time), will upset the regime of the canal.

No cross regulators have been provided for feeding the offtaking distributaries. It will not be possible to feed these distributaries without control structure when the canal will be running with low discharges most of the year. The operation of distributaries with partial supplies will be difficult due to provision of gated outlets. .Farmers in head reaches will be tempted to draw more water. This will encourage inequity in distribution of water.

Escapes have been provided only on the main canal. No escapes have been provided on the distributaries and minors to dispose of surplus water. This may cause flooding of tail reaches in low demand period and damage the crops, unless distributary flows are reduced accordingly.

Water User Associations (WUAs) play a key role in crop-based irrigation operations. Distribution of water within a watercourse will be the responsibility of the WUA. No institutional arrangements have been made for the utilization of additional supplies.

The mechanism for distribution of water as an alternate to traditional warabandi has not been worked out.

Training of the farmers to utilize water and to ascertain the timing and quantity of water to be given to the crop has not been planned.

The On-farm Water Management and other field staff of Agriculture Department have not been trained to guide the farmers in the new circumstances of increased canal capacity.

III. STUDY OBJECTIVES

3.1 Rationale for the Studv

While steps have been taken to redesign and remodel these irrigation systems and to provide larger water allocations for more intensive cropping, this effort has not been accompanied by the development of irrigation management procedures to achieve more appropriate matching of delivery and crop water requirements. The additional water allocated through the usual timed water-turn (warabandi) system provides capability: to increase cropped area, to produce at a higher level in the same cropped area, and to change the cropping pattern. A combination of all three options appear to be taking place in the project areas, but it 'is unlikely that performance is a? an optimum, technically, economically or socially. Also, there is a genergl ,recognition that the additional opportunities associated with the greater flexibility in water use may bring with them the danger of increased inetticiency, and that the higher water allocation through the remodelled system in this context may exacerbate drainage problems.

Although substantial improvements in system performance and agricultural production are possible using the "productive" concept of irrigation, changes in system management and operation must occur, both in terms of physical control and organizational procedures. However, if the traditional supply-oriented operational practices are allowed *to* continue in these systems, inefficiencies in water use will aggravate existing drainage problems, and depress the productivity of water and overall system performance because of the higher water availability. This in turn will have a severe negative impact on benefits from the substantial investments in irrigation infrastructure.

These negative trends have been observed in completed areas **of CRBC** and **LSC** in **NWFP,** where irrigation supplies are temporarily increased due to a lack of control because facilities are not yet fully developed and/or operational in the rest of the system. Farmers (and system operators) in these completed areas are not yet aware of the opportunities and constraints of the "productive" concept of irrigation, and are initially inclined to grow crops with high water requirements, such as rice and sugar-cane. Both wastage of water and the appearance of local waterlogging and salinity problems have been observed.

Recognizing these trends, a need can be identified to formalize policies and procedures for the development and operation of systems with high water allocations.

The following specific points form the basis of the rationale for the proposed technical assistance:

i) water resources are limited/constrained despite increased water availability at the system level;

ii) inefficient use of increased water availability may result in waterlogging and deprive downstream areas of adequate access to required water resources; and

iii) agency personnel and farmers are not geared up to or prepared for effective utilization of the increased water availability.

3.2 Objectives

The proposed technical assistance will aim to improve the overall productivity of water" through improved system management and irrigation operations, in accordance with crop water requirements within the authorized system-level water allocations and subject to available supplies.

Soecificallv, the proposed technical assistance will aim to:

i) identify a flexible management approach for irrigation operations that responds to crop water requirements under prevailing supply constraints;

ii) increase understanding of crop-based irrigation operations by agency personnel and farmers, and identify training needs;

iii) field-test and refine the management approach identified for crop-based irrigation operations; and

iv) evaluate the benefits of crop-based irrigation operations and identify costs and opportunities for implementation on a wider scale.

12. Crop yield per unit of water delivered.

IV. WORKPLAN

4.1 Main **Studv** Activities

Project's study activities will be in the following six main categories:

i) Supply and Demand of Irriqation Water: Conduct closely monitored studies to ascertain the availability of water at source level, and system capacities, seasonal variations and other constraints of water supply and delivery; and also to assess seasonal crop water requirements of viable cropping patterns.

ii) Irriqation System Operations: Undertake a program of action research, in close collaboration with the Provincial Irrigation and Agriculture Departments and WAPDA, to: (i) understand the existing irrigation system management practices, (ii) evaluate the technical feasibility of crop based irrigation operations from an engineering and agronomic standpoint, and (iii) establish operating principles and procedures for plarining, operating, monitoring and evaluating crop based irrigation operations.

iii) Irriqation Facilities: Review design concepts, advise on the construction of prototypes, and conduct field-level evaluations of hydraulic facilities (canals and control structures) to undertake Crop Based Irrigation Operation, with a view to improving design criteria and guidelines. Particular emphasis will be placed on the socio-technical aspects of system operation.

iv) Irriqation Institutions: Document, analyze and evaluate the management processes, organizational structures, roles, functions, and interaction of the Irrigation Department and other government agencies, water user groups and individual farmers in relation to the adoption of Crop Based Irrigation Operations, recommending modifications where necessary.

v) Economics of Crop Based Irriqation Operations: Conduct socio-economic surveys and maintain farm records to determine the costs and benefits of any improvements to be considered in a wider implementation of the technical recommendations. Particular attention will be given to the magnitude and mechanism of irrigation service fee collection.

vi) Policv Guidelines: As a consequence of undertaking the system- and field-level research activities, issues are expected to arise that will require resolution at the policy level. These issues will be documented, and the implications for policy changes be evaluated.

A detailed workplan for each of the main study categories above can not be fully developed at this time. In some cases, only after the project has provided some initial insights into relevant questions pertaining to those particular areas of study, will we be in a position to frame a more detailed plan of action.

This is particularly true in the case of category iii) Irrigation Facilities. It is too early to be able to discern a plan of action for that purpose. It should be expected that in forthcoming progress reports this particular topic can be tackled in earnest.

4.2 Initial Action Plan

The above paragraph notwithstanding, we provide below an initial action plan under each main category for the study.

4.2.1 Supply and Demand of Irrigation Water

Water distribution in Distributary # 3. A key issue in the design of the CRBC irrigation system was the increase in water duty from the traditional value of 0.21 lps/ha [3 cusecs/1000 acres] to 0.60 lpslha [8.56 cusecs/1000 acres].

Consequently, we will document this change by closely monitoring the water supply in the distributary and the selected watercourses. These figures will be matched to the requirement at different levels of the system to determine the real impact of the modification.

Several parameters can be determined in order to clarify the water distribution issue:

a) Delivery Performance Ratio (DPR). the relationship, in percentage, between actual and design flows. Daily observations at heads of stage I distributaries, tail of dist. # 3 (where flow is divided between Paharpur Canal and Ketcha Minor) and selected outlets. This parameter will provide information on IPHED's management at system level.

b) Water Losses. These will be measured at the distributary and water courses level. The magnitude of the main canal precludes measurements at that level since this would require specialized equipment not available to us. However, because the canal is fairly new and lined, its cross section can not have changed much so design losses can provide a good estimate.

The losses will be measured in blind reaches of the distributary at least three times per season and if possible at different flow stages. Losses at watercourses will be done with the same intensity and at different locations (both lined and unlined reaches). These measurements will provide information on the importance of this factor in the overall system management.

c) Relative Water Supply (RWS). At distributary and watercourse level. For an initial estimate, the parameter will be defined as follows:

$$RWS = \frac{\text{Supply (Irrigation + Rain)}}{\text{Demand (PET)}}$$

For the supply side actual field measurements will be utilized. As to the rationale for using PET only, as the demand, it can be argued that most crops produce maximum yields when the water available to them is at that level. In the case of rice, which during the first season of the study (Rabi 91/92) is not grown, considerations have to be made for percolation losses under flooded conditions.

A maximum value for demand will be obtained for PET values and a minimum demand values will be obtained based on cropping pattern information provided by the "Patwari" [Revenue Officiall. It is believe he underestimates the reporting on the more water demanding crops given the differential water rates which drive farmers to provide incentives for the under-reporting. An intermediate demand value will be obtained from our own cropping pattern inventory. The RWS will be done, at least, monthly at both Distributary and Watercourse level.

d) Areas and Cropping Pattern: In connection with c) above, we will monitor the cropping pattern at distributary and watercourse levels. However, unlike Punjab, where the land has been divided in a square grid fashion, the NWFP presents a very irregular scheme which makes assessing the cropping pattern a rather difficult undertaking.

To tackle this particular problem three different approaches will be taken into consideration : i) the cropping pattern reported by the revenue agency, ii) the cropping pattern derived from an intensive field assessment, and iii) the cropping pattern derived from a "transect" approach, where depending on shape and area of the watercourse, a number of "runs" in the field will be made to determine the crop configuration along those transects. Comparison of the three methods will help decide on the best option for future assessment of the cropping pattern in an area.

4.2.2 Irrigation System Operations

Simulation of main canal management. In Pakistan's traditional systems the design criteria for a main channel requites that it runs near the design discharge all the time in order to keep the canal in regime. *A* value of 75 percent of full supply discharge (FSD) is usually found in the Pakistan irrigation-related literature as the lower limit by which design operation conditions would still hold.

Since moving towards an increased management'level, to better match the needs of the agricultural system (that is, not only the crop requirements per se, but also cultural practices such as land preparation or harvesting etc) may require, at least as an option, that the traditional management of the main canal be modified, it is seen as pertinent that the effects of such potential changes be assessed.

If for example, the CRBC is to be managed strictly as per crop water requirements, (although it should be clear that IIMI is not advocating at this point that such be the case), then the flow in the main canal would be between 75 and 100 percent of the FSD on 38 percent of the time.[13]

The implications of running the canal at FSD all the time is, of course, having to escape surplus water. If the escaped water can be utilized further downstream this operational mode can be justified. This seems to be the case at CRBC now when only stage I is operational. However, as the project progresses, and more area is brought under the command of the system, the FSD operation mode becomes less and less a viable alternative. For example, total project annual water allocation is 0.296 Mha-m (2.4 MAF) while the FSD operation would require 0.432 Mha-m (3.5 MAF).

The best way to assess the impact that flow fluctuations in the main canal can have on system performance is through a simulation model. IIMI has had previous experience with just that type of tool. Steady state as well as non-steady state conditions can be simulated. The program performs the hydraulic flow computations by means of the continuity equation, and a modification of Saint Venant's partial differential equation.[14]

During the first months of the study, we will analyze the effects of flow variations in the main canal on the flows of the distributary canals of stage I (#s 1, 2, 3, and 4). Starting at 100 % FSD and through decreases of 10 %, we will try to answer, among others, the following two issues:

a) at what percentage of FSD does flow in each distributary go dry?

b) behavior of distributary # 3 vis-a-vis main canal operation.

<u>"Warabandi" vis-a-vis crop-based irriaation.</u> The theoretical concept of warabandi system in Pakistan is characterized, among other things by:

a) a shortage of the water supply,

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13. Firdousi G.R. (1991) Report on the visit to LSC and CRBC Projects 9-14 January. Page 11.

14. A complete description of this model is in Bhutta, M. N., (1990). Effect of varying discharges on the equity of water distribution in the irrigation system; Ph. D. Thesis (unpublished). University of Engineering and Technology. Lahore. Pakistan.

b) main canal operating at full supply level,

c) distributary operation at no less than 75 percent of fsl; when this is not possible distributaries are rotated,

d) no "illegal " outlets ,

e) outlets are ungated and deliver a flow rate proportional to the area commanded; they remain open all the time,

f) each farmer receives the total allocated flow of the watercourse; the time is proportional to his area,

g) the designed hydraulic characteristics of the channels need to be maintained to ensure the intended .performance of the system,

h) "equity" of water distribution is the perceived distinct value of the warabandi system.

Field observations, made during the study development process, indicate very clearly that these idealized conditions no longer hold true in either CRBC, or LSC. In fact it appears that there is already a de-facto move towards an incipient crop-based irrigation scheme.

Our initial activities will be geared towards the documentation of how conditions a) to h) above are being, or rather not being, met at each project'site. As explained earlier, the main focus of this component of the study will take place at CRBC (both distributary # 3 and Girsal Minor). At LSC the documentation will take place only within the context of understanding why the process of moving towards a 'crop-based irrigation operation encountered such a strong resistance on the part of the farmers which eventually led to the suspension of the establishment of a formalized demand-type of irrigation.

<u>Water manaaement at distributary level.</u> To document both IPHED and farmers activities, special observations will be made throughout the season. Under the ideal warabandi conditions discussed earlier in the report, farmers interventions at this level in the system should be non-existent; this is not however the case as we have observed during previous field trips. The type and reasons for these "unauthorized", if you will, interventions will be recorded to help us better understand the interrelationships between farmers and irrigation agency personnel.

<u>Water manaaement in Girsal Minor.</u> Because of the integration of the Paharpur Canal Irrigation System into the CRBC system, Girsal Minor is essentially a continuation of distributary # 3 of the latter. We will monitor the flows at selected points of the Minor which will essentially reflect the management of the tail-end of the distributary. The intensity of the monitoring, however, will be less since the main objective under this portion of the study is to gain a broad knowledge on how farmers have reacted to the

new water allowances. How the water is being distributed will be done at a macro level rather than through an intensive intervention.

4.2.3 Irrisation Facilities

As it was explained earlier above, this is the one main category of our study where we can not, at this point in time, be able to advance a work plan. Before that can be accomplished, it will be necessary that we gain a better understanding on the present operation of the system.

Once physical bottlenecks which may be currently ,affecting water distribution, are identified, they can be first attended to with suitable' management interventions. It is then that we will be in a position to decide whether it is appropriate for IIMI to evaluate canals and different types of structures, review designs, and eventually go for construction of structures' prototypes which may lead to improved facilities better tailored to the concept of crop-based irrigation operations in these systems.

4.2.4 Irrisation Institutions

In an essentially action-oriented research effort, a new dimension of study responsibility will be *to* identify the institutional context and develop adequate collaborative relationships with both the operating agencies and the farmers. This is essential for ensuring sufficient institutional capacity to undertake the field-testing of identified research recommendations and their subsequent replication on a wider scale.

In terms of supply and demand conditions and system operations, the research activities may concentrate on such aspects as, measures of reliability of water supply at the Distributary level and in command areas, duration of canal water turns according to the warabandi system, and equity in distribution at varying levels of water supply.

As has been already observed in our preliminary investigations, these areas are particularly vulnerable to increasing drainage problems and a lack of established procedures and practices for optimizing the use of increased capacity of the water delivery system. There is some evidence that the increased system capacity to deliver peak water requirements of an assumed cropping pattern is already being used by the farmers to increase the area under high value cash crops that need more water, and this may very soon pose another problem. The main objective of the CBIOP is to investigate more intimately into these problems as they appear in the study areas, and find management solutions to them for the purpose of improving the overall productivity of water resources in the two systems.

The interesting question would be: what are the actual causes of these symptomatic indicators? To what extent are they attributable to the defects in the design, construction and maintenance of the physical system, and to what extent are they caused by the institutional deficiencies ?

For instance, in regard to the low reliability of the canal water supply, if the findings are that the majority of the farms receive less than 50% of their theoretical share of canal water, the identification of significant causes for this problem and their order of contributing effect would greatly help in developing the possible management solutions to the problem. It is necessary to'know whether the physical features (such as the location of moghas. low supply levels at the source, seepage or leakage due to bad maintenance, and changes in the design characteristics in the canal) have contributed more to this problem, or whether the institutional deficiencies (such as lack of supervision, wrong procedure, inadequate manpower and other resources, stealing of water or any other form of irrigation misconduct by the farmers) should take the greater responsibility for it. What could be judged as the share of contribution by each of the identified causes ?

Study activities aimed at the institutional component will concentrate on studying three inter-related aspects of irrigation institutions as they correlate to the study areas:

i) Organizations - Irrigation Department, Agriculture Department, WAPDA, and other support service agencies, and farmer organizations. This will include their respective work programs, division of responsibility, delegation of authority, supervision and accountability, distribution of staff and their performance assessment methods, and also the intra and inter-agency, and agency-farmer coordination mechanisms. Information exchange and feedback mechanisms also will form an element in this aspect.

ii) Formal Rules - Acts, promulgations, subsidiary laws, manuals of procedure, official instructions, constitutions of associations, agreements and tribunal decisions.

iii) Informal Rules - Traditional practices such as kachcha warabandi, norms, conventions, and other forms of accepted informal behavior.

The Rapid Appraisal in the LSC area (see Annex 4) and the base-line socio-economic survey to be conducted through contract research in the CRBC (see Annex 3) will provide preliminary observations on some of these aspects. These observations will be used as the basis for questionnaires, interviews and process documentation to conduct further in-depth studies.

The emphasis will be to find possible correlations between the technical factors and the institutional factors, and to assess what combinations of these two aspects affect performance. The intended research emphasis is indicated in the following illustration.

In the two systems LSC and CRBC, new design changes have resulted in physical systems that are partly different from the modal type of canal systems elsewhere in Pakistan. While increased system capacity is a new feature common to both systems, the LSC has an additional new feature of regulation with adjustable gates at the watercourse heads. Basically both these physical features envisaged in their design a new organizational arrangement for water delivery, at least to regulate the flow when water at the peak requirement level is not needed in the field. Clearly, this change in the organization has not occurred, and not even been planned. This is illustrative of the gap between technical and institutional considerations. Reasons for this gap will be investigated to form the basis for possible solutions.

While these investigations are being carried out, an effort will be made to develop close collaborative relationships with operating agencies and with farmers. The intended methodology is to form several Working Groups to 'meet and deliberate regularly on the identified issues and to select components of research findings that would make viable implementation options. IIMI staff will play a prominent role in facilitating and coordinating group discussions, and providing for this.purpose the necessary technical inputs. In the selection of the most appropriate option, the relevant policy level personnel will be involved. The Study Advisory Committee and the Project Coordination Committee will be particularly useful at this stage.

The Working Group processes will be closely documented and used in successive meetings. This information will also be useful in writing research reports specifled in the Project Document.

As for measures to obtain farmer participation, the final product should best be from an evolutionary process. An attempt will be made in collaboration with the IPHED and the AD personnel to encourage the farmers themselves to identify the need for organization. Along with this process, necessary assistance will be given to establish the mechanisms to meet that need. It is understood that at this stage the project does not seem to require formal farmer organizations, but may require initially some mechanism for farmers and agency personnel to decide on collective seasonal plans for their respective involvements and to deliberate on some of their operational issues. The main thrust of the action research in this area will be therefore to promote, at least initially, some informal farmer organization, and similar inter-agency and agency- farmer coordination in the study areas.

The TA arrangement for the study also includes a <u>studv tour</u> for a selected number of operating personnel involved in the action research program. This is to provide them an opportunity to see similar management approaches, at least in one other location, such as Indonesia or Philippines where the institutional implications of irrigation are believed to have been more intensively analyzed and realized than in Pakistan. During the third year of work in the study, a <u>workshop</u> will be conducted involving senior members of the operating agencies and associated research and training institutes to discuss and concretize the research findings; particularly in relation to the institutional and management imperatives of implementing the identified management innovations.

4.2.5 Economics of Crop-Based Irriaation Ooerations

Evaluation of benefits of crop-based irriaation operations. To identify the benefits and costs derived from the increased management associated with seeking a better fit between the water supply and the agricultural system needs, it is necessary to establish a benchmark that would allow future comparisons.

Two situations are useful in this regard : i) the situation prior to the introduction of the higher water duties, and ii) the current situation, with higher water duties, but with no change in management intensity.

For the first one, the Paharpur Canal Irrigation System provides an ideal setting. Through the use of historical records we will try to evaluate the changes in the "before" and "after" situation.

For the second one, we have two options: again the Paharpur Canal or by comparing two areas within the new CRBC. This would be a "with" and "without" situation. We will start with the study at the Paharpur Canal by documenting what is currently taken place; and will conduct a benchmark survey at Distributary # 4 of CRBC that can be used later on to compare with the results of introducing management innovations in Distributary # 3.

To evaluate the benefits, it will be necessary to establish some performance indicators that can be used to define the potential areas of benefit. We intend to use the following three indicators for this purpose:

a) biological efficiency: will be determined by assessing the yield per unit of water. This will be specially valuable in evaluating the impact of operational changes on the efficiency in using the resource.

b) technical efficiency: the relationship between OUTPUT (water used by the crops) and INPUT (water supply, including rainfall). This parameter will give a good measure of the substitution of water for management. The physical efficiency can also be assessed by the relationship between the number of hectare-days (theoretical) and hectare-days (actual) that can be covered with the actual water supplies. This would provide at least a rough idea of where on the production function the farmers are operating.

c) economic return: rupeeslfarm; rupees/unit water; rupeeslunit land. The first would give information useful for understanding farmer response to changes, as well as a direct measure of the economic benefit. The second would provide the information on the economic efficiency in using the resource. The last probably is the least useful since it confounds within it the decisions of the farmers on how to spread the water supply over their area. It may be useful, however, in comparing farmer water spreading strategy in different parts of the system.

4.2.6 **Policv Guidelines**

The study covers investigations, deliberations, and analysis at three different levels:

i) Watercourse and farm level where demand conditions involving farming and on-farm irrigation practices, farmer-bureaucracy interface, farmer interaction processes, and farmers' socio-economic environment will be studied,

ii) Main and distributary system level where the emphasis will be on the supply side, and

iii) Policy level particularly in relation to the planned activities involving the Study Advisory Committee comprising representatives from IPHED, AD, WAPDA and the Planning and development Department of the Province.

Since the study is to consider new management approaches and related problems, many issues are expected to arise that will require resolution at the policy level. The issues will be deliberated, negotiated, and alternative solutions will be identified and tested. The process of these actions will be documented, and the implications for policy changes be evaluated.

One of the outputs of the study relating to the replicability of pilot-scale management solutions to be identified will be a set of policy guidelines covering these aspects.

V. PROJECT IMPLEMENTATION

5.1 Inception Mission

Inception activities of the study started with the ADB's Inception Mission to Islamabad on 16 March 1991. At the discussions chaired by the Additional Secretary to the Ministry of Water and Power, the Terms of Reference (TOR) for the study covering the commitments by GOP, GONWFP, and IIMI were reviewed. It was generally agreed that with some changes in the TOR, arrangements for starting the study could be made to capture the 1991 Kharif season from its beginning. (However, the delays in the TA Agreement did not allow this to happen).

IIMI had already taken the initial steps to recruit the necessary international and local staff, and identify several alternative study sites. On this basis, and anticipating early finalization of the TA Agreement, IIMI proceeded to recruit and mobilize some of the staff with effect from March 1991. As an initial activity, the literature survey was also started.

5.2 Site Selection

The TA agreement called for the selection of one working site at each of the modernized (higher water duty allocations) irrigation systems, i.e. Lower Swat Canal (LSC) and Chashma Right Bank Canal (CRBC). Below, a brief description on each project and the options for site selection follows.

5.2.1 *The LSC*

The LSC was originally completed in 1885 and remodelled in 1935 for an authorized full supply .discharge of 23.49 cumecs with a CCA of 50,040 ha. As part of the SCARP Mardan development work, a project to provide subsurface drainage and improvement of surface drainage, the LSC system is now being remodelled for a diversion capacity of 54.90 cumecs for the same area.

The system consists of a contour feeder channel 35.40 .km long, from which ten distributaries totalling 112.63 km in length offtake. It derives its supplies from the Swat River, which carries flows in excess of the projected irrigation requirements during the greater part of the year. Thus for a crop-based operation the supply is not likely to be a constraint.

From the early stages of project proposal the LSC was visited by IIMI personnel to identify a suitable project site for this component of the study.

Based on size of the CCA, accessibility to site, canal length and number of outlets, canal geographical position within system and general farmer's attitude towards the potential project, one distributary and two minors were identified as follows:

Canal	RD	Length (km)	CCA (ha)	# outlets
Distrib. # 3	64647-R	4.573	732	10
S. Yusuf Minor	24904-L	5.784	853	11
Guide Minor	30549-R	7.350	1126	12

While all three sites offered similar advantages for selection, Sheikh Yusuf Minor was finally selected an account of its tail-end position and proximity to the IPHED facilities. The drawback, of course, was not having the remodelling completed in terms of the installation of the gates at the time the selection was made. However, there was a strong commitment on the part of WAPDA indicating that it would be ready on time for project initiation.

For many practical and technical reasons, as already mentioned above, Sheikh Yusuf Minor was considered, by all parties concerned, to be the most suitable place in which to carry out the study. However, due to many reasons, among them being the logistical problems of the work contractor, the installation of gated outlets in the Minor did not take place as anticipated. By the time the Technical Assistance Agreement had been signed and thus IIMI was in a position to start its work,, the gates already installed in distributaries numbers 2, 3, and 4 of LSC had caused strong resistance on the part of the farmers leading to the damage of most, if not all, pf these devices.

As a result of these difficulties, the Irrigation Department asked WAPDA to discontinue the use of the gates and not to install any new ones. An exception was made with respect to Sheikh Yusuf Minor, where gates would be permitted for the pilot effort IIMI was expected to conduct[15]. However, since IIMI's basic mode of operating is to work in representative functioning systems, and since a decision has now been made to operate the LSC without outlet bates, IIMI requested that gates <u>not</u> be installed on Sheik Yusuf Minor. This was reinforced by the indications that neither WAPDA nor Irrigation Department could guarantee the security and the integrity of the gates.

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15. SCARP Mardan Project (Cr 877-Pak) Review Mission Aide Memoirs. August 1., 1991. Paragraph 8.

For a further evaluation of the new conditions in the LSC, IMII contracted for a Rapid Appraisal Survey to determine the likelihood for success of any isolated pilot study in the Sheik Yusuf Minor[16]. While the survey was still under way, preliminary observations suggested that working in **S.Y** Minor under those circumstances could not be productive.

The Rapid Appraisal conducted by a team from **EDC (Pvt.)** Limited (consisting of a Social Anthropologist, an Agronomist and an Irrigation Engineer) was completed in October 1991, and its report dealt with in detail the perceptions of the farmers and operating staff on the new system installed and its repercussions. The report also made the following specific recommendation:

> ***The system of gates at the head of watercourses requires strong and positive involvement from the Irrigation Department, without which any intervention would be problematic. This level of involvement could not be perceived; rather, there seemed an attitude of skepticism towards the, "crop-based" approach. While an IIMI- supported experimental operation of the Sheik Yusuf Minor would pay dividends in terms of curiosity-oriented research, clear short- and medium-term benefits are not foreseeable.***

These evaluations encouraged the shift from a pilot'trial effort in the LSC as originally proposed, to an intensive study of the circumstances leading up to the installation of the gates and the subsequent decision to remove them, and of the results of the increased water duties and related management issues.

The lessons to be learned from the LSC experience will be helpful to frame future activities to be undertaken at CRBC. Likewise, what we learn from CRBC can be used to improve our understanding on how to proceed at LSC.

5.2.2 <u>**The CRBC**</u>

The **CRBC** is a major perennial surface irrigation project designed to irrigate 230,675 ha with a 271.92 km long gravity flow main canal carrying a discharge capacity of 138.07 cumecs. The canal feeds a network of subsidiary canals with an aggregate length of 603.37 km. It derives its supplies from the combined river flows of the Indus and Kabul Rivers as regulated by the Tarbela Dam and again by the Chashma Barrage on the Indus.

The project, currently under implementation, has been designed in three stages, for construction purposes. Stage I serving 56,680 ha, a quarter of the total culturable command area (CCA), has been completed. This stage comprises 42,105 ha within the old Paharpur Canal System with the remainder constituting the so called New Area.

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16. A Note on the Rapid Appraisal giving some guidelines for the survey is at Annex 4.

Stage II is under execution and although the work is in full progress it is very much behind schedule. Only three of 13 distributaries, namely #s 5, 5a and 6 have been completed and made operative. The respective command areas, however, are in the initial stages of development. Recent inspection of these areas have led us to conclude that there is little scope for conducting any project-related activities there within the next couple of years.

Stage III, on the other hand, is in ttie advance planning stage and is not schedule to be in operation until the latter years of this century.

With the above information in mind, it is clear that the alternatives for selecting a study site in the CRBC system lay in Stage I. Three options 'could be considered : within the new area, within the old Paharpur canal system, or a combination of the above given the events just described for LSC.

Both the new and old areas have their pros and cons with respect to their suitability for selection towards project implementation.

For example, the former is much more physiographically representative of the future areas to be developed in stages II and III. In addition, the soils are generally heavier, clay to silty clay, than those encountered in the Indus alluvial plain, sand to silt loam, typical of the latter area.

The Paharpur canal system being a relatively old scheme has farmers who are experienced with irrigation practices. The new area, on the other hand, is obviously a new settlement where a large percentage of the occupants have had little or no previous experience with irrigated agriculture.

During project proposal preparation IIMI explored possibilities within the Paharpur Canal System and tentatively selected two minors : Shahkot and Girsar. Both are located almost in the center of the PCS's command area and are quite representative of irrigation development in D.I.Khan district.

Shahkot Minor previously took off from RD 131 of Paharpur Canal, but now it has been made part of distributary # 2 of CRBC taking off at RD 224 + 066. Its head discharge is 10.47 curnecs, it is 8,323 m long, and commands an area of 1,749 ha. It comprises 20 outlets.

Girsar Minor, previously took off from RD 152 of Paharpur Canal, but now it has been made part of distributary # 3 of CRBC off-taking at RD 237 + 320. Its head discharge is 10.84 cumecs, it is 12,395 m long, and commands an area of 1,808 ha.

Four distributaries in Stage I were considered. However, it became clear that distributaries # 1 and *2*, because of their small command areas, would not be good choices. That left #s 3 and **4** for consideration.

Basic information on these two distributaries is summarized below: ,

ITEM (units)	Disty # 3	Disty # 4
CCA (ha)	5,363.96	10,002.43
Length (m)	5,058.23	10,832.22
Design Discharge (cumecs)	32.10	58.01
Canal bed width (m)	7.22	9.15
Full supply discharge (m)	0.92	1.03
# of Outlets (pipes)	20	36
# of farmers (approx.)	600	1260

Distributary No.3 was chosen over No.4 for the following reasons:

a) smaller size will allow the team to conduct more intensive monitoring activities;

b) better spatial distribution of outlets within the distributary, an advantage for research layout purposes;

c) wider range of farm sizes;

d) greater interest on the part of farmers for project participation; and

e) the particular location of the distributary vis-a-vis the Paharpur canal system.

With items b), c) and d) above in mind, plus a careful field inspection to assess structural conditions of pipe outlets and other structures, 8 watercourses were chosen for the study, selecting two watercourses each per canal quartile. These are identified by the reduced (running) distances as follows :

570-L	690-R	6468-R	6486-L
10150-R	11920-L	4810-R	15382-R

After careful evaluation of the choices, operations were started by selecting one site within the new area. The idea of working with farmers that are newly established in the area had a strong appeal because of the potential for developing a strong working relationship by facing and learning of problems together. Mature farmers would be less inclined to accept changes in practices long engrained. This, coupled with the soils and area representation issues, decided in favor of starting the work in distributary # 3 of CRBC, and to have it as the starting point for our forthcoming action research activities.

A further decision was taken to consider fielding a second team at Girsar Minor. It was understood, however, that this should follow after reasonable progress in the installation of the first team. The recruitment process for this team has already begun. In addition, steps have been taken to start gathering the basic information for this study site.

The rationale behind this second choice was that Girsar Minor is in fact the "real" tail of distributary # 3, and the activities conducted here, albeit at a less intensive level than those to be conducted at the head, will provide valuable information on the overall behavior of the integrated (new'and old area) distributary.

5.3 Mobilization

5.3.1 Personnel Recruitment

A four-person team comprised of one field research professional (FRP) and three field assistants (FA) is to be fielded at each working site. They will each be supported by a driver and a laborer.

One of IIMI's most experienced FRP's was transferred from his Punjab post to supervise the CRBC field team. He is from the NWFP and speaks the local language. An experienced senior FA and one FA were also transferred to conform the teams.

IIMI set out to fill the remaining positions at a very early stage. Terms of reference for each position already exist as per the institute's hiring policies. Advertisements were placed in the newspaper and more than 180 applications were processed. More than 40 interviews, were held throughout the months of May to September.

Surprisingly, the recruitment process turned out to be quite difficult. The professional quality of the potential candidates was disappointing; this coupled with the reluctance to work in an area considered "harsh" by the interviewees made it a lengthy affair. Three more FAs have finally been recruited, two of them are from the D.I.Khan area and the remaining one comes from the Punjab.

The new members of the team were sent for intensive training to other IIMI field stations. For a period of three weeks they joined the staff in conducting regular field activities, i. e. water measurements at different system levels, monitoring of farmers activities, survey of cropping patterns, waterlogging and salinity related activities , interaction with farmers etc, etc.

A driver and a laborer have also been hired, the former on a project basis and the latter on a daily wage basis.

5.3.2 Staff Housing/Office

A suitable staff house has been rented at the outskirts of D.I.Khan city: The possibility of having two field teams at this location was kept in mind in the selection of the house. In addition, it will be used for office space as well.

The house and office have been furnished, and have been occupied as of 15 September 1991.

This facility will be complemented with one room at the Girsal Irrigation Guesthouse to be provided by the Irrigation Department. Although we explored the possibility of using this house as our staff house the idea had to be discarded because of the inaccessibility of the premises to a nearby market (the nearest facility of this type is 25 km away which *is* highly inconvenient as a permanent living facility for our staff).The Guesthouse, however, being quite close to the project site will be utilized on a daily basis as both a rest point and for temporary storage of field equipment.

5.3.3 Establishment of the Studv Advisorv Committee (SAC)

As called for under the TA agreement, IIMI contacted, in early August, Mr Khalid Aziz, Addl Chief Secretary (Planning and Development) for NWFP requesting him to initiate activities towards the creation of the SAC. Several contacts have been made since with his staff in the Planning and Development Department, who have called upon the concerned organizations to nominate their representative to the SAC. While the committee has yet to be established, the parties involved have shown their interest in this matter and nominations are being pursued.

As of the date of this reporting period (October 25/91), the composition of the Study Advisory Committee is as follows:

i) Mr Hashmatullah Awan, Director Water Sector Investment Planning Cell; representing the Planning and Development Department of the NWFP government.

ii) Mr Nawab Khan Mahsud, Chief Engineer Irrigation Department; representing the Irrigation Department of the NWFP government.

iii) Mr Muhammad Zaman Khan, Chief Engineer Mardan SCARP Project; representing the Water and Power Development Authority- North.

iv) Dr Carlos Garces, Irrigation Engineer; representing the International Irrigation Management Institute.

Terms of Reference for the Study Advisory Committee have been drawn up and will be discussed for approval during the first SAC meeting. These are as follows:

i. The Study Advisory Committee will be conformed as follows:

a. (TITLE) ....P&DD, NWFP, Chairman
b. (TITLE) ....IPHED, NWFP, Member!
c. (TITLE) ....WAPDA, NWFP, Member
d. (TITLE) ....AD, NWFP, Member
e. Project Leader, IIMI, Secretary and Member
f. Program Officer, ADB, Member

ii. The SAC will be responsible for the overall orientation of project implementation. It will coordinate,, at macro-level, activities among the various agencies and/or institutions involved, to assure prompt and effective accomplishment of goals and objectives.

iii. The SAC will review periodically, at least twice a year, results and achievements of project efforts; and will provide support and guidance to the executing institutions in order to overcome problems and constraints.

iv. The committee shall meet on a semi-annual basis, or more frequently as required. Any member of the committee may call for a meeting, through written request to the Secretary who will take necessary action in consultation with the Chairman.

v. [Others, if applicable]

5.3.4 **Initial Field** Activities

With the recruitment of field personnel and the establishment of the staff house, the project initiated field activities from mid-September.

The process of gathering basic information pertaining to the site was begun somewhat earlier; line agencies involved were contacted and provided with lists of the material needed falling under their purview. Given below are some of the information requested and obtained:

From Water and Power Development Authority (WAPDA);

- plans and profiles of main canal
- plans and profiles of distributaries # 3 and 4
- L-sections of main canal
- L-sections of distributaries # 3 and 4
- plan, section and details of structures of the above
- flow records for main canal and distributaries (1 to 4)

- samples of Engineering "Chack Bandi" maps
- schematic and general maps of the system

From Provincial Irrigation Department (IPHED);

- revenue "Chack Bandi" maps of the site
- cropping pattern of last 3 years
- outlet registers for distributaries # 3 and 4
- farmers list of study area
- limited flow records
- sample forms and other support information of area

Other agencies contacted were the Directorate of On Farm Water Management (OFWM), Department of Agriculture Extension (DAE), the Directorate of Agricultural Research and the Local Meteorological Station which is part of the worldwide Pilot Balloon Observation Network. Contact with these institutions will strengthen project ties and will help delineate forthcoming activities.

A special effort went into the installation of water measuring devices: stage recorders at the head and tail-end of distributary # 3 were placed at strategic locations. Staff gauges at selected pipe outlets were installed; gauges were placed to monitor flows at points such as drops and siphons, and at particular canal reaches to be utilized for measurements of distributary losses. **At** watercourse level, places for locating portable flumes to be used for measurements of water losses were identified.

Calibration of pipe outlets and development of rating curves has started. In a similar manner, special observations related to unusual happenings at all levels of the system are now being recorded. Among other things, these observations will provide valuable insight into maintenance-related issues.

Contact with farmers was initiated from the very beginning stages of project implementation; listing for each of the watercourses selected are now available and proving useful towards the identification of those willing to participate in project's activities.

5.3.5 Socio-Economic **Survey**

In line with the TA agreement, a socio-economic survey is to be conducted at the outset *of* the project. The activity was to be contracted with either a governmental or private firm on a competitive basis.

IIMI established contacts with both the Institute of Development Studies attached to Peshawar University, and with Enterprise and Development Consulting, a private firm working out of Islamabad.

The IIMI team prepared guidelines with terms and conditions for the exercise (see Annex 3). Each firm was visited to discuss their proposals; we then asked the organizations to submit their bid accordingly. After careful evaluation of final proposals the team decided to award the contract to EDC (Pvt) Limited.

The EDC proposal was found to be more realistic to project needs and presented a stronger roster of personnel to be involved with the survey. EDC also had a significant budget advantage over IDS. The survey was schedule to start in the first week of October. This survey had to be delayed as a result of the developments occurring in the LSC system which prompted IIMI to initiate a complementary, but previous, activity described below.

5.3.6 Rapid Appraisal

Because of the LSC's construction delays and the IPHED's decision to shift from the proposed gated outlets to the traditional adjustable proportional modules (APMs), the IIMI team, in consultation with other IIMI-Pakistan colleagues, considered it prudent to seek additional and prior information regarding the perceptions of both farmers and operating staff towards the pilot project in the LSC under those new circumstances, before pursuing any further activities in this irrigation system.

The following concerns prompted the team to seek a rapid appraisal of the field situation:

the novel feature of regulatory gates at the moghas will be seen only in this rather academic pilot-study area.

only the farmers in this particular minor will be subjected to some kind of intervention and regulation.

for these interventions, the operating agency is likely to be a passive observer, shifting an unexpected field responsibility to an external group i.e. IIMI.

replicability of any research results would seem to have only a remote chance.

The Rapid Appraisal exercise was also contracted with EDC because of the obvious advantages from a logistical point of view. IIMI, however, worked closely with the contractor to plan and monitor the' effort. The time allocated for the entire effort from initiation to submission and discussion of final report was four weeks ending 24 October 1991. The report was received on 22 October. Its main csnclusions are referred to in Section 5.2.1 (Also, see Annex 4 for the guidelines given to the Rapid Appraisal survey team).

5.4 Procurement

Because IIMI considered procurement of field and support equipment a crucial activity in the implementation of the project, we started this process well in advance of the signing of the agreement.

A small internal procurement cell composed of IIMI-Pakistan Director, General Manager (Admin and Finance) and Project Team Leader was established for this purpose. In addition, contacts were made with Mr T.C. Patterson, Manager ADB to explore ways by which the procurement process could be expedited. This proved quite helpful and indeed resulted in substantial time savings.

Based on the TA agreement's equipment list, a call for bids was sent out to 15 international and 10 local firms. Nine of the former and all the local ones responded. Although not all the companies bidded on the entire list requested, all the items received 3 or more different quotations. Countries represented were U.S.A., The Netherlands, Japan, U.K., Singapore, Hong Kong and, of course, Pakistan.

Final selection of the companies benefited was based on the following, in priority order, criteria:

- suitability of the equipment to our needs
- potential for service/maintenance in country
- price
- timeframe for delivery of goods

The present status of the equipment, by main categories follows :

- vehicles and motorcycles. Three motorcycles already at field, vehicles ordered (two double cab pick ups).
- computer equipment. All have been received.
- field equipment. All has been ordered. Surveying equipment items purchased in country already in place.
- other support equipment. All orders effected and in place.

With the exception of the vehicles which are scheduled to be delivered in late December or early January 92 we expect to have all equipment by late October 91. At the end of this reporting period, approximately, 71.5 percent of the available budget for equipment has been committed or already expended.

5.5 Constraints

Although the project is in the very early stages of implementation, some constraints that can have a profound impact in its development have already been encountered.

Undoubtedly, the decision taken by the Irrigation Department to move away from the concept of crop-based irrigation to return to the traditional proportional water distribution approach, can have a long lasting effect on the implementation of our study. This decision affects both the CRBC and the LSC systems, although in somewhat different ways.

5.5.1 Situation in the LSC

In LSC, the irrigation agency is already implementing the change by removing or locking in fixed position the gates which were in place in several of the distributaries, and that constituted the main infrastructural innovation by which crop-based irrigation was going to be pursued. However, as a result of implied commitments to the project of providing one distributary or minor with such devices, a parallel decision was taken to go ahead and install gates in a minor previously identified by the project as a potential action research site.

While the latter decision was clearly well intentioned, and a reflection of the IPHED's willingness to contribute to the project's effort, in fact, it has been an unfortunate one since it represents the wurst of both worlds. The decision was to establish a pilot-project to pursue an idea which has already been rejected by the IPHED as a failure. High resistance towards implementation activities under this,scenario from the operating staff is a foregone conclusion. Furthermore, the pilot-area as such is no longer representative of a "live" system situation, a necessary -but not sufficient- condition if some reasonable chance for success of the proposed interventions is expected.

It is this unique situation which prompted us to consider conducting a rapid appraisal in the LSC area in order to assess the impact that such decision might have on the likelihood for success of a pilot project. The results of this survey which has just been finalized confirm the position indicated in the foregoing. As explained earlier,in this report, IIMI has asked WAPDA that the installation of gates in *S.Y.* Minor need not be pursued.

5.5.2 Effects on the CRBC

This situation is likely to affect the study activities in the CRBC as well. IPHED's decision regarding the gates in the LSC may have some implications on attempts to find out new management options in the CRBC as the same agencies are involved in design, construction and operation activities in both project areas.

In the CRBC system the decision implies going from the present pipe outlets to APMs; the initial idea of installing some type of control structure has therefore been set aside. Unlike in the LSC, the decision itself has limited repercussions on direct project's implementation activities. But, for the not so distant future, the decision taken diminishes the chances for any kind of follow-up activities related to the installation of control structures that might be derived from project's results. It is unlikely that the GOP would be prepared to make yet one more investment in the system within such a relatively short period of time.

In a sense, one would argue that going back to APMs at this particular point in time has been premature, specially when this initiating project has been design precisely to assess the feasibility of moving towards a crop-based irrigation operations in the context of Pakistan's present irrigation development.

5.5.3 Special Needs of Inter-Agency Coordination

The pattern of departmentalism and isolation that characterize many government organizations in the irrigated agriculture sector will have to undergo some modification to fully implement and profit from a crop-based irrigation delivery system. The current separation of view points, and unfortunate friction between WAPDA and the IPHED must be overcome for the necessary coordination of activities to take place. Similarly, there must be much more interaction between the Agriculture Department, the IPHED and WAPDA. There must be closer linkage among the government agencies before there can be effective interaction between the agencies and the ,farmers for the purpose of more closely matching of water needs and supplies. IIMI will strive to foster these relationships, but the primary responsibility for sustained good relations must rest with the agencies themselves.

IIMI wishes to record its appreciation that all agencies have been extremely helpful in providing available background material when the requests were made. IIMI looks forward to conducting field work in collaboration with the representatives of these agencies during the coming months. Similarly, participation at the Study Advisory Committee and the project Coordination Committee, and many useful discussions on study objectives and its progress are enthusiastically anticipated.

5.6 Literature Review

A literature survey was conducted to understand and document the theoretical aspects of demand based irrigation, the design features of the two projects, and the general socio-economic background of the two project areas, CRBC and LSC. The results of this effort, supplemented by primary data to be collected through the base-line socio-economic surveys, will be presented later in the form of a project report. Only some salient theoretical aspects arising from the literature survey are extracted below. These would clarify the concepts behind the various irrigation scheduling practices, and help to see in their perspective the limited potential in applying typical demand-based irrigation in the study areas.

The higher water allowance in the two systems implies that a primary consideration should be to avoid over-irrigation or waste of water. Merriam and Burt (1988) point out that social and economic losses associated with over-irrigation can be substantially reduced by improving the water supply schedule and the supply and application systems. The argument here is that the excessive costs involved in the disposal of drainage water can be avoided by reducing the quantity of irrigation water through source control. This requires a system that can supply .water in a flexible manner, and irrigators or farmers who are knowledgeable to control the water at the point of application as to the frequency, rate, and duration of flow.

The way water is delivered in terms of frequency, rate and duration is expressed by the water supply delivery schedules. The American Society of Civil Engineers have described the delivery schedules generally in three main categories: Rotation, Arranoed, and Demand (ASCE, 1984, 1987). These variations in irrigation schedules depend on 1) the degree of flexibility given to the water user in terms of the flow rates, frequency and duration, and 2) the level within the delivery system at which irrigation delivery decisions are made.

The rotation schedules are preset, as in the classical case of Pakistan's canal water warabandi system, and do not permit any irrigator or user control. The arranged schedules require communication with the supplier to arrange the time and the quantity of delivery, whereas the demand schedules provide the irrigator with water as he needs it under his own control within the limits of system capacity.

Clemmens (1987) provides a detailed description of the basic schedules and their variations. Based on this description, three main categories of irrigation schedules can be placed on a continuum of extreme rigidity to extreme flexibility.

Rotation Schedules

Rotation schedules are the most restrictive of all irrigation schedules, as the rate, frequency and duration are fixed by the central irrigation agency and remain fixed for the entire season. Such systems are common in developing countries. A rotation schedule is considered more fair and equitable than a flexible delivery schedule, where in the former management intensity has to be kept at a low level with less administrative control over the operations. Several variations can be seen in pure rotation schedules:

> Continuous Flow Schedules are a special case of rotation systems, where the duration is the entire season and the frequency is mostly once per year. Continuous flow systems can be used in places where water is plentiful and the growing season is short, and the efficiency of irrigation practices for maximum yield is not considered essential. Here, flow rates can be varied over the season to better meet crop water needs. In many cases, while a constant rate is delivered to a farm, the stream is rotated between fields. In the Pakistan context, this type of schedule has little relevance due to shortage of supplies for most systems except for the few non perennial rice

commands where the system represents a continuous flow schedule but without any rotation or controlled variation of the rate.

Varied-Amount Rotation Schedules are one way of adjusting the volume of water delivered over different parts of the growing season. In general, the frequency remains fixed, while the duration and/or rate are varied to apply more or less water to a particular area. Adjustments in rate are fairly easily accomplished; however, adjustments in duration without adjustments in frequency are a little more difficult. One example would be to supply water half the time to aiternate rotation areas. A manifestation of this type of schedule occurs inadvertently in Pakistan at times of water shortage, when the rate is reduced while the frequency remains the same.

Varied-Freauencv Rotation Schedules are another way of adjusting for variations in crop water use over the irrigation season. Under these schedules, the frequency of delivery is varied. Again it is somewhat difficult to accomplish without rate and duration variations. except in even multiples, for example, twice the irrigation frequency during peak use periods over that in the early and late season. This type of rotation schedule is not quite feasible in Pakistan due to the design limitations of the irrigation systems.

Arranged Schedules

Under arranged schedules, the rate, frequency and duration are arranged between the user (farmer) and the water supply agency. Often, these arrangements are made on a local level, rather than on the project level. This allows for greater flexibility in arrangements, for example last minute changes in arrangement. The advantage of arranged schedules is that while they provide flexibility for farm operations they also allow for simpler delivery system operations than do demand systems. In fact, the delivery system operational capabilities have a very direct impact on how flexible an arranged schedule can be. In essence, there is a continuum of possibilities from a pure demand system to a very restricted arranged system. The distinction between these schedules and rotation schedules is that in the latter, all decisions are made by a central authority.

The timing of arrangements is an important feature of arranged schedules and can have a significant impact on the success or failure of the arranged schedule. The characteristics of the irrigation system would determine whether the lead-time would be short or long. These differences can be significant, particularly for some irrigation scheduling methods. In addition, it may be necessary to change duration (or even rate) during the course of an irrigation. This is easier to accomplish when durations are not fixed by the operating agency since it may just mean rearranging the start time for the subsequent user. A number of common arranged schedules are given below.

Limited Rate Arranaed Schedules are very flexible in that restrictions are placed only on the flow rate, with frequency and duration arranged according to farmer needs. ,These arrangements allow for changes in rate and duration during the irrigation, not under direct farmer control.

Restricted Arranaed Schedules are somewhat less flexible in that once set for an irrigation,, rate and duration are fixed and unchangeable. This precludes any irrigation adjustments for conditions during the irrigation process.

Other schedules include the fixed duration arranaed schedule where the irrigation duration is fixed and unchangeable even by arrangement and the fixed rate arranaed schedule, where the flow rate is fixed and non-negotiable.

Demand Schedules

Demand schedules, being the most flexible of all irrigation schedules, should allow, in their ideal form, an unrestricted amount of water to be taken from the system at the user's convenience. Such ideal systems would not only be technically impractical (particularly in Pakistan), but also prohibitively expensive. Two demand schedules which seem practical are sumrnarized below:

Limited Rate Demand Schedules: These allow the user to determine the rate, frequency and duration, but within a flow rate limited to a maximum amount, and provide a considerably flexible and at the same time a feasible system of operations. Very little communication is needed between the operator and the user. **A** number of such systems for surface irrigation are in use through the use of reservoirs and level top canals, akin to 'water on tap' in domestic water supply systems.

Arranaed Freauencv Demand Schedules: These add a further restriction on water delivery in that the time an irrigation can begin is arranged, but once the irrigation begins, the user is in complete control of the water supply and delivery. Such a scheduling system would be feasible for trickle or sprinkler irrigation.

In addition to the three main categories of scheduling methods, a new method of scheduling irrigation operations was proposed by the **U.S.** Bureau of Reclamation in the 1970's (Clemmens, 1987). The idea behind this method, called Central Svstem Schedulina, was to improve the predictive ability of the project in estimating water needs several days ahead of time. This would hopefully reduce errors in diversions of water, while reducing the lead time for ordering water as well. The idea was for the irrigation district to schedule all irrigations for the farmers on a project wide basis based on forecast of future demand. This could be used to better match crop water needs within flow rate capacity restrictions of the delivery system. Early attempts at scheduling in this way were unsuccessful and it was found that farmers were unwilling to give up the important functions of scheduling to a bureaucratic organization.

Merriam has extensively documented his experience in a pilot project on arranged demand schedule, covering 147 one-hectare farms in Area H of the Mahaweli Project in Sri Lanka. (Merriam and Davids, 1986; and Merriam et. al., 1987). A similar attempt was made by him in 1989, in a pilot area of about 60 acres in the Distributary No.8 in the LSC, NWFP in Pakistan, to demonstrate a demand system, based on flexible arranged schedule basis. The pilot project was to take supplies from remodelled level top canal facilities to a distribution box from where an underground concrete pipeline would serve different areas in the watercourse command. The total cost of the pilot project amounted to about Rs. 3,366,000 which was considered by the authorities as excessive.

Information gathered during the literature review will help considerably to proceed with the collaborative work of the study, and will contribute to a separate report once the more data is obtained through the base-line economic survey and the preliminary field investigations which are under way.

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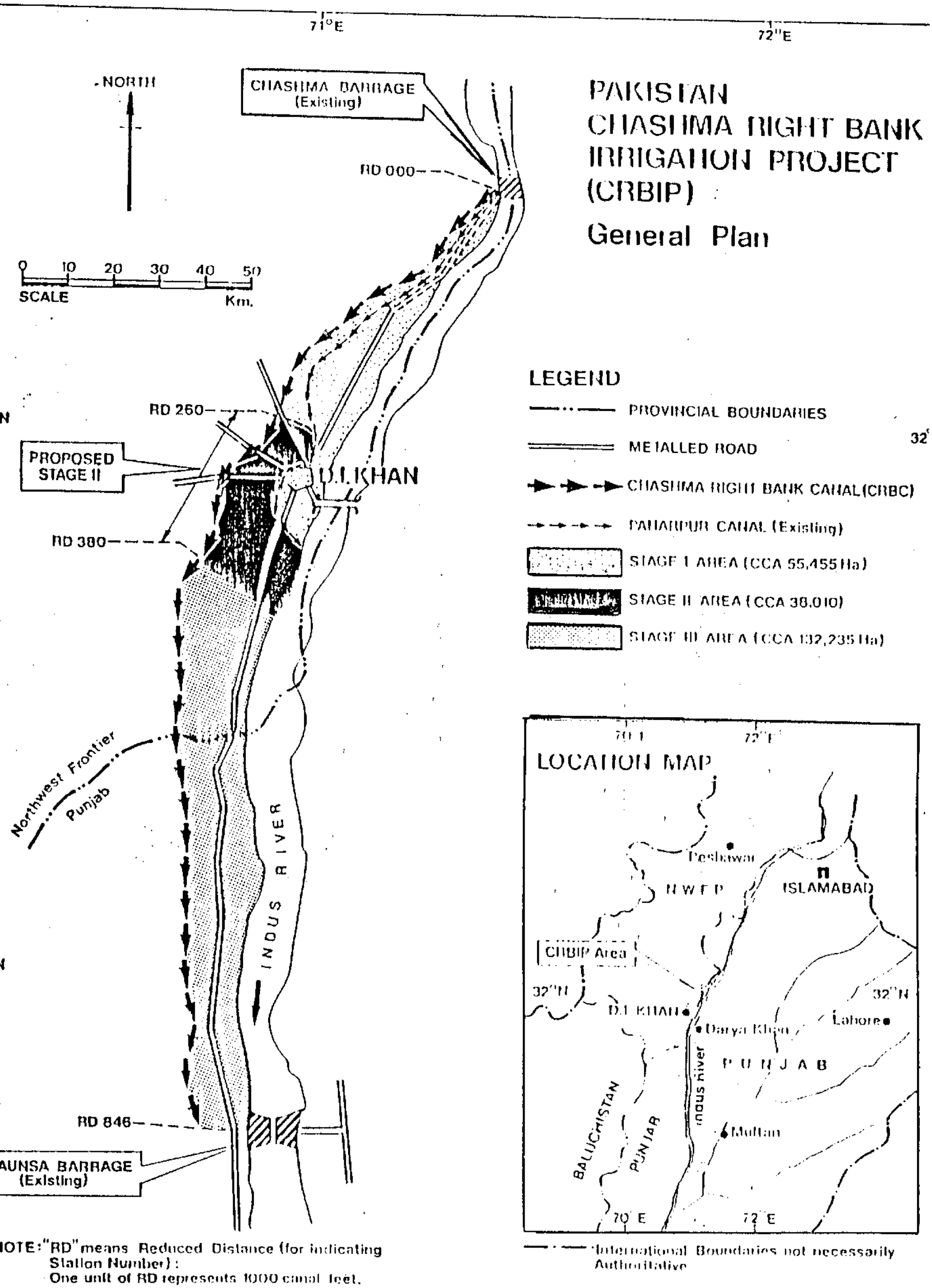
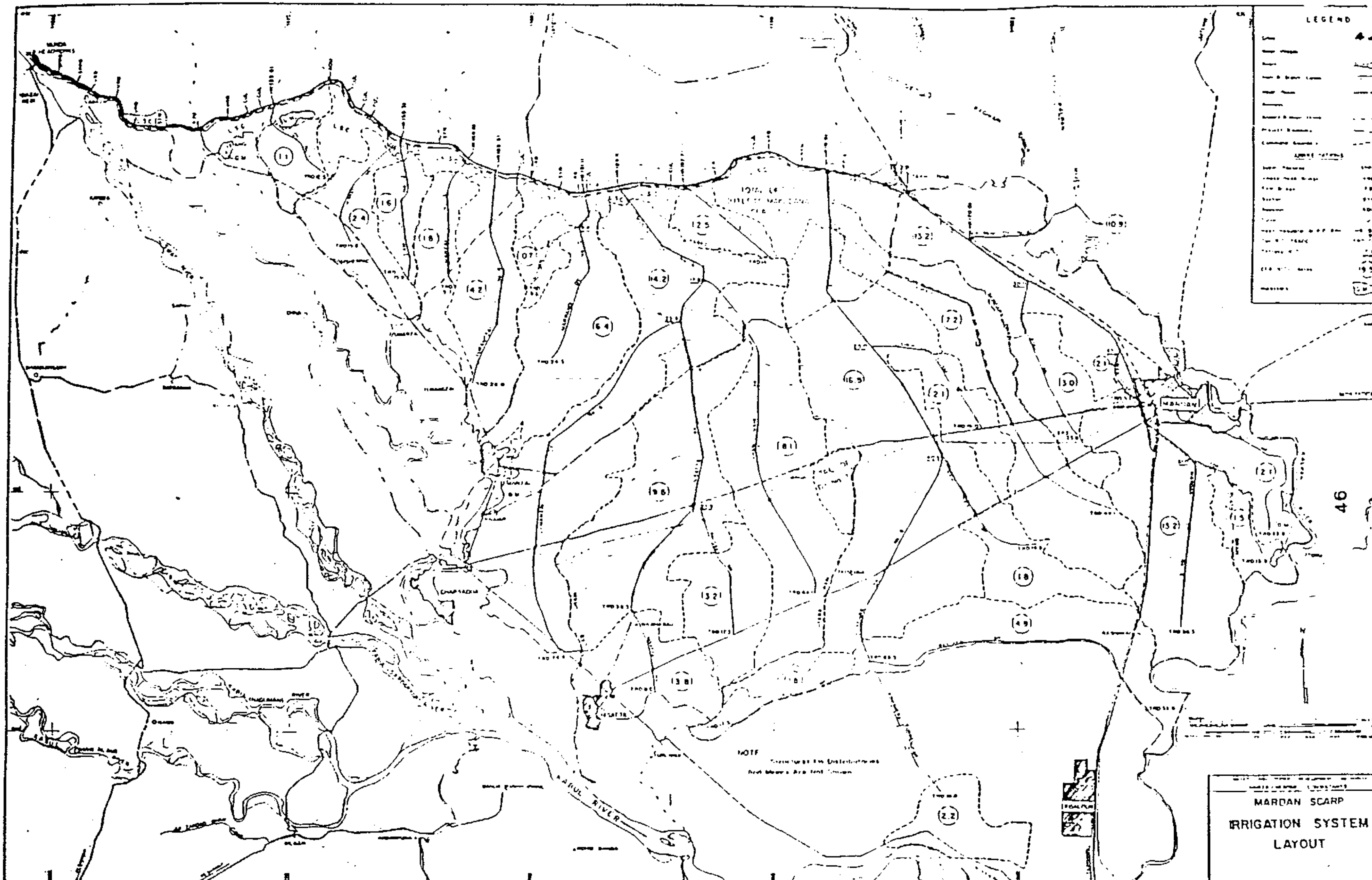

PAKISTAN
CHASHMA RIGHT BANK IRRIGATION PROJECT (CRBIP)
General Plan
71°E
72°E
NORTH
0 10 20 30 40 50
SCALE Km.
CHASHMA BARRAGE (Existing)
RD 000
RD 260
PROPOSED STAGE II
D.I.KHAN
RD 380
Northwest Frontier
Punjab
INDUS RIVER
RD 846
TAUNSA BARRAGE (Existing)
32°
LEGEND
PROVINCIAL BOUNDARIES
METALLED ROAD
CHASHMA RIGHT BANK CANAL(CRBC)
PAHARPUR CANAL (Existing)
STAGE I AREA (CCA 55,455 Ha)
STAGE II AREA (CCA 38,010)
STAGE III AREA (CCA 132,235 Ha)
LOCATION MAP
Peshawar
N W F P
ISLAMABAD
CRBIP Area
32°N
D.I. KHAN
Darya Khan
Lahore
P U N J A B
Indus River
BALUCHISTAN
PUNJAB
Multan
70°E
72°E
International Boundaries not necessarily Authoritative
NOTE: "RD" means Reduced Distance (for indicating Station Number):
One unit of RD represents 1000 canal feet.



LEGEND
NOTE
MARDAN SCARP
IRRIGATION SYSTEM
LAYOUT
KABUL RIVER
MARDAN

IRRIGATION IN PAKISTAN

Irrigation has been practiced along the rivers and streams of Pakistan for centuries. The present irrigation system of Indus Basin is based on the pioneering work *of* the British during the period from 1850 to the time of establishment of Pakistan in 1947. Major development took place as a result of Indus Water Treaty of 1960 with the allocation of water of three eastern rivers i.e., Sutlej. Beas and Ravi Rivers to India and of three western rivers i.e., Chenab. Jhelum and Indus to Pakistan. A network of 6 new Barrages and 8 Link Canals was added as a result of the Indus Water Treaty. Two dams at Mangla on River Jhelum and Tarbela on River. Indus were constructed to provide assured supplies to the irrigation network.

The present diversion capacity of the canals of Pakistan' is 258,600 cusecs and the irrigation network of about 40,000 miles length of the canals delivers water to the fields through 89,100 farms outlets. Province-wise distribution of supplies is as under:

Province	Canal Capacity (Cusecs)	Length of Canals (Miles)	Culturable Commanded Area (M. Acres)	Outlets (Number)
NWFP	5403	1500	0.82	3,357
PUNJAB	119006	22910	20.28	49,332
SIND	125892	12879	12.79	35,018
BALUCHISTAN	299	1649	0.74	1,393
TOTAL:-	258600	39936	34.63	89,100

These canals can pass 11.69 million cubic feet per year. Average annual utilization is about 100 MAF out of an average annual flow of 142 MAF of the three western Rivers i.e., Indus, Jhelum and Chenab.

The irrigation system of Pakistan has been designed as a run-of-the river system with an objective to command maximum area with the available supplies in the river. Due to insufficiency of water in rivers during winter, the total area to be commanded (34.6 million acres) could not be actually commanded. The sole objective, therefore, was "equitable distribution of available supplies" not only between various rivers, canals, branches and distributaries but also between individual outlets. The duty of water i.e., water allowance was fixed low in order to irrigate maximum area. **A** water allowance of 3 - 4.00 cusecs/1000 acres was fixed for most of the canal systems. This has resulted in relatively low production per unit of land. Above all, irrigation systems were designed to keep the administrative and operational requirements as low as possible. The systems were intended to provide "equitable distribution" of water without much interference by the canal establishment while operating the system.

By design, the number of control structures in a canal was kept to a minimum. Cross Regulators were installed only where necessary to control operating levels for the head regulators of "off-taking" channels. For example, on the Lower Chenab Main Canal, the first regulation structure is at 28 miles from headwork and on the Upper Gugera Branch Canal at 55 miles from its head. The lowest point for regulation is at the head regulator of distributaries. In practice, the regulating flows in distributaries is not common. The distributaries either run full supply or are shut down completely if the supply falls short of about 75% of the full supply to avoid disturbance of regime of the channels as well as siltation. From distributaries, water is delivered to the fields through outlets which vary in discharge from 1.0 to 3.0 cusecs. Gates are not provided at the outlets but were designed to pass a specified quantity of water at authorized full supply level. The outlets (called Moghas) act as proportional flow distributors, each taking proportionatety less when the canal level is lower than the normal, and more when the supply level is higher. The design assumption is that the entire system, from the main canal headworks down to the last outlet on the last distributary/minor will draw its designed discharge when the head flow is at full supply and moghas are in good condition. The tail outlets are normally designed with 1.0 ft head gauge and this gauge is the criteria for the proper functioning of the whole system ensuring equitable distribution of supplies throughout the system.

The Indus River system carries a large volume of suspended sediment during the flood season. This heavy silt load was the main source of silting up of the inundation canals and posed a big challenge to the engineers while designing the canals. Efforts were, thus, made to dispose of heavy load of silt by construction of silt "excluders" as part of the headwork and water was drawn into the canals from the upper layers carrying comparatively lesser silt load. Once, silt entered the canals, all efforts were made to dispose of the silt load through the Moghas for it to be deposited on the irrigated lands.

Different theories were evolved to perfect the design of canals. The "Regime Theory" of Mr. Lacey, an Irrigation Engineer of Punjab Irrigation Department was accepted as a criterion in 1939. The canals were designed with slopes, velocities and sections in regime i.e., non-silting and non-scouring channels. The canals were to run most of the time with authorized full supply discharge and be closed when the supplies fall short of 75% of the full supply discharge to avoid silting.

Silt accumulation reduces channel cross-sectional area, which means that operating water levels must be raised to maintain design flows. A higher water level leads to reduced free-board, more bank over-topping and breaching and generally encourages further silting. It also increases flow through moghas at upstream locations, depriving farmers in lower portions of the system of their fair share of water and thereby creating a potential for equity problem between the head reach and tail reach users.

A study[17] of the pattern of the irrigation supplies and the crop water requirements of the existing irrigation systems in Pakistan has revealed that there is a mismatch between the two and has resulted in:

1. Low productivity as supplies fall short of the crop water requirements during the growing periods or at critical stage of growth.

2. The inadequacy of supplies at the time of sowing of crop results in protracting the sowing period beyond the proper time and thus lower productivity.

3. The design canal capacities of the present system do not permit to run more supplies to match the crop requirements even if excess supplies are available in the rivers during summer season.

4. Inadequate supplies available at the time of sowing season restricts the area under crop although excess supplies are available later in the season.

5. Irrigation supplies in excess of the crop requirements cause drainage problems and have resulted in waterlogging and salinity.

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17. Revised Action Programme for Irrigated Agriculture, WAPDA, 1979. Vol 1, Chapter V, pp V 60-73.

Annex - 2

IIMI TEAM

A. International Staff

1. Carlos Garces, Irrigation Engineer and Project Team Leader
2. Tissa Bandaragoda, Senior Management Specialist
3. Pierre Strosser, Agricultural Economist

IIMI will call upon others of its international staff, both in- and out-country if and when the need arises. international staff work on TA staff allocation basis.

B. National staff

4. Hakim Khan, Field Research Professional
5. M. Rafiq Khan, Senior Field Assistant
6. Mahmood Ahmad, Field Assistant
7. Talha Awam. Field Assistant
8. Arshad Nadim, Field Assistant
9. Habibullah Baloch, Field Assistant
10. Moharnmad Iqbal, Driver

IIMI will call upon other of its local staff if and when the need arises. The national staff are assigned full time to the project.

GUIDELINES FOR THE BASE LINE SOCIO-ECONOMIC SURVEY

Crop Based Irrigation Operations in the NWFP is a government approved research project, to be implemented by the International Irrigation Management Institute (IIMI) with Technical Assistance from the Asian Development Bank.

Obiectives of the Overall Research Proiect

The need for the base line socio-economic survey may be better explained and understood in the context of the overall research project objectives.

The broad objective of the proposed research project is to *improve the overall productivity of water resources in the two irrigation project areas (Lower Swat Canal and Chashma Right Bank Canal) through improved irrigation operations in accordance with crop water requirements within the authorized water allocations and subject to available water supplies.*

To achieve this overall objective, the proposed project will,

i) *identify a management approach for irrigation operations that responds to crop water requirements under prevailing constraints and identify additional infrastructure improvements that may be necessary for such an approach;*
ii) *increase the understanding of crop-based irrigation operations by agency personnel and farmers, and identify further training needs;*
iii) *field-test and refine the management approach identified for crop-based irrigation operations;* and
iv) *evaluate the benefits of crop-based irrigation Operations and identify costs and opportunities for implementation on a wider scale.*

Objective's of the Base Line Socio-Economic Survev

The main objective of this survey is to obtain an understanding of the present socio-economic conditions of the farmers in the watercourses selected for the above research project. This understanding would help not only to relate the socio-economic aspects of the farmer sample to their irrigation behavior and how they cope up with the problems under study, but also to evaluate the impact of any interventions that may be made arising from the study. The base line socio-economic data will also be used later in the research project to find out the relationship if any between the social and economic factors, and the problems associated with flexible water management and irrigation scheduling methods.

The base line socio-economic survey under reference. is limited to investigations of selected social and economic aspects only, and to those aspects that relate to farmers and farmer households only.

Ease line information relating to other aspects, such as, soil and water characteristics, supply and delivery of water, and physical and management conditions of the overall system, will be studied separately through other surveys.

The Focus

The focus of the survey should be on the actual farmer of the selected farm holding, and on his household. The person who actually cultivates or operates the farm holding (not as a laborer but as a decision-maker in operations) is defined as the *farmer* for the purpose of this survey. When the actual farmer is not the owner of the farm holding, their shared responsibility for farming and irrigation management decisions should be clearly brought out through the survey.

The Sample

If there are 20 or more watercourses in the selected Distributary or Minor, at least 2 watercourses from each quarter of the Distributary/Minor length should be selected for the survey. If the number of watercourses is less than 20, the sample should be from at least 2 watercourses in each of head, middle and tail areas of the Distributary/Minor.

Similarly, if there are more than 30 farmers in the selected watercourse, an appropriate sample of farmers may be, selected depending on the situational factors, such as farm sizes, social differentiation of the farmer population and the distance area involved. If the total number of farmers in the selected watercourse is 30 or less, all of them should be included in the survey. ***The sample area and the sample size for the survey should be finalized only after further consultation with IIMI.***

The Data Base

To facilitate the use of information gathered during the base line survey for subsequent investigation and analysis, it is suggested that data is recorded in English, or if recorded in any other language it is transferred into a computer data base. Either the proposal or the contract should incorporate an understanding that such data base will be made available to IIMI, including the raw data collected during the survey. Also, the survey instruments will have to be developed with this requirement in mind.

The Main Areas of Inquiry to be Included in the Survey

1. General Characteristics of the Farm, Farmer and Farmer Household - This includes the location of the farm in relation to the Distributary/Minor and the watercourse, land tenure status of the farmer, his educational and family background.

2. Land ownership and land use details of the farm, including the existing cropping pattern.

3. Water management practices both on-farm and relating to the operation and maintenance of the watercourse, including any rotation/warabandi scheduling practices.

4. Practices relating to the use of other inputs, including their supply sources.

5. Crop production practices, farm power, yields, and cost of production.

6. Credit, and marketing of produce.

7. Farmer awareness on farming and irrigation practices, and on interacting with his social and economic environment.

8. Farmer organization and farmer-agency relations.,

9. Estimated family expenditure and income.

The Proposal for the Survey

The prospective sub-contractor for the socio-economic survey should submit a proposal to IIMI, based on these guidelines and the details of the Distributary/Minor selected by IIMI for the study. A contract and terms of reference for the survey would be finalized based on this proposal which should contain among other things, the survey instrument developed for this purpose, methodology to be used, and analyses intended to be carried out, a budget estimate, manpower deployment pattern and a time table for the various survey activities including the finalization of the survey report.

In indicating the analyses to be carried out, the proposal should particularly mention what kind of correlations are to he determined among the variables such as, farm size, tenure status, awareness, extension, irrigation practices, yield and income etc.

The proposal will be the basis for further negotiation, if necessary, before entering into the contract. As ADB's Terms of Reference to IIMI specifies a strict time schedule for preliminary study activities including this Base Line Socio-Economic Survey, it is expected that the proposal would be submitted very soon based on the above details and the initial discussions already held.

A Note on the Suggested Rapid Appraisal in the Lower Swat Canal System

BACKGROUND INFORMATION[18]

The International Irrigation Management Institute (IIMI) will be conducting an action research activity in selected study areas within the Lower Swat Canal and the Chashma Right Bank Canal, in close collaboration with the NWFP agencies associated with irrigated-agriculture. The project will be supported by the Asian Development Bank on the basis of a Technical Assistance Agreement entered into between the Government of Pakistan, the Government of NWFP, IIMI and the Bank.

Since 1988, both the Federal Government and the Government of Northwest Frontier Province (NWFP) have requested for IIMI's participation in irrigation management research activities in the Province's modernized irrigation systems. Specifically, the need was to introduce improved water management methods in the new Chashma Right Bank Canal irrigation project (CRBC), and to identify and field-test appropriate management approaches for the conversion of irrigation operations to a demand-based system in the Lower Swat Canal irrigation project (LSC). IIMI, after discussions with Government officials and Bank staff, prepared a proposal that was submitted for consideration in February 1990. A Bank Fact-Finding Mission visited Pakistan between 2 and 10 April 1990 to finalize the details of the proposed Advisory Technical Assistance (ADTA). Subsequent to this Mission, a PC-II document was prepared for the project and approved by the Ministry of Water and Power Departmental Development Working Party (DDWP) on 21 August 1990. After another series of evaluations and approvals, the TA Agreement was finally signed on 25 July 1991.

The long drawn out deliberations and negotiations resulted in realizing the difficulties involved in trying to shift to a complete demand irrigation system. Accordingly, the objectives of the research to be undertaken were formulated to reflect both the current needs and the feasibility of action research (see Guidelines for the Base Line Socio-Economic Survey).

The title of the research project, "Crop-based Irrigation Operations", reflects this agreed change in emphasis.

18. This information may also be used in developing proposals for the socio-economic survey.

This title has been selected to distinguish between "on-demand" system operations where individual farmers control when and how much water they receive, and "crop-based" system management which aims to supply water to the watercourse head and the farms on the basis of crop water requirements, determined from monitored variables such as cropping patterns, planting dates and evapotranspiration rates.

The design of the new CRBC project and remodelling of LSC project (and also the Upper Swat Canal project which is still being designed) appear to be based on the concept of "productive" irrigation. Allowances for greater delivery capacity seem to be a deviation from the traditional "protective" irrigation.

The CRBC and LSC systems have main canal capacities determined on the basis of maximum water requirements for the design cropping patterns, but it is recognized that during periods of the year with limited water availability, irrigation deliveries must be adjusted according to both the consumptive use of the crop and the authorized water allocations for the system. The main canal capacities of CRBC and LSC are about 8.6 and 11 cusecs/1000 acres (about 0.6 and 0.8 liters/sec/ha), respectively, compared to the more traditional capacity of about 4 cusecs/1000 acres (about 0.3 liters/sec/ha) in NWFP.

The capacity of the CRBC has been fixed to meet peak crop water requirements for a projected annual cropping intensity of 150% (90% in Rabi and 60% in Kharif) relating to an assumed cropping calendar as shown in the Project's PC - I document.

LOWER SWAT CANAL SYSTEM

The original design of the LSC was based on an annual cropping intensity of 100% 160% in Kharif and 40% in Rabi), with channel capacities of 6 cusecs per 1000 acres. Distribution of water to watercourses was via adjustable proportional modules (APMs), a typically supply-oriented system. As part of the remodelling effort under the Mardan SCARP development work, the LSC is being remodelled for a diversion capacity of 1940 cusecs, and the design for remodelling has been not only to overcome channel capacity constraints for increasing cropping intensity from 100% to 180%. but also to replace the APMs with gates, making it possible for discharges to watercourses adjustable in accordance with the requirements of a modern demand system.

In the LSC, many of the components of the remodelled system are still in various stages of development. There is no Distributary or Minor fully developed according to the remodelling design which includes both increased channel capacity and gated outlets in operational condition. Where the gates have been installed (eg. Disty 3), they have already been damaged, and the farmers appear to be freely drawing water making use of the increased supply.

Even after completion *of* these items, the newly established systems need to be tested for sustainable application. Preliminary observations suggest that farmers within these system areas are not yet prepared to effectively use the increased water allocations.

They show a preference to grow crops with higher water requirements, .such as rice and sugar-cane. The agencies do not appear to be ready to take over and operate new infrastructure.

Recently, the Irrigation Department has urged the construction authority, WAPDA, to stop installing the gates at the Distributary outlets and to make the system operations possible through the conventional APMs. Apparently having taken this decision, the authorities have also suggested that one Minor (Sheik Yusuf) be installed with the gates as originally designed for the purpose of experimentation by IIMI.

THE ISSUE

Under these circumstances, it is considered prudent that some prior information is obtained regarding the perceptions of farmers and operating 'staff, before IIMI undertakes further field activities. The following concerns prompt us to take a rapid appraisal of the field situation:

1. The novel feature of regulatory gates at the moghas will be seen only in this rather academic pilot-study area.
2. Only the farmers in this particular minor will be subjected to some kind of intervention and regulation.
3. For these interventions, the operating agency is likely to be a passive observer, shifting an unexpected field responsibility to an external group (IIMI).
4. Replicability of any research results seems to be having only a very remote chance.

THE RAPID APPRAISAL

Since the socio-economic survey in the **LSC,** and possibly also in the CRBC, and other related inception activities have all to await this additional information required, it is essential that the rapid appraisal is completed in the shortest possible time. Therefore it has to be necessarily focussed on the main issues and concerns, and has to be accomplished by appropriately experienced professionals.

Field visits with interviews of farmers and local leaders or key informants and meeting with IPHED/AD/WAPDA staff at different levels are suggested as ways to obtain the information we are looking for.

IIMI will work quite closely with the contractor to monitor the whole effort, starting with some brainstorming meetings. The time allocated to the effort (appraisal + meeting with IIMI staff + time to write a final report) should not exceed 3-4 weeks.

The following are some of the items illustrative of our need:

1) Perceptions on the Crop Based Irrigation Operations (philosophy, advantages/disadvantages, implication on the farming system, relationships between the different actors of the system, sources of information on the new method...)

2) Perceptions on the LSC project (work done, role of the different actors - IPHED, AD, Farmers, WAPDA - before and during the project, future of 'the project...)

3) How to improve the system ? (and willingness to improve it) The point of view of the Agency staff and of the farmers.

A proposal is requested for this Rapid Appraisal based on the lines suggested above, and also on your experience in this type of work and in this particular area.

Annex - 5

CROP BASED IRRIGATION OPERATIONS' IN NWFP PROJECT

LIST OF EQUIPMENT PROCURED AS OF OCT 31, 1991

S.No.	MAIN CATEGORY	QTY	DESCRIPTION
A.	**VEHICLES**		
1		2	Toyota Hilux 4x4 Double Cabin Pick-ups, White Color, 2778 CC, RHD Diesel, 5 Speed manual floor transmission, Power Steering, Airconditioner.
2		3	Honda CD 125 CC Motorcycles
B.	**COMPUTER EQUIPMENT**		
1		2	PC 386 - 33 MHZ, with 4MB ram, 64K cache, 80MB HD and one 1.44 MB FDD.
2		1	Portable computer
3		2	Monitor, Super VGA 1024x768, 28 Dot Pitch with 1MB Super VGA card.
4		1	Laser Printer HP-IIIP
5		1	Epson LQ 1050 Printer
6		1	Epson LQ 870 Printers
7		3	Voltage Stabilizer for computers
8		4	UPS PK US 2000

S.No.	MAIN CATEGORY	QTY	DESCRIPTION
C.	**FIELD EQUIPMENT**		
1		2	Propeller type current meter, with 2.4 m wading rod, audio reading for work under rugged conditions, complete with case. Velocity range 0.03 - 3.0 mps
2		2	Pygmy Propeller type current meter, with 1.2 m wading rod, audio reading for work under rugged conditions, complete with case. Velocity range 0.01 - 1.5 mps.
3		2	Bucket auger 3" dia auger, complete with handle for general soil sampling
4.		2	Regular, soil sampler for visual checking of moisture conditions. 30 to 36" overall length, 1 to 2" outside diameter, with extra coring tip
5.		2	Regular corkscrew type auger for checking moisture conditions. 30 to 36" overall length.
6.		2	Evaporation station including U.S. Class A pan, hook gauge and still well. Metric calibrations.
7.		2	Thermometer
8.		24	Plastic rain gauges, fence-post-type. Metric or dual scale

S.No.	MAIN CATEGORY	QTY	DESCRIPTION
9.		2	Sets of 3 cylinder infiltrometers O 26, 27 and 28 cm for easy transport. Cold rolled or galvanized steel not to exceed 14 gauge; sharp cutting edge, 30 cm length. With driving plate with handle no less 1 cm thick, O 34 cm with lugs to keep plate centered. Hook gauge and scale in metric system.
10		40	2-meter staff gauges, metric system, 65 mm wide by meter sections or whole, rust and discoloration proof. Graduations to one, hundredth for canal gauging.
11.		1	Engineer auto-level, erect image, magnification no less than 26X, horizontal circle at 1 degree division, reading range at least 300 meters, complete with case and corresponding heavy duty tripod.
12.		10	Engineering 3-M steel retractable tapes
13.		4	30-M cloth roller surveying tape. Heavy duty. Metric or dual system
14.		4	Engineering surveying staff gauges 3-M with extension. Metric reading. Heavy duty.
15.		8	Engineering surveying rods. 4-M length.
16.		2	Analog EC-Meter, rang 0-10,000 S complete with electrode, battery and case.
17.		1	Soil salinity probe, for measuring in situ soil salinity.
18.		1	Water level recorder with light or sound indicator, *for* measuring water depth in observation wells.

S.No.	MAIN CATEGORY	QTY	DESCRIPTION
19.		2	RBC Portable flumes, 10 cm width.
D.	OTHER SUPPORT EQUIP		
1		1	Casio FX 1015 Calculator
2		2	Casio HL 812 Calculators
3		1	Nikon, Zoom Touch 500S, Power zoom 35-80 mm auto focus camera.
4		1	Photocopier, Toshiba BD-3910