PRODUCTIVITY AND SUSTAINABILITY OF IRRIGATED AGRICULTURE

A COMPREHENSIVE PERFORMANCE ASSESSMENT SYSTEM

METHODOLOGY AND APPLICATION

IN THE CHISHTIAN SUB-DIVISION,

FORDWAH BRANCH CANAL IRRIGATION SYSTEM

PAKISTAN

DRAFT INCEPTION REPORT

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

APRIL 1995

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Study objectives
1.2 IIMI's Performance Program
1.3 Previous work
1.4 Ongoing research activities of IIMI Pakistan in Chishtian Sub-division
1.5 Research activities of WAPDA and PID in Fordwah

2. REVIEW OF IRRIGATION IN CHISHTIAN SUB-DIVISION

2.1 Research locale
2.2 Water resources and delivery system
2.3 Cropping pattern and farming conditions
2.4 System design
2.5 Management characteristics

3. RESEARCH PROGRAM

3.1 Performance Indicators
  3.1.1 Defining indicators
  3.1.2 Measurement
    3.1.2.1 Data Requirement
    3.1.2.2 Data Source

3.2 Methodology
  3.2.1 Field Surveys
  3.2.2 Sampling
  3.2.3 Data Analysis

4. STUDY IMPLEMENTATION

4.1 Staff involvement and activities
4.2 Steering Group and Working Group
4.3 Budget
4.4 Work plan and time frame
4.5 Outputs
  4.5.1 Performance Indicators
  4.5.2 Workshops & Seminars
  4.5.3 Publications
4.6 Impacts

REFERENCES
ANNEXES

SUMMARY

During phase one (1994-1995) of IIMI's Performance Program, the main activity will be applying and field testing a comprehensive Performance Assessment System for Irrigated Agriculture. Building on past work done at IIMI on performance assessment frameworks, the proposed system will cover all aspects of an irrigation scheme including productivity, economic efficiency, equity, financial viability and environmental sustainability.

The objective of this collaborative study between IIMI-Headquarters, IIMI-Pakistan, Punjab Irrigation Department (PID) and Water and Power Development Authority (WAPDA) will be to apply a Comprehensive Performance Assessment System in the Chishtian sub-division of the Fordwah Branch Canal in Punjab, Pakistan. A set of performance indicators will be measured from a sample which will consist of approximately 60 watercourses and 500 farmers from all 14 distributaries and 7 minors off-taking from the Fordwah Branch Canal. Two field surveys will be utilized to collect agricultural production, socio-economic and environmental data for Rabi 93/94 and Kharif 94 seasons. Water delivery data will be obtained from an MIS database already in use. It is also proposed that once the performance indicators have been measured, this same assessment system will be used to test the impact of identified management interventions on the performance of the system. The relationship between water delivery and agricultural production, water productivity and water profitability will be studied in detail. The Watercourse Monitoring And Evaluation Directorate of WAPDA is currently carrying out a research study in the Eastern Sadiqia Branch which is the southern region of the system. Therefore, the Chishtian sub-division being in the northern region of the system, the long term objective would be to combine both activities which would then provide an opportunity to do a comprehensive performance study from a larger representative sample of the entire Fordwah Irrigation System.

1. INTRODUCTION

1.1 Study objectives

The objective of this collaborative study will be to field test a Comprehensive Performance Assessment System in the Chishtian sub-division of the Fordwah Branch Canal in Punjab, Pakistan. The field testing of this Performance Assessment System will entail two distinct components namely, measurement and assessment. The measurement activity will consist of quantifying (measuring) selected performance indicators thus obtaining actual values. In the assessment activity these values will be measured against norms which are system/agro climatic region specific. These activities will be carried out during 1994 and 1995.

The Performance Assessment System will be used to evaluate the performance impacts of a set of identified management practices and interventions such as rotational water delivery, introduction of decision support systems, investment in drainage, and presence of water markets.

The short-term objective of the study would be to measure the different indicators choosing a sample from the Chishtian sub-division which is a part of the Northern region of the Fordwah-Sadiqia Irrigation System. (The Watercourse Monitoring And Evaluation Directorate of WAPDA has a data collection program for a sample of 26 watercourses in the Eastern Sadiqia Branch, which is the southern region of the system). Thus, the long-term objective would be to combine both of these activities by filling in the gaps, which would then provide an opportunity to do a comprehensive performance assessment study in which the sample would be much more representative of the entire Fordwah Irrigation System.

It is envisaged that the data required for quantification of the parameters will be sufficient in order to statistically test the relationship between water delivery and agricultural production. Hence, it is proposed to correlate water delivery and agricultural production data initially at the distributary level. Further, it is also proposed to study water productivity and water profitability at the distributary level.

1.2 IIMI's Performance Program activities

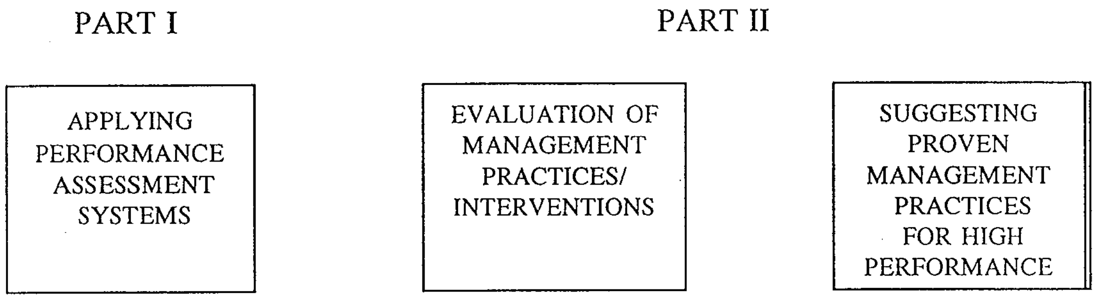
Comprehensive Performance Assessment System

During phase one (1994-1995) of IIMI's Performance Program, the main activity will be applying and field testing a comprehensive Performance Assessment System for Irrigated Agriculture. Building on past work done at IIMI on performance assessment frameworks, the proposed system will cover all aspects of an irrigation scheme including productivity, economic efficiency, equity, financial viability and environmental sustainability.

The proposed activities under this program will integrate and carry forward research presently underway on both performance assessment and decision support packages. Based on the framework developed earlier (Bos et al 1994) and other work (Small and Svendsen 1992, Abernethy 1991, Rao 1993 and Murray-Rust and Snellen 1993), a set of specific indicators will be identified that can be used by policy makers, irrigation managers and researchers. Performance indicators will be grouped into three types: (i) water supply performance; (ii) agricultural performance; and (iii) economic and social impacts, and (iv) environmental performance. These performance indicators will be applied and field-tested in selected irrigation schemes as discussed below.

As outlined in Figure 1, the major activities of the Program are divided into two interrelated parts. Part I will focus on developing, applying and refining a comprehensive Performance Assessment System which will provide data regarding an irrigation scheme in terms of productivity, equity, financial viability, environmental sustainability and the degree to which the existing "scheme" meets current and further agricultural requirements. The outputs of these activities would be a package of practical and cost-effective performance indicators which will be used to assist policy makers and irrigation managers to assess and improve the performance of irrigated agriculture.

Figure 1
MAJOR ACTIVITIES OF THE PERFORMANCE PROGRAM



Part II of the program will concentrate on using the performance assessment system to evaluate the performance impacts of a set of management practices and interventions. The empirical studies will evaluate the impact of an existing management practice (e.g. fixed rotational water supply) in selected irrigation schemes or assess the performance improvements achieved as a consequence of a management intervention (e.g. use of a decision support system). The outputs of this part of the Program will be to generate and disseminate knowledge about proven management practices associated with high performance. These evaluations will generate empirical information about the "determinants" of performance-enhancing management practices and institutional changes. Thus, Part I refers to the "Assessment" component of IIMI's Program on Assessing and Improving the Performance of Irrigated Agriculture" where as Part II covers the "Improvement" component. It is expected that, over time, the second component might be integrated with IIMI's other programs, rather than considered a part of IIMI's performance program as such. Proposed activities under the two parts of the Program are described below:

Part I : Developing and Applying a comprehensive Performance Assessment System

As outlined in Figure 2 , the major components of the performance assessment system are:

* Identification of objectives and performance indicators (to be completed by July 1, 1994);

* Development of practical and cost-effective methodologies for measurement of performance over large irrigation systems;

* Quantification (measurement) of these performance indicators in selected systems;

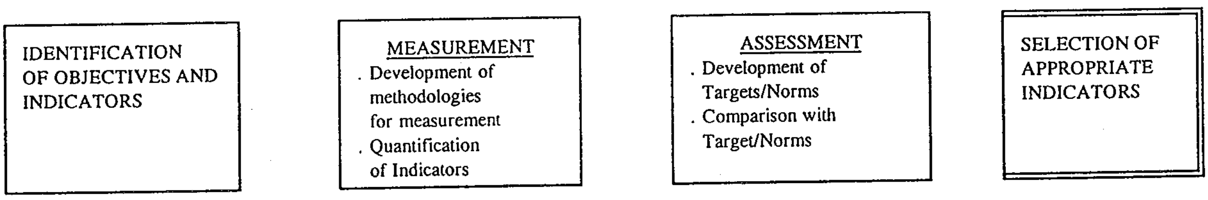
* Development and specification of targets or assessment norms/standards against which the actual values of performance indicators are to be compared;

* Comparison of "actual values" of performance indicators with targets and assessment norms to derive conclusions regarding the "performance level" of the scheme/sub-scheme (or a group of schemes) for a given year and/or changes over time.

* Selection of "appropriate" indicators for a given scheme.

Figure 2

STEPS IN PERFORMANCE ASSESSMENT



It is essential to use performance indicators which are optimally appropriate for the objectives of the user. For example, the objectives of the policy maker may be one or more of the following : maximizing irrigated area from given supplies of water; maximization of productivity per unit of land/water/labour; meeting targets of food self-sufficiency, employment; providing benefits to small farmers, and for livelihoods of rural people including women; enhancing farmers' profitability and ensuring environmental and financial sustainability. The performance indicators will have to be so selected as to reflect such concerns. Table XX on page 15 illustrates some of the linkages between various objectives and corresponding performance indicators. The selection of "relevant" performance parameters will depend on the interest of the policy maker in assessing the contributions made and to be made by irrigated agriculture.

In contrast to the policy maker, the concerns of the irrigation manager, would relate to more specific aspects of system management e.g. adequacy and predictability of water supply to the farmers; equitable distribution of water supplies between head and tail-enders; and the effectiveness of infrastructure. On the other hand, the farmers' concern will be the effect of water supply on his productivity and net profitability. The indicators for these concerns are given in Table 1.

It may be emphasized that an irrigation manager or a policy maker will require a small number of performance indicators for which data can be collected in a timely and cost-effective manner. This "preferred" set of indicators will vary depending upon agro-ecological conditions, methods of water delivery and allocation and the size of the system. However, to enable an irrigation manager and policy maker to select an appropriate set of indicators, there is a need to carry out field research to quantify the cost of measuring various indicators. In view of the fact that methodologies for practical measurement of performance in terms of various indicators over large systems do not yet exist, the design of such field research will be a challenge.

Currently, as part of the main activity in Phase 1 (1994-1995), this Assessment System is being applied and field tested in two major irrigation schemes in Malaysia and Pakistan.

In Malaysia, work has already commenced in the MUDA Irrigation System where the study will focus on the application of the Performance Assessment System with a view to quantifying water delivery, productivity and sustainability indicators. The study, which commenced at the beginning of 1994, is a collaborative effort between IIMI and MUDA Agricultural Development Agency (MADA). In this study, quantitative linkages between performance indicators and management interventions are currently being analyzed for the following management interventions:

* Development of tertiary canals, drains, and roads in 38 out of 110 irrigation blocks,

* Reducing irrigation supply period in the first season, in response to dry sowing (from 197 days for 1984-86 to 152 days for 1990-93),

* Decision support system, and

* Establishment of farmer organizations (Kelompoks and Mini-Estates)

The study will assess the contribution made by each of the above mentioned interventions on the performance of irrigation performance with the help of two types of indices: Impact indices which measure the immediate impacts of the interventions and determinant indices which measure the extent to which the intervention is implemented.

Another five year collaborative effort - Research Program on Irrigation Performance (RPIP) - is also currently being carried out between IIMI, the International Institute for Land Reclamation and Improvement (ILRI) and the International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE) in four irrigation systems in India (Mahi-Kadana), Sudan (Rahad), Morocco (Moulouya) and Argentina (Rio Tunuyan). The program is funded by the Dutch government. Here too, the scope of the research program is to test the relative utility of a variety of performance indicators for irrigation water management, and to test the impact of identified operational interventions. Many national institutes of the respective countries will play an important role in carrying out the research namely, Water and Land Management Institute (WALMI) of Gujarat, India, the Office Regional de Mise en Valeur Agricole de la Moulouya (ORMVAM) in Morocco, Rahad Agricultural Corporation in Sudan and the National Institute for Water Science and Technology (INCYTH) in Argentina.

IIMI will coordinate all four programs with a view to adopting a common methodology so that the performance parameters will be comparable across all four systems. The wide spectrum of agro-ecological as well as irrigation characteristics of these four countries will ultimately result in a wealth of data which would facilitate the comparison of the performance of irrigated agriculture across many different countries. Table 1 provides a comparison of the four systems.

Table 1. A Comparison of Rahad, Moulouya, Mahi-Kadana and Rio Tunuyan Irrigation Systems.

	Rahad	Moulouya	Mahi-Kadana	Rio Tunuyan
Agro-climate				
Ecological zone	warm, arid	warm, arid	warm, semi arid	cool, subtropic
Sub-system	-	Triffa Scheme	Umreth/Borsad	Vieja Retamo Canal
Water supply				
Source	river	reservoir	river/ reservoir	-
Storage capacity (MCM)	-	512	1,300	-
Ground-water	N/A	used	used	used
Command area (ha)	126,000	110,000	212,000	74,270
Cropping				
Major crops	cotton, wheat, sorghum	tree industrial fodder	rice, tobacco	vine, fruit
Cropping intensity	98%	65%	72%	-
Farming conditions				
Farm size (ha)	9	5	1.6	-
Farmers' participation	N/A	N/A	N/A	water user's assn.
Soil	clay	brown	sandy loam	-

1.3 Previous work done by IIMI

Irrigation and Agricultural Performance was studied in the Fordwah Branch command area at main canal, distributary and water course level (Irrigation Management In The Fordwah Branch Command Area South East Punjab, Pakistan, by M. Kuper and J. Kijne, 1992, and The Appropriateness Of Canal Water Supplies: The Responses Of The Farmers, by M. Kuper and P. Strosser, 1992). The objective of the study was to research possible improvements in irrigation management to prevent further land degradation and to mitigate the effects of salinity on crop production. Performance indicators in terms of adequacy and dependability of supply and equity in distribution were measured and quantified with respect to canal operations.

In the first study, performance indicators were quantified in terms of adequacy and dependability of supply and equity in distribution. The sample for water delivery data consisted of eight water courses from Fordwah and Azim distributaries (Chishtian sub-division consists of 14 distributaries). In the analysis, the performance of Fordwah Branch Canal was compared with that of canals of previous IIMI research locations. Much of this research work was carried out in the command area of Upper and Lower Gugera Branch of Lower Chenab Circle East, Mananwala and Lagar distributary in the upper reach and Khikhi and Pir Mahal in the lower reach of the system.

Table 2 provides the values for the above mentioned performance indicators for Fordwah Branch and Gujera canals (Source: Kuper and Kijne).

Table 2. Performance indicators for Fordwah and Gugera Canals Systems in Kharif 1992

Indicators	Fordwah Branch	Rating	Gujera Branch	Rating
Adequacy	0.67	poor		
DPR	0.76	poor	0.81	fair
Dependability	0.47	poor		
Temporal CV	0.41	poor	0.24	poor
Equity	0.63	poor		
Spatial CV	0.56	poor	0.38	poor

The performance of the Fordwah Branch Canal system leaves much to be desired when all three indicators with respect to the crop water requirements and the design discharges are rated "poor" (the ratings were based on values provided by Molden and Gates, 1990). The difference in calculated values between Fordwah and Gujera canal systems is substantial, even though the difference in rating is not.

The performance of the of the sub-division was made by comparing three sections of the branch canal - head to tail reaches. The calculated values in Table 3 shows a marked difference in performance between the three sections. Pa, an indicators for the total volume of water delivered is rapidly decreasing towards the tail of the Fordwah Branch from a level of 0.79 to 0.45 in the tail reach. However, the variation in the discharge (Pd value) does not change towards the tail. The distribution (Pe value) of water between the distributaries, however, appears to be worse in the tail section than the two upstream sections.

Table 3. Performance of sections of Chishtian sub-division in kharif 1992

Section	Equity (Pe)	Dependability (Pd)	Adequacy (Pa)
Takhat Mal	0.52	0.26	0.79
Chak Abdullah	0.46	0.26	0.57
Chishtian	0.65	0.25	0.45

When adequacy and dependability values were compared for the Azim and Fordwah distributaries, it was found that the delivery of water to the secondary canals differ substantially in terms of adequacy and dependability, with Fordwah performing better than Azim distributary (see Table 4). The table also provides a comparison of these values against the average for the sub-division.

Table 4. Water delivery to Fordwah and Azim distributaries during Kharif 1992

Distributary	Dependability (Pd)	Adequacy (Pa)
Azim	0.66	0.39
Fordwah	0.37	0.57
Average Chishtian sd	0.41	0.76

The measurements of water supply to sample watercourses, expressed as mm of water supplied to the service areas of the watercourses are presented in Table 5. The same table provides values of water supplied through tubewell water and rainfall. It is clear from the values that tubewell water is an important source of water.

Table 5. Sources of irrigation water and Relative Water Supply (RWS) for sample watercourses in Kharif 1992

Watercourse	Canal (mm)	Tubewell (mm)	Rainfall (mm)	RWS
Azim 63	256	248	135	0.91
Azim 11	120	671	88	1.05
Fordwah 62	413	78	121	0.74
Fordwah 130	482	165	127	0.93

A pilot study is being conducted in the Fordwah Branch Canal in order to test the potential of Decision Support interventions (Setting Up An Information System At The Main Canal Level: Participatory Approach In Sri Lanka And Pakistan, by J. Rey, M. Kuper and M. Hemakumara). The objective of this study is to identify and address the needs of decision support tools by irrigation managers to enhance and better manage the water distribution at the main canal level.

1.4 Ongoing research activities of IIMI Pakistan at Chishtian sub-division

A comprehensive data collection program is being carried out by IIMI Pakistan presently in the Chishtian sub-division. The data collection, which commenced in the Kharif season of 1991 for five water courses, has now been extended to eight water courses since Rabi 1992/93 season. The sample consists of eight water courses (from two distributaries - Fordwah and Azim) and approximately 280 farmers. In addition to the selected sample water courses, discharge measurements are also available for all 14 distributaries of the Fordwah Branch canal.

The following measurements are taken: daily monitoring of canal water supply at the head of the watercourses; duration of the daily canal water turn used by every farmer; and daily tubewell operations. The analysis of this data would provide a good estimate of quantity of canal water supplied to a farm, the total quantity of irrigation water received, the percentage of tubewell and canal water used and the quality of water used for irrigation.

Further, agricultural data such as cropping patterns collected through periodic crop census, and socio-economic data collected through farm surveys are also available.

The above mentioned research activities (past and present) in the Fordwah region have resulted in a wealth of data and research findings at sub-division, distributary, water course and farm levels. This together with IIMI Pakistan's recent involvement at the sub-division level, and its the ongoing data collection program would be a distinct advantage for the type of collaborative work required for extensive data collection in order to quantify a large number of indicators. In terms of the long term objectives of the Performance Program (IIMI-HQ) work plan and objectives of IIMI-Pakistan research projects, here lies a great opportunity for complementing the work by maximizing the use of the available financial and human resources.

1.5 Research Activities of WAPDA at Fordwah/Eastern Sadiqia Irrigation System

WAPDA's involvement in Chishtian dates back to 1988 when a Agro-Economic Evaluation Baseline Survey was carried out for Kharif 1988 and Rabi 1988/89. Water course command data, farm level data and secondary data were collected through this survey for a sample of 42 water courses and 378 farms of the Fordwah Eastern Sadiqia system. Five water courses were from the Chishtian sub-division.

Building upon the Baseline Survey done in 1988, the Watercourse Monitoring And Evaluation Directorate of WAPDA has commenced further data collection activities for a sample of 26 water courses in the southern part of the system since Kharif 1993 and will continue until 1998. The data collection will cover water delivery data (to measure water delivery to the water courses and to measure the conveyance efficiency within the water courses), land use data and agro-economic data. The main objective of the ongoing research is to develop an information package to reflect the changes in the agro-economic aspects expected to occur on account of implementation of the irrigation and drainage works. Other research objectives include the study of the impact of Sub-surface Tile Drainage on agro-economic performance of the system; the study of the correlation between conveyance efficiency and agricultural production; and the application and field testing of an appropriate Geographic Information System (GIS).

The ongoing work by WAPDA would no doubt complement and facilitate IIMI's Performance Program long-term objective of developing and field testing a Comprehensive Performance Assessment System for the entire Fordwah Eastern Sadiqia system.

2. REVIEW OF IRRIGATION IN CHISHTIAN SUB-DIVISION

2.1 Research locale

The command area of the Fordwah/Eastern Sadiqia area is located in the southeast of the Punjab and is confined by the Sutlej river in the north-west, the Indian border in the east and by the Cholistan desert in the south-east (see Annex 1) It commands a gross area of 301,000 ha, out of which 232,000 ha. is considered as culturable command area.

2.2 Water resources and delivery system

Fordwah Canal and Eastern Sadiqia Canal receive their water from the Sutlej at the left abutment of Suleimanki Headworks (see Annex 1). Both canal commands were developed under the Sutlej Valley Project of 1921, which was launched to increase the reliability of the water supply to low lying areas along the Sutlej in Kharif. These canals were previously irrigated by inundation canals.

The XEN Fordwah Division has introduced an 8-day rotation between 3 sub-divisions in his Division for Kharif. Within this 8-day period first, second and third preferences are given to the three sub-divisions . The sub-division that is in first preference takes all the water it requires according to its indent, enabling its main distributaries to run at full supply level. Only the requirements of smaller distributaries can be met when the sub-division is in second or third preference. After the sub-division in first preference has taken its full share, the remaining water may be used by the sub-division that has second preference, with the sub-division in third preference taking all the water that is left over.

This rotational program does not apply to water allocation in Rabi, when only 6 perennial canals in the Division draw water, all of which are located towards the tail of Fordwah Branch.

At the design, the area to be irrigated annually was based on the availability of water and the total culturable area under command (CCA) by fixing design cropping intensities. In the Fordwah Division the non-perennial canals have a cropping intensity of 70% (35% in each of Kharif and Rabi), whereas the perennial canals have an intensity of 80% (32% and 48% in Kharif and Rabi respectively). The duties for most perennial distributaries in the Fordwah Branch are 0.25 l/s/ha CCA (3.5 cfs/1000 acres), while the non-perennial distributaries have a duty of 0.4-0.5 l/s/ha CCA (5.5-7.0 cfs/1000 acres).

2.3 Cropping pattern and farming conditions

There are two irrigation seasons: Kharif, the summer season from mid April to mid October and Rabbi, the winter season covering the rest of the year (November to March), which is interrupted for one month for the maintenance of the canals.

The climate is semi-arid with annual evaporation (2400 mm) far in excess of annual rainfall (260 mm). The area is part of the cotton-wheat agro-ecological zone of the Punjab, with cotton, rice and forage crops dominating in Kharif (summer season), and wheat, sugar cane and forage crops in Rabi (winter season). In Fordwah Division almost a quarter of the area is cropped with rice during Kharif, mainly in the alluvial areas of the Sutlej. In contrast, the Eastern Sadiqia Division, not forming part of the riparian tract , is almost devoid of rice (5%). Table 6 provides figures of the cropping pattern for Rabi 90/91 and Kharif 91 for Fordwah Division and E.Sadiqia Division.

Table 6. Cropping pattern in Fordwah/Eastern Sadiqia Divisions 1990/1991 (Source: Kuper and Strosser, 1992)

Season	Crop	Fordwah Division Area (ha) (%)	E. Sadiqia Division Area (ha) (%)
Rabi 90/91	wheat oilseed fodder other	694.34 (72) 418.3 (4) 173.34 (18) 5287 (6)	55514 (46) 26885 (22) 36128 (30) 3275 (2)
Total		**96238**	**121802**
Kharif 91	cotton rice fodder other	45117 (42) 23179 (22) 25093 (24) 13055 (12)	67709 (57) 5969 (5) 24465 (21) 21190 (16)
Total		**106444**	**119333**

2.4 System design

The Fordwah scheme offtakes directly from the river at the headworks. Branch canals, which offtakes from the main canal, convey the water with cross-regulators spaced along these canals to control the water levels. Subsequently, distributaries offtaking from the branch canals and water courses offtaking from the distributaries convey the water to the farms through outlets locally named *moghas* (see Annex 2). The mogha is not equipped with a regulation device. This structure is designed to provide a specified quantity of water when the distributary is at its full supply level.

To distribute the available, but limited water supplies over the Fordwah/Eastern Sadiqia system, some areas, which are prone to waterlogging, were labelled non-perennial (i.e.they only receive water during Kharif, April-October) and others perennial, with supplies the year round.

Part of the Fordwah/Eastern Sadiqia irrigation system, combining perennial and non-perennial canals in its command, was chosen for the study. A distinct hydraulic sub-unit (Chishtian sub-division) was selected starting ar RD (Reduced Distance from the head of a canal, in 1000 feet) 199 of Fordwah Branch (off-taking from Fordwah Canal) and going down to the tail at RD 371, which includes the 14 off-taking distributaries (see Annex 3).

The Chishtian sub-division, with a command area of approximately 67,597 ha, consists of 14 distributaries and approximately 485 water courses. The total length of this stretch of main canal is 52.4 km. with 24 direct outlets. The design discharge of Fordwah Branch where it enters the study area is 33 m^3/s. The main characteristics of the 14 distributaries are presented in Table 7. Apart from the distributaries, there are 7 minors directly off-taking from the Fordwah Branch. These minors consist of a total of approximately 78 (17%) watercourses at the secondary level.

Table 7. Characteristics of distributaries in Chishtian sub-division (Source: Kuper & Kijne 1992)

Name of distributary	Offtake at RD (feet)	CCA (ha)	Status	Design Discharge (m3/s)	Water Allocation (l/s/ha)
Daulat	245+600	13570	NP	5.9	0.38
Mohar	245+600	1446	NP	1.1	0.49
3 L	245+600	1166	NP	0.7	0.49
Phogan	267+700	949	NP	0.5	0.49
Khemgargh	281+000	2032	NP	0.8	0.38
4 L	281+000	877	NP	0.5	0.49
Jagir	297+500	1604	P	1.1	0.42
Shahar Farid	316+400	10255	NP	4.3	0.38
Masood	316+400	3295	P	1.0	0.25
Soda Minor	334+000	4093	NP	2.2	0.49
5 L	348+800	357	P	0.1	0.25
Azim	371+600	12199	NP	6.9	0.49
Mehmud	371+600	813	P	0.2	0.25
Fordwah	371+600	14941	P	4.5	0.25

RD: Reduced Distance in 1000 ft from the head of canal
CCA: Culturable Command Area
P: Perennial
NP: Non-Perennial

The four largest distributaries, Daulat, Shahar Farid, Azim and Fordwah commands an area of approximately 51,000 ha which is almost 71% of the total command area. It is interesting to note that the difference between the smallest command area (Shahar Farid-10,255 ha) of these four distributaries and the largest in the other ten (Masood-3,295 ha) is 6,163 ha. The command area of the fourth largest distributary (Fordwah-14,941 ha) is 42 times larger than the smallest distributary in the system (5 L-357 ha). Of the four largest distributaries, except for Fordwah which is perennial, the other three (Daulat, Shahar Farid and Azim) are non-perennial canals. The non-perennial canals receive water only during Kharif, and a maximum of three allocations during Rabi. The perennial canals receive water year round for both seasons.

2.5 Management characteristics

The study area forms part of the Fordwah Division, which falls under the administrative control of the Executive Engineer (XEN), Fordwah Division. The Division is divided into three sub-divisions. The study area is located in the tail sub-division which is Chishtian, headed by a Sub-Divisional Officer (SDO), a qualified engineer, who is responsible for the operation and maintenance (O&M) of the canals in his charge.

The Chishtian sub-division is sub-divided into five sections, each headed by a sub-engineer, responsible for the day-to-day O&M of a portion of the main canal and its off-taking distributaries (see Figure 3 and Table 8).

Figure 3. Organizational chart of the Chishtian sub-division (Source: Riviere, 1993)

Table 8. Sections in Chishtian sub-division (Source: Kuper & Kijne, 1992)

Section	Area of Authority Fordwah Branch (RD)	Area of Authority Distributaries (RD)
Takhat Mal	199-281	Mohar, Daulat (0-63), 3L, 4L, Phogan
Chak Abdullah	281-334	Jagir, Masood, Shahar, Farid (0-47), Soda
Chishtian	334-371	5L, Mehmud, Fordwah (0-64), Azim (0-52)
Khemgarh	-	Daulat (63-tail), Shahar Farid (47-tail)
Hasilpur	-	Fordwah (64-tail), Azim (52-tail)

The Fordwah Branch has six control points (cross-regulators) in the Chishtian sub-division (see Annex 3), with distributaries off-taking just upstream of five of these regulators (RD 199, RD 245, RD 281, RD 316 and RD 371). The remaining cross regulator at RD 353 controls only the water level in the Fordwah Branch itself. Gauge Readers observe the water levels twice daily at all these control points. The readings are transmitted through signalers to SDO and/or XEN via telegraph, and on this basis the irrigation officers are supposed to take decisions regarding the operation of the irrigation system in their (sub-) division.

3. RESEARCH PROGRAM

3.1 PERFORMANCE INDICATORS

3.1.1 Defining indicators

The following section provides descriptions and definitions of the performance indicators to be quantified. In Table 9, the description of the indicators are listed against the objectives (for quantifying the indicators).

Table 9. Linkages between Objectives and Performance Indicators

Objective	Indicator
Food Security	- Project output as ratio of food demand - Food imports as ratio of agricultural exports
Reducing Rural-Urban Migration	- Net rural incomes after subsidies
Agricultural Productivity	- Area irrigated per unit of water (m^3) - Irrigation intensity (cropping intensity) - Gross value of output per ha/m3/worker - Production of major crops per unit of land/water/worker
Economic Profitability	- Net value of output at farmers prices/economic prices - Cost of production at farmers prices/economic prices
Environmental Sustainability	- Area lost due to water logging - Area lost due to salinity - Water quality for irrigation - Decline in level of groundwater table
Financial Sustainability	- Total revenue as percent of O&M expenses and capital charges
Quality of Service to Farmers	
Equity of water distribution	- Ratio of average Delivery Performance Ratio (DPR) of head to average DPR of tail
Reliability	- Coefficient of variation of DPR
Adequacy	- Relative water supply

3.1.2 Measurement

All details pertaining to measuring the performance indicators are provided in this section. These details entail all formulas and their definitions (descriptions).

The section is further sub-divided into two additional areas namely, a section on data requirement (3.1.2.1) and a section on data availability (3.1.2.2).

Food Security

1. Project output as a ratio of food demand

2. Food imports as a ratio of agricultural exports

Agricultural Productivity

1. Cropping Intensity = The ratio of Actual Cultivated Area to the Culturable Command Area (CCA).

2. Land Productivity = Production (Kg) per unit of area (ha).

3. Water Productivity = Production (Kg) per cubic meter of water (m3).

Economic Profitability

Farmers' Profitability of Irrigation

This indicator essentially would mean the Net Value of Output (due to irrigation) at Farmers' Prices. Profitability will be calculated using prices received by farmers for its output (crops) and prices paid by farmers for inputs (seed, fertilizer etc.). These prices will reflect subsidized output and input prices.

Economic Profitability of Irrigation

This would mean the Net Value of Output (due to irrigation) at Economic Prices. Profitability will be calculated using prices which will be corrected for subsidies on input and output prices. (These prices are usually referred to as "Shadow Prices"). (See Annex 6).

Estimation of farmers' and economic profitability

There are two performance indicators of profitability for land and water. These are defined as follows:

1. Farmers' Profitability of Irrigation = Additional Net Value of Output due to Irrigation.

Additional Net Value of Output due to Irrigation =

Net Value of Output at Farmers' Prices with Irrigation *minus* Net Value of Output at Farmers' Prices without Irrigation.

2. Economic Profitability of Irrigation =

Net Value of Output at Economic Prices with Irrigation *minus* Net Value of Output at Economic Prices without Irrigation.

Environmental Sustainability

Decline in level of ground water =

Rate of Change of Groundwater Depth = New Depth *minus* Old Depth as a ratio of Old Depth.

Salinity =

Rate of Change of EC = New EC Value *minus* Old EC Value as a ratio of Old EC Value.

Financial Sustainability

Total revenue as percent of O&M expenses and capital charges

Quality of Service to Farmers

1) Adequacy of water supply:

a). Relative Water supply(RWS)

$$RWS = \frac{Irrigation\ water\ supply + Rainfall}{Seepage + Percolation + ET}$$

b). Cumulative RWS

c). Water Delivery Performance (WDP)

This indicator can be used as a single value for the entire irrigation season in this form.

WDP = actual volume supplied/target volume supplied

$$WDP_i = \sum_{i=1}^{n} \frac{K(t)\, V_i(t)}{V_i^*(t)}, \quad if \quad V_i(t) \leq V_i^*(t)$$

$$= \sum_{i=1}^{n} \frac{K(t)\, V_i^*(t)}{V_i(t)}, \quad if \quad V_i(t) > V_i^*(t)$$

This also can be aggregated over different time periods to measure the adequacy and timeliness of water supply, in the following manner;

where, $V_i(t)$ =Volume of water delivered to unit i during the time period t of cropping season

$V_i^*(t)$ =Target volume of water to be delivered to unit i during the time period t of the cropping season, calculated for actual crops grown and existing conditions of soil, rainfall and other sources of water, and

K(t) =Weighing factor indicating the relative importance of water at different stages of crop growth.

2) Reliability of water supply:

a).Gap between Official and Actual water supply

b). Coefficient of Variation of weekly DPR

3) Equity of Water Supply:

a). Delivery Performance Ratio(DPR)

$$DPR = \frac{Actual\ total\ water\ supply}{Target\ water\ supply}$$

b). Theil's Information Measure

$$H(y) = \sum_{i=1}^{n} y_i \log\frac{1}{y_i}, \quad where\ 0 \le H(y) \le \log(n)$$

and, y_i= Fraction of water supply for the i^{th} unit from the total water supply

c). Modified Interquartile Ratio

- Ratio of averages of the best and poorest third of water deliveries
- Ratio of averages of water deliveries of the head end to the tail end
- Ratio of average water deliveries to the units with sizes(areas) in the upper two third to the lower one third.

The performance parameters for adequacy, dependability and equity according to Molden and Gates (1990) are as follows:

1) Adequacy:
where Qd/Qr is the ratio of water delivered (supply) over water required (demand). The equation indicates that the values of Qd and Qr are defined for discrete locations where water is delivered within region R, and for finite times within the period T.

$$Pa = \frac{1}{T}\sum_{T} \frac{1}{R}\sum \frac{Qd}{Qr}$$

2) Dependability:

$$Pd = \frac{1}{R}\sum_{R} CV_T \frac{Qd}{Qr}$$

where dependability is defined as the temporal variability in the ratio of water delivered (Qd) over water required (Qr), supply over demand.
CV_t(Qd/Qr) is the temporal coefficient of variation (i.e. the ratio of standard deviation to the mean) of the ratio Qd/Qr for one specific location within the region R, over the time period T.

3) Equity:

$$Pe = \frac{1}{T}\sum_{T} CV_R \frac{Qd}{Qr}$$

where the equity parameter is defined as the spatial uniformity of the ratio of the delivered amount (Qd) to the required amount (Qr). CV_r(Qd/Qr) is the spatial coefficient of variation of the ratio Qd/Qr for a specific time T over the region R.

3.1.2.1 Data Requirement

Table 10 describes the data requirement for quantifying the indicators together with the objective, type of indicator and the unit of measurement for the indicators.

Table 10. Data requirement for quantifying performance indicators

Objective	Type of Performance Indicator	Indicator	Unit
1. Food Security	Self Sufficiency	Additional agricultural income due to irrigation. - Gross - Net Foreign Exchange Earned/Saved	Million Rs. Million Rs.
2. Agricultural productivity	Irrigation utilization	Gross irrigated area - Canal water - Groundwater - Other - Total	000 ha
		Additional food grain prod. (due to irrigation)	000 tons
		Water released (season 1+2) - Canal water - Groundwater - Other - Total	MCM
		Area irrigated per unit of water released	HA/MCM
	Net value of output per ha	Additional food grain prod. per unit of water	Tons/MCM
3. Economic Profitability	Economic profitability of irrigation	Net value of output at economic prices	Rs.
	Farmers' Profitability of irrigation	Net value of output at farmers' prices	Rs.
		Cost of prod. at economic prices	Rs.

4. Environmental Sustainability		Area lost due to water logging	000 ha
		Area lost due to salinity	000 ha
		Area with ground water within 1.5m	000 ha
5. Financial sustainability	Financial viability	Revenue (rice area)	Million Rs.
		Revenue per ha	Rs. per ha
		Revenue as % of O&M costs	Percent
6. Quality of service to farmers	Adequacy	Irrigation intensity	Percent
		Relative water supply	
	Reliability	Water delivery performance	Actual volume/ Target volume
	Equity		Avg. DPR of tail 25% of the system

3.1.2.2 Data Source

A detailed breakdown of the data available (indicator type against system level) with IIMI Pakistan - required for the purpose of quantifying the performance indicators - are given in Table 11.

Water delivery data collected by IIMI-Pakistan and PID (which is being entered into the IMIS software) will be utilized for quantifying the water delivery (quality of service to farmers) performance indicators at the distributary level. The field survey carried out in September will provide the necessary data in order to quantify the agricultural, socio-economic, and environmental performance indicators.

Table 11. Data availability for calculation of Performance Indicators

	Performance Indicators	Sub-division	Distributary	Water-course	Farm
1.	Strategic				
	- Project output as ratio of food demand	-	-	-	-
	- Food imports as ratio of agricultural exports	-	-	-	-
	- Net rural incomes after subsidies	-	-	-	-
2.	Agricultural Productivity				
	- Irrigated area per unit of water	X	X	XX	XX (FS)
	- Irrigation intensity	X	X	XX	XX (FS)
	- Gross value of output per ha/m^3/worker	-	X	XX	XX (FS)
	- Production per unit land/water/worker	-	X	XX	XX (FS)
	- Net value of output at farmers' prices & economic prices	-	-	XX	XX (FS)
	- Cost of production at farmers' prices & economic prices	-	-	XX	XX (FS)
4.	Economic Sustainability				
	- Net value of output at economic prices	XX	-	XX	XX (FS)
	- Cost of production at economic prices	XX	-	XX	XX (FS)
3.	Environmental Sustainability				
	- Area lost due to water logging	-	-	XX	XX (FS)
	- Area lost due to salinity	-	-	XX	XX (FS)
	- Water quality for irrigation	-	-	XX	-
	- Decline in level of water table	XXX	-	XX	XX (FS)
5.	Financial Sustainability				
	- Total revenue as percent of O&M expenses	X	-	XX	XX
6.	Quality of Service to Farmers				
	- Equity of water distribution	-	XX	XX	XX
	- Reliability	XX	XX	XX	XX
	- Adequacy	XX	XX	XX	XX

X - With ID
XX - With IIMI-Pakistan (only for 8 selected watercourses and 278 farms)
XXX - WMED/WAPDA
FS - From Field Survey

At the system and distributary level, the primary data available consists of water delivery data. The agricultural production data would have to be obtained from secondary sources. However, there is no data available for environmental aspects at this level.

At water course and farm level, almost all of the three types of data are available for the selected sample only (8 water courses). Hence, data for additional water courses of the remaining 12 distributaries will have to be collected for better representativeness of the entire system. The following is a summary of the data which is being collected by IIMI-Pakistan staff.

Water Delivery Data:

Main canal level (Sub-division):

Daily stage readings at all control structures, and at the head and tail of all 14 distributaries are taken and entered into the IMIS software for analysis of reliability and equity measures.

Distributary level:

Stage readings are taken at regular intervals for Fordwah and Azim distributaries to measure the discharges at the head and the supply to the sample water courses.

Water course level:

Warabandi turns are monitored in 8 sample water courses of Azim and Fordwah distributaries. Farmers of each watercourse is visited each day, and visits are made once a week to the sample water courses to observe water turns. Data on the changes in the warabandi schedules and water trading practices are recorded. Visits are made 2 to 3 times per week for the purpose of recording data on the operation of private tubewells and water trading practices. A crop sensus is carried out once per season and data on farming systems and agricultural production is collected via farmers' interviews at the end of the season.

3.2 Methodology

3.2.1 Field surveys

Field surveys for the Fordwah study were designed using stratified random sampling techniques so as to minimize the costs of data collection. These sample surveys will cover the entire command area of the Chishtian sub-division and will generate agricultural production information including crop patterns, cropping intensities, crop yields and value of output per unit of land/water. These large scale surveys will be supplemented by in-depth case studies of sample households in order to quantify the relationships among water delivery, water allocation, input use, agricultural output and profitability. These case studies will provide insights into farmers' response to alternative methods of water allocation and changes in input and output prices. Information collected from large scale surveys and in-depth studies will be correlated and analyzed to draw conclusions regarding sample size, the size and type of questionnaires and number of seasons for which data should be collected.

Field-testing of these indicators will generate information about the costs of quantifying various indicators, alternative methodologies for data collection, the ease of data collection and replicability and robustness (in terms of variability) of these parameters. The relationships among various performance indicators will be quantified to identify groups of indicators which give similar results. This information will be useful for selecting a set of practical and cost-effective indicators for a given irrigation scheme.

In complementing the ongoing data collection program of IIMI-Pakistan in 2 distributaries (Azim and Fordwah), 8 water courses, and 278 farmers, there were two alternatives with regards to carrying out new surveys: either to increase the number of water courses in Azim and Fordwah distributaries, or take additional distributaries from the remaining 12 and thereby additional water courses. In terms of getting a representative sample of the Chishtian sub-division it was decided to increase the number of distributaries and thereby the water courses. Further, in order to correlate water delivery and agricultural production data at the distributary level, it was decided to select all 14 distributaries.

Two field surveys will be conducted. The first survey will be carried out in September 1994 to obtain agricultural production and socio-economic data for Rabi 93/94 season and some preliminary data for Kharif 94 season. The field survey will contracted out and it is proposed that the field staff will be trained at IIMI-Pakistan Lahore, in September to coincide with the pre-testing of the questionnaire. It is proposed to conduct the second survey in January/February of 95 to obtain the balance data for Kharif 94.

3.2.2 Sampling

A multistage sampling strategy has been utilized to select the sample from the Chishtian sub-division. The farmer at the watercourse level was considered as the basic sampling unit. The main stratification criteria used for selection of water courses (from the distributaries) and farmers (from the water courses) was based on the water reach namely, the head, middle and tail of each distributary and water course. These reaches were considered the stratums for the sample. Simple random sampling was used for selection of water courses and farms.

Distributary level

All 14 distributaries of the Chishtian sub-division were included in the sample (see Table 10). Since an attempt will be made to correlate water delivery and agricultural production data at the distributary level in order to study the relationship between these two sets of data, all the distributaries of the sub-division were selected. The range of the CCA of the distributaries is 357-14,941 ha. (see Table 1). Of the 14 distributaries, there are 4 extremely large distributaries (Shahar Farid, Azim, Daulat and Fordwah) with CCA's greater than 10,000 ha. (the range being 10,255-14,941 ha.). The remaining 10 distributaries consists of CCA's less than 10,000 ha. (the range being 357-4,093 ha). The difference between the smallest command area of these four distributaries and the largest in the remaining 10 distributaries is 6,613 ha. Therefore, in order to obtain a proportionate representation of the small as well as the 4 large distributaries, additional water courses were selected from the 4 large distributaries.

Since almost 17% (78) of the total number of watercourses in the entire Chishtian sub-division off-take from minors, and these minors directly off-take from the main Fordwah Branch, it was not possible to eliminate the minors from the random selection process. Hence, 6 minors were also considered as primary units together with the distributaries. Further, one branch canal (Fordwah Branch), which directly off-takes from the main branch was also considered as a primary unit. Therefore, the sample consists of 21 primary units namely, 14 distributaries, 6 minors and 1 branch canal.

Water course level

A total of approximately 60 water courses were randomly selected from the 14 distributaries and 7 minors (see Table 10). The distributaries and the minors were stratified into head, middle and tail reaches and the watercourses were selected proportionate to the size of each unit. For example, in the larger units a total of 6 watercourses (2 each from head, middle and tail) were selected, while in the medium size units a total of 3 watercourses (1 each from head, middle and tail) were selected. In the smallest units, 1 watercourse was selected randomly.

Farm level

Approximately 500 farmers have been selected. The selection was random from head, middle and tail, based on the number of farmers on each watercourse as follows: 12 farmers from watercourses with a large number of farmers, 6 farmers from the units with a small number of farmers and 9 farmers from watercourses with a number in between. If the watercourses had only a few farmers (i.e. less than 9) then all the farmers were selected (see Table 12). Prior to the selection of watercourses, a watercourse census was carried out for all the selected watercourses in order to obtain this information. (For details of the entire sample, see Annex 4).

Table 12. Summary description of selected sample

Distributary	No. of Watercourses	CCA (acres)	No. of Farmers
1) 3-L	3	1,056	30
2) 4-L	3	562	18
3) 5-L	1	173	12
4) Azim	6	1,691	42
5) Daulat	6	1,865	66
6) Feroze Minor	1	350	15
7) Fordwah	6	1,814	42
8) Fordwah Branch	2	502	12
9) Hirwah Minor	3	991	18
10) Hussain Abad Minor	1	231	12
11) Jagir	3	959	30
12) Jiwan Minor	3	920	27
13) Khem Garh	3	1,445	24
14) Mahmood	3	1,000	33
15) Masood	3	1,252	27
16) Mohar	3	601	18
17) Neekwaha Minor	3	1,033	21
18) Phogan	3	677	17
19) Rathi Minor	3	589	18
20) Shahar Farid	6	2,022	42
21) Soda	3	1,197	24
Total	68	**20,930**	**548**

It will be important to note that as a long term objective of the study - which is to finally study both North and South of Fordwah Branch - it would be advantages to use a similar sampling frame to that which is currently being used by the WM&ED (WAPDA) in Fordwah South, which is based on command area and location (reaches) along the water courses.

3.2.4 Data analysis

As shown in Table 11, except for the water delivery data, the data for the other three indicator types will be analyzed at IIMI-Pakistan (Lahore) and/or IIMI-HQ (Colombo) depending on the requirements. However, it is proposed that the water delivery data be analyzed at IIMI-Pakistan since much of the data collection and analysis is already being done at this location. The new data to be collected at water course level for the additional water courses if necessary, would be analyzed in Colombo.

4. STUDY IMPLEMENTATION

4.1 Staff involvement and activities

The staff involved, their respective areas of involvement, and the location where the activities are to be performed specifically with reference to the field surveys are provided in Table 13. (A similar field survey will be carried out in 1995).

Table 13. Component-wise staff involvement (1994)

	Component	IIMI-HQ	IIMI-Pak
1.	Secondary data collection (water delivery, agricultural production, environment)		XX
2.	**Field Survey**		
	Sample selection		XX
	Questionnaire development	XX	
	Survey pretest/training		XX
	Field interviews*	-	-
	Data entry		XX
3.	**Data Analysis**		
	Water delivery		XX
	Agricultural production	XX	XX
	Socio economic aspects	XX	XX
	Environment and health	XX	XX
4.	Report writing	XX	

* IFPRI Field Staff (Sub-contracted)

The following staff will be directly involved in the study and will be responsible for most of the activities:

IIMI-HQ - Dr. Bhatia (Economist and Leader-Performance Program), Lalith Dassenaike (Research Associate), Upali Amerasinghe (Research Data Analyst), Wasantha Kumara (Research Officer).

IIMI-Pakistan - Pierre Strosser (Agricultural Economist), Marcel Kuper (Associate Expert), Saeed-ur-Rehman (Senior Field Research Economist), Gauhar Rehman (GIS specialist), Robina Wahaj (Agricultural Engineer), Khalid Riaz (Agricultural Economist) .

Others - Dr. S. K. Raheja (Statistician-Consultant), IFPRI field staff.

. Dr. S.K. Raheja is currently the Director - Center for Agricultural & Rural Development Studies New Delhi, India. He will serve as an consultant for the study. His work will consist of advising on the selection of sample, input into the analysis of data and participation in workshops related to the project. Since he is already involved with similar activities with respect to the Performance Study in Malaysia, his involvement in this study will ensure common approaches and methodologies in both cases, which will facilitate comparison of the performance of the two systems in the future.

The field survey will be sub-contracted to IFPRI field staff from Islamabad, Pakistan. IFPRI field staff consist of both supervisors and enumerators who will be responsible for carrying-out the field survey, and will be trained by IIMI-Pakistan staff accordingly.

In addition to the above mentioned activities which essentially would consist of activities to be completed during 1994, the activities for 1995 have been planned with the following additional objectives and activities in mind:

1. To identify with PID the line agency responsible for O&M of the irrigation system the potential for strengthening the performance assessment system, and to propose an approach for the implementation:

In proposing an approach for implementation of the assessment system, the institutional aspects related to the inclusion of such an approach in the routine activities of selected PID staff will be analyzed. Further, the decline in performance orientation of PID will be analyzed and the scope of for improvement will be determined, leading to a formulation of an approach to strengthen the performance assessment system.

2. To analyze and establish the correlation between water delivery and agricultural production at the watercourse level:

To estimate the correlation between water supply and agricultural production at watercourse level, selected watercourses will be monitored for two seasons. Cropping intensity and cropping pattern, areas under waterlogging and salinity will be collected through a seasonal survey of the command area of each sample watercourse. Water levels at the head of the watercourse will also be monitored for the same two seasons, and computed into discharges.

3. To compare data collection methodologies in terms of the accuracy of the data collected, the easiness of data collection program, the costs of the data collection activities, in order to identify the most appropriate data collection methods for assessing performance:

Although no additional data collection will be required for achieving this objective, data analysis will be required for this important activity of the program. Comparison of methods for collection of crop data (comparison of accuracy, data collection protocol, costs for crop census, farmers' interviews and remote sensing information); and comparison of methods for estimating the hydraulic performance at the distributary level will be two important activities. The GIS component of this activity will be a major activity, and crop data, water quality data, salinity data and tubewell data (all visual outputs of GIS) of the sample watercourses will be with similar data collected by PID and farm surveys.

The activities (component) and the respective staff involved are provided in Table 14.

Table 14. Component-wise staff involvement (1995)

	Component	IIMI-HQ	IIMI-Pak
1.	Secondary data collection		XX
2.	Field Survey kharif '94 rabi '94/'95	 XX XX	 XX XX
3.	Data entry		XX
4.	Data analysis preliminary analysis water delivery agricultural production	XX XX XX XX	XX XX XX XX
5.	Data collection at watercourse level		XX
6.	Report writing inception report progress report final report	 XX XX XX	
7.	Other outputs workshops seminar 1 seminar 2	 XX XX XX	 XX XX XX
8.	GIS work		XX
9.	Institutional aspects		XX
10.	Comparison of methodologies	XX	XX

4.2 Steering Group and Working Group

The Steering Group for the study will be the Consultative Group for IIMI-Pakistan.

The Working Group will consist of the following five members: Dr. R. Bhatia, Gaylord Skogerboe, Bashir Ahmed (Director Watercourse Monitoring & Evaluation Directorate - WAPDA), representative member from PID and a representative member from the International Water Logging And Salinity Research Institute (IWASRI).

The already existing Working Group on Irrigation Management Information Systems (IMIS) - the objective of which is to oversee and facilitate the implementation of an information system in the Fordwah/Eastern Sadiqia area, initially in the Chishtian sub-division is as follows:

Chairman: Chief Engineer Bahawalpur zone, Punjab Irrigation & Power Department (PID);

Members: Superintending Engineer Bahawalnagar circle PID, Executive Engineer Fordwah Division PID, Marcel Kuper (IIMI-Pakistan), and Zaigham Habib (IIMI-Pakistan).

There exits also a Planning Group for the ongoing activities on Decision Support Systems (DSS) which is as follows:

Chairman: M.H. Siddiqui, consultant PID;

Members: Chief Engineer Bahawalpur zone PID, Dr. M. Tariq Afzal Makhdoom (Director Indus Water Treaty & Regulation PID), Dr. Bagh Ali Shahid (Superintending Engineer PID), Principal Government Engineering Academy PID, G.V. Skogerboe (Director IIMI-Pakistan) and Marcel Kuper (IIMI-Pakistan).

The Umbrella Technical Group FES (S) includes the following members:

Chairman: General Manger (Water) Central, WAPDA;

Members: Director General, IWASRI, Chief Engineer (Headquarters) Central, WAPDA, Director IIMI-Pakistan;

Team Leader: Netherlands Research Assistant Project (NRAP);

Co-opted member: A reputed expert in saline agriculture.

4.3 Budget

The total budget in detail for 1994 and 1995 is provided in Annex 4. The budget estimated for 1994 is $87,600 and for 1995 it will be $175,000.

4.4 Workplan and time frame

The proposed workplan and time frame is given in Table 15. The workplan was developed with the primary objective of having an initial output (i.e. report) in time for the Board Meetings in December 1994. However, as indicated, report writing would continue into the first quarter of 1995 as a second farm survey would be carried out in early 1995. However, it is proposed that at least one report (interim/progress) be written in between the main outputs.

Table 15. Planning of activities (1994)

Activity	M	J	J	A	S	O	N	D	J	F and +
Planning - preparation*	X	XX	XX XX	XX XX						
Data collection 1. Rabi 1993/94 farm survey 2. Kharif 1994 farm survey					XX XX				XX XX	XX XX
Data entry and data processing					XX XX	XX XX	XX XX	XX XX	XX XX	
Data analysis and report writing						XX XX	XX XX	XX XX		XX XX

* Planning and preparation will include the following activities to be carried out during the specified time periods:

1. Sampling design and drawing of sample - by end July

2. Questionnaire development - by end July

3. Pre-test of survey - by mid August

4. Survey training - by end August

A field survey will be carried out in September which will make it possible to obtain agricultural production and socio-economic data for Rabi 1993/94. This would enable to secure agricultural production data on Rabi crops such as wheat and fodder. A second survey could be carried out in December/January in order to obtain the same data for Kharif 1994. By this time harvesting would have been completed for sugarcane, rice and cotton.

Table 16 provides all activities as planned for during 1995.

Table 16. Planning of activities (1995)

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Secondary data collection	xx	xx	xx	xx								
Field surveys												
kharif '94			xx									
rabi '94/'95							xx					
Data entry				xx				xx				
Data analysis												
preliminary analysis					xx	xx			xx	xx		
water delivery						xx	xx			xx	xx	
agricultural production						xx	xx			xx	xx	
Data collection at WC level	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Report writing												
progress report					xx	xx	xx					
final report										xx	xx	xx
Other outputs												
workshop			xx									
seminar 1				xx								
seminar 2											xx	
GIS component		xx						xx				
Institutional aspects	xx	xx	xx	xx	xx	xx						
Comparison of methodologies							xx	xx	xx	xx	xx	xx

4.5 Outputs

The following outputs are planned for during the course of the study (1994/1995):

* Performance indicators
* Workshops and seminars
* Publications

4.5.1 Performance indicators

The sets of indicators to be quantified is the same as given in section 3.1.

The initial output in terms of an interim or progress report is scheduled for middle of 1995 in the form of a draft I final report. This will be prepared jointly between IIMI-HQ and IIMI-Pakistan.. This report will consist of the initial findings regarding the methodology for sampling and data collection and the measurement/quantification of the performance indicators. A more detailed report (i.e. draft II final report) is proposed for end of 1995, at which stage it will be possible to correlate the water delivery data with that of the agricultural production data, at which time more firm conclusions can be made regards this relationship.

IPR papers (water delivery indicators, productivity/equity/environment), to be written and presented jointly between IIMI-HQ and IIMI-Pakistan staff are proposed for end of 1995. Papers to be written on water delivery indicators, agricultural production indicators, relation of water to crop production, productivity/equity/environment, performance and management intervention, and comparison of data collection methodologies, to be co-authored by the respective staff of IIMI-HQ and IIMI-Pakistan are proposed for 1995.

4.5.2 Workshops and seminars

The proposed workshops and seminars for 1995 are given in 17.

Table 17. Workshops and Seminars for 1995

Workshop/Seminar	Date	Location	Audience
1. Workshop on Methodologies	March 1995	Lahore, Pakistan	IIMI-HQ and IIMI-Pakistan staff
2. Workshop on Performance Assessment	November 1995	Lahore, Pakistan	Policy makers, Irrigation managers, IIMI staff
3. Seminar on Performance Assessment	November 1995	Islamabad, Pakistan	International experts, Policy makers, Irrigation Managers, IIMI staff

4.5.3 Publications

The following tentative titles are proposed for publications during the end of 1995:

1. Water Delivery, Productivity and Environmental Sustainability Indicators of Performance: An analysis of Fordwah/Eastern Sadiqia Irrigation System.

2. The Impact/Relationship of/between Water Delivery Performance on/and Agricultural Performance at the Distributary Level.

3. The Relationship Between Water Delivery Performance and Agricultural Production at the Watercourse Level.

4. Performance Assessment and Evaluation of Management Interventions: A Case Study of Chishtian Sub-Division, Fordwah Branch Canal Irrigation System.

5. Comparison of Data Collection Methodologies.

Initially, the above mentioned will be in the form of joint working papers, and will be subsequently revised for publications in refereed national and international journals. A set of these papers will also be considered for IIMI monographs.

4.6 Impacts

After the initial six months of work in the Chishtian region, IIMI has realized the need for the strengthening the ongoing research program. Primarily, the researchers feel the need to associate the potential users (PID staff) of any performance assessment approach to our activities. In light of these observations in 1994, activities for 1995 have been planned to focus on a major extension effort to sell the performance assessment idea to the system managers. Therefore, the immediate concern will be to strengthen the interaction between IIMI and PID staff.

Since research will be carried out in a collaborative mode, a continuous interaction is expected to take place among staff of IIMI, senior staff of Pakistan Irrigation Department (PID), staff of Water and Power Development Authority (WAPDA), Watercourse Monitoring and Evaluation Directorate of WAPDA, and other local researchers. It is envisaged that the results from this collaborative study will contribute to and complement the research findings of the WM&ED study currently underway in the Fordwah south. This activity by itself will ensure an increase in the knowledge with regard to methods of assessing performance and determinants of performance. A set of field tested performance indicators together with an appropriate methodology will be available to Irrigation managers and policy makers in Pakistan. Thus, the results from such studies will facilitate their understanding the linkages between performance improvement, management interventions and policy changes which are necessary in order to sustain the performance of irrigated agriculture in the country. In particular, the results of the study will provide a better understanding of the relationship between short-term operational (water delivery) performance, crop production, social and economic impacts, and long-term sustainability.

REFERENCES

Abernethy, C.L. 1991. Indicators and Criteria of the Performance of Irrigation Systems in Improved Irrigation System Performance of Sustainable Agriculture. Proceedings of the Regional Workshop organized by FAO in Bangkok, Thailand. 22-26 October 1990. Rome: FAO.

Bandaragoda, D.J. and G.R. Firdousi. 1992. Institutional Factors Affecting Irrigation Performance in Pakistan: Research and Policy Priorities. IIMI Country Paper - No. 4.

Boss M.G., D.H. Murray-Rust, D.J. Merrey, H.G. Johnson, and W.B. Snellen. 1993. Methodologies for Assessing Performance of Irrigation and Drainage Management. Workshop of the working group on irrigation and drainage performance, the 15th international congress of the ICID, Netherlands.

Kijne, J.W. and E.J. Vander Velde. 1992. Salinity in Punjab Watercourse Commands and Irrigation System Operations. Advancements in IIMI's Research 1989-1991. Pp. 139-176. Colombo: IIMI.

Kuper, M. and J.W. Kijne. 1992. Irrigation Management In The Fordwah Branch Command Area South East Punjab, Pakistan. Paper presented at the 1992 Internal Programme Review, International Irrigation Management Institute, Colombo, Sri Lanka.

Kuper, M. and P. Strosser. 1992. The Appropriateness Of Canal Water Supplies: The Response Of The Farmers. A case study in the Fordwah/Eastern Sadiqia area, Punjab, Pakistan. Discussion paper 6. International Irrigation Management Institute, Lahore, Pakistan.

Malhotra, S.P., S.K. Raheja and David Seckler. 1984. A Methodology for Monitoring the Performance of Large-Scale Irrigation Systems: A Case Study of the Warabandi System of Northwest India. Agricultural Administration 17:231-259.

Molden, David J. and Timothy K. Gates. 1990. Performance Measures for Evaluation of Irrigation -Water-Delivery Systems. In: Journal of Irrigation and Drainage Engineering, Vol. 116, No. 6, ASCE.

Murray-Rust, D.H. and Vander Velde, Edward J. Impacts of Physical and Managerial Interventions on Canal Performance in Pakistan: A Review of Five Years of Field Research Studies. Advancements in IIMI's Research 1992.

Rao,P.S. 1993. Review of Selected Literature on Indicators of Irrigation Performance . IIMI, 1993.

Riviere, Nicola. 1993. Introduction Of A Management Information System At The Main-Canal Level. A study in the Chishtian sub-division, Fordwah/Eastern Sadiqia area, Punjab, Pakistan.

ENGREF, France and IIMI, Colombo, Sri Lanka.

Seckler, David, R.K. Sampath and S.K.Raheja. 1988. An Index for Measuring the Performance of Irrigation Management Systems with an Application. Water Resources Bulletin 24 (4): 855-860.

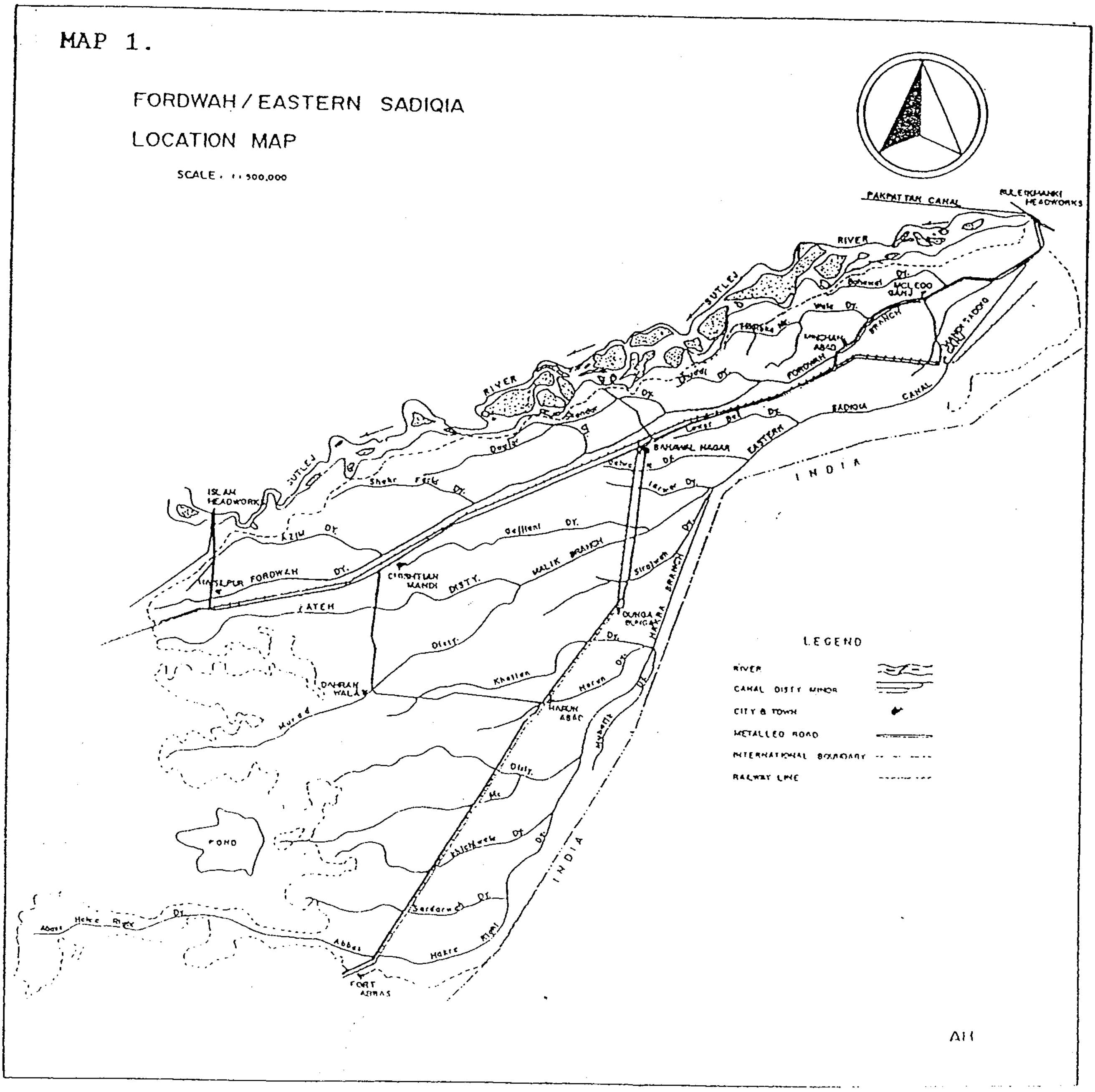
Small, L.E. and Mark Svendsen. 1992. A Framework for Assessing Irrigation Performance. Working Paper on Irrigation Performance 1. International Food Policy Research Institute, Washington, D.C.

Strosser, P. and T. Rieu. A Research Methodology To Analyze The Impact Of Water Markets On The Quality Of Irrigation Services And Agricultural Production. Paper presented at the 1993 Internal Programme Review, International Irrigation Management Institute, Colombo, Sri Lanka.

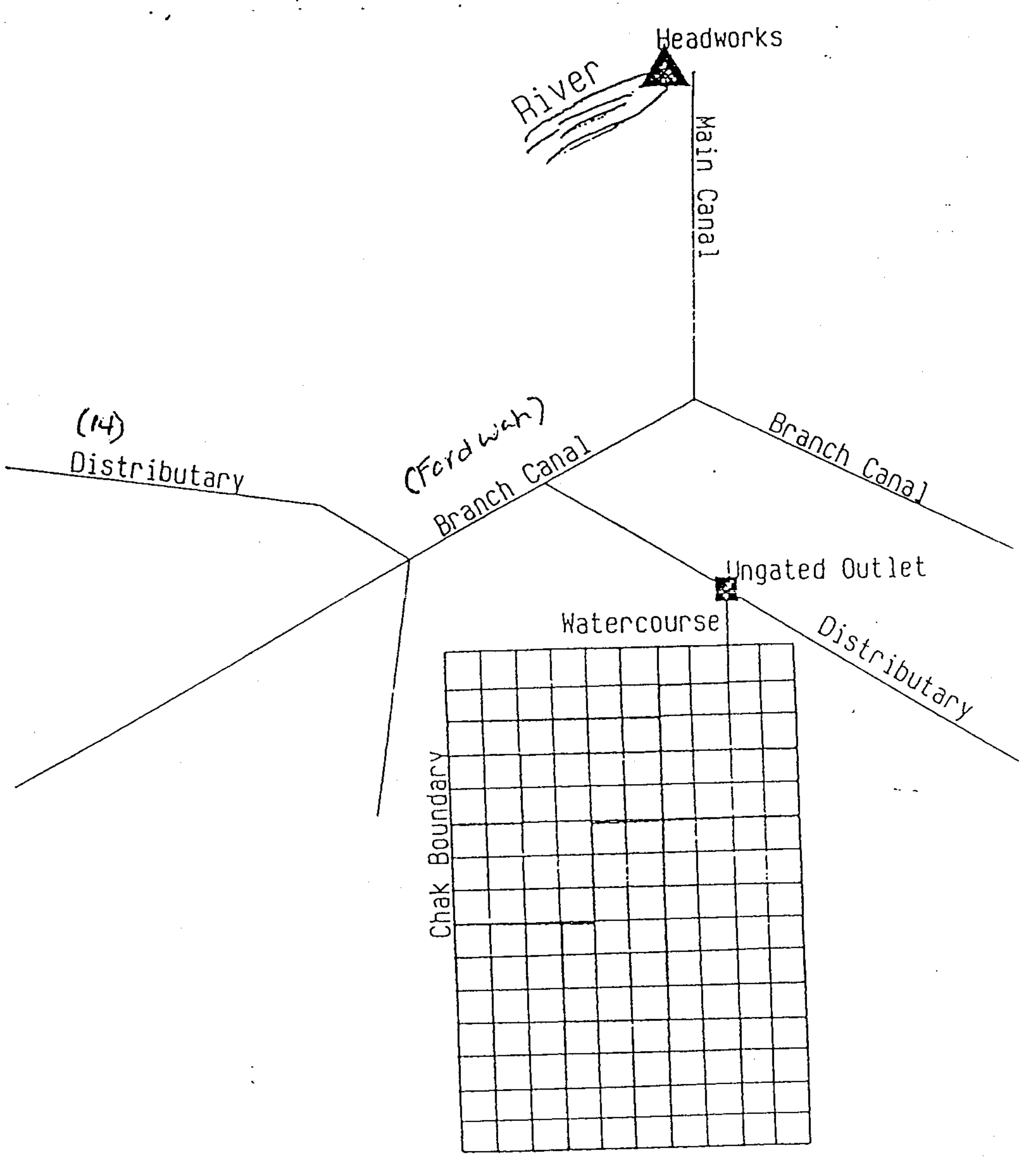
Water and Power Development Authority (WAPDA): Agro-Economic Evaluation Baseline Survey. Fordwah Eastern Sadiqia Project. Watercourse monitoring and evaluation directorate, Lahore, Pakistan, 1989.

ANNEXES

Map 1
Fordwah/Eastern Sadiqia
Location Map
(Source: Kuper and Kijne 1992)



Typical Distribution System
(Suleikhanki Headworks)



Map 2
Lay-Out Fordwah Branch
Chishtian Sub-Divison [RD245-RD371]
(Source: Kuper and Kijne 1992)

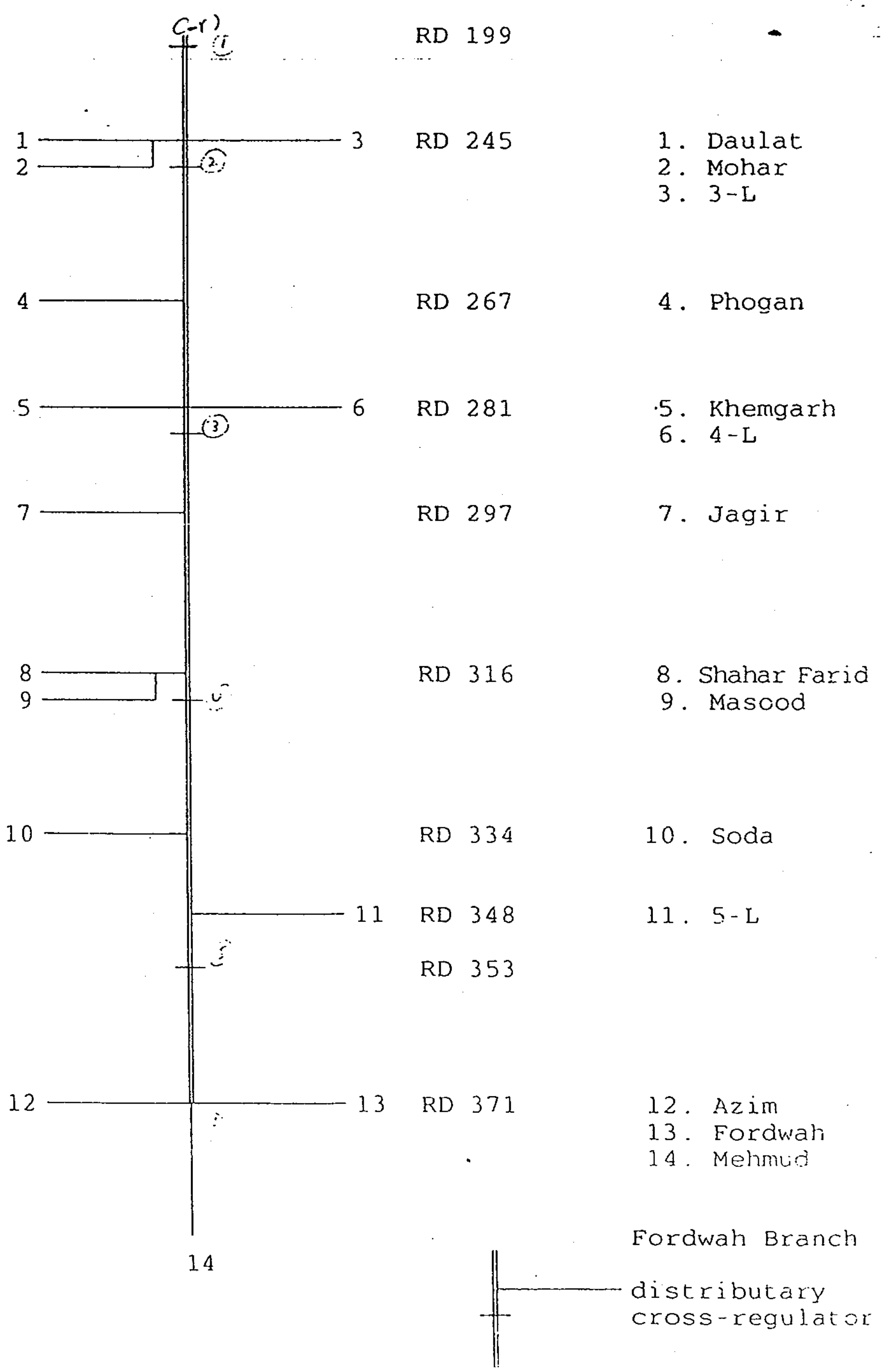


Table 10 (Cont.)

Hirwah Minor	6400-L		24	6
10) Hussain Abad Minor	6630-R		20	12
11) Jagir	200-R		77	12
Jagir	7200-R		62	12
Jagir	9090-R		24	6
12) Jiwan Minor	21461-L		43	9
Jiwan Minor	43420-TR		38	9
Jiwan Minor	7500-R		48	9
13) Khem Garh	1300-R		71	12
Khem Garh	3800-R		20	6
Khem Garh	8720-R		6	6
14) Mahmood	1030-R		66	12
Mahmood	11860-TR		36	9
Mahmood	5200-R		77	12
15) Masood	13650-R		45	9
Masood	34800-R		37	9
Masood	44330-R		48	9
16) Mohar	12690-R		9	6
Mohar	1300-L		9	6
Mohar	13880-R		12	6
17) Neekwaha Minor	29040-L		21	6
Neekwaha Minor	43800-TR		28	6
Neekwaha Minor	550-L		50	9
18) Phogan	200-L		21	6
Phogan	7620-R		34	9
Phogan	8750-TL		2	2
19) Rathi Minor	10000-TL		21	6
Rathi Minor	500-R		18	6
Rathi Minor	5000-L		20	6

Table 10 (Cont.)

20) Shahar Farid	19847-L		14	6
Shahar Farid	33075-R		38	9
Shahar Farid	46020-R		53	9
Shahar Farid	5240-L		11	6
Shahar Farid	63484-R		12	6
Shahar Farid	70100-TL		13	6
21) Soda	23550-R		23	6
Soda	38150-R		81	12
Soda	990-R		26	6
Total	**68**		**2309**	**548**

Annex 4

Table 10. Description of selected sample

Distributary	Watercourse	Watercourse CCA	No. of farmers	No. of selected farmers
1) 3-L	10-L		57	12
3-L	22000-TF		38	9
3-L	6000-L		37	9
2) 4-L	19700-TR		53	9
4-L	3225-L		3	3
4-L	6390-L		18	6
3) 5-L	11300-R		22	12
4) Azim	118980-L		39	9
Azim	17530-R		24	6
Azim	30900-R		36	9
Azim	39030-R		14	6
Azim	44410-R		12	6
Azim	58250-L		19	6
5) Daulat	45810-R		47	9
Daulat	49990-L		60	12
Daulat	63470-L		69	12
Daulat	9000-R		64	12
Daulat	97560-L		54	9
Daulat	99440-L		75	12
6) Feroze Minor	8000-TR		37	15
7) Fordwah	107820-R		51	9
Fordwah	28110-R		55	9
Fordwah	33000-R		25	6
Fordwah	57640-L		23	6
Fordwah	68260-L		25	6
Fordwah	96300-L		21	6
8) Fordwah Branch	316235-L		11	6
Fordwah Branch	352275-L		21	6
9) Hirwah Minor	15896-R		30	6
Hirwah Minor	32160-R		11	6

Annex 5

Budget for 1994 and 1995

Cost Items	1994		1995	
	Description	Amount (US$)	Description	Amount (US$)
International staff(HQ Senior Associates National staff	4 person months @ $12,000 18 person months @ $800	48,000 13,600	8 person months @ $12,000 20 person months @ $800	96,000 16,000
International travel and per diem for IIMI HQ and IIMI-Pak staff		5,000		5,000
Local travel and per diem for IIMI HQ and IIMI-Pak staff		3,000		-
Consultant		8,000		18,000
Contract Research: Field Survey and Data Analysis	1 FRP X 2 months x $350 4 En x 1 months x $750 Driver/vehicle/fuel = $2300 1/4 months x $250 = $1000	7,000		15,000
Water course survey (for sampling)		1,500		-
Workshop		1,000		25,000
Miscellaneous & Contingencies		500		-
Total		**87,600**		**175,000**
Indirect Cost		0		0
Gross Total		**87,600**		**175,000**

Socio-Economic Performance Indicators

1. Net Irrigated Area(ha)		
2. Total water supply(m^3) Estimated[1]		
3. Value of Out puts	Farmers Profitability(FP)[2]	Economic Profitability(EP)[3]
a). Total Gross Production(in kg)		
b). Price per kg		
c). Gross Value of Outputs		
d). Value of By-products		
e). Income from Labor inputs to others		
f). Income from Machine inputs to others		
Total Income		
4. Cost of Production		
a). Seeds		
b). Labor-Family		
c). Labor-Hired		
d). Machine Input		
e). Fertilizer		
f). Pesticide		
g). Weedicide		
h). Rodenticide		
i). Transportations		
j). Rent for Pumps		
k). Rent of Broadcaster		
l). Fuel		
m). Engine Oil		
n). Water Charges		
o). Others		
Total Cost of Production		
5. Net Value Output = Gross Output - Cost of Production = (3 - 4)		
6. Net Value Output/Ha = NVO / Net Irrigated Area = (5/1)		
7. Net Value Output/m3 of water = NVO / Total Irrigation Water Supply = (5/2)		
8. Gross Output Per Ha = (Kgs/Ha)		
9. Gross Output Per m3 = (Kgs/m3)		

[1] Details about the methodology used in estimating/measuring water input at the field level described in attached notes.
[2] Farmers Profitability is calculated using prices received or paid by the farmers for outputs. Th these prices reflect subsidized output and input prices.
[3] Economic Profitability is calculated using economic prices which reflects the benefits and costs the society. (i.e, by eliminating subsidies or input and output prices).